APPENDIX A— DATA TABLES

This appendix contains a compilation of previously reported analytical data used in the remedial investigation and feasibility study report for the Lockheed West Site. The data includes recent remedial investigation data, historical investigation data, recent data collected from nearby sediment sites, recently collected data from the "Bold Study" survey of Puget Sound, and Washington Department of Ecology data collected from Elliott Bay.

This page intentionally left blank.

LIST OF TABLES

ATTACHMENTS

This page intentionally left blank.

Table A-1. 2007 Remedial Investigation Subsurface Cores Analytical Data

Location			1	1	1	2	2	2	3	3	3	4	4	4	5	5	5	6
Sample ID			TT01-CS-A	TT01-CS-B	TT01-CS-C	TT02-CS-B	TT02-CS-C	TT02-CS-D	TT03-CS-B	TT03-CS-C	TT03-CS-D	TT04-CS-B	TT04-CS-C	TT04-CS-J	TT05-CS-A	TT05-CS-B	TT05-CS-C	TT06-CS-A
Sample Date			1/19/2007	1/19/2007	1/19/2007	1/18/2007	1/18/2007	1/18/2007	1/18/2007	1/18/2007	1/18/2007	1/22/2007	1/22/2007	1/22/2007	1/12/2007	1/12/2007	1/12/2007	1/17/2007
Sample Depth (MLLW)			-30 To -31 ft	-31 To -32 ft	-32 To -33 ft	-39 To -40 ft	-40 To -41 ft	-41 To -42 ft	-17.61 To -19 ft	-19 To -20 ft	-20 To -21 ft	-24 To -25 ft	-25 To -26 ft	-32 To -33 ft	-5.9 To -7 ft	-7 To -8 ft	-8 To -9 ft	-43 To -43.97 ft
Parameter	**Method**	**Units**																
Antimony	EPA 6020	mg/Kg	0.14 * J	0.054 * J	0.043 U* UJ	0.104 * J	0.045 U* UJ	0.049 B,* J	0.181 * J	0.065 * J	0.521 * J	2.36 * J	1.36 * J	0.252 * J	0.66	0.84	0.53	33.2 * J
Arsenic	EPA 6020	mg/Kg	2.3 J	2.42 J	2.39 J	5.36 J	3.04 J	2.54 J	3.18 J	7.93 J	1.39 J	12.2 J	5.61 J	7.4 J	3.91	4.28	3.34	88.9
Cadmium	EPA 6020	mg/Kg	0.033 B	0.036 B	0.047 B	0.177	0.074	0.052 B	0.093	0.051 B	0.032 B	0.82	0.27	0.681	0.144	0.177	0.19	0.794
Chromium	EPA 6010B	mg/Kg	14.4	12.8	12.6	24.2	12.7	11.8	15.5	12.5	10.7	45.8	19.9	25.8	33.7	35.3	17.3	130
Cobalt	EPA 6020	mg/Kg	3.33 J	3.41 J	3.36 J	5.86 J	3.52 J	3.4 J	2.75 J	2.27 J	2.07 J	5.49 J	3.52 J	4.17 J	3.63	3.76	3.2	9.06
Copper	EPA 6010B	mg/Kg	10.9 * J	14.5 * J	15.3 * J	27.8 * J	13.5 * J	13.4 * J	14.4 * J	8.9 * J	8.6 * J	173 * J	50.6 * J	45.9 * J	41.9	55.5	44.2	1110
Lead	EPA 6020	mg/Kg	3.26	1.8	1.76	6.64	1.93	1.9	21.3	8.31	6.54	159	47.9	57.6	27.5	31.1	44.5	253
Mercury	EPA 7471A	mg/Kg	0.028	0.02	0.018 B	0.079	0.016 B	0.02	0.158	0.033	0.029	1.39	0.425	0.623	0.143	0.312	0.297	2.09
Molybdenum	EPA 6020	mg/Kg	0.26	0.26	0.28	0.68	0.59	0.52	0.43	0.28	0.24	1.74	1	1.46	1.67	2.03	1.19	4.57
Nickel	EPA 6020	mg/Kg	10.1 J	7.07 J	6.69 J	14.9 J	7.02 J	6.73 J	6.55 J	5.49 J	5.04 J	14 J	8.91 J	10.6 J	15.7	12.7	8.19	41.4
Selenium	EPA 6020	mg/Kg	0.4 B	0.2 B	0.3 B	0.4 B	0.4 B	0.4 B	0.2 U	0.2 B	0.2 U	0.8 B	0.3 B	0.4 B	0.1 U	0.1 B	0.3 B	0.8 B
Silver	EPA 6020	mg/Kg	0.034	0.052	0.046	0.123	0.046	0.034	0.084	0.029	0.033	1.29	0.225	0.367	0.098	0.155	0.215	0.741
Thallium	EPA 6020	mg/Kg	0.033	0.046	0.048	0.103	0.051	0.049	0.031	0.027	0.024	0.104	0.051	0.107	0.05	0.05	0.05	0.14
Vanadium	EPA 6010B	mg/Kg	32.3	44.4	45.4	59.7	41.8	40.7	41.4	38.4	33.7	59.7	40	50.9	45.7	53.9	36.6	54.6
Zinc	EPA 6010B	mg/Kg	24.2	26.5	27.4	49.5	26.1	25	38.6	29.9	30.4	244	111	97.3	89.2	96.2	60.9	544
PCBs (total)	TT calculated	ug/Kg	70	2.3 U	2.4 U	6.2	2.4 U	2.4 U	22	11.9	5.9	570	94	45	89.6	75.6	29	1870
		mg/kg OC		0.36 U	0.35 U	0.47	0.33 U	0.47 U				23.4	15.4	3.1				121.4
PCB-1016	EPA 8082	ug/Kg	2.2 U	2.3 U	2.4 U UJ	2.5 U	2.4 U	2.4 U	2.3 U	2.2 U	2.2 U	2.9 U	2.3 U	2.5 U	2.1 U UJ	2.2 U UJ	2.2 U	59 U
PCB-1221	EPA 8082	ug/Kg	2.2 U	2.3 U	2.4 U UJ	2.5 U	2.4 U	2.4 U	2.3 U	2.2 U	2.2 U	2.9 U	2.3 U	2.5 U	2.1 U UJ	2.2 U UJ	2.2 U	59 U
PCB-1232	EPA 8082	ug/Kg	2.2 U	2.3 U	2.4 U UJ	2.5 U	2.4 U	2.4 U	2.3 U	2.2 U	2.2 U	2.9 U	2.3 U	2.5 U	2.1 U UJ	2.2 U UJ	2.2 U	59 U
PCB-1242	EPA 8082	ug/Kg	2.2 U	2.3 U	2.4 U	2.5 U	2.4 U	2.4 U	2.3 U	2.2 U	2.2 U	2.9 U	2.3 U	2.5 U	2.1 U UJ	2.2 U UJ	2.2 U UJ	59 U
PCB-1248	EPA 8082	ug/Kg	2.2 U	2.3 U	2.4 U	2.5 U	2.4 U	2.4 U	2.3 U	2.2 U	2.2 U	2.9 U	2.3 U	2.5 U	2.1 U UJ	2.2 U UJ	2.2 U UJ	59 U
PCB-1254	EPA 8082	ug/Kg	46	2.3 U	2.4 U	3.3 J	2.4 U	2.4 U	12	6.2	3.2 J	300	49	2.5 U	49 J	38 J	29 J	1000 D
PCB-1260	EPA 8082	ug/Kg	24 P J	2.3 U	2.4 U	2.9 J	2.4 U	2.4 U	10	5.7	2.7 J	270	45	2.5 U	33 J	33 J	2.2 U UJ	870 D
PCB-1262	EPA 8082	ug/Kg	2.2 U	2.3 U	2.4 U	2.5 U	2.4 U	2.4 U	2.3 U	2.2 U	2.2 U	2.9 U	2.3 U	31	2.1 U UJ	2.2 U UJ	2.2 U UJ	59 U
PCB-1268	EPA 8082	ug/Kg	2.2 U	2.3 U	2.4 U	2.5 U	2.4 U	2.4 U	2.3 U	2.2 U	2.2 U	2.9 U	2.3 U	14	7.6 J	4.6 J	2.2 U UJ	59 U
Aldrin	EPA 8081A	ug/Kg	0.2 U UJ	0.2 U UJ	0.21 U UJ	0.37 Ui UJ	0.21 U UJ	0.21 U UJ	0.2 U UJ	0.2 U UJ	0.19 U UJ	2.6 U UJ	2.1 U UJ	0.22 U UJ	0.93 U UJ	0.95 U UJ	0.97 U UJ	110 U UJ
alpha-BHC	EPA 8081A	ug/Kg	0.34 U UJ	0.35 U UJ	0.36 U UJ	0.39 U UJ	0.36 U UJ	0.36 U UJ	0.35 U UJ	0.34 U UJ	0.33 U UJ	4.5 U UJ	3.6 U UJ	0.64 Ui UJ	1.7 U UJ	1.7 U UJ	1.7 U UJ	190 U UJ
alpha-Chlordane	EPA 8081A	ug/Kg	0.3 U UJ	0.31 U UJ	0.32 U UJ	0.34 U UJ	0.32 U UJ	0.32 U UJ	0.31 U UJ	0.3 U UJ	0.29 U UJ	4 U UJ	3.2 U UJ	0.34 U UJ	1.5 U UJ	1.5 U UJ	1.5 U UJ	170 U UJ
beta-BHC	EPA 8081A	ug/Kg	0.39 U UJ	0.4 U UJ	0.41 U UJ	0.62 Ui UJ	0.42 U UJ	0.41 U UJ	0.4 U UJ	0.39 U UJ	0.38 U UJ	5.2 U UJ	4.1 U UJ	0.44 U UJ	1.9 U UJ	1.9 U UJ	2 U UJ	220 U UJ
delta-BHC	EPA 8081A	ug/Kg	0.13 Ui UJ	0.074 U UJ	0.075 U UJ	0.49 Ui UJ	0.076 U UJ	0.075 U UJ	0.073 U UJ	0.085 Ui UJ	0.07 U UJ	5.1 Ui UJ	0.75 U UJ	0.51 Ui UJ	1.8 Ui UJ	0.35 U UJ	1.5 Ui UJ	39 U UJ
Dieldrin	EPA 8081A	ug/Kg	0.38 U UJ	0.39 U UJ	0.4 U UJ	0.43 U UJ	0.4 U UJ	0.4 U UJ	0.39 U UJ	0.38 U UJ	0.37 U UJ	5 U UJ	4 U UJ	0.43 U UJ	1.8 U UJ	1.9 U UJ	1.9 U UJ	210 U UJ
Endosulfan I	EPA 8081A	ug/Kg	0.22 U UJ	0.23 U UJ	0.24 U UJ	0.25 U UJ	0.24 U UJ	0.24 U UJ	0.23 U UJ	0.22 U UJ	0.22 U UJ	2.9 U UJ	2.3 U UJ	0.25 U UJ	1.1 U UJ	1.1 U UJ	1.1 U UJ	120 U UJ
Endosulfan II	EPA 8081A	ug/Kg	0.25 U UJ	0.26 U UJ	0.26 U UJ	0.28 U UJ	0.27 U UJ	0.26 U UJ	0.26 U UJ	0.25 U UJ	0.24 U UJ	3.3 U UJ	2.6 U UJ	0.5 Ui UJ	1.2 U UJ	1.2 U UJ	1.3 U UJ	140 U UJ
Endosulfan sulfate	EPA 8081A	ug/Kg	0.26 Ui UJ	0.52 Ui UJ	0.15 Ui UJ	0.12 U UJ	0.11 U UJ	0.21 Ui UJ	0.17 Ui UJ	0.11 U UJ	0.1 U UJ	5.1 Ui UJ	1.1 U UJ	0.12 U UJ	0.49 U UJ	0.5 U UJ	0.51 U UJ	56 U UJ
Endrin	EPA 8081A	ug/Kg	0.26 U UJ	0.27 U UJ	0.28 U UJ	0.3 U UJ	0.28 U UJ	0.28 U UJ	0.27 U UJ	0.26 U UJ	0.26 U UJ	3.5 U UJ	2.7 U UJ	0.3 U UJ	1.3 U UJ	1.3 U UJ	1.3 U UJ	150 U UJ
Endrin aldehyde	EPA 8081A	ug/Kg	0.26 Ui UJ	0.071 U UJ	0.072 U UJ	0.21 JP UJ	0.084 J UJ	0.072 U UJ	0.16 Ui UJ	0.13 Ui UJ	0.083 Ui UJ	5.1 Ui UJ	0.72 U UJ	0.44 JP UJ	1.7 JPD UJ	1.5 Ui UJ	1.2 Ui UJ	38 U UJ
gamma-BHC	EPA 8081A	ug/Kg	0.2 U UJ	0.2 U UJ	0.21 U UJ	0.51 Ui UJ	0.47 Ui UJ	0.21 U UJ	0.2 U UJ	0.2 U UJ	0.19 U UJ	5.1 Ui UJ	2.1 U UJ	1.2 Ui UJ	0.93 U UJ	0.95 U UJ	0.97 U UJ	110 U UJ
gamma-Chlordane	EPA 8081A	ug/Kg	0.66 P JN	0.086 U UJ	0.087 U UJ	0.53 P JN	0.088 U UJ	0.087 U UJ	0.22 JP JN	0.082 U UJ	0.081 U UJ	6.9 Ui UJ	0.87 U UJ	0.86 Ui UJ	1.3 JPD JN	2.3 JD JN	0.42 U UJ	45 U UJ
Heptachlor	EPA 8081A	ug/Kg	0.11 U UJ	0.11 U UJ	0.11 U UJ	0.12 U UJ	0.11 U UJ	0.11 U UJ	0.11 U UJ	0.11 U UJ	0.11 U UJ	1.5 Ui UJ	1.1 U UJ	0.12 U UJ	0.5 U UJ	0.51 U UJ	0.52 U UJ	57 U UJ
Heptachlor epoxide	EPA 8081A	ug/Kg	0.42 Ui UJ	0.18 U UJ	0.18 U UJ	0.34 J JN	0.18 U UJ	0.18 U UJ	0.18 U UJ	0.17 U UJ	0.17 U UJ	2.3 U UJ	1.8 U UJ	0.2 U UJ	2.5 JPD JN	1.1 Ui UJ	1.2 JD JN	92 U UJ
Methoxychlor	EPA 8081A	ug/Kg	0.13 U UJ	0.14 U UJ	0.14 U UJ	0.15 U UJ	0.14 U UJ	0.14 U UJ	0.14 U UJ	0.13 U UJ	0.13 U UJ	2.9 JD JN	1.4 U UJ	0.43 Ui UJ	0.62 U UJ	1.2 Ui UJ	1.5 Ui UJ	71 U UJ
Mirex	EPA 8081A	ug/Kg	0.13 U UJ	0.14 U UJ	0.14 U UJ	0.15 U UJ	0.14 U UJ	0.14 U UJ	0.14 U UJ	0.13 U UJ	0.13 U UJ	1.9 JD JN	1.4 U UJ	0.24 J JN	0.62 U UJ	0.71 JD JN	0.65 U UJ	71 U UJ
Nonachlor (cis)	EPA 8081A	ug/Kg	1.5 Ui UJ	0.52 Ui UJ	0.17 Ui UJ	0.13 U UJ	0.12 U UJ	0.12 U UJ	0.18 Ui UJ	0.3 Ui UJ	0.11 U UJ	3.4 Ui UJ	3.4 Ui UJ	0.13 U UJ	2.9 Ui UJ	2.4 Ui UJ	1.3 Ui UJ	59 U UJ
Nonachlor (trans)	EPA 8081A	ug/Kg	0.63 Ui UJ	0.12 U UJ	0.13 U UJ	0.14 U UJ	0.13 U UJ	0.13 U UJ	0.12 U UJ	0.12 U UJ	0.12 U UJ	1.6 U UJ	1.3 U UJ	0.51 Ui UJ	0.95 Ui UJ	0.57 U UJ	0.58 U UJ	63 U UJ
Oxychlordane	EPA 8081A	ug/Kg	0.48 U UJ	0.5 U UJ	0.51 U UJ	0.55 U UJ	0.51 U UJ	0.51 U UJ	0.49 U UJ	0.48 U UJ	0.47 U UJ	6.4 U UJ	5 U UJ	0.55 U UJ	2.3 U UJ	2.4 U UJ	2.4 U UJ	260 U UJ
Toxaphene	EPA 8081A	ug/Kg	25 Ui UJ	12 U UJ	13 U UJ	14 U UJ	13 U UJ	13 U UJ	17 Ui UJ	12 U UJ	12 U UJ	380 Ui UJ	130 U UJ	65 Ui UJ	56 U UJ	73 Ui UJ	58 U UJ	6400 U UJ
o,p'-DDD	EPA 8081A	ug/Kg	1.2 Ui UJ	0.28 U UJ	0.29 U UJ	0.31 U UJ	0.29 U UJ	0.29 U UJ	0.86 P JN	0.54 JN	0.27 U UJ	29 D JN	5.5 D JN	0.31 U UJ	7.4 D JN	5.5 PD JN	3.9 D JN	150 U UJ
o,p'-DDE	EPA 8081A	ug/Kg	0.95 Ui UJ	0.31 U UJ	0.32 U UJ	0.34 U UJ	0.32 U UJ	0.32 U UJ	0.31 U UJ	0.3 U UJ	0.29 U UJ	4 U UJ	3.2 U UJ	0.51 Ui UJ	1.5 U UJ	1.5 U UJ	1.5 U UJ	170 U UJ
o,p'-DDT	EPA 8081A	ug/Kg	2.7 JN	0.19 U UJ	0.19 U UJ	0.21 U UJ	0.2 U UJ	0.19 U UJ	0.58 JN	0.41 J JN	0.18 U UJ	21 D JN	3.9 JD JN	0.51 Ui UJ	4.9 D JN	3 D JN	1.9 JD JN	99 U UJ
p,p'-DDD	EPA 8081A	ug/Kg	0.24 J JN	0.52 Ui UJ	0.17 U UJ	0.18 U UJ	0.17 U UJ	0.17 U UJ	0.43 J JN	0.19 JP JN	0.16 U UJ	11 D JN	3.7 Ui UJ	0.18 U UJ	0.95 JPD JN	3.2 PD JN	5.5 PD JN	85 U UJ
p,p'-DDE	EPA 8081A	ug/Kg	0.13 U UJ	0.14 U UJ	0.14 U UJ	0.15 U UJ	0.14 U UJ	0.14 U UJ	0.14 U UJ	0.13 U UJ	0.13 U UJ	6.8 PD JN	1.4 U UJ	0.15 U UJ	0.9 JD JN	0.63 U UJ	1.8 JPD JN	71 U UJ
p,p'-DDT	EPA 8081A	ug/Kg	3.4 JN	0.086 U UJ	0.087 U UJ	0.14 JP JN	0.14 Ui UJ	0.087 U UJ	0.87 JN	0.59 JN	0.3 J JN	27 D JN	4.7 D JN	1.3 JN	7.9 D JN	6.2 D JN	2.4 JD JN	110 JD JN
Total DDT	TT Calculated	ug/Kg	6.34 JN	0.52 U UJ	0.32 U UJ	0.14 JN	0.32 U UJ	0.32 U UJ	2.74 JN	1.73 JN	0.3 JN	94.8 JN	14.1 JN	1.3 JN	22.05 JN	17.9 JN	15.5 JN	110 JN
Total Chlordane	TT Calculated	ug/Kg	0.66 JN	0.52 U UJ	0.51 U UJ	0.53 JN	0.51 U UJ	0.51 U UJ	0.22 JN	0.48 U UJ	0.47 U UJ	6.9 U UJ	5 U UJ	0.86 U UJ	1.3 JN	2.3 JN	2.4 U UJ	260 U UJ
1,2,4-Trichlorobenzene	EPA 8270C	ug/Kg	2 U	2 U	2.1 U	2.3 U	2.1 U	2.1 U	2 U	2 U	1.9 U	2.6 U UJ	2.1 U UJ	2.2 U UJ	1.9 U	9.5 U	9.7 U	27 U
		mg/kg OC		0.3 U	0.3 U	0.2 U	0.3 U	0.4 U				0.1 U UJ	0.3 U UJ	0.2 U UJ				1.8 U
1,2-Dichlorobenzene	EPA 8270C	ug/Kg	1.7 U	1.8 U	1.8 U	2 U	1.8 U	1.8 U	1.8 U	1.7 U	1.7 U	2.3 U UJ	1.8 U UJ	2 U UJ	1.7 U	8.2 U	8.4 U	23 U
		mg/kg OC		0.3 U	0.3 U	0.2 U	0.2 U	0.4 U				0.1 U UJ	0.3 U UJ	0.1 U UJ				1.5 U
1,3-Dichlorobenzene	EPA 8270C	ug/Kg	2.1 U	2.2 U	2.2 U	2.4 U	2.2 U	2.2 U	2.2 U	2.1 U	2.1 U	2.8 U UJ	2.2 U UJ	2.4 U UJ	2 U	11 U	11 U	29 U
1,4-Dichlorobenzene	EPA 8270C	ug/Kg	2.5 U	2.6 U	2.6 U	2.8 U	2.7 U	2.6 U	2.6 U	2.5 U	2.4 U	3.3 U UJ	2.6 U UJ	2.8 U UJ	2.4 U	12 U	13 U	34 U
		mg/kg OC		0.4 U	0.4 U	0.2 U	0.4 U	0.5 U				0.1 U UJ	0.4 U UJ	0.2 U UJ				2.2 U
1-Methylnaphthalene	EPA 8270C	ug/Kg	13 U UJ	14 U UJ	14 U UJ	15 U UJ	14 U UJ	14 U UJ	14 U UJ	13 U UJ	13 U UJ	18 U UJ	14 U UJ	39 J	13 U UJ	63 U UJ	65 U UJ	180 U UJ
2,4,5-Trichlorophenol	EPA 8270C	ug/Kg	3.9 U	4 U	4.1 U	4.5 U	4.2 U	4.1 U	4 U	3.9 U	3.8 U	5.2 U UJ	4.1 U UJ	4.4 U UJ	3.8 U	19 U	20 U	53 U
2,4,6-Trichlorophenol	EPA 8270C	ug/Kg	2.4 U	2.4 U	2.5 U	2.7 U	2.5 U	2.5 U	2.4 U	2.4 U	2.3 U	3.1 U UJ	2.5 U UJ	2.7 U UJ	2.3 U	12 U	12 U	32 U
2,4-Dichlorophenol	EPA 8270C	ug/Kg	2.4 U	2.4 U	2.5 U	2.7 U	2.5 U	2.5 U	2.4 U	2.4 U	2.3 U	3.1 U UJ	2.5 U UJ	2.7 U UJ	2.3 U	12 U	12 U	32 U
2,4-Dimethylphenol	EPA 8270C	ug/Kg	7.1 U	7.4 U	7.5 U	8.1 U	7.6 U	7.5 U	7.3 U	7.1 U	7 U	9.4 U UJ	7.5 U UJ	8.1 U UJ	6.8 U	35 U	36 U	97 U
2,4-Dinitrophenol	EPA 8270C	ug/Kg	47 U UJ	48 U UJ	49 U UJ	53 U UJ	50 U	49 U	48 U UJ	47 U UJ	46 U UJ	62 U UJ	49 U UJ	53 U UJ	45 U	230 U	240 U	640 U UJ
2,4-Dinitrotoluene	EPA 8270C	ug/Kg	3.6 U	3.8 U	3.8 U	4.2 U	3.9 U	3.8 U	3.7 U	3.6 U	3.6 U	4.8 U UJ	3.8 U UJ	4.1 U UJ	3.5 U	18 U	19 U	50 U
2,6-Dinitrotoluene	EPA 8270C	ug/Kg	3.6 U	3.8 U	3.8 U	4.2 U	3.9 U	3.8 U	3.7 U	3.6 U	3.6 U	4.8 U UJ	3.8 U UJ	4.1 U UJ	3.5 U	18 U	19 U	50 U
2-Chloronaphthalene	EPA 8270C	ug/Kg	4.7 U	4.8 U	4.9 U	5.3 U	5 U	4.9 U	4.8 U	4.7 U	4.6 U	6.2 U UJ	4.9 U UJ	5.3 U UJ	4.5 U	23 U	24 U	64 U
2-Chlorophenol	EPA 8270C	ug/Kg	2.2 U	2.3 U	2.4 U	2.5 U	2.4 U	2.4 U	2.3 U	2.2 U	2.2 U	2.9 U UJ	2.3 U UJ	2.5 U UJ	2.1 U	11 U	11 U	30 U
2-Methylnaphthalene	EPA 8270C	ug/Kg	1.6 U	1.6 U	1.7 U	4.2 J	1.7 U	1.7 U	6.2 J	1.6 U	1.6 U	7.7 J J	10 J	100 JD	4.3 J	12 JD	55 D	35 JD
		mg/kg OC		0.3 U	0.2 U	0.3 J	0.2 U	0.3 U				0.3 J J	1.6 J	6.8 JD				2.3 JD
2-Methylphenol	EPA 8270C	ug/Kg	4.4 U	4.6 U	4.7 U	5 U	4.7 U	4.7 U	4.5 U	4.4 U	4.3 U	5.8 U UJ	4.6 U UJ	5 U UJ	4.2 U	22 U	22 U	60 U
2-Nitroaniline	EPA 8270C	ug/Kg	3.5 U	3.6 U	3.7 U	4 U	3.7 U	3.7 U	3.6 U	3.5 U	3.4 U	4.6 U UJ	3.7 U UJ	4 U UJ	3.4 U	18 U	18 U	48 U
2-Nitrophenol	EPA 8270C	ug/Kg	3.4 U	3.5 U	3.6 U	3.9 U	3.6 U	3.6 U	3.5 U	3.4 U	3.3 U	4.5 U UJ	3.6 U UJ	3.9 U UJ	3.3 U	17 U	17 U	46 U
3,3'-Dichlorobenzidine	EPA 8270C	ug/Kg	4.8 U	5 U	5.1 U	5.5 U	5.1 U	5.1 U	4.9 U	4.8 U	4.7 U	6.4 U UJ	5 U UJ	5.5 U UJ	4.6 U	24 U UJ	24 U UJ	65 U
3-Nitroaniline	EPA 8270C	ug/Kg	3.4 U	3.5 U	3.6 U	3.9 U	3.6 U	3.6 U	3.5 U	3.4 U	3.3 U	4.5 U UJ	3.6 U UJ	3.9 U UJ	3.3 U	17 U	17 U	46 U

Table A-1. 2007 Remedial Investigation Subsurface Cores Analytical Data

Location			1	1	1	2	2	2	3	3	3	4	4	4	5	5	5	6
Sample ID			TT01-CS-A	TT01-CS-B	TT01-CS-C	TT02-CS-B	TT02-CS-C	TT02-CS-D	TT03-CS-B	TT03-CS-C	TT03-CS-D	TT04-CS-B	TT04-CS-C	TT04-CS-J	TT05-CS-A	TT05-CS-B	TT05-CS-C	TT06-CS-A
Sample Date			1/19/2007	1/19/2007	1/19/2007	1/18/2007	1/18/2007	1/18/2007	1/18/2007	1/18/2007	1/18/2007	1/22/2007	1/22/2007	1/22/2007	1/12/2007	1/12/2007	1/12/2007	1/17/2007
Sample Depth (MLLW)			-30 To -31 ft	-31 To -32 ft	-32 To -33 ft	-39 To -40 ft	-40 To -41 ft	-41 To -42 ft	-17.61 To -19 ft	-19 To -20 ft	-20 To -21 ft	-24 To -25 ft	-25 To -26 ft	-32 To -33 ft	-5.9 To -7 ft	-7 To -8 ft	-8 To -9 ft	-43 To -43.97 ft
Parameter	**Method**	**Units**																
4,6-Dinitro-o-cresol	EPA 8270C	ug/Kg	2.2 U	2.3 U	2.4 U	2.5 U	2.4 U	2.4 U	2.3 U	2.2 U	2.2 U	2.9 U UJ	2.3 U UJ	2.5 U UJ	2.1 U	11 U	11 U	30 U
4-Bromophenyl phenyl ether	EPA 8270C	ug/Kg	1.8 U	1.9 U	1.9 U	2.1 U	2 U	1.9 U	1.9 U	1.8 U	1.8 U	2.4 U UJ	1.9 U UJ	2.1 U UJ	1.8 U	8.9 U	9.1 U	25 U
4-Chloro-3-methylphenol	EPA 8270C	ug/Kg	2.7 U	2.8 U	2.9 U	3.1 U	2.9 U	2.9 U	2.8 U	2.7 U	2.7 U	3.6 U UJ	2.9 U UJ	3.1 U UJ	2.6 U	14 U	14 U	37 U
4-Chloroaniline	EPA 8270C	ug/Kg	2.7 U	2.8 U	2.9 U	3.1 U	2.9 U	2.9 U	2.8 U	2.7 U	2.7 U	3.6 U UJ	2.9 U UJ	3.1 U UJ	2.6 U	14 U	14 U	37 U
4-Chlorophenyl phenyl ether	EPA 8270C	ug/Kg	2.6 U	2.7 U	2.8 U	3 U	2.8 U	2.8 U	2.7 U	2.6 U	2.6 U	3.5 U UJ	2.7 U UJ	3 U UJ	2.5 U	13 U	13 U	36 U
4-Methylphenol	EPA 8270C	ug/Kg	3.8 U	3.9 U	4 U	4.3 U	4 U	4 U	3.9 U	3.8 U	3.7 U	5 U UJ	4 U UJ	8.4 J J	9.6 J	19 U	19 U	51 U
4-Nitroaniline	EPA 8270C	ug/Kg	4.4 U	4.6 U	4.7 U	5 U	4.7 U	4.7 U	4.5 U	4.4 U	4.3 U	5.8 U UJ	4.6 U UJ	5 U UJ	4.2 U	22 U	22 U	60 U
4-Nitrophenol	EPA 8270C	ug/Kg	39 U	40 U	41 U	45 U	42 U	41 U	40 U	39 U	38 U	52 U UJ	41 U UJ	44 U UJ	38 U	190 U	200 U	530 U
Acenaphthene	EPA 8270C	ug/Kg	2.1 J	1.4 U	1.4 U	3 J	1.4 U	1.4 U	5.5 J	19	2.3 J	28 JD	21 JD	150 D	11	28 JD	190 D	130 D
		mg/kg OC		0.2 U	0.2 U	0.2 J	0.2 U	0.3 U				1.1 JD	3.4 JD	10.3 D				8.4 D
Acenaphthylene	EPA 8270C	ug/Kg	2 J	1.9 U	1.9 U	4 J	2 U	1.9 U	11	4.9 J	3.2 J	59 JD	22 JD	90 JD	47	21 JD	29 JD	140 D
		mg/kg OC		0.3 U	0.3 U	0.3 J	0.3 U	0.4 U				2.4 JD	3.6 JD	6.2 JD				9.1 D
Aniline	EPA 8270C	ug/Kg	2 U	2 U	2.1 U	2.3 U	2.1 U	2.1 U	2 U	2 U	1.9 U	2.6 U UJ	2.1 U UJ	2.2 U UJ	1.9 U	11 JD	11 JD	27 U
Anthracene	EPA 8270C	ug/Kg	4.7 J	1.9 U	1.9 U	6.3 J	2 U	1.9 U	23	11	8.1 J	230 D	70 JD	300 D	180	74 D	130 D	420 D
		mg/kg OC		0.3 U	0.3 U	0.5 J	0.3 U	0.4 U				9.4 D	11.5 JD	20.5 D				27.3 D
Benzo(a)anthracene	EPA 8270C	ug/Kg	13	1.9 U	1.9 U	6.9 J	2 U	1.9 U	25	15	17	620 D	160 D	360 D	560	81 D	82 D	1200 D
		mg/kg OC		0.3 U	0.3 U	0.5 J	0.3 U	0.4 U				25.4 D	26.2 D	24.7 D				77.9 D
Benzo(a)pyrene	EPA 8270C	ug/Kg	15	2.2 U	2.2 U	2.4 U	2.2 U	2.2 U	50	26	21	410 D	150 D	490 D	230	110 D	150 D	1600 D
		mg/kg OC		0.3 U	0.3 U	0.2 U	0.3 U	0.4 U				16.8 D	24.6 D	33.6 D				103.9 D
Benzo(b)fluoranthene	EPA 8270C	ug/Kg	22	3.4 U	3.4 U	8.3 J	3.5 U	3.4 U	75	37	29	650 D	240 D	740 D	440	150 D	200 D	1900 D
Benzo(g,h,i)perylene	EPA 8270C	ug/Kg	9.6 J	3.1 U	3.2 U	5.4 J	3.2 U	3.2 U	34	17	14	210 D	89 JD	290 D	76	67 D	66 D	830 D
		mg/kg OC		0.5 U	0.5 U	0.4 J	0.4 U	0.6 U				8.6 D	14.6 JD	19.9 D				53.9 D
Benzo(k)fluoranthene	EPA 8270C	ug/Kg	7.2 J	3.4 U	3.4 U	3.7 U	3.5 U	3.4 U	27	13	10	240 D	87 JD	270 D	120	110 D	170 D	1400 D
Benzofluoranthenes (total)	TT calculated	ug/Kg	29.2	3.4 U	3.4 U	8.3	3.5 U	3.4 U	102	50	39	890	327	1010	560	260	370	3300
		mg/kg OC		0.5 U	0.5 U	0.6	0.5 U	0.7 U				36.5	53.6	69.2				214.3
Benzoic acid	EPA 8270C	ug/Kg	130 U	130 U	130 U	150 U	140 U	140 U	130 U	130 U	130 U	170 U UJ	130 U UJ	150 U UJ	120 U UJ	610 U UJ	620 U UJ	1700 U
Benzyl alcohol	EPA 8270C	ug/Kg	4.8 U	5 U	5.1 U	5.5 U	5.1 U	5.1 U	4.9 U	4.8 U	4.7 U	6.4 U UJ	5 U UJ	5.5 U UJ	4.6 U	24 U	24 U	65 U
bis(2-chloroethoxy)methane	EPA 8270C	ug/Kg	1.7 U	1.8 U	1.8 U	2 U	1.8 U	1.8 U	1.8 U	1.7 U	1.7 U	2.3 U UJ	1.8 U UJ	2 U UJ	1.7 U	8.2 U	8.4 U	23 U
bis(2-chloroethyl)ether	EPA 8270C	ug/Kg	3.1 U	3.2 U	3.3 U	3.6 U	3.3 U	3.3 U	3.2 U	3.1 U	3.1 U	4.1 U UJ	3.3 U UJ	3.6 U UJ	3 U	16 U	16 U	43 U
bis(2-chloroisopropyl)ether	EPA 8270C	ug/Kg	1.6 U	1.6 U	1.7 U	1.8 U	1.7 U	1.7 U	1.6 U	1.6 U	1.6 U	2.1 U UJ	1.7 U UJ	1.8 U UJ	1.5 U	7.6 U	7.8 U	22 U
bis(2-ethylhexyl)phthalate	EPA 8270C	ug/Kg	14 J U	2.3 U	4.5 J U	6.7 J U	8.8 J U	4.2 J U	14 J U	7.1 J U	6.9 J U	1500 D	69 JD U	11 J UJ	44 J	64 JD U	22 JD U	790 JD
		mg/kg OC		0.4 U	0.7 J U	0.5 J U	1.2 J U	0.8 J U				61.5 D	11.3 JD U	0.8 J UJ				51.3 JD
Butyl benzyl phthalate	EPA 8270C	ug/Kg	2 U	2 U	2.1 U	2.3 U	2.1 U	2.1 U	2 U	2 U	1.9 U	2.6 U UJ	2.1 U UJ	2.2 U UJ	33	9.5 U	9.7 U	27 U
		mg/kg OC		0.3 U	0.3 U	0.2 U	0.3 U	0.4 U				0.1 U UJ	0.3 U UJ	0.2 U UJ				1.8 U
Chrysene	EPA 8270C	ug/Kg	15	1.9 U	1.9 U	7.1 J	2 U	1.9 U	36	20	25	760 D	200 D	600 D	580	150 D	120 D	1500 D
		mg/kg OC		0.3 U	0.3 U	0.5 J	0.3 U	0.4 U				31.1 D	32.8 D	41.1 D				97.4 D
Dibenzo(a,h)anthracene	EPA 8270C	ug/Kg	2.9 U	3 U	3 U	3.3 U	3.1 U	3 U	6.5 J	6.3 J	3.4 J	62 JD	17 J	74 JD	24	19 JD	21 JD	250 D
		mg/kg OC		0.5 U	0.4 U	0.2 U	0.4 U	0.6 U				2.5 JD	2.8 J	5.1 JD				16.2 D
Dibenzofuran	EPA 8270C	ug/Kg	1.7 U	1.8 U	1.8 U	3 J	1.8 U	1.8 U	4.7 J	7.6 J	1.7 U	14 J	12 J	100 JD	8.5 J	20 JD	120 D	61 JD
		mg/kg OC		0.3 U	0.3 U	0.2 J	0.2 U	0.4 U				0.6 J	2.0 J	6.8 JD				4.0 JD
Diethylphthalate	EPA 8270C	ug/Kg	4.5 U	5.9 J	4.8 U	5.2 U	4.8 U	4.8 U	10	4.5 U	4.4 U	6 U UJ	4.8 U UJ	5.2 U UJ	4.4 U	23 U	23 U	62 U
		mg/kg OC		0.9 J	0.7 U	0.4 U	0.7 U	0.9 U				0.2 U UJ	0.8 U UJ	0.4 U UJ				4.0 U
Dimethyl phthalate	EPA 8270C	ug/Kg	2.4 U	2.4 U	2.5 U	2.7 U	2.5 U	2.5 U	2.4 U	2.4 U	2.3 U	3.1 U UJ	2.5 U UJ	2.7 U UJ	5.8 J	12 U	12 U	32 U
		mg/kg OC		0.4 U	0.4 U	0.2 U	0.3 U	0.5 U				0.1 U UJ	0.4 U UJ	0.2 U UJ				2.1 U
Di-n-butyl phthalate	EPA 8270C	ug/Kg	5.2 J U	3.9 J U	4.7 J U	4.6 J U	4.1 J U	5.1 J U	7.1 J U	4.8 J U	5.4 J U	11 UJ	9.7 J UJ	12 UJ	3.3 U	17 U	17 U	89 JD
		mg/kg OC		0.6 J U	0.7 J U	0.3 J U	0.6 J U	1.0 J U				0.5 UJ	1.6 J UJ	0.8 UJ				5.8 JD
Di-n-octyl phthalate	EPA 8270C	ug/Kg	1.6 U	1.6 U	1.7 U	1.8 U	1.7 U	1.7 U	1.6 U	1.6 U	1.6 U	2.1 U UJ	1.7 U UJ	1.8 U UJ	1.5 U	7.6 U	7.8 U	22 U
		mg/kg OC		0.3 U	0.2 U	0.1 U	0.2 U	0.3 U				0.1 U UJ	0.3 U UJ	0.1 U UJ				1.4 U
Fluoranthene	EPA 8270C	ug/Kg	21	3 U	3 U	28	3.1 U	3 U	48	30	34	1300 D	540 D	760 D	2800 D	210 D	430 D	2700 D
		mg/kg OC		0.5 U	0.4 U	2.1	0.4 U	0.6 U				53.3 D	88.5 D	52.1 D				175.3 D
Fluorene	EPA 8270C	ug/Kg	2.2 U	2.3 U	2.4 U	3.7 J	2.4 U	2.4 U	5.1 J	9.2 J	2.2 U	45 JD	24 JD	160 D	38	36 JD	190 D	150 D
		mg/kg OC		0.4 U	0.3 U	0.3 J	0.3 U	0.5 U				1.8 JD	3.9 JD	11.0 D				9.7 D
Hexachlorobenzene	EPA 8081A	ug/Kg	0.11 U	0.11 U	0.11 U	0.12 U	0.11 U	0.11 U	0.11 U	0.11 U	0.1 U	1.4 U	1.1 U	0.12 U	0.49 U	0.5 U	0.51 U	
		mg/kg OC		0.02 U	0.02 U	0.01 U	0.02 U	0.02 U				0.06 U	0.18 U	0.01 U				
Hexachlorobenzene	EPA 8270C	ug/Kg																37 U
		mg/kg OC																2.4 U
Hexachlorobutadiene	EPA 8081A	ug/Kg	0.63 U	0.66 U	0.67 U	0.84 Ui	0.68 U	0.67 U	0.65 U	0.63 U	0.62 U			1.1 Ui		3.1 U	3.2 U	
		mg/kg OC		0.1 U	0.1 U	0.1 Ui	0.1 U	0.1 U						0.1 Ui				
Hexachlorobutadiene	EPA 8270C	ug/Kg										2.4 U UJ	1.9 U UJ		1.8 U			25 U
		mg/kg OC										0.1 U UJ	0.3 U UJ					1.6 U
Hexachlorocyclopentadiene	EPA 8270C	ug/Kg	20 U	20 U	21 U	23 U	21 U	21 U	20 U	20 U	19 U	26 U UJ	21 U UJ	22 U UJ	19 U	95 U	97 U	270 U UJ
Hexachloroethane	EPA 8270C	ug/Kg	2.9 U	3 U	3 U	3.3 U	3.1 U	3 U	2.9 U	2.9 U	2.8 U	3.8 U UJ	3 U UJ	3.3 U UJ	2.8 U	14 U	15 U	39 U
Indeno(1,2,3-cd)pyrene	EPA 8270C	ug/Kg	10 J	2.6 U	2.6 U	5.3 J	2.7 U	2.6 U	35	17	13	200 D	92 JD	290 D	100	71 D	75 D	930 D
		mg/kg OC		0.4 U	0.4 U	0.4 J	0.4 U	0.5 U				8.2 D	15.1 JD	19.9 D				60.4 D
Isophorone	EPA 8270C	ug/Kg	2.1 U	2.2 U	2.2 U	2.4 U	2.2 U	2.2 U	2.2 U	2.1 U	2.1 U	2.8 U UJ	2.2 U UJ	2.4 U UJ	2 U	11 U	11 U	29 U
Naphthalene	EPA 8270C	ug/Kg	2.3 J	1.8 U	1.8 U	7.5 J	1.8 U	1.8 U	15	12	3.5 J	20 J	29 JD	250 D	11	29 JD	91 D	63 JD
		mg/kg OC		0.3 U	0.3 U	0.6 J	0.2 U	0.4 U				0.8 J	4.8 JD	17.1 D				4.1 JD
Nitrobenzene	EPA 8270C	ug/Kg	2.6 U	2.7 U	2.8 U	3 U	2.8 U	2.8 U	2.7 U	2.6 U	2.6 U	3.5 U UJ	2.7 U UJ	3 U UJ	2.5 U	13 U	13 U	36 U
N-Nitrosodimethylamine	EPA 8270C	ug/Kg	7.9 U	8.2 U	8.3 U	9 U	8.4 U	8.3 U	8.1 U	7.9 U	7.7 U	11 U UJ	8.3 U UJ	9 U UJ	7.6 U	39 U	40 U	110 U
N-Nitroso-di-n-propylamine	EPA 8270C	ug/Kg	4.2 U	4.3 U	4.4 U	4.7 U	4.4 U	4.4 U	4.3 U	4.1 U	4.1 U	5.5 U UJ	4.4 U UJ	4.7 U UJ	4 U	21 U	21 U	57 U
N-Nitrosodiphenylamine	EPA 8270C	ug/Kg	2.9 U	3 U	3 U	3.3 U	3.1 U	3 U	2.9 U	2.9 U	2.8 U	3.8 U UJ	3 U UJ	3.3 U UJ	2.8 U	14 U	15 U	39 U
		mg/kg OC		0.5 U	0.4 U	0.2 U	0.4 U	0.6 U				0.2 U UJ	0.5 U UJ	0.2 U UJ				2.5 U
Pentachlorophenol	EPA 8270C	ug/Kg	11 U	12 U	12 U	13 U	12 U	12 U	12 U	11 U	11 U	15 U UJ	12 U UJ	13 U UJ	19 J	54 U	55 U	150 U
Phenanthrene	EPA 8270C	ug/Kg	11	3.8 J	2.9 J	16	3.1 J	1.8 J	28	22	12	240 D	95 JD	510 D	150	140 D	540 D	1300 D
		mg/kg OC		0.6 J	0.4 J	1.2	0.4 J	0.4 J				9.8 D	15.6 JD	34.9 D				84.4 D
Phenol	EPA 8270C	ug/Kg	2.5 U	2.6 U	2.6 U	2.8 U	2.7 U	2.6 U	2.6 U	2.5 U	2.4 U	3.3 U UJ	6.5 J UJ	7 J UJ	2.4 U	12 U	13 U	42 JD
Pyrene	EPA 8270C	ug/Kg	26	1.8 U	2.4 J	26	2.8 J	1.8 J	140	71	61	2100 D	890 D	1200 D	1100 E	350 D	910 D	2600 D
		mg/kg OC		0.3 U	0.3 J	2.0	0.4 J	0.4 J				86.1 D	145.9 D	82.2 D				168.8 D
Total HPAH	TT calculated	ug/Kg	138.8	3.4 U	2.4	87	2.8	1.8	476.5	252.3	227.4	6552	2465	5074	6030	1318	2224	14910
		mg/kg OC		0.5 U	0.3	6.5	0.4	0.4				268.5	404.1	347.5				968.2
Total LPAH	TT calculated	ug/Kg	22.1	3.8	2.9	40.5	3.1	1.8	87.6	78.1	29.1	622	261	1460	437	328	1170	2203
		mg/kg OC		0.6	0.4	3.0	0.4	0.4				25.5	42.8	100.0				143.1
Total PAH	TT calculated	ug/Kg	160.9	3.8	5.3	127.5	5.9	3.6	564.1	330.4	256.5	7174	2726	6534	6467	1646	3394	17113
Butyltin	KRONE	ug/Kg	0.039 U	0.04 U	0.04 U	0.045 U	0.042 U UJ	0.041 U	0.49 J J	0.039 U	0.038 U	1.1 J J	0.51 J J	0.044 U	1.1 J	1.2 J	0.24 J	61
Dibutyltin	KRONE	ug/Kg	2.6	0.038 U	0.34 J U	0.84 J U	0.37 J U	0.25 J U	1.8 U	0.31 J U	0.29 J U	8.1	11	0.45 J U	7.6	8.3	1.6 U	500 D

Table A-1. 2007 Remedial Investigation Subsurface Cores Analytical Data

Location			1	1	1	2	2	2	3	3	3	4	4	4	5	5	5	6
Sample ID			TT01-CS-A	TT01-CS-B	TT01-CS-C	TT02-CS-B	TT02-CS-C	TT02-CS-D	TT03-CS-B	TT03-CS-C	TT03-CS-D	TT04-CS-B	TT04-CS-C	TT04-CS-J	TT05-CS-A	TT05-CS-B	TT05-CS-C	TT06-CS-A
Sample Date			1/19/2007	1/19/2007	1/19/2007	1/18/2007	1/18/2007	1/18/2007	1/18/2007	1/18/2007	1/18/2007	1/22/2007	1/22/2007	1/22/2007	1/12/2007	1/12/2007	1/12/2007	1/17/2007
Sample Depth (MLLW)			-30 To -31 ft	-31 To -32 ft	-32 To -33 ft	-39 To -40 ft	-40 To -41 ft	-41 To -42 ft	-17.61 To -19 ft	-19 To -20 ft	-20 To -21 ft	-24 To -25 ft	-25 To -26 ft	-32 To -33 ft	-5.9 To -7 ft	-7 To -8 ft	-8 To -9 ft	-43 To -43.97 ft
Parameter	**Method**	**Units**																
Tetrabutyltin	KRONE	ug/Kg	0.09 U	0.094 U	0.092 U	0.11 U	0.096 U	0.095 U	0.093 U	0.09 U	0.088 U	0.12 U	0.095 U	0.11 U	0.44 JP J	0.089 U	0.091 U	23
Tributyltin	KRONE	ug/Kg	11	0.075 U	0.074 U	2	0.077 U	0.076 U	3.2	0.57 J	0.54 J	16	26	0.082 U	36	20	2.2	1700 D
		mg/kg OC		0.012 U	0.011 U	0.2	0.011 U	0.015 U				0.7	4.3	0.006 U				110.4 D
Total Solids	EPA 160.3	Percent	83.2	77.4	76.2	68.6	74.9	74	76.7	79.1	79.5	60.9	73.9	69.2	81	79.4	77.7	57
Total Organic Carbon	ASTM D4129-98M	Percent	0.48	0.64	0.69	1.33	0.73	0.51	0.3	0.16	0.15	2.44	0.61	1.46	0.26	0.39	0.46	1.54
Fractional % phi >-1	PSEP Grain Size	Percent	1.05	0.25	0.1	0.2	0.35	0.11	0.23	0.43	0.27	1.75	0.78	0.35	2.64	1.5	0.87	1.23
Fractional % phi 0-1	PSEP Grain Size	Percent	5.4	0.48	0.16	0.31	1	0.51	3.1	4.21	3.63	3.28	5.13	0.3	4.47	2.53	1.93	2.81
Fractional % phi 1-2	PSEP Grain Size	Percent	39.34	11.91	1.45	1.63	18.36	17.42	34.14	40.84	46.18	17.48	45.98	1.4	22.9	14.1	17.4	7.9
Fractional % phi 2-3	PSEP Grain Size	Percent	33.08	35.58	30.97	10.54	34.26	31.57	41.45	42.09	37.07	17.63	25.05	13.24	38.8	35.8	36	18.5
Fractional % phi 3-4	PSEP Grain Size	Percent	6.38	24.72	29.05	15.08	19.06	21.11	10.54	8.12	7.55	7.98	7.82	28.4	19.9	23.1	27.2	22.3
Fractional % phi 4-5	PSEP Grain Size	Percent	2.09	10.79	15.46	14.41	9.9	11.22	2.7	1.55	1.1	6.19	3.78	24.62	4.13	4.09	6.83	8.74
Fractional % phi 5-6	PSEP Grain Size	Percent	1.3	5.4	8.5	20.4	5.6	7	0.9	0.4	0.4	10.7	2.9	11.7	1.03	0.9	2	19
Fractional % phi 6-7	PSEP Grain Size	Percent	0.96	3.3	5.85	14.13	3.7	3.7	0.91	0.4	0.29	11.74	2.87	6.5	0.66	0.68	0.96	6.87
Fractional % phi 7-8	PSEP Grain Size	Percent	0.81	1.87	3.03	8.17	0	2.09	0.83	0.33	0.24	5.51	1.4	4.01	0.4	0.5	0.52	2.63
Fractional % phi 8-9	PSEP Grain Size	Percent	0.62	1.3	1.89	4.56	79.11	1.29	0.63	0.23	0.24	2.93	0	2.96	0.23	0.34	0.57	2.08
Fractional % phi 9-10	PSEP Grain Size	Percent	0.33	0.79	1.27	3.52	0.8	0.97	0.24	0	0	2.17	0.47	2.16	0.22	0.31	0.3	1.6
Fractional % phi >10	PSEP Grain Size	Percent	0.94	2.04	2.71	5.8	2.04	2	1.14	1	0.93	4.44	1.73	4.16	0.74	0.87	1.12	4.52
Gravel	PSEP Grain Size	Percent	7.46	0.36	0.04	0.07	0.49	0.16	0.81	0.66	0.46	10.03	0.91	0.85	3.17	16.4	1.84	1.06

Notes:

0.14 U J = Result followed by laboratory data qualifier followed by data validator qualifier
Sample depth (MLLW) = the core increment elevation in mean lower low water
mg/kg = milligrams per kilogram
ug/kg = micrograms per kilogram
mg/L = milligrams per liter
ug/L = micrograms per liter
ng/L = nanograms per liter

Data Validation Qualifiers
U = Result should be considered not-detected at the quantitation limit shown
J = Result is an estimated concentration
R = Rejected - Quality Control indicates the data is not usable
UJ = The compound was not detected and the sample detection limit should be considered an estimated value
N - Pesticide result is tentatively identified.

Laboratory Data Qualifiers
U = result was not detected at or above the method detection limit
J (for organics) = result is an estimated concentration that is less than the reporting limit but greater than or equal to the detection limit
B (for metals) = result is an estimated concentration that is less than the reporting limit but greater than or equal to the detection limit
* (for metals) = duplicate analysis not within control limits. See case narrative (in laboratory report)
D (for organics) = result reported is from a dilution
P (for organics) = The GC or HPLC confirmation criteria was exceeded. The relative percent difference is greater than 40% between the two analytical results.
i (for organics) = the MRL/MDL has been elevated due to a chromatographic interference.

Table A-1. 2007 Remedial Investigation Subsurface Cores Analytical Data

Location			6	6	7	7	7	8	8	8	9	9	9	9	10	10	10	11	11
Sample ID			TT06-CS-B	TT06-CS-C	TT07-CS-B	TT07-CS-C	TT07-CS-D	TT08-CS-B	TT08-CS-C	TT08-CS-I	TT09-CS-B	TT09-CS-C	TT09-CS-E	TT09-CS-M	TT10-CS-B	TT10-CS-C	TT10-CS-D	TT11-CS-B	TT11-CS-C
Sample Date			1/17/2007	1/17/2007	1/16/2007	1/16/2007	1/16/2007	1/16/2007	1/16/2007	1/16/2007	1/16/2007	1/16/2007	1/16/2007	1/16/2007	1/22/2007	1/22/2007	1/22/2007	1/19/2007	1/19/2007
Sample Depth (MLLW)			-43.97 To -45 ft	-45 To -45.9 ft	-6 To -7 ft	-7 To -8 ft	-8 To -9 ft	-41 To -42 ft	-42 To -43 ft	-48 To -49 ft	-41 To -42 ft	-42 To -43 ft	-44.2 To -45 ft	-51.6 To -53 ft	-32 To -33 ft	-33 To -34 ft	-34 To -35 ft	-45 To -46 ft	-46 To -47 ft
Parameter	**Method**	**Units**																	
Antimony	EPA 6020	mg/Kg	16.1 * J	1.27 * J	27.1 * J	22.4 * J	23.3 * J	249 * J	256 * J	108 * J	17.8 * J	12.1 * J	12.8 * J	0.15 * J	1.76	0.213	0.138	7.65 * J	3.91 * J
Arsenic	EPA 6020	mg/Kg	65.4	14.7	58.4	47.8	49	374	298 J	148	29.9	56.4 J	30.5	6.25	6.58	5.97	5.76	11.5 J	9.28 J
Cadmium	EPA 6020	mg/Kg	0.998	0.64	0.813	0.307	0.449	1.1 J	0.93 J	0.978	0.287	0.277 J	0.428	0.287	0.21	0.241	0.313	0.361	0.249
Chromium	EPA 6010B	mg/Kg	97.9	53	210	151	147	197	193	122	115	446	206	20.4	20.3	23	23.7	28	27.1
Cobalt	EPA 6020	mg/Kg	7.31	5.26	27.9	29.9	28.8	22.2 J	27.1 J	16	12.3	14.6 J	9.05	5.62	4.83 J	5.87 J	6.66 J	6.08 J	5.62 J
Copper	EPA 6010B	mg/Kg	1170	794	1670	1760	1520	2110	2620	1470	1240	707	640	33.3	35.5	35.4	40.8	60.1 * J	45.2 * J
Lead	EPA 6020	mg/Kg	418	152	401	232	236	998	982	568	264	306	292	11.5	23.6 J	15 J	5.92 J	40.3	17.5
Mercury	EPA 7471A	mg/Kg	9.43	9.67	1.48	0.772	1.38	6.96	3.78	10.2	7.33	2.41	4.74	0.188	0.399 * J	0.243 * J	0.075 * J	0.622	0.15
Molybdenum	EPA 6020	mg/Kg	4.01	2.42	6.39	5.77	6.35	21 J	18.2 J	11.6	3.7	6.53 J	3.09	1.12	1.25	1.45	1	2.85	1.2
Nickel	EPA 6020	mg/Kg	29.3	16.2	61.6	40.5	50.6	61.5 J	73.2 J	79.1	177	262 J	93.8	12.1	11.5 J	15.4 J	14.6 J	17.1 J	13.3 J
Selenium	EPA 6020	mg/Kg	0.6 B	0.6 B	0.5 B	0.6 B	0.6 B	1.3 B J	1.1 B J	0.7 B	0.5 U	0.5 U UJ	0.6 B	0.5 B	0.4 U	0.4 U	0.4 U	0.5 B	0.7 B
Silver	EPA 6020	mg/Kg	0.683	0.362	0.731 * J	0.692 * J	0.916 * J	1.26 * J	1.42 * J	0.741 * J	0.318 * J	0.261 * J	0.438 * J	0.136 * J	0.143	0.197	0.175	0.274	0.161
Thallium	EPA 6020	mg/Kg	0.106	0.091	0.107	0.115	0.107	0.249	0.244	0.132	0.046 B	0.052	0.052	0.112	0.079	0.106	0.13	0.129	0.124
Vanadium	EPA 6010B	mg/Kg	53.1	51.5	81.3	96.3	87.8	54.5	76.5	49.4	53.3	336	75.3	57.2	52.6	59.8	67.6	61.9	64.3
Zinc	EPA 6010B	mg/Kg	799	331	683	661	651	2680	2410	1640	1500	550	646	50.5	56	52.8	47.3	109	74.5
PCBs (total)	TT calculated	ug/Kg	1560	770	4300	2400	2180	1380	1130	2400	820	490	1340	5.2	29.8	2.7 U	3 U	27	29
		mg/kg OC	119.1	72.6	398.1	387.1	325.4	131.4		226.4			223.3	0.36	2.4	0.17 U	0.1 U	1.5	1.8
PCB-1016	EPA 8082	ug/Kg	53 U	50 U	48 U	42 U	45 U	44 U UJ	43 U UJ	47 U UJ	43 U	42 U	46 U	2.5 U	2.6 U	2.7 U	3 U	2.7 U	2.7 U
PCB-1221	EPA 8082	ug/Kg	53 U	50 U	48 U	42 U	45 U	44 U UJ	43 U UJ	47 U UJ	43 U	42 U	46 U	2.5 U	2.6 U	2.7 U	3 U	2.7 U	2.7 U
PCB-1232	EPA 8082	ug/Kg	53 U	50 U	48 U	42 U	45 U	44 U UJ	43 U UJ	47 U UJ	43 U	42 U	46 U	2.5 U	2.6 U	2.7 U	3 U	2.7 U	2.7 U
PCB-1242	EPA 8082	ug/Kg	53 U	50 U	48 U UJ	42 U UJ	45 U UJ	44 U UJ	43 U UJ	47 U UJ	43 U	42 U	46 U	2.5 U	2.6 U UJ	2.7 U UJ	3 U UJ	2.7 U	2.7 U
PCB-1248	EPA 8082	ug/Kg	53 U	50 U	48 U UJ	42 U UJ	45 U UJ	44 U UJ	43 U UJ	47 U UJ	43 U	42 U	46 U	2.5 U	2.6 U UJ	2.7 U UJ	3 U UJ	2.7 U	2.7 U
PCB-1254	EPA 8082	ug/Kg	900 D	530 D	2500 D J	1400 D J	1500 D J	940 D J	770 D J	1400 D J	580 D	330 D	890 D	2.5 U	20 J	2.7 U UJ	3 U UJ	18	17
PCB-1260	EPA 8082	ug/Kg	450 PD J	240 PD J	1800 D J	1000 D J	680 PD J	440 PD J	360 PD J	1000 D J	240 PD J	160 PD J	450 PD J	5.2	9.8 P J	2.7 U UJ	3 U UJ	9 P J	12
PCB-1262	EPA 8082	ug/Kg	53 U	50 U	48 U UJ	42 U UJ	45 U UJ	44 U UJ	43 U UJ	47 U UJ	43 U	42 U	46 U	2.5 U	2.6 U UJ	2.7 U UJ	3 U UJ	2.7 U	2.7 U
PCB-1268	EPA 8082	ug/Kg	210 D	50 U	48 U UJ	42 U UJ	45 U UJ	44 U UJ	43 U UJ	47 U UJ	43 U	42 U	46 U	2.5 U	2.6 U UJ	2.7 U UJ	3 U UJ	2.7 U	2.7 U
Aldrin	EPA 8081A	ug/Kg	47 U UJ	44 U UJ	4.2 U UJ	3.7 U UJ	4 U UJ	9.9 Ui UJ	10 Ui UJ	4.1 U UJ	3.8 U UJ	3.7 U UJ	4.1 U UJ	4.4 U UJ	0.31 J JN	0.24 U UJ	0.27 U UJ	0.23 U UJ	0.24 U UJ
alpha-BHC	EPA 8081A	ug/Kg	81 U UJ	76 U UJ	7.3 U UJ	6.4 U UJ	6.9 U UJ	6.7 U UJ	6.5 U UJ	7.1 U UJ	6.5 U UJ	6.4 U UJ	7.1 U UJ	7.6 U UJ	0.4 U UJ	0.4 U UJ	0.46 U UJ	0.4 U UJ	0.41 U UJ
alpha-Chlordane	EPA 8081A	ug/Kg	71 U UJ	67 U UJ	6.4 U UJ	5.7 U UJ	6.1 U UJ	5.9 U UJ	5.8 U UJ	6.3 U UJ	5.8 U UJ	5.6 U UJ	6.3 U UJ	6.8 U UJ	0.35 U UJ	0.36 U UJ	0.4 U UJ	0.36 U UJ	0.36 U UJ
beta-BHC	EPA 8081A	ug/Kg	93 U UJ	87 U UJ	13 Ui UJ	7.4 U UJ	8 U UJ	7.7 U UJ	7.5 U UJ	8.2 U UJ	7.5 U UJ	7.3 U UJ	8.2 U UJ	8.8 U UJ	0.46 U UJ	0.47 U UJ	0.53 U UJ	0.46 U UJ	0.47 U UJ
delta-BHC	EPA 8081A	ug/Kg	17 U UJ	16 U UJ	1.6 U UJ	1.4 U UJ	1.5 U UJ	2 Ui UJ	10 Ui UJ	5.2 Ui UJ	8.8 Ui UJ	1.4 U UJ	2.1 Ui UJ	1.7 U UJ	0.083 U UJ	0.085 U UJ	0.36 Ui UJ	0.085 U UJ	0.11 Ui UJ
Dieldrin	EPA 8081A	ug/Kg	90 U UJ	84 U UJ	21 Ui UJ	7.2 U UJ	7.7 U UJ	12 Ui UJ	10 Ui UJ	8 U UJ	7.3 U UJ	7.1 U UJ	7.9 U UJ	8.5 U UJ	0.44 U UJ	0.45 U UJ	0.51 U UJ	0.45 U UJ	0.45 U UJ
Endosulfan I	EPA 8081A	ug/Kg	53 U UJ	50 U UJ	31 PD JN	11 Ui UJ	5.5 JPD JN	4.6 JPD JN	4.7 Ui UJ	6 Ui UJ	8.1 Ui UJ	4.2 U UJ	4.6 U UJ	5 U UJ	0.26 U UJ	0.27 U UJ	0.3 U UJ	0.27 U UJ	0.27 U UJ
Endosulfan II	EPA 8081A	ug/Kg	59 U UJ	55 U UJ	9.5 Ui UJ	4.7 U UJ	5.1 U UJ	4.9 U UJ	4.8 U UJ	10 Ui UJ	4.8 U UJ	4.7 U UJ	5.2 U UJ	5.6 U UJ	0.29 U UJ	0.3 U UJ	0.41 Ui UJ	0.3 U UJ	0.3 U UJ
Endosulfan sulfate	EPA 8081A	ug/Kg	25 U UJ	23 U UJ	2.2 U UJ	2 U UJ	2.1 U UJ	2.1 U UJ	2 U UJ	2.2 U UJ	2 U UJ	2 U UJ	2.2 U UJ	2.4 U UJ	0.45 Ui UJ	0.13 U UJ	0.14 U UJ	0.21 Ui UJ	0.45 Ui UJ
Endrin	EPA 8081A	ug/Kg	62 U UJ	58 U UJ	16 PD JN	5 U UJ	5.3 U UJ	5.1 U UJ	5 U UJ	5.5 U UJ	5 U UJ	4.9 U UJ	5.5 U UJ	5.9 U UJ	0.31 U UJ	0.31 U UJ	0.35 U UJ	0.5 Ui UJ	0.31 U UJ
Endrin aldehyde	EPA 8081A	ug/Kg	17 U UJ	16 U UJ	31 PD JN	19 PD JN	16 PD JN	9.9 Ui UJ	10 Ui UJ	11 Ui UJ	13 Ui UJ	2.5 Ui UJ	7.2 JPD JN	1.6 U UJ	0.33 Ui UJ	0.26 Ui UJ	0.11 Ui UJ	0.55 Ui UJ	0.34 Ui UJ
gamma-BHC	EPA 8081A	ug/Kg	47 U UJ	44 U UJ	9.5 Ui UJ	9.9 Ui UJ	10 Ui UJ	3.9 U UJ	4.8 JD UJ	10 Ui UJ	3.8 U UJ	3.7 U UJ	10 Ui UJ	4.4 U UJ	0.72 Ui UJ	3.2 P UJ	0.5 Ui UJ	3.7 JN	0.51 Ui UJ
gamma-Chlordane	EPA 8081A	ug/Kg	20 U UJ	19 U UJ	86 PD JN	52 PD JN	47 PD JN	38 PD JN	10 Ui UJ	20 PD JN	25 PD JN	16 PD JN	37 PD JN	1.9 U UJ	0.55 P JN	0.099 U UJ	0.12 U UJ	0.51 Ui UJ	0.51 Ui UJ
Heptachlor	EPA 8081A	ug/Kg	25 U UJ	24 U UJ	2.3 U UJ	2 U UJ	2.2 U UJ	5.4 Ui UJ	2.3 Ui UJ	2.2 U UJ	2 U UJ	2 U UJ	2.2 U UJ	2.4 U UJ	0.13 U UJ	0.13 U UJ	0.14 U UJ	0.53 Ui UJ	0.13 U UJ
Heptachlor epoxide	EPA 8081A	ug/Kg	41 U UJ	38 U UJ	19 Ui UJ	11 Ui UJ	3.5 U UJ	30 PD JN	10 Ui UJ	10 Ui UJ	19 PD JN	11 D JN	28 D JN	3.8 U UJ	0.2 U UJ	0.2 U UJ	0.23 U UJ	0.2 U UJ	0.69 P JN
Methoxychlor	EPA 8081A	ug/Kg	31 U UJ	29 U UJ	16 Ui UJ	29 PD JN	10 Ui UJ	18 Ui UJ	16 Ui UJ	17 Ui UJ	9.2 JD JN	4.9 JD JN	11 PD JN	3 U UJ	1 P JN	0.56 Ui UJ	0.18 U UJ	1.2 Ui UJ	0.16 U UJ
Mirex	EPA 8081A	ug/Kg	31 U UJ	29 U UJ	9.5 Ui UJ	9.9 Ui UJ	10 Ui UJ	9.9 Ui UJ	2.5 U UJ	2.8 U UJ	4.2 Ui UJ	9.9 Ui UJ	7.5 JPD JN	3 U UJ	0.16 U UJ	0.3 J JN	0.18 U UJ	0.27 Ui UJ	0.16 U UJ
Nonachlor (cis)	EPA 8081A	ug/Kg	34 Ui UJ	25 U UJ	66 Ui UJ	9.9 Ui UJ	10 Ui UJ	27 Ui UJ	24 Ui UJ	38 Ui UJ	10 Ui UJ	12 Ui UJ	25 Ui UJ	2.5 U UJ	0.32 Ui UJ	0.13 U UJ	0.15 U UJ	0.86 P JN	0.57 Ui UJ
Nonachlor (trans)	EPA 8081A	ug/Kg	28 U UJ	26 U UJ	36 Ui UJ	20 Ui UJ	20 Ui UJ	17 Ui UJ	13 Ui UJ	22 Ui UJ	2.3 U UJ	2.2 U UJ	2.5 U UJ	2.6 U UJ	0.14 U UJ	0.14 U UJ	0.16 U UJ	0.23 Ui UJ	0.51 Ui UJ
Oxychlordane	EPA 8081A	ug/Kg	120 U UJ	110 U UJ	11 U UJ	9.2 U UJ	9.8 U UJ	9.5 U UJ	9.3 U UJ	11 U UJ	9.3 U UJ	9.1 U UJ	10 U UJ	11 U UJ	0.56 U UJ	0.57 U UJ	0.65 U UJ	0.57 U UJ	0.58 U UJ
Toxaphene	EPA 8081A	ug/Kg	2800 U UJ	2700 U UJ	1100 Ui UJ	830 Ui UJ	760 Ui UJ	540 Ui UJ	490 Ui UJ	830 Ui UJ	670 Ui UJ	280 Ui UJ	740 Ui UJ	270 U UJ	20 Ui UJ	14 U UJ	16 U UJ	25 Ui UJ	20 Ui UJ
o,p'-DDD	EPA 8081A	ug/Kg	120 D JN	61 U UJ	52 Ui UJ	120 PD JN	32 Ui UJ	81 PD JN	61 D JN	130 PD JN	58 PD JN	41 D JN	100 PD JN	6.2 U UJ	1.5 P JN	0.33 U UJ	0.37 U UJ	0.51 Ui UJ	1.3 P JN
o,p'-DDE	EPA 8081A	ug/Kg	71 U UJ	67 U UJ	44 Ui UJ	34 Ui UJ	35 Ui UJ	16 Ui UJ	10 Ui UJ	21 Ui UJ	16 Ui UJ	5.6 U UJ	23 Ui UJ	6.8 U UJ	0.35 U UJ	0.36 U UJ	0.4 U UJ	0.86 Ui UJ	0.88 Ui UJ
o,p'-DDT	EPA 8081A	ug/Kg	63 JD JN	41 U UJ	130 D JN	79 D JN	72 PD JN	54 D JN	37 D JN	71 D JN	32 D JN	23 PD JN	54 PD JN	4.1 U UJ	1.1 P JN	0.22 U UJ	0.25 U UJ	0.76 JN	1 JN
p,p'-DDD	EPA 8081A	ug/Kg	110 D JN	35 U UJ	20 D JN	11 PD JN	9.8 JD JN	9.7 JD JN	10 Ui UJ	12 PD JN	32 PD JN	40 D JN	54 D JN	3.6 U UJ	0.25 J JN	0.19 U UJ	0.77 Ui UJ	0.71 P JN	0.77 Ui UJ
p,p'-DDE	EPA 8081A	ug/Kg	31 U UJ	29 U UJ	9.5 Ui UJ	2.5 U UJ	2.7 U UJ	9.9 Ui UJ	3.7 JPD JN	10 Ui UJ	7.6 JPD JN	7.3 JD JN	10 Ui UJ	3 U UJ	0.16 U UJ	0.16 U UJ	0.18 U UJ	0.29 J JN	0.16 U UJ
p,p'-DDT	EPA 8081A	ug/Kg	100 D JN	51 JD JN	170 Ui UJ	110 Ui UJ	90 D JN	60 Ui UJ	48 Ui UJ	80 Ui UJ	44 Ui UJ	32 Ui UJ	71 Ui UJ	4 Ui UJ	1.2 JN	0.41 JP JN	0.12 U UJ	1.1 P JN	1.1 JN
Total DDT	TT Calculated	ug/Kg	393 JN	51 JN	150 JN	210 JN	171.8 JN	144.7 JN	101.7 JN	213 JN	129.6 JN	111.3 JN	208 JN	6.8 U UJ	4.05 JN	0.41 JN	0.77 U UJ	2.86 JN	3.4 JN
Total Chlordane	TT Calculated	ug/Kg	120 U UJ	110 U UJ	86 JN	52 JN	47 JN	38 JN	24 U UJ	20 JN	25 JN	16 JN	37 JN	11 U UJ	0.55 JN	0.57 U UJ	0.65 U UJ	0.86 JN	0.58 U UJ
1,2,4-Trichlorobenzene	EPA 8270C	ug/Kg	47 U	11 U	21 U	37 U	40 U	39 U	19 U	21 U	19 U	9.2 U	41 U	4.4 U	2.3 U	2.4 U	2.7 U	2.3 U	2.4 U
		mg/kg OC	3.6 U	1.0 U	1.9 U	6.0 U	6.0 U	3.7 U		2.0 U			6.8 U	0.3 U	0.2 U	0.2 U	0.1 U	0.1 U	0.2 U
1,2-Dichlorobenzene	EPA 8270C	ug/Kg	41 U	9.5 U	19 U	32 U	35 U	34 U	17 U	18 U	17 U	8 U	36 U	3.8 U	2 U	2 U	2.3 U	2 U	2.1 U
		mg/kg OC	3.1 U	0.9 U	1.8 U	5.2 U	5.2 U	3.2 U		1.7 U			6.0 U	0.3 U	0.2 U	0.1 U	0.1 U	0.1 U	0.1 U
1,3-Dichlorobenzene	EPA 8270C	ug/Kg	50 U	12 U	23 U	40 U	43 U	41 U	20 U	22 U	20 U	9.8 U	44 U	4.7 U	2.5 U	2.5 U	2.8 U	2.5 U	2.5 U
1,4-Dichlorobenzene	EPA 8270C	ug/Kg	59 U	14 U	27 U	47 U	51 U	49 U	24 U	26 U	24 U	12 U	52 U	5.6 U	2.9 U	3 U	3.3 U	3 U	3 U
		mg/kg OC	4.5 U	1.3 U	2.5 U	7.6 U	7.6 U	4.7 U		2.5 U			8.7 U	0.4 U	0.2 U	0.2 U	0.1 U	0.2 U	0.2 U
1-Methylnaphthalene	EPA 8270C	ug/Kg	310 U UJ	73 U UJ	140 U UJ	250 U UJ	270 U UJ	1200 D J	920 D J	340 D J	230 D J	130 D J	1200 D J	30 U UJ	25 J	32 J	18 U UJ	44 J	16 U UJ
2,4,5-Trichlorophenol	EPA 8270C	ug/Kg	93 U	22 U	42 U	74 U	80 U	77 U	38 U	41 U	38 U	19 U	82 U	8.8 U	4.6 U	4.7 U	5.3 U	4.6 U	4.7 U
2,4,6-Trichlorophenol	EPA 8270C	ug/Kg	56 U	14 U	25 U	45 U	48 U	46 U	23 U	25 U	23 U	11 U	49 U	5.3 U	2.8 U	2.8 U	3.2 U	2.8 U	2.8 U
2,4-Dichlorophenol	EPA 8270C	ug/Kg	56 U	14 U	25 U	45 U	48 U	46 U	23 U	25 U	23 U	11 U	49 U	5.3 U	2.8 U	2.8 U	3.2 U	2.8 U	2.8 U
2,4-Dimethylphenol	EPA 8270C	ug/Kg	170 U	40 U	77 U	140 U	150 U	140 U	69 U	75 U	69 U	34 U	150 U	17 U	8.3 U	8.5 U	9.6 U	8.5 U	8.6 U
2,4-Dinitrophenol	EPA 8270C	ug/Kg	1200 U UJ	270 U UJ	500 U	890 U	960 U	920 U UJ	450 U UJ	500 U UJ	450 U UJ	220 U UJ	980 U UJ	110 U	55 U	56 U	63 U	56 U UJ	56 U UJ
2,4-Dinitrotoluene	EPA 8270C	ug/Kg	87 U	21 U	39 U	69 U	74 U	72 U	35 U	39 U	35 U	18 U	76 U	8.2 U	4.3 U	4.4 U	4.9 U	4.3 U	4.4 U
2,6-Dinitrotoluene	EPA 8270C	ug/Kg	87 U	21 U	39 U	69 U	74 U	72 U	35 U	39 U	35 U	18 U	76 U	8.2 U	4.3 U	4.4 U	4.9 U	4.3 U	4.4 U
2-Chloronaphthalene	EPA 8270C	ug/Kg	120 U	27 U	50 U	89 U	96 U	92 U	45 U	50 U	45 U	22 U	98 U	11 U	5.5 U	5.6 U	6.3 U	5.6 U	5.6 U
2-Chlorophenol	EPA 8270C	ug/Kg	53 U	13 U	24 U	42 U	45 U	44 U	22 U	24 U	22 U	11 U	46 U	5 U	2.6 U	2.7 U	3 U	2.7 U	2.7 U
2-Methylnaphthalene	EPA 8270C	ug/Kg	100 JD	47 JD	100 D	61 JD	72 JD	1500 D	1100 D	320 D	68 JD	50 JD	190 JD	3.6 U	51	65	2.4 J	91	5.6 J
		mg/kg OC	7.6 JD	4.4 JD	9.3 D	9.8 JD	10.7 JD	142.9 D		30.2 D			31.7 JD	0.2 U	4.1	4.1	0.1 J	4.9	0.4 J
2-Methylphenol	EPA 8270C	ug/Kg	110 U	27 JD	48 U	84 U	90 U	87 U	43 U	47 U	43 U	21 U	92 U	10 U	5.2 U	5.3 U	6 U	5.3 U	5.3 U
2-Nitroaniline	EPA 8270C	ug/Kg	84 U	20 U	38 U	67 U	72 U	69 U	34 U	37 U	34 U	17 U	73 U	7.9 U	4.1 U	4.2 U	4.7 U	4.2 U	4.2 U
2-Nitrophenol	EPA 8270C	ug/Kg	81 U	19 U	37 U	64 U	69 U	67 U	33 U	36 U	33 U	16 U	71 U	7.6 U	4 U	4 U	4.6 U	4 U	4.1 U
3,3'-Dichlorobenzidine	EPA 8270C	ug/Kg	120 U	27 U	52 U	92 U	98 U	95 U	47 U	51 U	47 U	23 U	100 U	11 U	5.6 U	5.7 U	6.5 U	5.7 U	5.8 U
3-Nitroaniline	EPA 8270C	ug/Kg	81 U	19 U	37 U	64 U	69 U	67 U	33 U	36 U	33 U	16 U	71 U	7.6 U	4 U	4 U	4.6 U	4 U	4.1 U

Table A-1. 2007 Remedial Investigation Subsurface Cores Analytical Data

Location			6	6	7	7	7	8	8	8	9	9	9	9	10	10	10	11	11
Sample ID			TT06-CS-B	TT06-CS-C	TT07-CS-B	TT07-CS-C	TT07-CS-D	TT08-CS-B	TT08-CS-C	TT08-CS-I	TT09-CS-B	TT09-CS-C	TT09-CS-E	TT09-CS-M	TT10-CS-B	TT10-CS-C	TT10-CS-D	TT11-CS-B	TT11-CS-C
Sample Date			1/17/2007	1/17/2007	1/16/2007	1/16/2007	1/16/2007	1/16/2007	1/16/2007	1/16/2007	1/16/2007	1/16/2007	1/16/2007	1/16/2007	1/22/2007	1/22/2007	1/22/2007	1/19/2007	1/19/2007
Sample Depth (MLLW)			-43.97 To -45 ft	-45 To -45.9 ft	-6 To -7 ft	-7 To -8 ft	-8 To -9 ft	-41 To -42 ft	-42 To -43 ft	-48 To -49 ft	-41 To -42 ft	-42 To -43 ft	-44.2 To -45 ft	-51.6 To -53 ft	-32 To -33 ft	-33 To -34 ft	-34 To -35 ft	-45 To -46 ft	-46 To -47 ft
Parameter	**Method**	**Units**																	
4,6-Dinitro-o-cresol	EPA 8270C	ug/Kg	53 U	13 U	24 U	42 U	45 U	44 U	22 U	24 U	22 U	11 U	46 U	5 U	2.6 U	2.7 U	3 U	2.7 U	2.7 U
4-Bromophenyl phenyl ether	EPA 8270C	ug/Kg	44 U	11 U	20 U	35 U	37 U	36 U	18 U	20 U	35 U	8.6 U	190 U	4.1 U	2.2 U	2.2 U	2.5 U	2.2 U	2.2 U
4-Chloro-3-methylphenol	EPA 8270C	ug/Kg	65 U	16 U	30 U	52 U	56 U	54 U	27 U	29 U	27 U	13 U	57 U	6.2 U	3.2 U	3.3 U	3.7 U	3.3 U	3.3 U
4-Chloroaniline	EPA 8270C	ug/Kg	65 U	16 U	30 U	52 U	56 U	54 U UJ	27 U UJ	29 U UJ	27 U UJ	13 U UJ	57 U UJ	6.2 U	3.2 U	3.3 U	3.7 U	3.3 U	3.3 U
4-Chlorophenyl phenyl ether	EPA 8270C	ug/Kg	62 U	15 U	28 U	50 U	53 U	51 U	25 U	28 U	25 U	13 U	55 U	5.9 U	3.1 U	3.1 U	3.5 U	3.1 U	3.1 U
4-Methylphenol	EPA 8270C	ug/Kg	90 U	21 U	240 D	72 U	77 U	74 U	220 D	40 U	37 U	18 U	79 U	8.5 U	7.8 J	9.7 J	6.3 J	4.5 U	4.5 U
4-Nitroaniline	EPA 8270C	ug/Kg	110 U	47 JD	48 U	84 U	90 U	87 U	43 U	47 U	43 U	21 U	92 U	10 U	5.2 U	5.3 U	6 U	5.3 U	5.3 U
4-Nitrophenol	EPA 8270C	ug/Kg	930 U	220 U	420 U	740 U	800 U	770 U	380 U	410 U	380 U	190 U	820 U	88 U	46 U	47 U	53 U	46 U	47 U
Acenaphthene	EPA 8270C	ug/Kg	250 D	48 JD	630 D	330 D	400 D	8100 D	4200 D	2500 D	520 D	260 D	7300 D	15 JD	78	86	2 J	1.6 U	6.4 J
		mg/kg OC	19.1 D	4.5 JD	58.3 D	53.2 D	59.7 D	771.4 D		235.8 D			1216.7 D	1.0 JD	6.2	5.4	0.1 J	0.1 U	0.4 J
Acenaphthylene	EPA 8270C	ug/Kg	580 D	90 D	320 D	190 JD	170 JD	500 D	390 D	590 D	330 D	150 D	1300 D	11 JD	56	130	2.6 J	180	7.8 J
		mg/kg OC	44.3 D	8.5 D	29.6 D	30.6 JD	25.4 JD	47.6 D		55.7 D			216.7 D	0.8 JD	4.5	8.1	0.1 J	9.7	0.5 J
Aniline	EPA 8270C	ug/Kg	47 U	26 JD	21 U	37 U	40 U	39 U	19 U	21 U	19 U	9.2 U	41 U	4.4 U	2.3 U	2.4 U	2.7 U	2.3 U	2.4 U
Anthracene	EPA 8270C	ug/Kg	1200 D	150 D	2700 D	840 D	840 D	10000 D	5300 D	3600 D	910 D	450 D	5600 D	25 D	160	280	7.2 J	400	17
		mg/kg OC	91.6 D	14.2 D	250.0 D	135.5 D	125.4 D	952.4 D		339.6 D			933.3 D	1.7 D	12.8	17.5	0.3 J	21.5	1.1
Benzo(a)anthracene	EPA 8270C	ug/Kg	4100 D	270 D	7200 D	3700 D	3500 D	14000 D	7400 D	20 U	1900 D	910 D	8000 D	31 D	130	300	9.9 J	260	23
		mg/kg OC	313.0 D	25.5 D	666.7 D	596.8 D	522.4 D	1333.3 D		1.9 U			1333.3 D	2.1 D	10.4	18.8	0.4 J	14.0	1.4
Benzo(a)pyrene	EPA 8270C	ug/Kg	6400 D	690 D	4400 D	3100 D	2600 D	12000 D	6300 D	5300 D	1500 D	680 D	6400 D	32 D	150	290	7.1 J	310	29
		mg/kg OC	488.5 D	65.1 D	407.4 D	500.0 D	388.1 D	1142.9 D		500.0 D			1066.7 D	2.2 D	12.0	18.1	0.3 J	16.7	1.8
Benzo(b)fluoranthene	EPA 8270C	ug/Kg	7000 D	810 D	7200 D	3100 D	2700 D	16000 D	9300 D	6700 D	1900 D	890 D	7100 D	44 D	190	410 D	6.9 J	510	36
Benzo(g,h,i)perylene	EPA 8270C	ug/Kg	2900 D	400 D	2300 D	1600 D	1700 D	7200 D	3900 D	3200 D	930 D	420 D	3500 D	20 JD	79	150	4.6 J	190	18
		mg/kg OC	221.4 D	37.7 D	213.0 D	258.1 D	253.7 D	685.7 D		301.9 D			583.3 D	1.4 JD	6.3	9.4	0.2 J	10.2	1.1
Benzo(k)fluoranthene	EPA 8270C	ug/Kg	4600 D	680 D	2100 D	2500 D	2400 D	4700 D	2400 D	2100 D	660 D	340 D	2400 D	17 JD	120	140 D	6.3 J	140	14
Benzofluoranthenes (total)	TT calculated	ug/Kg	11600	1490	9300	5600	5100	20700	11700	8800	2560	1230	9500	61	310	550	13.2	650	50
		mg/kg OC	885.5	140.6	861.1	903.2	761.2	1971.4		830.2			1583.3	4.2	24.8	34.4	0.6	34.9	3.1
Benzoic acid	EPA 8270C	ug/Kg	3000 U	700 U	1400 U	2400 U	2600 U	2500 U	1200 U	1400 U	1200 U	590 U	2600 U	290 U	150 U	150 U	170 U	150 U	150 U
Benzyl alcohol	EPA 8270C	ug/Kg	120 U	27 U	52 U	92 U	98 U	95 U	47 U	51 U	47 U	23 U	100 U	11 U	5.6 U	5.7 U	6.5 U	5.7 U	5.8 U
bis(2-chloroethoxy)methane	EPA 8270C	ug/Kg	41 U	9.5 U	19 U	32 U	35 U	34 U	17 U	18 U	17 U	8 U	36 U	3.8 U	2 U	2 U	2.3 U	2 U	2.1 U
bis(2-chloroethyl)ether	EPA 8270C	ug/Kg	74 U	18 U	34 U	60 U	64 U	62 U	30 U	33 U	30 U	15 U	65 U	7.1 U	3.7 U	3.7 U	4.2 U	3.7 U	3.8 U
bis(2-chloroisopropyl)ether	EPA 8270C	ug/Kg	37 U	8.7 U	17 U	30 U	32 U	31 U	15 U	17 U	15 U	7.3 U	33 U	3.6 U	1.9 U	1.9 U	2.1 U	1.9 U	1.9 U
bis(2-ethylhexyl)phthalate	EPA 8270C	ug/Kg	860 JD	74 JD U	2600 D	1300 JD	2100 D	3900 D	2900 D	1300 D	820 JD	200 JD	430 JD	5 U	36 J U	14 J U	9.8 J U	2.7 U	11 J U
		mg/kg OC	65.6 JD	7.0 JD U	240.7 D	209.7 JD	313.4 D	371.4 D		122.6 D			71.7 JD	0.3 U	2.9 J U	0.9 J U	0.4 J U	0.1 U	0.7 J U
Butyl benzyl phthalate	EPA 8270C	ug/Kg	47 U	11 U	21 U	37 U	40 U	39 U	19 U	21 U	19 U	9.2 U	41 U	4.4 U	2.3 U	2.4 U	2.7 U	2.3 U	2.4 U
		mg/kg OC	3.6 U	1.0 U	1.9 U	6.0 U	6.0 U	3.7 U		2.0 U			6.8 U	0.3 U	0.2 U	0.2 U	0.1 U	0.1 U	0.2 U
Chrysene	EPA 8270C	ug/Kg	4800 D	360 D	9000 D	4100 D	3900 D	15000 D	8900 D	6300 D	2100 D	1100 D	10000 D	40 D	160	390	8.4 J	300	24
		mg/kg OC	366.4 D	34.0 D	833.3 D	661.3 D	582.1 D	1428.6 D		594.3 D			1666.7 D	2.8 D	12.8	24.4	0.4 J	16.1	1.5
Dibenzo(a,h)anthracene	EPA 8270C	ug/Kg	920 D	140 D	200 D	490 D	490 D	1900 D	280 D	240 D	280 D	110 D	1100 D	6.5 U	29	42	3.9 U	37	5.2 J
		mg/kg OC	70.2 D	13.2 D	18.5 D	79.0 D	73.1 D	181.0 D		22.6 D			183.3 D	0.4 U	2.3	2.6	0.2 U	2.0	0.3 J
Dibenzofuran	EPA 8270C	ug/Kg	120 JD	33 JD	340 D	180 JD	200 JD	3600 D	2300 D	1100 D	350 D	170 D	2700 D	9 JD	72	76	2.7 J	110	4.8 J
		mg/kg OC	9.2 JD	3.1 JD	31.5 D	29.0 JD	29.9 JD	342.9 D		103.8 D			450.0 D	0.6 JD	5.8	4.8	0.1 J	5.9	0.3 J
Diethylphthalate	EPA 8270C	ug/Kg	110 U	26 U	49 U	87 U	93 U	90 U	44 U	48 U	44 U	22 U	95 U	11 U	5.3 U	5.4 U	6.1 U	5.4 U	5.5 U
		mg/kg OC	8.4 U	2.5 U	4.5 U	14.0 U	13.9 U	8.6 U		4.5 U			15.8 U	0.8 U	0.4 U	0.3 U	0.3 U	0.3 U	0.3 U
Dimethyl phthalate	EPA 8270C	ug/Kg	56 U	14 U	25 U	45 U	48 U	46 U	23 U	25 U	23 U	11 U	49 U	5.3 U	2.8 U	2.8 U	3.2 U	2.8 U	2.8 U
		mg/kg OC	4.3 U	1.3 U	2.3 U	7.3 U	7.2 U	4.4 U		2.4 U			8.2 U	0.4 U	0.2 U	0.2 U	0.1 U	0.2 U	0.2 U
Di-n-butyl phthalate	EPA 8270C	ug/Kg	400 D	22 JD	37 U	64 U	69 U	1000 D	560 D	340 D	65 U	16 U	360 U	7.6 U	13 U	9.5 J U	7.1 J U	4 U	5.8 J U
		mg/kg OC	30.5 D	2.1 JD	3.4 U	10.3 U	10.3 U	95.2 D		32.1 D			60.0 U	0.5 U	1.0 U	0.6 J U	0.3 J U	0.2 U	0.4 J U
Di-n-octyl phthalate	EPA 8270C	ug/Kg	37 U	8.7 U	17 U	30 U	32 U	31 U	15 U	17 U	15 U	7.3 U	33 U	3.6 U	1.9 U	1.9 U	2.1 U	1.9 U	1.9 U
		mg/kg OC	2.8 U	0.8 U	1.6 U	4.8 U	4.8 U	3.0 U		1.6 U			5.5 U	0.2 U	0.2 U	0.1 U	0.1 U	0.1 U	0.1 U
Fluoranthene	EPA 8270C	ug/Kg	7900 D	520 D	15000 D J	9100 D	11000 D	36000 D	21000 D	14000 D	5000 D	2400 D	20000 D	67 D	470	830 E J	29	1200 D	47
		mg/kg OC	603.1 D	49.1 D	1388.9 D J	1467.7 D	1641.8 D	3428.6 D		1320.8 D			3333.3 D	4.6 D	37.6	51.9 E J	1.3	64.5 D	3.0
Fluorene	EPA 8270C	ug/Kg	270 D	51 D	750 D	370 D	400 D	8100 D	4700 D	2800 D	810 D	480 D	6200 D	14 JD	99	110	3.2 J	150	2.7 U
		mg/kg OC	20.6 D	4.8 D	69.4 D	59.7 D	59.7 D	771.4 D		264.2 D			1033.3 D	1.0 JD	7.9	6.9	0.1 J	8.1	0.2 U
Hexachlorobenzene	EPA 8081A	ug/Kg	25 U		2.2 U	2 U	2.1 U	2.1 U	2 U	2.2 U	2 U	2 U	2.2 U	2.4 U	0.12 U	0.13 U	0.14 U UJ	0.13 U	0.13 U
		mg/kg OC	1.9 U		0.2 U	0.3 U	0.3 U	0.2 U		0.2 U			0.4 U	0.2 U	0.01 U	0.01 U	0.01 U UJ	0.01 U	0.01 U
Hexachlorobenzene	EPA 8270C	ug/Kg		16 U															
		mg/kg OC		1.5 U															
Hexachlorobutadiene	EPA 8081A	ug/Kg			14 U	13 U	13 U	13 U	13 U	14 U	13 U		14 U		0.74 U	0.76 U	0.86 U UJ	0.76 U UJ	0.76 U
		mg/kg OC			1.3 U	2.1 U	1.9 U	1.2 U		1.3 U			2.3 U		0.1 U	0.05 U	0.04 U UJ	0.04 U UJ	0.05 U
Hexachlorobutadiene	EPA 8270C	ug/Kg	44 U	11 U								8.6 U		4.1 U					
		mg/kg OC	3.4 U	1.0 U										0.3 U					
Hexachlorocyclopentadiene	EPA 8270C	ug/Kg	470 U UJ	110 U UJ	210 U	370 U UJ	400 U UJ	390 U	190 U	210 U	190 U	92 U	410 U	44 U	23 U UJ	24 U UJ	27 U UJ	23 U	24 U
Hexachloroethane	EPA 8270C	ug/Kg	68 U	16 U	31 U	55 U	59 U	56 U	28 U	30 U	28 U	14 U	60 U	6.5 U	3.4 U	3.4 U	3.9 U	3.4 U	3.5 U
Indeno(1,2,3-cd)pyrene	EPA 8270C	ug/Kg	3200 D	420 D	2600 D	1900 D	1900 D	8400 D	4500 D	3300 D	1100 D	470 D	4100 D	21 D	79	140	4.4 J	180	20
		mg/kg OC	244.3 D	39.6 D	240.7 D	306.5 D	283.6 D	800.0 D		311.3 D			683.3 D	1.4 D	6.3	8.8	0.2 J	9.7	1.3
Isophorone	EPA 8270C	ug/Kg	50 U	12 U	23 U	40 U	43 U	41 U	20 U	22 U	20 U	9.8 U	44 U	4.7 U	2.5 U	2.5 U	2.8 U	2.5 U	2.5 U
Naphthalene	EPA 8270C	ug/Kg	210 D	130 D	210 D	120 JD	120 JD	4100 D	2500 D	910 D	490 D	250 D	2500 D	17 JD	170	270	4.2 J	400	11
		mg/kg OC	16.0 D	12.3 D	19.4 D	19.4 JD	17.9 JD	390.5 D		85.8 D			416.7 D	1.2 JD	13.6	16.9	0.2 J	21.5	0.7
Nitrobenzene	EPA 8270C	ug/Kg	62 U	15 U	28 U	50 U	53 U	51 U	25 U	28 U	25 U	13 U	55 U	5.9 U	3.1 U	3.1 U	3.5 U	3.1 U	3.1 U
N-Nitrosodimethylamine	EPA 8270C	ug/Kg	190 U	45 U	85 U	160 U	170 U	160 U	77 U	84 U	77 U	38 U	170 U	18 U	9.2 U UJ	9.4 U UJ	11 U	9.4 U	9.5 U
N-Nitroso-di-n-propylamine	EPA 8270C	ug/Kg	99 U	24 U	45 U	79 U	85 U	82 U	40 U	44 U	40 U	20 U	87 U	9.4 U	4.9 U	5 U	5.6 U	5 U	5 U
N-Nitrosodiphenylamine	EPA 8270C	ug/Kg	68 U	16 U	31 U	55 U	59 U	56 U	28 U	30 U	28 U	14 U	60 U	6.5 U	3.4 U	3.4 U	3.9 U	3.4 U	3.5 U
		mg/kg OC	5.2 U	1.5 U	2.9 U	8.9 U	8.8 U	5.3 U		2.8 U			10.0 U	0.4 U	0.3 U	0.2 U	0.2 U	0.2 U	0.2 U
Pentachlorophenol	EPA 8270C	ug/Kg	270 U	62 U	120 U	210 U	230 U	220 U	130 JD	120 U	220 U	52 U	1200 U	25 U	13 U	14 U	15 U	14 U	14 U
Phenanthrene	EPA 8270C	ug/Kg	2300 D	260 D	5200 D	3300 D	2900 D	39000 D	23000 D	14000 D	4100 D	2500 D	27000 D	44 D	340	500	13	700	33
		mg/kg OC	175.6 D	24.5 D	481.5 D	532.3 D	432.8 D	3714.3 D		1320.8 D			4500.0 D	3.0 D	27.2	31.3	0.6	37.6	2.1
Phenol	EPA 8270C	ug/Kg	230 JD	250 D	27 U	47 U	51 U	49 U	24 U	26 U	24 U	12 U	52 U	5.6 U	21 J	27 Ui	15 J	3 U	3 U
Pyrene	EPA 8270C	ug/Kg	15000 D	1700 D	15000 D J	5600 D	6900 D	30000 D	18000 D	16000 D	5700 D	2800 D	20000 D	110 D	640	860 E J	41	1600 D	84
		mg/kg OC	1145.0 D	160.4 D	1388.9 D J	903.2 D	1029.9 D	2857.1 D		1509.4 D			3333.3 D	7.6 D	51.2	53.8 E J	1.8	86.0 D	5.3
Total HPAH	TT calculated	ug/Kg	56820	5990	65000	35190	37090	145200	81980	57140	21070	10120	82600	382	2047	3552	117.6	4727	300.2
		mg/kg OC	4337.4	565.1	6018.5	5675.8	5535.8	13828.6		5390.6			13766.7	26.3	163.8	222.0	5.3	254.1	18.9
Total LPAH	TT calculated	ug/Kg	4810	729	9810	5150	4830	69800	40090	24400	7160	4090	49900	126	903	1376	32.2	1830	75.2
		mg/kg OC	367.2	68.8	908.3	830.6	720.9	6647.6		2301.9			8316.7	8.7	72.2	86.0	1.5	98.4	4.7
Total PAH	TT calculated	ug/Kg	61630	6719	74810	40340	41920	215000	122070	81540	28230	14210	132500	508	2950	4928	149.8	6557	375.4
Butyltin	KRONE	ug/Kg	0.9 J	0.72 J U	30	37	38	44	46	9.3	11 P J	7.7	3.4	0.044 U	0.046 U	0.047 U	0.053 U	0.046 U	0.047 U
Dibutyltin	KRONE	ug/Kg	7.3	7.4	740 D	680 D	790 D	1700 D	1400 D	240 D	800 D	150 D	69	0.37 JP UJ	1.7 U	0.65 JP UJ	0.46 J U	3	2.2

Table A-1. 2007 Remedial Investigation Subsurface Cores Analytical Data

Location			6	6	7	7	7	8	8	8	9	9	9	9	10	10	10	11	11
Sample ID			TT06-CS-B	TT06-CS-C	TT07-CS-B	TT07-CS-C	TT07-CS-D	TT08-CS-B	TT08-CS-C	TT08-CS-I	TT09-CS-B	TT09-CS-C	TT09-CS-E	TT09-CS-M	TT10-CS-B	TT10-CS-C	TT10-CS-D	TT11-CS-B	TT11-CS-C
Sample Date			1/17/2007	1/17/2007	1/16/2007	1/16/2007	1/16/2007	1/16/2007	1/16/2007	1/16/2007	1/16/2007	1/16/2007	1/16/2007	1/16/2007	1/22/2007	1/22/2007	1/22/2007	1/19/2007	1/19/2007
Sample Depth (MLLW)			-43.97 To -45 ft	-45 To -45.9 ft	-6 To -7 ft	-7 To -8 ft	-8 To -9 ft	-41 To -42 ft	-42 To -43 ft	-48 To -49 ft	-41 To -42 ft	-42 To -43 ft	-44.2 To -45 ft	-51.6 To -53 ft	-32 To -33 ft	-33 To -34 ft	-34 To -35 ft	-45 To -46 ft	-46 To -47 ft
Parameter	**Method**	**Units**																	
Tetrabutyltin	KRONE	ug/Kg	0.11 U	0.11 U	31	22	60	81	69	33	14	13	5.2 P J	0.11 U	0.11 U	0.11 U	0.13 U	0.11 U	0.11 U
Tributyltin	KRONE	ug/Kg	15	14	4300 D	3200 D	5400 D	8200 D	8600 D	4100 D	9100 D	1700 D	510 D	0.082 U	7.5	1.4 J	0.45 J	4.7	6
		mg/kg OC	1.1	1.3	398.1 D	516.1 D	806.0 D	781.0 D		386.8 D			85.0 D	0.006 U	0.6	0.09 J	0.02 J	0.3	0.4
Total Solids	EPA 160.3	Percent	64.9	69.1	72.2	81.3	75.7	78.6	80.1	73.4	80.1	82.2	74	68.5	66.5	65	57.6	65.9	65.6
Total Organic Carbon	ASTM D4129-98M	Percent	1.31	1.06	1.08	0.62	0.67	1.05	0.48	1.06	0.34	0.19	0.6	1.45	1.25	1.6	2.22	1.86	1.59
Fractional % phi >-1	PSEP Grain Size	Percent	2.42	1.6	23.2	25.5	19.2	7.14	16.7	7.22	3.1	8.29	10.4	0.44	0.79	0.77	0.86	0.65	0.41
Fractional % phi 0-1	PSEP Grain Size	Percent	11.4	4.96	30.6	35.5	29.7	21.9	31	22.2	29	41.1	24.2	0.37	1.06	0.8	0.54	1.2	0.89
Fractional % phi 1-2	PSEP Grain Size	Percent	18.9	8.97	16.7	17.1	16.1	32.2	25.6	32.7	45.3	35.2	23.5	1.16	2.85	3.07	2.42	3.37	1.04
Fractional % phi 2-3	PSEP Grain Size	Percent	13.8	14.3	12	7.8	12.1	16.2	8.27	15.9	10.6	7.72	11.9	2.96	29.58	10.31	5.92	7.03	2.25
Fractional % phi 3-4	PSEP Grain Size	Percent	11.7	18.6	5.97	2.87	5.35	5.29	2.44	5.86	2.82	1.98	10.4	9.78	30.49	20.49	5.91	15.79	9.42
Fractional % phi 4-5	PSEP Grain Size	Percent	8.22	13.1	1.21	0.32	0.88	1.82	0.94	3.23	1.21	0.44	3.17	17.2	14.95	17.01	8.14	20.23	17.2
Fractional % phi 5-6	PSEP Grain Size	Percent	19.1	14.9	1.49	0.64	0.74	1.94	1.35	4.83	0.97	0.56	2.49	27.2	8.9	15.6	20.7	14.1	18.7
Fractional % phi 6-7	PSEP Grain Size	Percent	3.71	8.44	0.87	0.41	0.69	2.29	1.43	3.78	0.76	0.44	1.73	13	4.37	11.31	22.2	12.22	22.38
Fractional % phi 7-8	PSEP Grain Size	Percent	1.53	3	0.49	0.48	0.51	1.19	1.17	1.83	0.87	0.51	1.33	8.23	3.48	8.27	12.84	7.86	9.89
Fractional % phi 8-9	PSEP Grain Size	Percent	0.99	1.72	0.21	0	0	0.8	0.79	1.28	0.41	0.23	0.91	5.13	2.65	5.95	8.22	4.99	6.52
Fractional % phi 9-10	PSEP Grain Size	Percent	1.1	1.48	0.24	0.16	0.13	0.77	0.4	1.28	0.33	0.28	0.53	3.24	1.74	4.36	6.09	4.14	4.4
Fractional % phi >10	PSEP Grain Size	Percent	2.28	3.51	0.92	0.62	0.77	0.89	0.91	2	0.67	0.57	0.95	5.17	3.79	8.38	11.38	6.4	7.86
Gravel	PSEP Grain Size	Percent	4.64	1.77	10.5	8.46	18.7	6.55	7.65	3.71	3.81	2.24	13.2	0.19	0.75	0.94	0.35	0.44	0.36

Notes:

0.14 U J = Result followed by laboratory data qualifier followed by data validator qualifier
Sample depth (MLLW) = the core increment elevation in mean lower low water
mg/kg = milligrams per kilogram
ug/kg = micrograms per kilogram
mg/L = milligrams per liter
ug/L = micrograms per liter
ng/L = nanograms per liter

Data Validation Qualifiers
U = Result should be considered not-detected at the quantitation limit shown
J = Result is an estimated concentration
R = Rejected - Quality Control indicates the data is not usable
UJ = The compound was not detected and the sample detection limit should be considered an estimated value
N - Pesticide result is tentatively identified.

Laboratory Data Qualifiers
U = result was not detected at or above the method detection limit
J (for organics) = result is an estimated concentration that is less than the reporting limit but greater than or equal to the detection limit
B (for metals) = result is an estimated concentration that is less than the reporting limit but greater than or equal to the detection limit
* (for metals) = duplicate analysis not within control limits. See case narrative (in laboratory report)
D (for organics) = result reported is from a dilution
P (for organics) = The GC or HPLC confirmation criteria was exceeded. The relative percent difference is greater than 40% between the two analytical results.
i (for organics) = the MRL/MDL has been elevated due to a chromatographic interference.

Table A-1. 2007 Remedial Investigation Subsurface Cores Analytical Data

Location			11	12	12	12	13	13	13	14	14	14	14	14	14	15	15	15
Sample ID			TT11-CS-D	TT12-CS-B	TT12-CS-C	TT12-CS-D	TT13-CS-A	TT13-CS-B	TT13-CS-C	TT14-CS-B	TT90-CS-A	TT14-CS-C	TT90-CS-B	TT14-CS-J	TT90-CS-C	TT15-CS-B	TT15-CS-C	TT15-CS-G
Sample Date			1/19/2007	1/15/2007	1/15/2007	1/15/2007	1/19/2007	1/19/2007	1/19/2007	1/13/2007	1/13/2007	1/13/2007	1/13/2007	1/13/2007	1/13/2007	1/18/2007	1/18/2007	1/18/2007
Sample Depth (MLLW)			-47 To -48 ft	-43 To -44 ft	-44 To -45 ft	-45 To -46 ft	-45.24 To -46.2 ft	-46.24 To -47 ft	-47 To -47.87 ft	-26 To -27 ft	duplicate of TT14-CS-B	-27 To -28 ft	duplicate of TT14-CS-C	-34.42 To -35 ft	duplicate of TT14-CS-J	-46.9 To -48 ft	-48 To -48.9 ft	-52.34 To -53 ft
Parameter	Method	Units																
Antimony	EPA 6020	mg/Kg	0.071 * J	4.23 * J	1.17 * J	0.27 * J	1.54	0.05 B	0.047 U	12.7	13.3	57.4	138	0.18	0.25	34.6 * J	40 * J	61.1 * J
Arsenic	EPA 6020	mg/Kg	5.85 J	9.03	4.92	2.91	6.09	3.36	3.07	25.7 J	18.6 J	112 J	127 J	3.89 J	4.85 J	117	94.7	41.1
Cadmium	EPA 6020	mg/Kg	0.233	0.183	0.096 B	0.072 B	0.24	0.115	0.117	0.464	0.36	1.37	1.37	0.221	0.33	0.728	0.356	0.156
Chromium	EPA 6010B	mg/Kg	23.1	28.1	15.5	19.9	20.8	15.8	16	57.4	45	290	315	18.1	18	502	925	37.3
Cobalt	EPA 6020	mg/Kg	5.57 J	3.87	3.55	3.46	5.27 J	4.43 J	4.32 J	10.9 J	7.67 J	15.1 J	17 J	3.69 J	4.19 J	24.8	17.8	5.8
Copper	EPA 6010B	mg/Kg	34.7 * J	44	22.1	16.2	63.4	20.4	20.2	287	287	558	500	24.7	22.7	2280	699	153
Lead	EPA 6020	mg/Kg	5.13	23.8	11.1	3.11	15.1 J	2.53 J	2.38 J	235	94.1	450	561	13.8	23	577	207	155
Mercury	EPA 7471A	mg/Kg	0.058	0.404	0.091	0.043	0.225	0.026	0.03	0.264	0.229	2.28	1.76	0.227	0.44	17.1	4.43	0.933
Molybdenum	EPA 6020	mg/Kg	1.14	0.97	0.66	0.39	1.09	0.77	0.58	3.36	2.42	9.92	10.5	1.31	1.31	11.5	6.51	3.61
Nickel	EPA 6020	mg/Kg	12 J	12	7.96	7.26	12.1 J	9.25 J	9.19 J	22.2 J	19.2 J	78.7 J	91.9 J	9.71 J	10.8 J	129	413	17.3
Selenium	EPA 6020	mg/Kg	0.6 B	0.5 B	0.5 U	0.4 U	0.4 U	0.4 U	0.5 U	0.6 B	0.6 B	1 B	1 B	0.3 B	0.4 B	1 B	0.4 U	0.4 U
Silver	EPA 6020	mg/Kg	0.119	0.117	0.069	0.055	0.137	0.082	0.059	0.328	0.263	0.723	1.16	0.119	0.143	0.869	0.341	0.371
Thallium	EPA 6020	mg/Kg	0.114	0.06	0.056	0.051	0.095	0.059	0.062	0.08	0.06	0.16	0.18	0.08	0.09	0.125	0.075	0.061
Vanadium	EPA 6010B	mg/Kg	63.2	47.9	45.2	48.1	53.2	51	51.8	38.5	40.7	50.3	46.1	45.7	51.9	79.7	41.2	41.7
Zinc	EPA 6010B	mg/Kg	46.6	81.9	58.8	32.7	65.3	31.5	31	315	329	1120	1410	39.6	37.7	1220	653	598
PCBs (total)	TT calculated	ug/Kg	2.7 U	79	36	24.5	58	2.5 U	2.5 U	380	410	2400	1960	62	34	8890	9620	215
		mg/kg OC	0.17 U	9.0		4.6	6.2	0.17 U	0.24 U	12.1	29.1	146.3	147.4	3.3	2.8	689.1		33.1
PCB-1016	EPA 8082	ug/Kg	2.7 U	52 U	2.4 U	2.4 U	2.7 U	2.5 U	2.5 U	30 U UJ	3 U UJ	32 U UJ	33 U UJ	2.3 U UJ	12 U	52 U	45 U	44 U
PCB-1221	EPA 8082	ug/Kg	2.7 U	52 U	2.4 U	2.4 U	2.7 U	2.5 U	2.5 U	30 U UJ	3 U UJ	32 U UJ	33 U UJ	2.3 U UJ	12 U	52 U	45 U	44 U
PCB-1232	EPA 8082	ug/Kg	2.7 U	52 U	2.4 U	2.4 U	2.7 U	2.5 U	2.5 U	30 U UJ	3 U UJ	32 U UJ	33 U UJ	2.3 U UJ	12 U	52 U	45 U	44 U
PCB-1242	EPA 8082	ug/Kg	2.7 U	52 U	2.4 U	2.4 U	2.7 U	2.5 U	2.5 U	30 U UJ	3 U UJ	32 U UJ	33 U UJ	2.3 U UJ	12 U	52 U	45 U	44 U
PCB-1248	EPA 8082	ug/Kg	2.7 U	52 U	2.4 U	2.4 U	2.7 U	2.5 U	2.5 U	30 U UJ	3 U UJ	32 U UJ	33 U UJ	2.3 U UJ	12 U	52 U	45 U	44 U
PCB-1254	EPA 8082	ug/Kg	2.7 U	79 JD	25	17	33	2.5 U	2.5 U	760 D UJ	230 J	1300 D J	1300 D J	2.3 U UJ	12 U	4900 D	4900 D	150 D
PCB-1260	EPA 8082	ug/Kg	2.7 U	52 U	11 P J	7.5 P J	25	2.5 U	2.5 U	380 PD J	180 J	1100 PD J	660 PD J	2.3 U UJ	34 D	3700 D	4100 D	65 JD
PCB-1262	EPA 8082	ug/Kg	2.7 U	52 U	2.4 U	2.4 U	2.7 U	2.5 U	2.5 U	30 U UJ	3 U UJ	32 U UJ	33 U UJ	62 J	12 U	52 U	45 U	44 U
PCB-1268	EPA 8082	ug/Kg	2.7 U	52 U	2.4 U	2.4 U	2.7 U	2.5 U	2.5 U	30 U UJ	3 U UJ	32 U UJ	33 U UJ	35 Ui UJ	16 Ui	290 D	620 PD J	44 U
Aldrin	EPA 8081A	ug/Kg	0.24 U UJ	4.6 U UJ	0.21 U UJ	0.21 U UJ	0.23 U UJ	0.22 U UJ	0.22 U UJ	5.3 U UJ	5.2 U UJ	5.6 U UJ	5.7 U UJ	4 U UJ	4 U UJ	4.6 U UJ	39 U UJ	3.9 U UJ
alpha-BHC	EPA 8081A	ug/Kg	0.41 U UJ	7.9 U UJ	0.37 U UJ	0.36 U UJ	0.4 U UJ	0.38 U UJ	0.38 U UJ	9.1 U UJ	9 U UJ	9.7 U UJ	9.9 U UJ	6.9 U UJ	6.9 U UJ	7.9 U UJ	67 U UJ	6.7 U UJ
alpha-Chlordane	EPA 8081A	ug/Kg	0.36 U UJ	7 U UJ	0.32 U UJ	0.32 U UJ	0.36 U UJ	0.34 U UJ	0.34 U UJ	8 U UJ	7.9 U UJ	8.6 U UJ	8.7 U UJ	6.1 U UJ	6.1 U UJ	7 U UJ	59 U UJ	6 U UJ
beta-BHC	EPA 8081A	ug/Kg	0.47 U UJ	9.1 U UJ	0.42 U UJ	0.42 U UJ	0.6 Ui UJ	0.44 U UJ	0.44 U UJ	11 U UJ	11 U UJ	12 U UJ	12 U UJ	7.9 U UJ	7.9 U UJ	9.1 U UJ	77 U UJ	7.8 U UJ
delta-BHC	EPA 8081A	ug/Kg	0.086 U UJ	1.7 U UJ	0.091 Ui UJ	0.076 U UJ	0.15 J JN	0.08 U UJ	0.081 U UJ	3.7 Ui UJ	1.9 U UJ	2.1 U UJ	2.1 U UJ	1.5 U UJ	1.5 U UJ	9.5 Ui UJ	15 U UJ	1.5 U UJ
Dieldrin	EPA 8081A	ug/Kg	0.45 U UJ	8.8 U UJ	0.41 U UJ	0.4 U UJ	0.45 U UJ	0.43 U UJ	0.43 U UJ	11 U UJ	10 U UJ	11 U UJ	11 U UJ	7.7 U UJ	7.7 U UJ	8.8 U UJ	75 U UJ	7.5 U UJ
Endosulfan I	EPA 8081A	ug/Kg	0.27 U UJ	5.2 U UJ	0.24 U UJ	0.24 U UJ	0.27 U UJ	0.25 U UJ	0.25 U UJ	6 U UJ	5.9 U UJ	6.4 U UJ	6.5 U UJ	4.5 U UJ	4.5 U UJ	55 PD JN	44 U UJ	4.4 U UJ
Endosulfan II	EPA 8081A	ug/Kg	0.3 U UJ	5.8 U UJ	0.89 P JN	0.47 Ui UJ	0.3 U UJ	0.28 U UJ	0.28 U UJ	6.7 U UJ	6.6 U UJ	7.1 U UJ	7.2 U UJ	5 U UJ	5 U UJ	15 Ui UJ	49 U UJ	4.9 U UJ
Endosulfan sulfate	EPA 8081A	ug/Kg	0.13 U UJ	2.4 U UJ	0.5 Ui UJ	0.11 U UJ	0.51 Ui UJ	0.3 J JN	0.23 Ui UJ	2.8 U UJ	2.8 U UJ	3 U UJ	3 U UJ	2.1 U UJ	2.1 U UJ	2.4 U UJ	21 U UJ	10 Ui UJ
Endrin	EPA 8081A	ug/Kg	0.32 U UJ	6.1 U UJ	0.28 U UJ	0.28 U UJ	0.31 U UJ	0.3 U UJ	0.3 U UJ	7 U UJ	6.9 U UJ	7.5 U UJ	7.6 U UJ	5.3 U UJ	5.3 U UJ	29 PD JN	52 U UJ	5.2 U UJ
Endrin aldehyde	EPA 8081A	ug/Kg	0.083 U UJ	1.6 U UJ	0.5 Ui UJ	0.13 Ui UJ	0.34 Ui UJ	0.51 Ui UJ	0.17 Ui UJ	11 PD JN	5.1 JPD UJ	9.9 Ui UJ	10 Ui UJ	2.1 Ui UJ	10 Ui UJ	58 PD JN	62 JPD JN	1.4 U UJ
gamma-BHC	EPA 8081A	ug/Kg	0.24 U UJ	4.6 U UJ	0.21 U UJ	0.21 U UJ	0.5 Ui UJ	0.22 U UJ	0.28 J UJ	5.3 U UJ	5.2 U UJ	5.6 U UJ	5.7 U UJ	4 U UJ	4 U UJ	9.5 Ui UJ	39 U UJ	3.9 U UJ
gamma-Chlordane	EPA 8081A	ug/Kg	0.1 U UJ	2 U UJ	0.089 U UJ	0.7 P JN	1.1 P JN	0.094 U UJ	0.51 Ui UJ	2.3 U UJ	15 PD JN	49 PD JN	2.5 U UJ	1.7 U UJ	1.7 U UJ	170 PD JN	17 U UJ	5.1 JPD JN
Heptachlor	EPA 8081A	ug/Kg	0.13 U UJ	2.5 U UJ	0.5 Ui UJ	0.11 U UJ	0.13 U UJ	0.14 Ui UJ	0.12 U UJ	2.8 U UJ	2.8 U UJ	3 U UJ	3.4 Ui UJ	2.2 U UJ	2.2 U UJ	2.5 U UJ	21 U UJ	2.1 U UJ
Heptachlor epoxide	EPA 8081A	ug/Kg	0.25 J JN	4 U UJ	0.19 U UJ	0.18 U UJ	0.4 Ui UJ	0.21 Ui UJ	0.51 Ui UJ	10 Ui UJ	5.7 Ui UJ	18 Ui UJ	46 PD JN	3.5 U UJ	3.5 U UJ	4 U UJ	34 U UJ	3.4 U UJ
Methoxychlor	EPA 8081A	ug/Kg	0.16 U UJ	3.1 U UJ	0.29 JP JN	0.31 JP JN	0.37 Ui UJ	0.15 U UJ	0.15 U UJ	4.9 Ui UJ	3.6 Ui UJ	8.4 Ui UJ	8.4 Ui UJ	2.8 Ui UJ	3.4 Ui UJ	14 Ui UJ	27 Ui UJ	2.6 U UJ
Mirex	EPA 8081A	ug/Kg	0.16 U UJ	3.1 U UJ	0.15 Ui UJ	0.17 Ui UJ	0.16 U UJ	0.15 U UJ	0.15 U UJ	4.7 Ui UJ	3.5 U UJ	14 Ui UJ	3.8 U UJ	2.7 U UJ	2.7 U UJ	9.5 Ui UJ	26 U UJ	2.6 U UJ
Nonachlor (cis)	EPA 8081A	ug/Kg	0.15 Ui UJ	2.5 U UJ	0.81 JN	0.54 Ui UJ	0.5 Ui UJ	0.18 Ui UJ	0.18 Ui UJ	2.9 U UJ	2.9 U UJ	15 Ui UJ	47 Ui UJ	2.7 Ui UJ	2.2 U UJ	140 Ui UJ	22 U UJ	3.5 Ui UJ
Nonachlor (trans)	EPA 8081A	ug/Kg	0.14 U UJ	2.7 U UJ	0.13 U UJ	0.13 U UJ	0.14 U UJ	0.13 U UJ	0.13 U UJ	10 Ui UJ	3.1 U UJ	3.4 U UJ	20 Ui UJ	2.4 U UJ	2.4 U UJ	9.5 Ui UJ	23 U UJ	2.3 U UJ
Oxychlordane	EPA 8081A	ug/Kg	0.58 U UJ	12 U UJ	0.52 U UJ	0.51 U UJ	0.57 U UJ	0.54 U UJ	0.54 U UJ	13 U UJ	13 U UJ	14 U UJ	14 U UJ	9.8 U UJ	9.8 U UJ	12 U UJ	95 U UJ	9.6 U UJ
Toxaphene	EPA 8081A	ug/Kg	14 U UJ	280 U UJ	19 Ui UJ	23 Ui UJ	32 Ui UJ	20 Ui UJ	14 U UJ	400 Ui UJ	310 U UJ	680 Ui UJ	730 Ui UJ	240 U UJ	260 Ui UJ	2700 Ui UJ	5200 Ui UJ	240 U UJ
o,p'-DDD	EPA 8081A	ug/Kg	0.33 U UJ	6.4 U UJ	0.51 Ui UJ	0.5 Ui UJ	2.4 P JN	0.31 U UJ	0.31 U UJ	71 PD JN	30 D JN	100 PD JN	120 PD JN	5.6 U UJ	5.6 U UJ	110 Ui UJ	150 Ui UJ	15 D JN
o,p'-DDE	EPA 8081A	ug/Kg	0.36 U UJ	7 U UJ	0.32 U UJ	0.6 Ui UJ	0.36 U UJ	0.34 U UJ	0.34 U UJ	24 Ui UJ	7.9 U UJ	21 Ui UJ	30 Ui UJ	6.1 U UJ	6.1 U UJ	82 Ui UJ	59 U UJ	6 U UJ
o,p'-DDT	EPA 8081A	ug/Kg	0.22 U UJ	4.3 U UJ	1.6 P JN	1.2 JN	1.6 JN	0.21 U UJ	0.21 U UJ	45 D JN	18 D JN	65 D JN	82 D JN	3.7 U UJ	3.7 U UJ	270 D JN	290 D JN	8.1 Ui UJ
p,p'-DDD	EPA 8081A	ug/Kg	0.26 J JN	3.7 U UJ	0.34 J JN	0.25 Ui UJ	0.4 JP JN	0.18 U UJ	0.25 Ui UJ	4.2 U UJ	4.2 U UJ	17 D JN	23 D JN	3.2 U UJ	4.2 Ui UJ	100 D JN	260 D JN	9.5 JD JN
p,p'-DDE	EPA 8081A	ug/Kg	0.16 U UJ	3.1 U UJ	0.14 U UJ	0.14 U UJ	0.16 U UJ	0.15 U UJ	0.15 U UJ	3.5 U UJ	3.5 U UJ	9.9 Ui UJ	10 Ui UJ	2.7 U UJ	2.7 U UJ	16 Ui UJ	26 U UJ	2.6 U UJ
p,p'-DDT	EPA 8081A	ug/Kg	0.1 U UJ	4 JD JN	1.8 JN	1.2 Ui UJ	2.4 JN	0.51 Ui UJ	0.51 Ui UJ	54 D JN	22 D JN	94 D JN	110 D JN	2.6 Ui UJ	4 JD JN	410 D JN	470 D JN	8.2 JD JN
Total DDT	TT Calculated	ug/Kg	0.26 JN	4 JN	3.74 JN	1.2 JN	6.8 JN	0.51 U UJ	0.51 U UJ	170 JN	70 JN	276 JN	335 JN	6.1 U UJ	4 JN	780 JN	1020 JN	32.7 JN
Total Chlordane	TT Calculated	ug/Kg	0.58 U UJ	12 U UJ	0.81 JN	0.7 JN	1.1 JN	0.54 U UJ	0.54 U UJ	13 U UJ	15 JN	49 JN	47 U UJ	9.8 U UJ	9.8 U UJ	170 JN	95 U UJ	5.1 JN
1,2,4-Trichlorobenzene	EPA 8270C	ug/Kg	2.4 U	2.3 U	2.1 U	2.1 U	2.3 U	2.2 U	2.2 U	27 U	2.6 U	28 U	15 U	20 U	2 U	24 U	20 U	3.9 U
		mg/kg OC	0.2 U	0.3 U		0.4 U	0.2 U	0.1 U	0.2 U	0.9 U	0.2 U	1.7 U	1.1 U	1.1 U	0.2 U	1.9 U		0.6 U
1,2-Dichlorobenzene	EPA 8270C	ug/Kg	2.1 U	2.3 J	1.9 U	1.8 U	2 U	1.9 U	1.9 U	23 U UJ	2.3 U UJ	25 U UJ	13 U UJ	18 U UJ	1.8 U UJ	21 U	43 JD	3.4 U
		mg/kg OC	0.1 U	0.3 J		0.3 U	0.2 U	0.1 U	0.2 U	0.7 U UJ	0.2 U UJ	1.5 U UJ	1.0 U UJ	1.0 U UJ	0.2 U UJ	1.6 U		0.5 U
1,3-Dichlorobenzene	EPA 8270C	ug/Kg	2.5 U	2.5 U	2.3 U	2.2 U	2.5 U	2.4 U	2.4 U	28 U	2.8 U	30 U	16 U	22 U	2.2 U	26 U	21 U	4.2 U
1,4-Dichlorobenzene	EPA 8270C	ug/Kg	3 U	2.9 U	2.7 U	2.7 U	3 U	2.8 U	2.8 U	34 U	3.3 U	36 U	18 U	25 U	2.5 U	31 U	25 U	4.9 U
		mg/kg OC	0.2 U	0.3 U		0.5 U	0.3 U	0.2 U	0.3 U	1.1 U	0.2 U	2.2 U	1.4 U	1.3 U	0.2 U	2.4 U		0.8 U
1-Methylnaphthalene	EPA 8270C	ug/Kg	16 U UJ	16 U UJ	14 U UJ	14 U UJ	16 U UJ	15 U UJ	15 U UJ	180 U UJ	18 U UJ	190 U UJ	95 U UJ	140 U UJ	22 J	160 U UJ	130 U UJ	26 U UJ
2,4,5-Trichlorophenol	EPA 8270C	ug/Kg	4.7 U	4.6 U	4.2 U	4.2 U	4.6 U	4.4 U	4.4 U	53 U	5.2 U	56 U	29 U	40 U	4 U	48 U	39 U	7.8 U
2,4,6-Trichlorophenol	EPA 8270C	ug/Kg	2.8 U	2.8 U	2.5 U	2.5 U	2.8 U	2.7 U	2.7 U	32 U	3.1 U	34 U	17 U	24 U	2.4 U	29 U	24 U	4.7 U
2,4-Dichlorophenol	EPA 8270C	ug/Kg	2.8 U	2.8 U	2.5 U	2.5 U	2.8 U	2.7 U	2.7 U	32 U	3.1 U	34 U	17 U	24 U	2.4 U	29 U	24 U	4.7 U
2,4-Dimethylphenol	EPA 8270C	ug/Kg	8.6 U	8.3 U	7.7 U	7.6 U	8.5 U	8 U	8.1 U UJ	96 U	9.5 U	110 U	52 U	73 U	7.3 U	87 U	71 U	15 U
2,4-Dinitrophenol	EPA 8270C	ug/Kg	56 U UJ	55 U UJ	50 U UJ	50 U UJ	56 U	53 U	53 U UJ	630 U	62 U	680 U	340 U	480 U	48 U	570 U UJ	470 U UJ	93 U UJ
2,4-Dinitrotoluene	EPA 8270C	ug/Kg	4.4 U	4.3 U	3.9 U	3.9 U	4.3 U	4.1 U	4.1 U	49 U	4.8 U	53 U	27 U	37 U	3.7 U	45 U	36 U	7.2 U
2,6-Dinitrotoluene	EPA 8270C	ug/Kg	4.4 U	4.3 U	3.9 U	3.9 U	4.3 U	4.1 U	4.1 U	49 U	4.8 U	53 U	27 U	37 U	3.7 U	45 U	36 U	7.2 U
2-Chloronaphthalene	EPA 8270C	ug/Kg	5.6 U	5.5 U	5 U	5 U	5.6 U	5.3 U	5.3 U	63 U	6.2 U	68 U	34 U	48 U	4.8 U	57 U	47 U	9.3 U
2-Chlorophenol	EPA 8270C	ug/Kg	2.7 U	2.6 U	2.4 U	2.4 U	2.7 U	2.5 U	2.5 U	30 U	3 U	32 U	17 U	23 U	2.3 U	27 U	22 U	4.4 U
2-Methylnaphthalene	EPA 8270C	ug/Kg	3.2 J	6.5 J	3.5 J	5.9 J	8.9 J	1.8 U	1.8 U	21 U	14	33 JD	46 JD	30 JD	35	130 D	93 JD	26 D
		mg/kg OC	0.2 J	0.7 J		1.1 J	0.9 J	0.1 U	0.2 U	0.7 U	1.0	2.0 JD	3.5 JD	1.6 JD	2.9	10.1 D		4.0 D
2-Methylphenol	EPA 8270C	ug/Kg	5.3 U	5.2 U	4.8 U	4.7 U	5.3 U	5 U	5 U	60 U	5.9 U	64 U	33 U	45 U	4.5 U	54 U	44 U	8.8 U
2-Nitroaniline	EPA 8270C	ug/Kg	4.2 U	4.1 U	3.8 U	3.7 U	4.2 U	4 U	4 U	47 U	4.7 U	51 U	26 U	36 U	3.6 U	43 U	35 U	7 U
2-Nitrophenol	EPA 8270C	ug/Kg	4.1 U	4 U	3.7 U	3.6 U	4 U	3.8 U	3.8 U	46 U	4.5 U	49 U	25 U	35 U	3.5 U	42 U	34 U	6.7 U
3,3'-Dichlorobenzidine	EPA 8270C	ug/Kg	5.8 U	5.6 U	5.2 U	5.1 U	5.7 U	5.4 U	5.4 U	65 U	6.4 U	69 U	35 U	49 U	4.9 U	59 U	48 U	9.6 U
3-Nitroaniline	EPA 8270C	ug/Kg	4.1 U	4 U	3.7 U	3.6 U	4 U	3.8 U	3.8 U	46 U	4.5 U	49 U	25 U	35 U	3.5 U	42 U	34 U	6.7 U

Table A-1. 2007 Remedial Investigation Subsurface Cores Analytical Data

Location			11	12	12	12	13	13	13	14	14	14	14	14	14	15	15	15
Sample ID			TT11-CS-D	TT12-CS-B	TT12-CS-C	TT12-CS-D	TT13-CS-A	TT13-CS-B	TT13-CS-C	TT14-CS-B	TT90-CS-A	TT14-CS-C	TT90-CS-B	TT14-CS-J	TT90-CS-C	TT15-CS-B	TT15-CS-C	TT15-CS-G
Sample Date			1/19/2007	1/15/2007	1/15/2007	1/15/2007	1/19/2007	1/19/2007	1/19/2007	1/13/2007	1/13/2007	1/13/2007	1/13/2007	1/13/2007	1/13/2007	1/18/2007	1/18/2007	1/18/2007
Sample Depth (MLLW)			-47 To -48 ft	-43 To -44 ft	-44 To -45 ft	-45 To -46 ft	-45.24 To -46.2 ft	-46.24 To -47 ft	-47 To -47.87 ft	-26 To -27 ft	duplicate of TT14-CS-B	-27 To -28 ft	duplicate of TT14-CS-C	-34.42 To -35 ft	duplicate of TT14-CS-J	-46.9 To -48 ft	-48 To -48.9 ft	-52.34 To -53 ft
Parameter	**Method**	**Units**																
4,6-Dinitro-o-cresol	EPA 8270C	ug/Kg	2.7 U	2.6 U	2.4 U	2.4 U	2.7 U	2.5 U	2.5 U	30 U	3 U	32 U	17 U	23 U	2.3 U	27 U	22 U	4.4 U
4-Bromophenyl phenyl ether	EPA 8270C	ug/Kg	2.2 U	2.2 U	2 U	2 U	2.2 U	2.1 U	2.1 U	25 U	2.4 U	27 U	14 U	19 U	1.9 U	23 U	18 U	3.6 U
4-Chloro-3-methylphenol	EPA 8270C	ug/Kg	3.3 U	3.2 U	3 U	2.9 U	3.3 U	3.1 U	3.1 U	37 U	3.6 U	40 U	20 U	28 U	2.8 U	34 U	27 U	5.4 U
4-Chloroaniline	EPA 8270C	ug/Kg	3.3 U	3.2 U	3 U	2.9 U	3.3 U	3.1 U	3.1 U	37 U	3.6 U	40 U	20 U	28 U	2.8 U	34 U	27 U	5.4 U
4-Chlorophenyl phenyl ether	EPA 8270C	ug/Kg	3.2 U	3.1 U	2.8 U	2.8 U	3.1 U	3 U	3 U	35 U	3.5 U	38 U	19 U	27 U	2.7 U	32 U	26 U	5.2 U
4-Methylphenol	EPA 8270C	ug/Kg	4.5 U	4.4 U	4.1 U	4 U	4.5 U	4.3 U	4.3 U	51 U	11	55 U	28 U	39 U	6.7 J	66 JD	42 JD	7.5 U
4-Nitroaniline	EPA 8270C	ug/Kg	5.3 U	5.2 U	4.8 U	4.7 U	5.3 U	5 U	5 U	60 U	5.9 U	64 U	33 U	45 U	4.5 U	54 U	44 U	8.8 U
4-Nitrophenol	EPA 8270C	ug/Kg	47 U	46 U	42 U	42 U	46 U	44 U	44 U	530 U	52 U	560 U	290 U	400 U	40 U	480 U	390 U	78 U
Acenaphthene	EPA 8270C	ug/Kg	2.9 J	12	3.6 J	3.2 J	8.3 J	1.5 U	1.5 U	69 JD	49	110 D	120 D	41 JD	56	660 D	540 D	19 JD
		mg/kg OC	0.2 J	1.4		0.6 J	0.9 J	0.1 U	0.1 U	2.2 JD	3.5	6.7 D	9.0 D	2.2 JD	4.7	51.2 D		2.9 JD
Acenaphthylene	EPA 8270C	ug/Kg	2.2 U	14	7 J	4.1 J	11	2.1 U	2.1 U	140 D J	100 J	120 D J	140 D J	40 JD J	34 J	250 D	170 D	34 D
		mg/kg OC	0.1 U	1.6		0.8 J	1.2	0.1 U	0.2 U	4.4 D J	7.1 J	7.3 D J	10.5 D J	2.2 JD J	2.8 J	19.4 D		5.2 D
Aniline	EPA 8270C	ug/Kg	2.4 U	6.5 J	7.3 J	16 J	2.3 U	2.2 U	2.2 U	27 U	2.6 U	28 U	15 U	20 U	2 U	24 U	20 U	7.5 JD
Anthracene	EPA 8270C	ug/Kg	7.4 J	36	13	7.1 J	27	2.1 U	2.1 U	280 D	230	310 D	360 D	150 D	150	1300 D	860 D	52 D
		mg/kg OC	0.5 J	4.1		1.3 J	2.9	0.1 U	0.2 U	8.9 D	16.3	18.9 D	27.1 D	8.1 D	12.5	100.8 D		8.0 D
Benzo(a)anthracene	EPA 8270C	ug/Kg	12	42	19	9 J	31	2.1 U	2.1 U	1200 D J	530 J	1000 D J	1700 D J	180 D J	200 J	4200 D	3200 D	290 D
		mg/kg OC	0.8	4.8		1.7 J	3.3	0.1 U	0.2 U	38.1 D J	37.6 J	61.0 D J	127.8 D J	9.7 D J	16.7 J	325.6 D		44.6 D
Benzo(a)pyrene	EPA 8270C	ug/Kg	2.5 U	69	29	12	46	2.4 U	2.4 U	950 D	590	1100 D	1700 D	300 D	270	4400 D	2000 D	210 D
		mg/kg OC	0.2 U	7.8		2.3	4.9	0.2 U	0.2 U	30.2 D	41.8	67.1 D	127.8 D	16.1 D	22.5	341.1 D		32.3 D
Benzo(b)fluoranthene	EPA 8270C	ug/Kg	9 J	86	33	13	69	3.7 U	3.7 U	1600 D	1000 D	1700 D	2600 D	360 D	420	5400 D	2200 D	210 D
Benzo(g,h,i)perylene	EPA 8270C	ug/Kg	4.6 J	35	17	7.2 J	28	3.4 U	3.4 U	420 D	310	630 D	960 D	150 D	140	2200 D	1000 D	110 D
		mg/kg OC	0.3 J	4.0		1.4 J	3.0	0.2 U	0.3 U	13.3 D	22.0	38.4 D	72.2 D	8.1 D	11.7	170.5 D		16.9 D
Benzo(k)fluoranthene	EPA 8270C	ug/Kg	3.9 U	65	25	11	23	3.7 U	3.7 U	560 D	260	600 D	800 D	270 D	120	3500 D	1800 D	180 D
Benzofluoranthenes (total)	TT calculated	ug/Kg	9	151	58	24	92	3.7 U	3.7 U	2160	1260	2300	3400	630	540	8900	4000	390
		mg/kg OC	0.6	17.2		4.5	9.8	0.2 U	0.3 U	68.6	89.4	140.2	255.6	33.9	45.0	689.9		60.0
Benzoic acid	EPA 8270C	ug/Kg	150 U	150 U	140 U	140 U	150 U	140 U	140 U R	1700 U	170 U	1800 U	910 U	1300 U	130 U	1600 U	1300 U	250 U
Benzyl alcohol	EPA 8270C	ug/Kg	5.8 U	5.6 U	5.2 U	5.1 U	5.7 U	5.4 U	5.4 U	65 U	6.4 U	69 U	35 U	49 U	4.9 U	59 U	48 U	9.6 U
bis(2-chloroethoxy)methane	EPA 8270C	ug/Kg	2.1 U	2 U	1.9 U	1.8 U	2 U	1.9 U	1.9 U	23 U	2.3 U	25 U	13 U	18 U	1.8 U	21 U	17 U	3.4 U
bis(2-chloroethyl)ether	EPA 8270C	ug/Kg	3.8 U	3.7 U	3.4 U	3.3 U	3.7 U	3.5 U	3.5 U	42 U	4.2 U	45 U	23 U	32 U	3.2 U	38 U	31 U	6.2 U
bis(2-chloroisopropyl)ether	EPA 8270C	ug/Kg	1.9 U	1.9 U	1.7 U	1.7 U	1.9 U	1.8 U	1.8 U	21 U	2.1 U	23 U	12 U	16 U	1.6 U	19 U	16 U	3.1 U
bis(2-ethylhexyl)phthalate	EPA 8270C	ug/Kg	14 J U	16 J U	9.7 J U	5.7 J U	14 J U	5.8 J U	3.2 J U	590 JD	350	830 JD	930 D	23 U	2.3 U	5200 D	1100 D	92 JD
		mg/kg OC	0.9 J U	1.8 J U		1.1 J U	1.5 J U	0.4 J U	0.3 J U	18.7 JD	24.8	50.6 JD	69.9 D	1.2 U	0.2 U	403.1 D		14.2 JD
Butyl benzyl phthalate	EPA 8270C	ug/Kg	2.4 U	2.3 U	2.1 U	2.1 U	2.3 U	2.2 U	2.2 U	92 JD	34	28 U	15 U	20 U	2 U	24 U	20 U	3.9 JD
		mg/kg OC	0.2 U	0.3 U		0.4 U	0.2 U	0.1 U	0.2 U	2.9 JD	2.4	1.7 U	1.1 U	1.1 U	0.2 U	1.9 U		0.6 JD
Chrysene	EPA 8270C	ug/Kg	3.8 J	60	26	12	41	2.1 U	2.1 U	1500 D J	910 D J	1400 D J	2000 D J	310 D J	300 J	4800 D	3500 D	300 D
		mg/kg OC	0.2 J	6.8		2.3	4.4	0.1 U	0.2 U	47.6 D J	64.5 D J	85.4 D J	150.4 D J	16.7 D J	25.0 J	372.1 D		46.2 D
Dibenzo(a,h)anthracene	EPA 8270C	ug/Kg	3.5 U	14	5.3 J	3.1 U	7.1 J	3.2 U	3.3 U	130 D	78	180 D	270 D	48 JD	31	820 D	330 D	31 D
		mg/kg OC	0.2 U	1.6		0.6 U	0.8 J	0.2 U	0.3 U	4.1 D	5.5	11.0 D	20.3 D	2.6 JD	2.6	63.6 D		4.8 D
Dibenzofuran	EPA 8270C	ug/Kg	3.4 J	8.5 J	3.3 J	6.8 J	8.5 J	1.9 U	1.9 U	38 JD	27	54 JD	64 D	36 JD	40	430 D	370 D	16 JD
		mg/kg OC	0.2 J	1.0 J		1.3 J	0.9 J	0.1 U	0.2 U	1.2 JD	1.9	3.3 JD	4.8 D	1.9 JD	3.3	33.3 D		2.5 JD
Diethylphthalate	EPA 8270C	ug/Kg	7.3 J	5.3 U	4.9 U	4.8 U	5.4 U	5.1 U	5.2 U	61 U	6 U	66 U	34 U	46 U	4.6 U	56 U	45 U	9 U
		mg/kg OC	0.5 J	0.6 U		0.9 U	0.6 U	0.3 U	0.5 U	1.9 U	0.4 U	4.0 U	2.6 U	2.5 U	0.4 U	4.3 U		1.4 U
Dimethyl phthalate	EPA 8270C	ug/Kg	2.8 U	2.8 U	2.5 U	2.5 U	2.8 U	2.7 U	2.7 U	32 U	4.1 J	34 U	17 U	24 U	2.4 U	29 U	24 U	4.7 U
		mg/kg OC	0.2 U	0.3 U		0.5 U	0.3 U	0.2 U	0.3 U	1.0 U	0.3 J	2.1 U	1.3 U	1.3 U	0.2 U	2.2 U		0.7 U
Di-n-butyl phthalate	EPA 8270C	ug/Kg	4.4 J U	6.3 J	4.2 J	5 J	6.1 J U	6.8 J U	3.9 J	46 U	24	51 JD	33 JD	35 U	6 J	96 JD	80 JD	190 D
		mg/kg OC	0.3 J U	0.7 J		0.9 J	0.6 J U	0.5 J U	0.4 J	1.5 U	1.7	3.1 JD	2.5 JD	1.9 U	0.5 J	7.4 JD		29.2 D
Di-n-octyl phthalate	EPA 8270C	ug/Kg	1.9 U	1.9 U	1.7 U	1.7 U	1.9 U	1.8 U	1.8 U	21 U	2.1 U	23 U	12 U	16 U	1.6 U	19 U	16 U	3.1 U
		mg/kg OC	0.1 U	0.2 U		0.3 U	0.2 U	0.1 U	0.2 U	0.7 U	0.1 U	1.4 U	0.9 U	0.9 U	0.1 U	1.5 U		0.5 U
Fluoranthene	EPA 8270C	ug/Kg	19	120	45	33	81	3.2 U	3.3 U	1200 D	990 D	1700 D	2900 D	360 D	380	15000 D	15000 D	1100 D
		mg/kg OC	1.2	13.6		6.2	8.6	0.2 U	0.3 U	38.1 D	70.2 D	103.7 D	218.0 D	19.4 D	31.7	1162.8 D		169.2 D
Fluorene	EPA 8270C	ug/Kg	3.9 J	13	4.1 J	4.6 J	11	2.5 U	2.5 U	81 JD	62	120 D	150 D	53 JD	56	720 D	480 D	22 D
		mg/kg OC	0.2 J	1.5		0.9 J	1.2	0.2 U	0.2 U	2.6 JD	4.4	7.3 D	11.3 D	2.8 JD	4.7	55.8 D		3.4 D
Hexachlorobenzene	EPA 8081A	ug/Kg	0.13 U	2.4 U	0.11 U	0.11 U	0.13 U	0.12 U	0.12 U	2.8 U	2.8 U	3 U	3 U	2.1 U	2.1 U	2.4 U	21 U	2.1 U
		mg/kg OC	0.01 U	0.3 U		0.02 U	0.01 U	0.01 U	0.01 U	0.1 U	0.2 U	0.2 U	0.2 U	0.1 U	0.2 U	0.2 U		0.3 U
Hexachlorobenzene	EPA 8270C	ug/Kg																
		mg/kg OC																
Hexachlorobutadiene	EPA 8081A	ug/Kg	0.76 U		0.68 U	0.68 U	0.76 U	0.72 U	0.72 U	18 U		19 U		13 U		15 U		
		mg/kg OC	0.05 U			0.1 U	0.1 U	0.05 U	0.1 U	0.6 U		1.2 U		0.7 U	0.0	1.2 U		0.0
Hexachlorobutadiene	EPA 8270C	ug/Kg		2.2 U							2.4 U		14 U		1.9 U		18 U	3.6 U
		mg/kg OC		0.3 U							0.2 U		1.1 U		0.2 U			0.6 U
Hexachlorocyclopentadiene	EPA 8270C	ug/Kg	24 U	23 U UJ	21 U UJ	21 U UJ	23 U	22 U	22 U	270 U UJ	26 U UJ	280 U UJ	150 U UJ	200 U UJ	20 U UJ	240 U UJ	200 U UJ	39 U UJ
Hexachloroethane	EPA 8270C	ug/Kg	3.5 U	3.4 U	3.1 U	3.1 U	3.4 U	3.2 U	3.3 U	39 U UJ	3.8 U UJ	41 U UJ	21 U UJ	29 U UJ	2.9 U UJ	35 U	29 U	5.7 U
Indeno(1,2,3-cd)pyrene	EPA 8270C	ug/Kg	4.3 J	39	19	7.6 J	27	2.8 U	2.8 U	520 D	370	720 D	1100 D	190 D	160	2600 D	1200 D	110 D
		mg/kg OC	0.3 J	4.4		1.4 J	2.9	0.2 U	0.3 U	16.5 D	26.2	43.9 D	82.7 D	10.2 D	13.3	201.6 D		16.9 D
Isophorone	EPA 8270C	ug/Kg	2.5 U	2.5 U	2.3 U	2.2 U	2.5 U	2.4 U	2.4 U	28 U UJ	2.8 U UJ	30 U UJ	16 U UJ	22 U UJ	2.2 U UJ	26 U	21 U	4.2 U
Naphthalene	EPA 8270C	ug/Kg	5.8 J	20	8.8 J	12	22	1.9 U	1.9 U	41 JD	24	62 JD	110 D	110 D	100	210 D	120 D	53 D
		mg/kg OC	0.4 J	2.3		2.3	2.3	0.1 U	0.2 U	1.3 JD	1.7	3.8 JD	8.3 D	5.9 D	8.3	16.3 D		8.2 D
Nitrobenzene	EPA 8270C	ug/Kg	3.2 U	3.1 U	2.8 U	2.8 U	3.1 U	3 U	3 U	35 U	3.5 U	38 U	19 U	27 U	2.7 U	32 U	26 U	5.2 U
N-Nitrosodimethylamine	EPA 8270C	ug/Kg	9.5 U	9.2 U	8.5 U	8.4 U	9.4 U	8.9 U	8.9 U	110 U	11 U	120 U	58 U	81 U	8.1 U	97 U	79 U	16 U
N-Nitroso-di-n-propylamine	EPA 8270C	ug/Kg	5 U	4.9 U	4.5 U	4.4 U	5 U	4.7 U	4.7 U	56 U	5.5 U	60 U	31 U	43 U	4.3 U	51 U	41 U	8.3 U
N-Nitrosodiphenylamine	EPA 8270C	ug/Kg	3.5 U	3.4 U	3.1 U	3.1 U	3.4 U	3.2 U	3.3 U	39 U	3.8 U	41 U	21 U	29 U	2.9 U	35 U	120 D	23 D
		mg/kg OC	0.2 U	0.4 U		0.6 U	0.4 U	0.2 U	0.3 U	1.2 U	0.3 U	2.5 U	1.6 U	1.6 U	0.2 U	2.7 U		3.5 D
Pentachlorophenol	EPA 8270C	ug/Kg	14 U	13 U	12 U	12 U	14 U	13 U	13 U	420 JD	200	160 U	81 U	120 U	12 U	140 U	110 U	22 U
Phenanthrene	EPA 8270C	ug/Kg	14	78	26	24	59	3.7 J	2 J	530 D	440	750 D	920 D	170 D	180	4900 D	5000 D	100 D
		mg/kg OC	0.9	8.9		4.5	6.3	0.2 J	0.2 J	16.8 D	31.2	45.7 D	69.2 D	9.1 D	15.0	379.8 D		15.4 D
Phenol	EPA 8270C	ug/Kg	3 U	8.1 J	7.1 J	6.5 J	3 U	2.8 U	2.8 U	34 U	32	64 JD	18 U	25 U	2.5 U	52 JD	52 JD	39 JD
Pyrene	EPA 8270C	ug/Kg	57	96	41	32	120	5.4 J	3.9 J	4300 D	2700 D	4900 D	6800 D	620 D	910 D	11000 D	6600 D	780 D
		mg/kg OC	3.6	10.9		6.0	12.8	0.4 J	0.4 J	136.5 D	191.5 D	298.8 D	511.3 D	33.3 D	75.8 D	852.7 D		120.0 D
Total HPAH	TT calculated	ug/Kg	109.7	626	259.3	136.8	473.1	5.4	3.9	12380	7738	13930	20830	2788	2931	53920	36830	3321
		mg/kg OC	6.9	71.1		25.8	50.3	0.4	0.4	393.0	548.8	849.4	1566.2	149.9	244.3	4179.8		510.9
Total LPAH	TT calculated	ug/Kg	34	173	62.5	55	138.3	3.7	2	1141	905	1472	1800	564	576	8040	7170	280
		mg/kg OC	2.1	19.7		10.4	14.7	0.2	0.2	36.2	64.2	89.8	135.3	30.3	48.0	623.3		43.1
Total PAH	TT calculated	ug/Kg	143.7	799	321.8	191.8	611.4	9.1	5.9	13521	8643	15402	22630	3352	3507	61960	44000	3601
Butyltin	KRONE	ug/Kg	0.047 U	0.046 U	0.042 U	0.042 U UJ	2.4 J	0.044 U UJ	0.044 U	64	15	11	4.8	0.04 U	0.87 J J	83 PD J	7.5	0.039 U
Dibutyltin	KRONE	ug/Kg	0.56 J U	5.2	3	0.75 J U	21	0.65 J UJ	0.46 J U	310 D	220 D	94	75	0.69 J U	1.4 J	1600 D	74	3.6

Table A-1. 2007 Remedial Investigation Subsurface Cores Analytical Data

Location			11	12	12	12	13	13	13	14	14	14	14	14	14	15	15	15
Sample ID			TT11-CS-D	TT12-CS-B	TT12-CS-C	TT12-CS-D	TT13-CS-A	TT13-CS-B	TT13-CS-C	TT14-CS-B	TT90-CS-A	TT14-CS-C	TT90-CS-B	TT14-CS-J	TT90-CS-C	TT15-CS-B	TT15-CS-C	TT15-CS-G
Sample Date			1/19/2007	1/15/2007	1/15/2007	1/15/2007	1/19/2007	1/19/2007	1/19/2007	1/13/2007	1/13/2007	1/13/2007	1/13/2007	1/13/2007	1/13/2007	1/18/2007	1/18/2007	1/18/2007
Sample Depth (MLLW)			-47 To -48 ft	-43 To -44 ft	-44 To -45 ft	-45 To -46 ft	-45.24 To -46.2 ft	-46.24 To -47 ft	-47 To -47.87 ft	-26 To -27 ft	duplicate of TT14-CS-B	-27 To -28 ft	duplicate of TT14-CS-C	-34.42 To -35 ft	duplicate of TT14-CS-J	-46.9 To -48 ft	-48 To -48.9 ft	-52.34 To -53 ft
Parameter	**Method**	**Units**																
Tetrabutyltin	KRONE	ug/Kg	0.11 U	0.11 U	0.098 U	0.096 U	0.11 U	0.11 U UJ	0.11 U	17	11	6.6	8.2	0.092 U	0.092 U UJ	100	3.7	0.09 U
Tributyltin	KRONE	ug/Kg	0.087 U	13	7.4	1.8	16	0.29 J J	0.082 U	820 D	670 D	390 D	440 D	0.86 J	3.1 J	8100 D	230 D	0.64 J
		mg/kg OC	0.005 U	1.5		0.3	1.7	0.019 J J	0.008 U	26.0 D	47.5 D	23.8 D	33.1 D	0.046 J	0.3 J	627.9 D		0.10 J
Total Solids	EPA 160.3	Percent	65.2	66.4	72.1	73	65.6	69.5	70.3	57.5	58.4	53.7	53	76.1	76.1	63.3	78.2	77.8
Total Organic Carbon	ASTM D4129-98M	Percent	1.6	0.88	0.42	0.53	0.94	1.49	1.06	3.15	1.41	1.64	1.33	1.86	1.2	1.29	0.46	0.65
Fractional % phi >-1	PSEP Grain Size	Percent	0.38	0.51	0.49	0.51	0.36	0.58	0.3	11.9	11.9	11.9	11.3	1.49	1.46	6.04	1.19	1.17
Fractional % phi 0-1	PSEP Grain Size	Percent	0.29	0.88	0.92	0.97	0.44	0.5	0.3	5.56	5.72	9.73	9.27	4.4	4.27	20.8	3.99	6.85
Fractional % phi 1-2	PSEP Grain Size	Percent	0.31	1.75	1.82	1.74	1.61	3.86	2.1	6.44	7.7	10.3	10.7	22.2	19.9	27.9	11.6	24.1
Fractional % phi 2-3	PSEP Grain Size	Percent	1.09	25.7	23.7	30.5	4.79	26.2	19.91	12.8	12.7	11.8	11.9	23.8	26.2	17.1	12.1	36.2
Fractional % phi 3-4	PSEP Grain Size	Percent	4.71	51.5	46.9	47.3	17.71	24.82	28.71	8.69	9.42	7.03	7.9	18.9	19.1	6.84	10.7	16.6
Fractional % phi 4-5	PSEP Grain Size	Percent	15.35	18.5	18.9	13.2	23.18	14.04	18.17	3.12	3.77	5.86	6.35	7.22	6.38	2.87	12.2	5.23
Fractional % phi 5-6	PSEP Grain Size	Percent	24.1	3.72	3.28	2.2	0	11.7	11.9	6.76	10.4	13	13	4.51	4.16	10.8	10.5	2.68
Fractional % phi 6-7	PSEP Grain Size	Percent	22.22	1.41	1.48	0.79	174.9	5.05	6.42	3.48	2.42	2.13	1.65	2.89	2.89	1.95	8.6	1.7
Fractional % phi 7-8	PSEP Grain Size	Percent	10.57	1.08	0.92	0.51	7.24	4.41	4.05	1.38	0.77	0.41	0.77	2.37	2.27	0.72	5.33	1.21
Fractional % phi 8-9	PSEP Grain Size	Percent	6.12	0.47	0.73	0.4	3.99	2.57	1.84	0.46	0.57	0.35	0.32	1.8	1.48	0.64	4.1	0.83
Fractional % phi 9-10	PSEP Grain Size	Percent	4.02	0.86	0.64	0.41	3.2	1.7	2.1	0.94	0.82	0.37	0.26	1.65	1.39	0.36	2.53	0.38
Fractional % phi >10	PSEP Grain Size	Percent	8.63	1.53	1.39	1.37	4.95	2.87	3.17	2.64	2.48	3.04	3.2	2.04	2.05	2	5.03	1.06
Gravel	PSEP Grain Size	Percent	0.01	0.24	0.18	0.2	0.39	1.15	0.7	41.3	37.9	25.5	27.2	5.72	4.6	4.41	1.19	1.14

Notes:

0.14 U J = Result followed by laboratory data qualifier followed by data validator qualifier
Sample depth (MLLW) = the core increment elevation in mean lower low water
mg/kg = milligrams per kilogram
ug/kg = micrograms per kilogram
mg/L = milligrams per liter
ug/L = micrograms per liter
ng/L = nanograms per liter

Data Validation Qualifiers
U = Result should be considered not-detected at the quantitation limit shown
J = Result is an estimated concentration
R = Rejected - Quality Control indicates the data is not usable
UJ = The compound was not detected and the sample detection limit should be considered an estimated value
N - Pesticide result is tentatively identified.

Laboratory Data Qualifiers
U = result was not detected at or above the method detection limit
J (for organics) = result is an estimated concentration that is less than the reporting limit but greater than or equal to the detection limit
B (for metals) = result is an estimated concentration that is less than the reporting limit but greater than or equal to the detection limit
* (for metals) = duplicate analysis not within control limits. See case narrative (in laboratory report)
D (for organics) = result reported is from a dilution
P (for organics) = The GC or HPLC confirmation criteria was exceeded. The relative percent difference is greater than 40% between the two analytical results.
i (for organics) = the MRL/MDL has been elevated due to a chromatographic interference.

Table A-1. 2007 Remedial Investigation Subsurface Cores Analytical Data

Location			16	16	16	16	17	17	17	18	18	18	19	19	19	19	19
Sample ID			TT16-CS-B	TT16-CS-C	TT16-CS-D	TT16-CS-I	TT17-CS-B	TT17-CS-C	TT17-CS-D	TT18-CS-B	TT18-CS-C	TT18-CS-D	TT19-CS-A	TT91-CS-A	TT19-CS-B	TT91-CS-B	TT19-CS-C
Sample Date			1/22/2007	1/22/2007	1/22/2007	1/22/2007	1/12/2007	1/12/2007	1/12/2007	1/15/2007	1/15/2007	1/15/2007	1/15/2007	1/15/2007	1/15/2007	1/15/2007	1/15/2007
Sample Depth (MLLW)			-39.1 To -40 ft	-40 To -41 ft	-41 To -42 ft	-46 To -47 ft	-43 To -44 ft	-44 To -44.84 ft	-44.84 To -46 ft	-34.99 To -36 ft	-36 To -37 ft	-37 To -38 ft	-32.9 To -34 ft	duplicate of TT19-CS-A	-34 To -35 ft	duplicate of TT19-CS-B	-35 To -35.58 ft
Parameter	**Method**	**Units**															
Antimony	EPA 6020	mg/Kg	10.2	14	0.044 U	0.044 U	26.6	19.8	38.5	238 * J	58.1 * J	2.52 * J	5.13 * J	5.09 * J	6.85 * J	7.44 * J	7.19 * J
Arsenic	EPA 6020	mg/Kg	13.1	19	2.26	2.32	83 J	108 J	123 J	224	59.7	4.54	17.6	21.2	18.5	20.1	15.4
Cadmium	EPA 6020	mg/Kg	0.104	1.93	0.065	0.055 B	0.594	0.621	0.536	1.09	0.491	0.035 B	0.416	0.515	0.395	0.407	0.274
Chromium	EPA 6010B	mg/Kg	19.4	32.5	13.6	13.7	209	321	181	179	51	11.4	49.2	51.2	47.4	48.7	58.4
Cobalt	EPA 6020	mg/Kg	3.87 J	3.73 J	3.88 J	3.84 J	31.7 J	27.9 J	18.8 J	10	6.12	2.78	6.54	7.04	6.5	6.3	5.33
Copper	EPA 6010B	mg/Kg	43.8	43.5	15.8	16.2	2350	1160	1730	666	349	20.9	114	119	146	165	72.3
Lead	EPA 6020	mg/Kg	35.4 J	44.1 J	2.35 J	1.86 J	616	371	410	513	232	8.98	72.1	78.3	80.8	167	94.1
Mercury	EPA 7471A	mg/Kg	2.74 * J	0.063 * J	0.021 * J	0.025 * J	2.88	3.45	6.96	9.74	4.42	0.082	0.252	0.294	0.255	0.27	0.163
Molybdenum	EPA 6020	mg/Kg	0.94	1.2	0.3	0.29	9.8	7.11	6.98	9.47	3.65	0.32	3.05	3.39	1.74	1.66	1.72
Nickel	EPA 6020	mg/Kg	8.94 J	7.58 J	8.07 J	8.27 J	97.6 J	85.5 J	52.1 J	33.1	16.6	5.66	21.5	19.9	17.4	16.2	22.4
Selenium	EPA 6020	mg/Kg	0.4 U	0.4 U	0.4 U	0.4 U	0.6 B	0.7 B	0.6 B	0.6 B	0.5 B	0.5 U	0.6 B	0.7 B	0.5 B	0.6 B	0.4 U
Silver	EPA 6020	mg/Kg	0.095	0.098	0.046	0.05	0.595	0.409	0.258	1.35	0.608	0.049	0.257 * J	0.247 * J	0.228 * J	0.215 * J	0.143 * J
Thallium	EPA 6020	mg/Kg	0.038	0.041	0.049	0.049	0.15	0.16	0.14	0.225	0.108	0.032 B	0.103	0.124	0.093	0.09	0.087
Vanadium	EPA 6010B	mg/Kg	37.4	38.4	45	44.5	91.7	74.1	51.7	51	54.5	35.4	65.3	67.5	59.9	58.9	50
Zinc	EPA 6010B	mg/Kg	111	317	30.5	25.1	945	685	1220	1570	547	40.2	251	182	199	222	149
PCBs (total)	TT calculated	ug/Kg	290	20.4	2.3 U	2.3 U	2000	1800	2100	2550	880	29	170	230	251	340	192
		mg/kg OC			0.44 U	0.37 U	227.3	257.1	151.1	193.2	57.5		11.6	16.4	5.5	34.7	16.4
PCB-1016	EPA 8082	ug/Kg	12 U	2.3 U	2.3 U	2.3 U	23 U UJ	23 U UJ	25 U UJ	54 U	50 U	2.1 U	2.7 U	57 U	50 U	48 U	51 U
PCB-1221	EPA 8082	ug/Kg	12 U	2.3 U	2.3 U	2.3 U	23 U UJ	23 U UJ	25 U UJ	54 U	50 U	2.1 U	2.7 U	57 U	50 U	48 U	51 U
PCB-1232	EPA 8082	ug/Kg	12 U	2.3 U	2.3 U	2.3 U	23 U UJ	23 U UJ	25 U UJ	54 U	50 U	2.1 U	2.7 U	57 U	50 U	48 U	51 U
PCB-1242	EPA 8082	ug/Kg	12 U UJ	2.3 U UJ	2.3 U UJ	2.3 U UJ	23 U UJ	23 U UJ	25 U UJ	54 U UJ	50 U UJ	2.1 U	2.7 U	57 U UJ	50 U UJ	48 U UJ	51 U UJ
PCB-1248	EPA 8082	ug/Kg	12 U UJ	2.3 U UJ	2.3 U UJ	2.3 U UJ	23 U UJ	23 U UJ	25 U UJ	54 U UJ	50 U UJ	2.1 U	2.7 U	57 U UJ	50 U UJ	48 U UJ	51 U UJ
PCB-1254	EPA 8082	ug/Kg	190 D J	13 J	2.3 U UJ	2.3 U UJ	2000 D J	1800 D J	2100 D J	1700 D J	620 D J	16	88	160 D J	170 D J	190 D J	110 D J
PCB-1260	EPA 8082	ug/Kg	100 D J	7.4 J	2.3 U UJ	2.3 U UJ	23 U UJ	23 U UJ	25 U UJ	850 PD J	260 PD J	13 P J	82	70 JPD J	81 PD J	150 D J	82 D J
PCB-1262	EPA 8082	ug/Kg	12 U UJ	2.3 U UJ	2.3 U UJ	2.3 U UJ	23 U UJ	23 U UJ	25 U UJ	54 U UJ	50 U UJ	2.1 U	2.7 U	57 U UJ	50 U UJ	48 U UJ	51 U UJ
PCB-1268	EPA 8082	ug/Kg	12 U UJ	2.3 U UJ	2.3 U UJ	2.3 U UJ	23 U UJ	23 U UJ	25 U UJ	54 U UJ	50 U UJ	2.1 U	2.7 U	57 U UJ	50 U UJ	48 U UJ	51 U UJ
Aldrin	EPA 8081A	ug/Kg	2 U UJ	0.2 U UJ	0.2 U UJ	0.21 U UJ	4 U UJ	4.1 U UJ	4.4 U UJ	4.8 U UJ	4.4 U UJ	3.7 U UJ	4.7 U UJ	5 U UJ	4.4 U UJ	4.3 U UJ	4.5 U UJ
alpha-BHC	EPA 8081A	ug/Kg	3.5 U UJ	0.35 U UJ	0.35 U UJ	0.36 U UJ	6.9 U UJ	7 U UJ	7.6 U UJ	8.3 U UJ	7.6 U UJ	6.4 U UJ	8.1 U UJ	8.7 U UJ	7.7 U UJ	7.4 U UJ	7.8 U UJ
alpha-Chlordane	EPA 8081A	ug/Kg	3.1 U UJ	0.31 U UJ	0.31 U UJ	0.32 U UJ	8.6 Ui UJ	6.2 U UJ	6.7 U UJ	7.3 U UJ	6.7 U UJ	5.7 U UJ	7.2 U UJ	7.7 U UJ	6.8 U UJ	6.5 U UJ	6.9 U UJ
beta-BHC	EPA 8081A	ug/Kg	4 U UJ	0.4 U UJ	0.4 U UJ	0.41 U UJ	8 U UJ	8.1 U UJ	8.7 U UJ	9.5 U UJ	8.8 U UJ	7.4 U UJ	9.3 U UJ	10 U UJ	8.8 U UJ	8.5 U UJ	9 U UJ
delta-BHC	EPA 8081A	ug/Kg	0.74 U UJ	0.074 U UJ	0.074 U UJ	0.075 U UJ	9.8 Ui UJ	1.5 U UJ	1.6 U UJ	2.7 Ui UJ	1.7 U UJ	1.4 U UJ	1.8 U UJ	1.9 U UJ	1.7 U UJ	1.6 U UJ	1.7 U UJ
Dieldrin	EPA 8081A	ug/Kg	3.9 U UJ	0.39 U UJ	0.39 U UJ	0.4 U UJ	16 Ui UJ	7.8 U UJ	8.4 U UJ	9.2 U UJ	8.5 U UJ	7.2 U UJ	9 U UJ	9.7 U UJ	8.5 U UJ	8.2 U UJ	8.7 U UJ
Endosulfan I	EPA 8081A	ug/Kg	2.3 U UJ	0.23 U UJ	0.23 U UJ	0.23 U UJ	9.5 Ui UJ	9.4 Ui UJ	14 Ui UJ	14 Ui UJ	5 U UJ	4.2 U UJ	5.3 U UJ	5.7 U UJ	5 U UJ	4.8 U UJ	5.1 U UJ
Endosulfan II	EPA 8081A	ug/Kg	2.6 U UJ	0.26 U UJ	0.26 U UJ	0.63 JN	5.1 U UJ	5.2 U UJ	10 Ui UJ	6 U UJ	5.6 U UJ	4.7 U UJ	5.9 U UJ	6.4 U UJ	5.6 U UJ	5.4 U UJ	5.7 U UJ
Endosulfan sulfate	EPA 8081A	ug/Kg	1.1 U UJ	0.11 U UJ	0.11 U UJ	0.5 Ui UJ	2.1 U UJ	2.2 U UJ	2.3 U UJ	2.5 U UJ	2.3 U UJ	2 U UJ	2.5 U UJ	2.7 U UJ	2.4 U UJ	2.3 U UJ	2.4 U UJ
Endrin	EPA 8081A	ug/Kg	2.7 U UJ	0.27 U UJ	0.27 U UJ	0.27 U UJ	5.6 Ui UJ	5.5 Ui UJ	7.6 Ui UJ	6.4 U UJ	5.9 U UJ	5 U UJ	6.2 U UJ	6.7 U UJ	5.9 U UJ	5.7 U UJ	6 U UJ
Endrin aldehyde	EPA 8081A	ug/Kg	0.71 U UJ	0.18 JP UJ	0.12 Ui UJ	0.088 Ui UJ	11 PD JN	9.9 JPD JN	18 PD JN	21 PD JN	9.1 JD JN	1.4 U UJ	1.7 U UJ	2.6 Ui UJ	1.6 U UJ	1.5 U UJ	2 Ui UJ
gamma-BHC	EPA 8081A	ug/Kg	2 U UJ	0.2 U UJ	0.2 U UJ	0.21 U UJ	9.8 Ui UJ	4.1 U UJ	4.4 U UJ	4.8 U UJ	4.4 U UJ	3.7 U UJ	4.7 U UJ	9.9 Ui UJ	4.4 U UJ	4.3 U UJ	4.5 U UJ
gamma-Chlordane	EPA 8081A	ug/Kg	5.5 PD JN	0.45 JP JN	0.086 U UJ	0.087 U UJ	9.8 Ui UJ	29 PD JN	44 PD JN	65 PD JN	25 PD JN	1.6 U UJ	2 U UJ	2.2 U UJ	7.4 JPD JN	9 JPD JN	1.9 U UJ
Heptachlor	EPA 8081A	ug/Kg	1.1 U UJ	0.11 U UJ	0.11 U UJ	0.11 U UJ	2.2 U UJ	2.2 U UJ	2.4 U UJ	4.4 Ui UJ	2.4 U UJ	2 U UJ	2.5 U UJ	2.7 U UJ	2.4 U UJ	2.3 U UJ	2.4 U UJ
Heptachlor epoxide	EPA 8081A	ug/Kg	1.8 U UJ	0.18 U UJ	0.18 U UJ	0.18 U UJ	63 PD JN	3.5 U UJ	14 Ui UJ	18 Ui UJ	9.6 Ui UJ	3.2 U UJ	5.6 JD JN	5 Ui UJ	3.9 U UJ	7.7 JD JN	4.6 JD JN
Methoxychlor	EPA 8081A	ug/Kg	1.4 U UJ	0.14 U UJ	0.14 U UJ	0.14 U UJ	14 D JN	8.3 Ui UJ	11 D JN	13 D JN	5.6 Ui UJ	2.5 U UJ	3.1 U UJ	9.9 Ui UJ	3 U UJ	3 Ui UJ	3 U UJ
Mirex	EPA 8081A	ug/Kg	1.4 U UJ	0.14 U UJ	0.14 U UJ	0.14 U UJ	9.8 Ui UJ	2.7 U UJ	2.9 U UJ	3.2 U UJ	3 U UJ	2.5 U UJ	3.1 U UJ	3.4 U UJ	3 U UJ	2.9 U UJ	3 U UJ
Nonachlor (cis)	EPA 8081A	ug/Kg	2.9 Ui UJ	0.33 Ui UJ	0.12 U UJ	0.12 U UJ	53 Ui UJ	22 Ui UJ	21 Ui UJ	10 Ui UJ	17 Ui UJ	2.1 U UJ	5 Ui UJ	5.7 Ui UJ	6 Ui UJ	2.4 U UJ	3.9 Ui UJ
Nonachlor (trans)	EPA 8081A	ug/Kg	1.2 U UJ	0.12 U UJ	0.12 U UJ	0.13 U UJ	9.8 Ui UJ	2.4 U UJ	2.6 U UJ	2.9 U UJ	2.6 U UJ	2.2 U UJ	2.8 U UJ	3 U UJ	2.7 U UJ	3.2 Ui UJ	2.7 U UJ
Oxychlordane	EPA 8081A	ug/Kg	5 U UJ	0.5 U UJ	0.5 U UJ	0.5 U UJ	9.8 U UJ	10 U UJ	11 U UJ	12 U UJ	11 U UJ	9.2 U UJ	12 U UJ	13 U UJ	11 U UJ	11 U UJ	11 U UJ
Toxaphene	EPA 8081A	ug/Kg	120 U UJ	12 U UJ	12 U UJ	13 U UJ	790 Ui UJ	930 Ui UJ	1200 Ui UJ	830 Ui UJ	340 Ui UJ	230 U UJ	280 U UJ	300 U UJ	270 U UJ	260 U UJ	270 U UJ
o,p'-DDD	EPA 8081A	ug/Kg	13 D JN	1.2 JN	0.28 U UJ	0.29 U UJ	180 PD JN	160 PD JN	59 Ui UJ	44 Ui UJ	69 PD JN	5.2 U UJ	11 D JN	18 D JN	16 D JN	19 D JN	14 D JN
o,p'-DDE	EPA 8081A	ug/Kg	3.1 U UJ	0.31 U UJ	0.31 U UJ	0.32 U UJ	36 Ui UJ	39 Ui UJ	53 Ui UJ	29 Ui UJ	14 Ui UJ	5.7 U UJ	8.2 Ui UJ	7.7 U UJ	8.5 Ui UJ	7 Ui UJ	6.9 U UJ
o,p'-DDT	EPA 8081A	ug/Kg	8.6 D JN	0.69 JN	0.19 U UJ	0.19 U UJ	110 PD JN	100 D JN	150 PD JN	96 PD JN	35 PD JN	3.5 U UJ	7 JD JN	7.9 JD JN	9.4 JD JN	12 D JN	6.8 JD JN
p,p'-DDD	EPA 8081A	ug/Kg	1.6 U UJ	0.25 J JN	0.16 U UJ	0.17 U UJ	45 D JN	39 D JN	29 D JN	15 PD JN	14 D JN	3 U UJ	3.8 U UJ	4 U UJ	3.6 U UJ	4.6 JD JN	3.6 U UJ
p,p'-DDE	EPA 8081A	ug/Kg	1.4 U UJ	0.14 U UJ	0.14 U UJ	0.14 U UJ	12 Ui UJ	10 Ui UJ	10 Ui UJ	10 Ui UJ	11 PD JN	2.5 U UJ	3.1 U UJ	3.4 U UJ	3 U UJ	2.9 U UJ	3 U UJ
p,p'-DDT	EPA 8081A	ug/Kg	13 D JN	0.87 JN	0.086 U UJ	0.087 U UJ	120 Ui UJ	120 Ui UJ	160 Ui UJ	120 Ui UJ	44 Ui UJ	2.8 JPD JN	13 D JN	12 D JN	13 D JN	55 D JN	8.8 JD JN
Total DDT	TT Calculated	ug/Kg	34.6 JN	3.01 JN	0.31 U UJ	0.32 U UJ	335 JN	299 JN	179 JN	111 JN	129 JN	2.8 JN	31 JN	37.9 JN	38.4 JN	90.6 JN	29.6 JN
Total Chlordane	TT Calculated	ug/Kg	5.5 JN	0.45 JN	0.5 U UJ	0.5 U UJ	53 U UJ	29 JN	44 JN	65 JN	25 JN	9.2 U UJ	12 U UJ	13 U UJ	7.4 JN	9 JN	11 U UJ
1,2,4-Trichlorobenzene	EPA 8270C	ug/Kg	20 U	2 U	2 U	2.1 U	20 U	21 U	22 U	48 U	11 U	1.9 U	24 U	25 U	4.4 U	11 U	4.5 U
		mg/kg OC			0.4 U	0.3 U	2.3 U	3.0 U	1.6 U	3.6 U	0.7 U		1.6 U	1.8 U	0.1 U	1.1 U	0.4 U
1,2-Dichlorobenzene	EPA 8270C	ug/Kg	18 U	1.8 U	1.8 U	1.8 U	18 U UJ	18 U UJ	19 U UJ	42 U	9.5 U	1.6 U	21 U	22 U	3.9 U	9.2 U	3.9 U
		mg/kg OC			0.3 U	0.3 U	2.0 U UJ	2.6 U UJ	1.4 U UJ	3.2 U	0.6 U		1.4 U	1.6 U	0.1 U	0.9 U	0.3 U
1,3-Dichlorobenzene	EPA 8270C	ug/Kg	22 U	2.2 U	2.2 U	2.2 U	22 U	22 U	24 U	51 U	12 U	2 U	25 U	27 U	4.7 U	12 U	4.8 U
1,4-Dichlorobenzene	EPA 8270C	ug/Kg	26 U	2.6 U	2.6 U	2.6 U	26 U	26 U	28 U	60 U	14 U	2.4 U	30 U	32 U	7 JD	14 U	5.7 U
		mg/kg OC			0.5 U	0.4 U	3.0 U	3.7 U	2.0 U	4.5 U	0.9 U		2.0 U	2.3 U	0.2 JD	1.4 U	0.5 U
1-Methylnaphthalene	EPA 8270C	ug/Kg	140 U UJ	14 U UJ	14 U UJ	14 U UJ	190 D J	140 U UJ	150 U UJ	320 U UJ	73 U UJ	13 U UJ	160 U UJ	170 U UJ	30 U UJ	71 U UJ	30 U UJ
2,4,5-Trichlorophenol	EPA 8270C	ug/Kg	40 U	4 U	4 U	4.1 U	40 U	41 U	44 U	95 U	22 U	3.7 U	47 U	50 U	8.8 U	22 U	9 U
2,4,6-Trichlorophenol	EPA 8270C	ug/Kg	24 U	2.4 U	2.4 U	2.5 U	24 U	25 U	26 U	57 U	14 U	2.3 U	28 U	30 U	5.3 U	13 U	5.4 U
2,4-Dichlorophenol	EPA 8270C	ug/Kg	24 U	2.4 U	2.4 U	2.5 U	24 U	25 U	26 U	57 U	14 U	2.3 U	28 U	30 U	5.3 U	13 U	5.4 U
2,4-Dimethylphenol	EPA 8270C	ug/Kg	74 U	7.4 U	7.4 U	7.5 U	73 U	74 U	80 U	180 U	41 U	6.8 U	86 U	92 U	17 U	39 U	17 U
2,4-Dinitrophenol	EPA 8270C	ug/Kg	480 U	48 U	48 U	49 U	480 U	490 U	520 U	1200 U	270 U	45 U UJ	560 U	600 U	110 U	260 U	110 U
2,4-Dinitrotoluene	EPA 8270C	ug/Kg	38 U	3.8 U	3.8 U	3.8 U	37 U	38 U	41 U	89 U	21 U	3.5 U	44 U	47 U	8.2 U	20 U	8.4 U
2,6-Dinitrotoluene	EPA 8270C	ug/Kg	38 U	3.8 U	3.8 U	3.8 U	37 U	38 U	41 U	89 U	21 U	3.5 U	44 U	47 U	8.2 U	20 U	8.4 U
2-Chloronaphthalene	EPA 8270C	ug/Kg	48 U	4.8 U	4.8 U	4.9 U	48 U	49 U	52 U	120 U	27 U	4.5 U	56 U	60 U	11 U	26 U	11 U
2-Chlorophenol	EPA 8270C	ug/Kg	23 U	2.3 U	2.3 U	2.3 U	23 U	23 U	25 U	54 U	13 U	2.1 U	27 U	29 U	5 U	12 U	5.1 U
2-Methylnaphthalene	EPA 8270C	ug/Kg	48 JD	1.6 U	1.6 U	1.7 U	260 D	89 JD	63 JD	61 JD	41 JD	1.5 U	19 U	28 JD	21 D	21 JD	15 JD
		mg/kg OC			0.3 U	0.3 U	29.5 D	12.7 JD	4.5 JD	4.6 JD	2.7 JD		1.3 U	2.0 JD	0.5 D	2.1 JD	1.3 JD
2-Methylphenol	EPA 8270C	ug/Kg	46 U	4.6 U	4.6 U	4.6 U	45 U	46 U	50 U	110 U	25 U	4.2 U	53 U	57 U	10 U	24 U	11 U
2-Nitroaniline	EPA 8270C	ug/Kg	36 U	3.6 U	3.6 U	3.7 U	36 U	37 U	39 U	86 U	20 U	3.4 U	42 U	45 U	8 U	20 U	8.1 U
2-Nitrophenol	EPA 8270C	ug/Kg	35 U	3.5 U	3.5 U	3.6 U	35 U	35 U	38 U	83 U	19 U	3.2 U	41 U	44 U	7.7 U	19 U	7.8 U
3,3'-Dichlorobenzidine	EPA 8270C	ug/Kg	50 U	5 U	5 U	5 U	49 U	50 U	54 U	120 U	27 U	4.6 U	58 U	62 U	11 U	27 U	11 U
3-Nitroaniline	EPA 8270C	ug/Kg	35 U	3.5 U	3.5 U	3.6 U	35 U	35 U	38 U	83 U	19 U	3.2 U	41 U	44 U	7.7 U	19 U	7.8 U

Table A-1. 2007 Remedial Investigation Subsurface Cores Analytical Data

Location			16	16	16	16	17	17	17	18	18	18	19	19	19	19	19
Sample ID			TT16-CS-B	TT16-CS-C	TT16-CS-D	TT16-CS-I	TT17-CS-B	TT17-CS-C	TT17-CS-D	TT18-CS-B	TT18-CS-C	TT18-CS-D	TT19-CS-A	TT91-CS-A	TT19-CS-B	TT91-CS-B	TT19-CS-C
Sample Date			1/22/2007	1/22/2007	1/22/2007	1/22/2007	1/12/2007	1/12/2007	1/12/2007	1/15/2007	1/15/2007	1/15/2007	1/15/2007	1/15/2007	1/15/2007	1/15/2007	1/15/2007
Sample Depth (MLLW)			-39.1 To -40 ft	-40 To -41 ft	-41 To -42 ft	-46 To -47 ft	-43 To -44 ft	-44 To -44.84 ft	-44.84 To -46 ft	-34.99 To -36 ft	-36 To -37 ft	-37 To -38 ft	-32.9 To -34 ft	duplicate of TT19-CS-A	-34 To -35 ft	duplicate of TT19-CS-B	-35 To -35.58 ft
Parameter	Method	Units															
4,6-Dinitro-o-cresol	EPA 8270C	ug/Kg	23 U	2.3 U	2.3 U	2.3 U	23 U	23 U	25 U	54 U	13 U	2.1 U	27 U	29 U	5 U	12 U	5.1 U
4-Bromophenyl phenyl ether	EPA 8270C	ug/Kg	19 U	1.9 U	1.9 U	1.9 U	19 U	19 U	21 U	45 U	11 U	1.8 U	22 U	24 U	4.1 U	9.9 U	4.2 U
4-Chloro-3-methylphenol	EPA 8270C	ug/Kg	28 U	2.8 U	2.8 U	2.9 U	28 U	29 U	31 U	67 U	16 U	2.6 U	33 U	35 U	6.2 U	15 U	6.3 U
4-Chloroaniline	EPA 8270C	ug/Kg	28 U	2.8 U	2.8 U	2.9 U	28 U	29 U	31 U	67 U	16 U	2.6 U	33 U	35 U	6.2 U	15 U	6.3 U
4-Chlorophenyl phenyl ether	EPA 8270C	ug/Kg	27 U	2.7 U	2.7 U	2.7 U	27 U	27 U	29 U	64 U	15 U	2.5 U	31 U	34 U	5.9 U	15 U	6 U
4-Methylphenol	EPA 8270C	ug/Kg	39 U	3.9 U	3.9 U	4 U	39 U	39 U	42 U	92 U	22 U	3.6 U	45 U	49 U	15 JD	21 U	8.7 U
4-Nitroaniline	EPA 8270C	ug/Kg	46 U	4.6 U	4.6 U	4.6 U	45 U	46 U	50 U	110 U	25 U	4.2 U	53 U	57 U	10 U	24 U	11 U
4-Nitrophenol	EPA 8270C	ug/Kg	400 U	40 U	40 U	41 U	400 U	410 U	440 U	950 U	220 U	37 U	470 U	500 U	88 U	220 U	90 U
Acenaphthene	EPA 8270C	ug/Kg	94 JD	1.6 J	1.4 U	1.4 U	1400 D	670 D	270 D	120 JD	88 D	2.4 J	38 JD	53 JD	65 D	49 JD	30 D
		mg/kg OC			0.3 U	0.2 U	159.1 D	95.7 D	19.4 D	9.1 JD	5.8 D		2.6 JD	3.8 JD	1.4 D	5.0 JD	2.6 D
Acenaphthylene	EPA 8270C	ug/Kg	89 JD	3.7 J	1.9 U	1.9 U	410 D J	210 D J	240 D J	45 U	190 D	5.7 J	69 JD	120 D	70 D	41 JD	27 D
		mg/kg OC			0.4 U	0.3 U	46.6 D J	30.0 D J	17.3 D J	3.4 U	12.4 D		4.7 JD	8.6 D	1.5 D	4.2 JD	2.3 D
Aniline	EPA 8270C	ug/Kg	20 U	2 U	2 U	2.1 U	20 U	21 U	22 U	48 U	27 JD	2.9 J	24 U	25 U	4.4 U	11 U	4.5 U
Anthracene	EPA 8270C	ug/Kg	110 D	7.6 J	1.9 U	1.9 U	2700 D	810 D	430 D	310 D	350 D	10	140 D	220 D	200 D	100 D	89 D
		mg/kg OC			0.4 U	0.3 U	306.8 D	115.7 D	30.9 D	23.5 D	22.9 D		9.5 D	15.7 D	4.4 D	10.2 D	7.6 D
Benzo(a)anthracene	EPA 8270C	ug/Kg	440 JD	17	1.9 U	1.9 U	8000 D J	3200 D J	2200 D J	1200 D	1000 D	28	410 D	410 D	340 D	280 D	110 D
		mg/kg OC			0.4 U	0.3 U	909.1 D J	457.1 D J	158.3 D J	90.9 D	65.4 D		27.9 D	29.3 D	7.4 D	28.6 D	9.4 D
Benzo(a)pyrene	EPA 8270C	ug/Kg	630 JD	28	2.2 U	2.2 U	5100 D	1900 D	1400 D	1200 D	1400 D	33	520 D	560 D	490 D	390 D	130 D
		mg/kg OC			0.4 U	0.4 U	579.5 D	271.4 D	100.7 D	90.9 D	91.5 D		35.4 D	40.0 D	10.7 D	39.8 D	11.1 D
Benzo(b)fluoranthene	EPA 8270C	ug/Kg	1100 D	33	3.4 U	3.4 U	7500 D	3100 D	2100 D	1800 D	1600 D	33	840 D	1100 D	640 D	590 D	150 D
Benzo(g,h,i)perylene	EPA 8270C	ug/Kg	460 JD	15	3.1 U	3.2 U	1600 D	350 D	850 D	700 D	690 D	16	310 D	290 D	250 D	220 D	65 D
		mg/kg OC			0.6 U	0.5 U	181.8 D	50.0 D	61.2 D	53.0 D	45.1 D		21.1 D	20.7 D	5.4 D	22.4 D	5.6 D
Benzo(k)fluoranthene	EPA 8270C	ug/Kg	370 JD	27	3.4 U	3.4 U	2300 D	1000 D	680 D	610 D	940 D	29	280 D	360 D	440 D	220 D	120 D
Benzofluoranthenes (total)	TT calculated	ug/Kg	1470	60	3.4 U	3.4 U	9800	4100	2780	2410	2540	62	1120	1460	1080	810	270
		mg/kg OC			0.7 U	0.5 U	1113.6	585.7	200.0	182.6	166.0		76.2	104.3	23.5	82.7	23.1
Benzoic acid	EPA 8270C	ug/Kg	1300 U	130 U	130 U	130 U	1300 U	1300 U	1400 U	3100 U	700 U	120 U	1500 U	1600 U	290 U	680 U	290 U
Benzyl alcohol	EPA 8270C	ug/Kg	50 U	5 U	5 U	5 U	49 U	50 U	54 U	120 U	27 U	4.6 U	58 U	62 U	11 U	27 U	11 U
bis(2-chloroethoxy)methane	EPA 8270C	ug/Kg	18 U	1.8 U	1.8 U	1.8 U	18 U	18 U	19 U	42 U	9.5 U	1.6 U	21 U	22 U	3.9 U	9.2 U	3.9 U
bis(2-chloroethyl)ether	EPA 8270C	ug/Kg	32 U	3.2 U	3.2 U	3.3 U	32 U	33 U	35 U	76 U	18 U	3 U	38 U	40 U	7.1 U	17 U	7.2 U
bis(2-chloroisopropyl)ether	EPA 8270C	ug/Kg	16 U	1.6 U	1.6 U	1.7 U	16 U	17 U	18 U	38 U	8.8 U	1.5 U	19 U	20 U	3.6 U	8.5 U	3.6 U
bis(2-ethylhexyl)phthalate	EPA 8270C	ug/Kg	390 JD U	18 J U	7.2 J U	11 J U	4800 D	1100 D	1300 D	1000 JD	150 JD	8.9 J U	200 JD U	730 JD	210 D	220 JD	27 JD U
		mg/kg OC			1.4 J U	1.8 J U	545.5 D	157.1 D	93.5 D	75.8 JD	9.8 JD		13.6 JD U	52.1 JD	4.6 D	22.4 JD	2.3 JD U
Butyl benzyl phthalate	EPA 8270C	ug/Kg	20 U	4.2 J	2 U	2.1 U	20 U	21 U	22 U	48 U	11 U	1.9 U	24 U	25 U	7.6 JD	11 U	4.5 U
		mg/kg OC			0.4 U	0.3 U	2.3 U	3.0 U	1.6 U	3.6 U	0.7 U		1.6 U	1.8 U	0.2 JD	1.1 U	0.4 U
Chrysene	EPA 8270C	ug/Kg	400 JD	18	1.9 U	1.9 U	7700 D J	3600 D J	2300 D J	1400 D	1300 D	30	690 D	960 D	440 D	360 D	130 D
		mg/kg OC			0.4 U	0.3 U	875.0 D J	514.3 D J	165.5 D J	106.1 D	85.0 D		46.9 D	68.6 D	9.6 D	36.7 D	11.1 D
Dibenzo(a,h)anthracene	EPA 8270C	ug/Kg	300 U	4.3 J	3 U	3 U	830 D	330 D	250 D	190 JD	250 D	4.5 J	96 JD	86 JD	91 D	63 D	21 D
		mg/kg OC			0.6 U	0.5 U	94.3 D	47.1 D	18.0 D	14.4 JD	16.3 D		6.5 JD	6.1 JD	2.0 D	6.4 D	1.8 D
Dibenzofuran	EPA 8270C	ug/Kg	64 JD	1.8 U	1.8 U	1.8 U	760 D	400 D	110 D	69 JD	54 D	1.9 J	28 JD	33 JD	37 D	30 JD	23 D
		mg/kg OC			0.3 U	0.3 U	86.4 D	57.1 D	7.9 D	5.2 JD	3.5 D		1.9 JD	2.4 JD	0.8 D	3.1 JD	2.0 D
Diethylphthalate	EPA 8270C	ug/Kg	47 U	4.7 U	4.7 U	4.8 U	47 U	47 U	51 U	120 U	26 U	4.4 U	55 U	59 U	11 U	25 U	11 U
		mg/kg OC			0.9 U	0.8 U	5.3 U	6.7 U	3.7 U	9.1 U	1.7 U		3.7 U	4.2 U	0.2 U	2.6 U	0.9 U
Dimethyl phthalate	EPA 8270C	ug/Kg	24 U	2.4 U	2.4 U	2.5 U	24 U	25 U	26 U	57 U	14 U	2.3 U	28 U	30 U	11 JD	13 U	5.4 U
		mg/kg OC			0.5 U	0.4 U	2.7 U	3.6 U	1.9 U	4.3 U	0.9 U		1.9 U	2.1 U	0.2 JD	1.3 U	0.5 U
Di-n-butyl phthalate	EPA 8270C	ug/Kg	35 U	16 U	4.3 J U	9.4 J U	75 JD	130 D	300 D	2100 D	71 D	9.4 J	41 U	44 U	23 D	19 U	8.8 JD
		mg/kg OC			0.8 J U	1.5 J U	8.5 JD	18.6 D	21.6 D	159.1 D	4.6 D		2.8 U	3.1 U	0.5 D	1.9 U	0.8 JD
Di-n-octyl phthalate	EPA 8270C	ug/Kg	160 U	1.6 U	1.6 U	1.7 U	16 U	17 U	18 U	38 U	8.8 U	1.5 U	19 U	20 U	3.6 U	8.5 U	3.6 U
		mg/kg OC			0.3 U	0.3 U	1.8 U	2.4 U	1.3 U	2.9 U	0.6 U		1.3 U	1.4 U	0.1 U	0.9 U	0.3 U
Fluoranthene	EPA 8270C	ug/Kg	490 D	36	3 U	3 U	17000 D	8200 D	4600 D	2200 D	1900 D	67	670 D	2000 D	1300 D	660 D	330 D
		mg/kg OC			0.6 U	0.5 U	1931.8 D	1171.4 D	330.9 D	166.7 D	124.2 D		45.6 D	142.9 D	28.3 D	67.3 D	28.2 D
Fluorene	EPA 8270C	ug/Kg	23 U	2.4 J	2.3 U	2.3 U	1300 D	450 D	160 D	110 JD	94 D	3.1 J	51 JD	68 JD	62 D	48 JD	33 D
		mg/kg OC			0.4 U	0.4 U	147.7 D	64.3 D	11.5 D	8.3 JD	6.1 D		3.5 JD	4.9 JD	1.4 D	4.9 JD	2.8 D
Hexachlorobenzene	EPA 8081A	ug/Kg	1.1 U	0.11 U	0.11 U	0.11 U	2.1 U	2.2 U	2.3 U	2.5 U	2.3 U	2 U	2.5 U	2.7 U	2.4 U	2.3 U	2.4 U
		mg/kg OC			0.02 U	0.02 U	0.2 U	0.3 U	0.2 U	0.2 U	0.2 U		0.2 U	0.2 U	0.1 U	0.2 U	0.2 U
Hexachlorobenzene	EPA 8270C	ug/Kg															
		mg/kg OC															
Hexachlorobutadiene	EPA 8081A	ug/Kg	6.6 U	0.66 U	0.66 U	0.67 U	13 U	14 U	15 U	16 U			16 U	17 U			
		mg/kg OC			0.1 U	0.1 U	1.5 U	2.0 U	1.1 U	1.2 U			1.1 U	1.2 U			
Hexachlorobutadiene	EPA 8270C	ug/Kg									11 U	1.8 U			4.1 U	9.9 U	4.2 U
		mg/kg OC									0.7 U				0.1 U	1.0 U	0.4 U
Hexachlorocyclopentadiene	EPA 8270C	ug/Kg	200 U UJ	20 U UJ	20 U UJ	21 U UJ	200 U UJ	210 U UJ	220 U UJ	480 U	110 U UJ	19 U UJ	240 U	250 U	44 U UJ	110 U	45 U UJ
Hexachloroethane	EPA 8270C	ug/Kg	30 U	3 U	3 U	3 U	30 U UJ	30 U UJ	32 U UJ	70 U	17 U	2.8 U	35 U	37 U	6.5 U	16 U	6.6 U
Indeno(1,2,3-cd)pyrene	EPA 8270C	ug/Kg	320 JD	17	2.6 U	2.6 U	3700 D	1300 D	1000 D	620 D	770 D	18	320 D	340 D	280 D	260 D	72 D
		mg/kg OC			0.5 U	0.4 U	420.5 D	185.7 D	71.9 D	47.0 D	50.3 D		21.8 D	24.3 D	6.1 D	26.5 D	6.2 D
Isophorone	EPA 8270C	ug/Kg	22 U	2.2 U	2.2 U	2.2 U	22 U UJ	22 U UJ	24 U UJ	51 U	12 U	2 U	25 U	27 U	4.7 U	12 U	4.8 U
Naphthalene	EPA 8270C	ug/Kg	230 D	3.3 J	1.8 U	1.8 U	170 D	120 D	110 D	87 JD	110 D	3.1 J	39 JD	49 JD	53 D	48 JD	45 D
		mg/kg OC			0.3 U	0.3 U	19.3 D	17.1 D	7.9 D	6.6 JD	7.2 D		2.7 JD	3.5 JD	1.2 D	4.9 JD	3.8 D
Nitrobenzene	EPA 8270C	ug/Kg	27 U	2.7 U	2.7 U	2.7 U	27 U	27 U	29 U	64 U	15 U	2.5 U	31 U	34 U	5.9 U	15 U	6 U
N-Nitrosodimethylamine	EPA 8270C	ug/Kg	82 U UJ	8.2 U	8.2 U	8.3 U	81 U	82 U	89 U	200 U	45 U	7.6 U	95 U	110 U	18 U	44 U	19 U
N-Nitroso-di-n-propylamine	EPA 8270C	ug/Kg	43 U	4.3 U	4.3 U	4.4 U	43 U	43 U	47 U	110 U	24 U	4 U	50 U	54 U	9.4 U	23 U	9.5 U
N-Nitrosodiphenylamine	EPA 8270C	ug/Kg	30 U	3 U	3 U	3 U	30 U	30 U	32 U	70 U	17 U	2.8 U	35 U	37 U	6.5 U	16 U	6.6 U
		mg/kg OC			0.6 U	0.5 U	3.4 U	4.3 U	2.3 U	5.3 U	1.1 U		2.4 U	2.6 U	0.1 U	1.6 U	0.6 U
Pentachlorophenol	EPA 8270C	ug/Kg	120 U	12 U	12 U	12 U	510 JD	920 JD	130 U	270 U	62 U	11 U	140 U	150 U	71 JD	60 U	26 U
Phenanthrene	EPA 8270C	ug/Kg	260 D	17	2.3 J	2 J	9400 D	5000 D	1600 D	880 D	600 D	19	280 D	430 D	490 D	360 D	160 D
		mg/kg OC			0.4 J	0.3 J	1068.2 D	714.3 D	115.1 D	66.7 D	39.2 D		19.0 D	30.7 D	10.7 D	36.7 D	13.7 D
Phenol	EPA 8270C	ug/Kg	26 U	3.9 J	5.7 J	9.3 J	26 U	26 U	6100 Ui	60 U	79 JD	4.8 J	56 JD	32 U	16 JD	14 U	9.8 JD
Pyrene	EPA 8270C	ug/Kg	5800 D	110	2.6 J	1.8 U	24000 D	9600 D	7100 D	3600 D	3200 D	76	960 D	1800 D	950 D	910 D	330 D
		mg/kg OC			0.5 J	0.3 U	2727.3 D	1371.4 D	510.8 D	272.7 D	209.2 D		65.3 D	128.6 D	20.7 D	92.9 D	28.2 D
Total HPAH	TT calculated	ug/Kg	10010	305.3	2.6	3.4 U	77730	32580	22480	13520	13050	334.5	5096	7906	5221	3953	1458
		mg/kg OC			0.5	0.5 U	8833.0	4654.3	1617.3	1024.2	852.9		346.7	564.7	113.7	403.4	124.6
Total LPAH	TT calculated	ug/Kg	783	35.6	2.3	2	15380	7260	2810	1507	1432	43.3	617	940	940	646	384
		mg/kg OC			0.4	0.3	1747.7	1037.1	202.2	114.2	93.6		42.0	67.1	20.5	65.9	32.8
Total PAH	TT calculated	ug/Kg	10793	340.9	4.9	2	93110	39840	25290	15027	14482	377.8	5713	8846	6161	4599	1842
Butyltin	KRONE	ug/Kg	6.3 J	0.04 U	0.04 U	0.041 U UJ	77	35	3.6	3.4	2.6	0.037 U	7.6	7.7	23	14	1.1 J
Dibutyltin	KRONE	ug/Kg	170 D	1.4 J U	0.37 JP UJ	0.38 J U	1000 D	500 D	64	52	29	1.9 U	78	73	370 D	150 D	15

Table A-1. 2007 Remedial Investigation Subsurface Cores Analytical Data

Location			16	16	16	16	17	17	17	18	18	18	19	19	19	19	19
Sample ID			TT16-CS-B	TT16-CS-C	TT16-CS-D	TT16-CS-I	TT17-CS-B	TT17-CS-C	TT17-CS-D	TT18-CS-B	TT18-CS-C	TT18-CS-D	TT19-CS-A	TT91-CS-A	TT19-CS-B	TT91-CS-B	TT19-CS-C
Sample Date			1/22/2007	1/22/2007	1/22/2007	1/22/2007	1/12/2007	1/12/2007	1/12/2007	1/15/2007	1/15/2007	1/15/2007	1/15/2007	1/15/2007	1/15/2007	1/15/2007	1/15/2007
Sample Depth (MLLW)			-39.1 To -40 ft	-40 To -41 ft	-41 To -42 ft	-46 To -47 ft	-43 To -44 ft	-44 To -44.84 ft	-44.84 To -46 ft	-34.99 To -36 ft	-36 To -37 ft	-37 To -38 ft	-32.9 To -34 ft	duplicate of TT19-CS-A	-34 To -35 ft	duplicate of TT19-CS-B	-35 To -35.58 ft
Parameter	**Method**	**Units**															
Tetrabutyltin	KRONE	ug/Kg	16	0.093 U	0.094 U	0.095 U	68	36	6	7.2	1.7	0.087 U	4	4.7	15	13	0.29 Ui
Tributyltin	KRONE	ug/Kg	880 D	6.2	1 J	0.076 U	5300 D	2300 D	280 D	390 D	130 D	12	160 D	180 D	1400 D	770 D	46
		mg/kg OC			0.2 J	0.012 U	602.3 D	328.6 D	20.1 D	29.5 D	8.5 D		10.9 D	12.9 D	30.5 D	78.6 D	3.9
Total Solids	EPA 160.3	Percent	75.3	75.3	75.1	74.1	75.8	74.5	69.3	63.4	66.6	81.3	64.7	60.1	68.3	68.6	67.4
Total Organic Carbon	ASTM D4129-98M	Percent	0.45	0.45	0.52	0.62	0.88	0.7	1.39	1.32	1.53	0.09	1.47	1.4	4.59	0.98	1.17
Fractional % phi >-1	PSEP Grain Size	Percent	0.82	0.37	0.1	0.15	12.4	14.1	4.17	0.42	1.06	0.41	1.95	2.3	1.95	0.96	0.77
Fractional % phi 0-1	PSEP Grain Size	Percent	4.56	6.7	1.9	0.13	43.6	30.9	8.77	3.92	2.86	8.7	5.25	6.3	3.1	2.83	1.43
Fractional % phi 1-2	PSEP Grain Size	Percent	32.89	44.45	20.12	1.76	24.8	15.5	16.2	14	5.72	51.7	19.2	20.9	12.5	12.7	12
Fractional % phi 2-3	PSEP Grain Size	Percent	34.26	42.64	20.03	17.41	7.35	9.46	20	28.9	28.1	26.8	18.2	20.4	22.7	23.4	33.2
Fractional % phi 3-4	PSEP Grain Size	Percent	12.18	7.29	24.53	34.36	3.62	8.68	25.1	22	24.3	6.59	11.9	11.9	20.9	21.1	16.6
Fractional % phi 4-5	PSEP Grain Size	Percent	4.69	1.24	16.8	20.81	1.21	3.24	10.8	10.7	13.9	1.46	7.28	7.98	14.9	14.6	7.74
Fractional % phi 5-6	PSEP Grain Size	Percent	5.7	0.6	8.1	9	2.27	3.15	6.32	18.1	9.6	0.67	10.7	8.75	9.36	8.92	10.3
Fractional % phi 6-7	PSEP Grain Size	Percent	2.1	0.61	4.86	4.8	1.14	1.61	3.78	2.65	6.7	0.53	4.73	6.48	5.79	5.36	4.97
Fractional % phi 7-8	PSEP Grain Size	Percent	1.14	0.49	2.98	3.29	0.76	0.67	0.93	1.1	2.57	0.29	2.48	2.68	2.15	2.24	4.17
Fractional % phi 8-9	PSEP Grain Size	Percent	0.64	0.28	2.14	1.89	0.33	0.19	0.47	0.62	1.4	0.21	1.67	2.1	1.56	1.85	0.75
Fractional % phi 9-10	PSEP Grain Size	Percent	0.56	0.06	1.54	1.51	0.09	0.15	0.2	0.36	1.43	0.13	1.97	2.41	1.76	1.74	0.71
Fractional % phi >10	PSEP Grain Size	Percent	1.77	1.2	2.68	2.36	1.24	1.17	1.54	1.73	2.13	0.82	3.51	4.07	2.77	2.48	1.65
Gravel	PSEP Grain Size	Percent	0.66	0.3	0.01	0.16	1.17	8.86	0.92	2.07	3.28	0.26	2.16	4.61	0.95	2.95	1.36

Notes:

0.14 U J = Result followed by laboratory data qualifier followed by data validator qualifier
Sample depth (MLLW) = the core increment elevation in mean lower low water
mg/kg = milligrams per kilogram
ug/kg = micrograms per kilogram
mg/L = milligrams per liter
ug/L = micrograms per liter
ng/L = nanograms per liter

Data Validation Qualifiers
U = Result should be considered not-detected at the quantitation limit shown
J = Result is an estimated concentration
R = Rejected - Quality Control indicates the data is not usable
UJ = The compound was not detected and the sample detection limit should be considered an estimated value
N - Pesticide result is tentatively identified.

Laboratory Data Qualifiers
U = result was not detected at or above the method detection limit
J (for organics) = result is an estimated concentration that is less than the reporting limit but greater than or equal to the detection limit
B (for metals) = result is an estimated concentration that is less than the reporting limit but greater than or equal to the detection limit
* (for metals) = duplicate analysis not within control limits. See case narrative (in laboratory report)
D (for organics) = result reported is from a dilution
P (for organics) = The GC or HPLC confirmation criteria was exceeded. The relative percent difference is greater than 40% between the two analytical results.
i (for organics) = the MRL/MDL has been elevated due to a chromatographic interference.

Table A-1. 2007 Remedial Investigation Subsurface Cores Analytical Data

Location			22	22	22	23	23	23	24	24	24	24	25	25	25	25	26	26
Sample ID			TT22-CS-B	TT22-CS-C	TT22-CS-D	TT23-CS-B	TT23-CS-C	TT23-CS-H	TT24-CS-B	TT24-CS-C	TT24-CS-E	TT24-CS-H	TT25-CS-B	TT25-CS-C	TT25-CS-J	TT25-CS-L	TT26-CS-B	TT26-CS-C
Sample Date			1/12/2007	1/12/2007	1/12/2007	1/10/2007	1/10/2007	1/10/2007	1/10/2007	1/10/2007	1/10/2007	1/10/2007	1/12/2007	1/12/2007	1/12/2007	1/12/2007	1/12/2007	1/12/2007
Sample Depth (MLLW)			-44 To -45 ft	-45 To -46 ft	-46 To -47 ft	-44 To -45 ft	-45 To -46 ft	-50 To -51.2 ft	-27 To -28.6 ft	-28.6 To -29.9 ft	-30.8 To -32 ft	-34 To -35 ft	-25 To -26 ft	-26 To -27 ft	-33 To -34 ft	-35 To -36 ft	-31 To -32 ft	-32 To -33 ft
Parameter	**Method**	**Units**																
Antimony	EPA 6020	mg/Kg	0.11	0.06	0.05 U	5.66	0.52	0.04 U	0.27	0.71	0.17	0.17	6.49	1.31	0.1	0.58	15.9	45.3
Arsenic	EPA 6020	mg/Kg	7.31	3.99	3.12	3.63	2.77	2.34	2.49 J	7.96 J	3.58 J	5.21 J	19.1	12.6	4.57 J	10 J	38.7	316
Cadmium	EPA 6020	mg/Kg	0.366	0.163	0.126	0.1	0.054	0.057	0.113	0.57	0.195	0.346	1.76	1.29	0.32	2.38	0.4	0.747
Chromium	EPA 6010B	mg/Kg	25.2	19.8	17.8	14.1	15.3	14.8	13.6	34.4	20.2	20.4	60.6	50.6	19.9	35.9	52.1	140
Cobalt	EPA 6020	mg/Kg	8.3	5.91	5.09	3.46	4.29	4.06	3.43 J	6.29 J	4.14 J	5.27 J	7.72	6.95	5.21 J	5.54 J	10.4	22.2
Copper	EPA 6010B	mg/Kg	44.7	24.3	19.4	26.8	23.4	16.1	23.5	81	27.5	38.6	105	77.9	32	64.7	200	335
Lead	EPA 6020	mg/Kg	8.81	4.17	2.93	5.1	3.23	2.05	6.64	52	10.5	16	123	62.5	14.1	80.9	115	360
Mercury	EPA 7471A	mg/Kg	0.083	0.088	0.041	0.03	0.018 B	0.018	0.074	0.451	0.13	0.22	0.712	0.577	0.162	0.733	0.156	0.139
Molybdenum	EPA 6020	mg/Kg	1.49	1.09	0.87	0.72	0.63	0.37	0.48	1.9	0.67	1	4.57	2.39	0.87	3.28	3.08	11.7
Nickel	EPA 6020	mg/Kg	18.2	12.6	11.2	7.73	8.22	7.86	8.06 J	15.5 J	9.44 J	12 J	23.4	20	11.7 J	18.9 J	21.7	40.6
Selenium	EPA 6020	mg/Kg	0.9 B	0.4 B	0.3 B	0.2 B	0.2 B	0.3 B	0.4 B	0.5 B	0.3 B	0.5 B	0.9	1 B	0.4 B	0.8 B	0.5 B	0.7 B
Silver	EPA 6020	mg/Kg	0.159	0.091	0.069	0.098	0.064	0.056	0.069	0.403	0.144	0.148	0.684	0.774	0.139	0.929	0.194	0.143
Thallium	EPA 6020	mg/Kg	0.17	0.1	0.08	0.05	0.04	0.06	0.06	0.14	0.07	0.13	0.19	0.17	0.13	0.21	0.09	0.24
Vanadium	EPA 6010B	mg/Kg	69	58.7	51.6	43.7	49.5	49.5	35.8	59.4	51.5	54.2	55.9	54.9	52.5	54.5	56.6	45.6
Zinc	EPA 6010B	mg/Kg	52.4	37.4	32	43.3	31.3	26.1	32	111	42.1	49.1	308	161	49.1	182	303	1260
PCBs (total)	TT calculated	ug/Kg	3 U	2.6 U	2.4 U	4.6	2.2 U	2.3 U	25.8	580	13 U	14 U	223	122	4.1	211	162	183
		mg/kg OC	0.1 U	0.3 U	0.3 U			0.4 U		38.9	1.5 U	1.1 U	5.8	4.2	0.3	4.6	16.9	5.3
PCB-1016	EPA 8082	ug/Kg	3 U	2.6 U	2.4 U	2.2 U UJ	2.2 U UJ	2.3 U UJ	2.4 U	16 U	13 U UJ	14 U UJ	3.5 U	3.1 U	2.4 U UJ	3.2 U	2.5 U	2.6 U
PCB-1221	EPA 8082	ug/Kg	3 U	2.6 U	2.4 U	2.2 U UJ	2.2 U UJ	2.3 U UJ	2.4 U	16 U	13 U UJ	14 U UJ	3.5 U	3.1 U	2.4 U UJ	3.2 U	2.5 U	2.6 U
PCB-1232	EPA 8082	ug/Kg	3 U	2.6 U	2.4 U	2.2 U UJ	2.2 U UJ	2.3 U UJ	2.4 U	16 U	13 U UJ	14 U UJ	3.5 U	3.1 U	2.4 U UJ	3.2 U	2.5 U	2.6 U
PCB-1242	EPA 8082	ug/Kg	3 U	2.6 U	2.4 U	2.2 U UJ	2.2 U UJ	2.3 U UJ	2.4 U	16 U	13 U UJ	14 U UJ	3.5 U	3.1 U	2.4 U UJ	3.2 U	2.5 U	2.6 U
PCB-1248	EPA 8082	ug/Kg	3 U	2.6 U	2.4 U	2.2 U UJ	2.2 U UJ	2.3 U UJ	2.4 U	16 U	13 U UJ	14 U UJ	3.5 U	3.1 U	2.4 U UJ	3.2 U	2.5 U	2.6 U
PCB-1254	EPA 8082	ug/Kg	3 U	2.6 U	2.4 U	4.6 J	2.2 U UJ	2.3 U UJ	14	340 D	13 U UJ	14 U UJ	190	100	2.4 U UJ	81	130	150
PCB-1260	EPA 8082	ug/Kg	3 U	2.6 U	2.4 U	2.2 U UJ	2.2 U UJ	2.3 U UJ	9.2	200 D	13 U UJ	14 U UJ	3.5 U	3.1 U	4.1 J	100	2.5 U	2.6 U
PCB-1262	EPA 8082	ug/Kg	3 U	2.6 U	2.4 U	2.2 U UJ	2.2 U UJ	2.3 U UJ	2.4 U	16 U	13 U UJ	14 U UJ	3.5 U	3.1 U	2.4 U UJ	3.2 U	2.5 U	2.6 U
PCB-1268	EPA 8082	ug/Kg	3 U	2.6 U	2.4 U	2.2 U UJ	2.2 U UJ	2.3 U UJ	2.6 J	40 D	13 U UJ	14 U UJ	33	22	2.4 U UJ	30	32 P J	33
Aldrin	EPA 8081A	ug/Kg	1.4 U UJ	1.2 U UJ	0.21 U UJ	0.19 U UJ	0.2 U UJ	0.98 U UJ	4.2 U UJ	5.4 U UJ	4.4 U UJ	4.7 U UJ	3.1 U UJ	2.7 U UJ	4.2 U UJ	5.6 U UJ	2.2 U UJ	2.3 U UJ
alpha-BHC	EPA 8081A	ug/Kg	2.3 U UJ	2 U UJ	0.37 U UJ	0.33 U UJ	0.34 U UJ	1.7 U UJ	7.3 U UJ	9.3 U UJ	7.6 U UJ	8.1 U UJ	5.3 U UJ	4.7 U UJ	7.3 U UJ	9.7 U UJ	3.8 U UJ	3.9 U UJ
alpha-Chlordane	EPA 8081A	ug/Kg	2.1 U UJ	1.8 U UJ	0.33 U UJ	0.29 U UJ	0.3 U UJ	1.6 U UJ	6.4 U UJ	8.3 U UJ	6.8 U UJ	7.1 U UJ	4.7 U UJ	4.2 U UJ	6.5 U UJ	8.6 U UJ	3.4 U UJ	3.5 U UJ
beta-BHC	EPA 8081A	ug/Kg	2.7 U UJ	2.3 U UJ	0.42 U UJ	0.38 U UJ	0.39 U UJ	2 U UJ	8.4 U UJ	11 U UJ	8.8 U UJ	9.3 U UJ	12 Ui UJ	9.4 Ui UJ	8.4 U UJ	12 U UJ	4.4 U UJ	4.5 U UJ
delta-BHC	EPA 8081A	ug/Kg	0.48 U UJ	0.42 U UJ	0.077 U UJ	0.095 Ui UJ	0.072 U UJ	0.36 U UJ	1.6 U UJ	2 U UJ	1.7 U UJ	1.7 U UJ	1.6 Ui UJ	2.3 Ui UJ	1.6 U UJ	3.2 Ui UJ	0.8 U UJ	0.83 U UJ
Dieldrin	EPA 8081A	ug/Kg	2.6 U UJ	2.2 U UJ	0.41 U UJ	0.37 U UJ	0.38 U UJ	1.9 U UJ	8.1 U UJ	11 U UJ	8.5 U UJ	9 U UJ	6 U UJ	5.3 U UJ	8.2 U UJ	11 U UJ	4.2 U UJ	4.4 U UJ
Endosulfan I	EPA 8081A	ug/Kg	1.5 U UJ	1.3 U UJ	0.24 U UJ	0.22 U UJ	0.22 U UJ	1.2 U UJ	4.8 U UJ	6.1 U UJ	5 U UJ	5.3 U UJ	3.5 U UJ	3.1 U UJ	4.8 U UJ	6.4 U UJ	2.5 U UJ	2.6 U UJ
Endosulfan II	EPA 8081A	ug/Kg	1.7 U UJ	1.5 U UJ	0.27 U UJ	0.24 U UJ	0.25 U UJ	1.3 U UJ	5.3 U UJ	6.8 U UJ	5.6 U UJ	5.9 U UJ	3.9 U UJ	3.5 U UJ	5.4 U UJ	7.1 U UJ	3.5 Ui UJ	2.9 U UJ
Endosulfan sulfate	EPA 8081A	ug/Kg	0.69 U UJ	0.6 U UJ	0.5 Ui UJ	0.39 J JN	0.28 J JN	0.52 U UJ	2.2 U UJ	2.9 U UJ	2.4 U UJ	2.5 U UJ	1.7 U UJ	1.5 U UJ	2.3 U UJ	3 U UJ	1.2 U UJ	1.2 U UJ
Endrin	EPA 8081A	ug/Kg	1.8 U UJ	1.6 U UJ	0.28 U UJ	0.26 U UJ	0.26 U UJ	1.4 U UJ	5.6 U UJ	7.2 U UJ	5.9 U UJ	6.2 U UJ	5.9 Ui UJ	4.7 Ui UJ	5.6 U UJ	9.1 Ui UJ	2.9 U UJ	3 U UJ
Endrin aldehyde	EPA 8081A	ug/Kg	0.47 U UJ	0.4 U UJ	0.075 U UJ	0.11 J UJ	0.069 U UJ	0.35 U UJ	1.5 U UJ	1.9 U UJ	1.6 U UJ	1.7 U UJ	7.5 Ui UJ	4.2 JD UJ	1.5 U UJ	6 JPD JN	2.4 Ui UJ	4.2 JD UJ
gamma-BHC	EPA 8081A	ug/Kg	1.4 U UJ	1.2 U UJ	0.36 Ui UJ	0.19 U UJ	0.5 Ui UJ	0.98 U UJ	4.2 U UJ	5.4 U UJ	4.4 U UJ	4.7 U UJ	3.1 U UJ	5 Ui UJ	4.2 U UJ	11 Ui UJ	5 Ui UJ	5.4 Ui UJ
gamma-Chlordane	EPA 8081A	ug/Kg	0.56 U UJ	0.49 U UJ	0.09 U UJ	0.081 U UJ	0.083 U UJ	0.42 U UJ	1.8 U UJ	14 PD JN	1.9 U UJ	2 U UJ	5 Ui UJ	5 Ui UJ	1.8 U UJ	8.4 JD JN	0.93 U UJ	5 Ui UJ
Heptachlor	EPA 8081A	ug/Kg	0.7 U UJ	0.61 U UJ	0.12 U UJ	0.11 U UJ	0.11 U UJ	0.53 U UJ	2.3 U UJ	2.9 U UJ	2.4 U UJ	2.5 U UJ	1.7 U UJ	1.5 U UJ	2.3 U UJ	3.7 Ui UJ	1.2 U UJ	1.2 U UJ
Heptachlor epoxide	EPA 8081A	ug/Kg	1.2 U UJ	0.98 U UJ	0.31 J JN	0.17 U UJ	0.17 U UJ	0.85 U UJ	3.7 U UJ	4.7 U UJ	3.8 U UJ	4.1 U UJ	7.6 Ui UJ	3.5 JD JN	3.7 U UJ	4.9 U UJ	5.6 PD JN	5.4 D JN
Methoxychlor	EPA 8081A	ug/Kg	0.88 U UJ	0.76 U UJ	0.14 U UJ	0.5 Ui UJ	0.13 U UJ	0.66 U UJ	2.8 U UJ	3.6 U UJ	3 U UJ	3.1 U UJ	14 Ui UJ	6.3 D UJ	2.8 U UJ	15 Ui UJ	5 Ui UJ	5 Ui UJ
Mirex	EPA 8081A	ug/Kg	0.88 U UJ	0.76 U UJ	0.14 U UJ	0.13 U UJ	0.13 U UJ	0.66 U UJ	2.8 U UJ	3.6 U UJ	3 U UJ	3.1 U UJ	4.2 JD JN	2.1 JPD JN	2.8 U UJ	3.8 U UJ	2.5 JPD JN	1.8 Ui UJ
Nonachlor (cis)	EPA 8081A	ug/Kg	0.73 U UJ	0.63 U UJ	0.12 U UJ	0.11 U UJ	0.11 U UJ	0.55 U UJ	2.4 U UJ	7.7 Ui UJ	2.5 U UJ	2.6 U UJ	5.6 Ui UJ	4.7 Ui UJ	2.4 U UJ	5.7 Ui UJ	5.7 Ui UJ	2.6 Ui UJ
Nonachlor (trans)	EPA 8081A	ug/Kg	0.78 U UJ	0.67 U UJ	0.13 U UJ	0.12 U UJ	0.12 U UJ	0.59 U UJ	2.5 U UJ	3.2 U UJ	2.6 U UJ	2.8 U UJ	1.9 U UJ	1.6 U UJ	2.5 U UJ	6.2 JPD JN	1.3 U UJ	5 Ui UJ
Oxychlordane	EPA 8081A	ug/Kg	3.3 U UJ	2.8 U UJ	0.52 U UJ	0.47 U UJ	0.48 U UJ	2.5 U UJ	11 U UJ	14 U UJ	11 U UJ	12 U UJ	7.6 U UJ	6.7 U UJ	11 U UJ	14 U UJ	5.4 U UJ	5.6 U UJ
Toxaphene	EPA 8081A	ug/Kg	79 U UJ	68 U UJ	13 U UJ	15 Ui UJ	12 U UJ	59 U UJ	260 U UJ	330 U UJ	270 U UJ	280 U UJ	430 Ui UJ	210 Ui UJ	260 U UJ	360 Ui UJ	130 U UJ	170 Ui UJ
o,p'-DDD	EPA 8081A	ug/Kg	1.9 U UJ	1.6 U UJ	0.3 U UJ	0.49 J JN	0.28 U UJ	1.4 U UJ	5.9 U UJ	34 D JN	6.2 U UJ	6.5 U UJ	19 D JN	11 Ui UJ	5.9 U UJ	7.9 U UJ	14 D JN	13 D JN
o,p'-DDE	EPA 8081A	ug/Kg	2.1 U UJ	1.8 U UJ	0.33 U UJ	0.29 U UJ	0.3 U UJ	1.6 U UJ	6.4 U UJ	8.3 U UJ	6.8 U UJ	7.1 U UJ	4.7 U UJ	4.2 U UJ	6.5 U UJ	8.6 U UJ	3.4 U UJ	3.5 U UJ
o,p'-DDT	EPA 8081A	ug/Kg	1.3 U UJ	1.1 U UJ	0.2 U UJ	0.3 J JN	0.19 U UJ	0.92 U UJ	3.9 U UJ	18 D JN	4.1 U UJ	4.4 U UJ	11 D JN	6.5 D JN	4 U UJ	5.3 U UJ	9.3 D JN	9.1 D JN
p,p'-DDD	EPA 8081A	ug/Kg	1.1 U UJ	0.91 U UJ	0.17 U UJ	0.16 U UJ	0.16 U UJ	2.5 Ui UJ	3.4 U UJ	11 D JN	3.5 U UJ	3.8 U UJ	6 D JN	7.9 D JN	3.4 U UJ	9.3 JD JN	5 Ui UJ	1.8 U UJ
p,p'-DDE	EPA 8081A	ug/Kg	0.88 U UJ	0.79 Ui UJ	0.14 U UJ	0.13 U UJ	0.13 U UJ	2.5 Ui UJ	2.8 U UJ	3.6 U UJ	3 U UJ	3.1 U UJ	2.9 Ui UJ	2 Ui UJ	2.8 U UJ	3.8 U UJ	1.5 U UJ	1.5 U UJ
p,p'-DDT	EPA 8081A	ug/Kg	0.56 U UJ	0.49 U UJ	0.09 U UJ	0.59 Ui UJ	0.083 U UJ	0.42 U UJ	1.8 U UJ	20 Ui UJ	1.9 U UJ	2 U UJ	13 D JN	8.3 D JN	1.8 U UJ	7.6 JD JN	12 Ui UJ	13 D JN
Total DDT	TT calculated	ug/Kg	2.1 U UJ	1.8 U UJ	0.33 U UJ	0.79 JN	0.3 U UJ	2.5 U UJ	6.4 U UJ	63 JN	6.8 U UJ	7.1 U UJ	49 JN	22.7 JN	6.5 U UJ	16.9 JN	23.3 JN	35.1 JN
Total chlordane	TT calculated	ug/Kg	3.3 U UJ	2.8 U UJ	0.52 U UJ	0.47 U UJ	0.48 U UJ	2.5 U UJ	11 U UJ	14 JN	11 U UJ	12 U UJ	7.6 U UJ	6.7 U UJ	11 U UJ	14.6 JN	5.7 U UJ	5.6 U UJ
1,2,4-Trichlorobenzene	EPA 8270C	ug/Kg	2.7 U	2.3 U	2.1 U	1.9 U	2 U	2 U	2.1 U	14 U	2.2 U	2.4 U	31 U	27 U	2.1 U	56 U	2.2 U	2.3 U
		mg/kg OC	0.1 U	0.2 U	0.3 U			0.3 U		0.9 U	0.3 U	0.2 U	0.8 U	0.9 U	0.2 U	1.2 U	0.2 U	0.1 U
1,2-Dichlorobenzene	EPA 8270C	ug/Kg	2.3 U	2 U	1.9 U	1.7 U	1.7 U	1.7 U	1.9 U UJ	12 U UJ	1.9 U UJ	2.1 U UJ	27 U	24 U	1.9 U UJ	49 U UJ	1.9 U	2 U
		mg/kg OC	0.1 U	0.2 U	0.2 U			0.3 U	UJ	0.8 U UJ	0.2 U UJ	0.2 U UJ	0.7 U	0.8 U	0.1 U UJ	1.1 U UJ	0.2 U	0.1 U
1,3-Dichlorobenzene	EPA 8270C	ug/Kg	2.8 U	2.5 U	2.3 U	2.1 U	2.1 U	2.1 U	2.3 U	15 U	2.4 U	2.5 U	33 U	29 U	2.3 U	60 U	2.4 U	2.4 U
1,4-Dichlorobenzene	EPA 8270C	ug/Kg	3.4 U	2.9 U	2.7 U	2.4 U	2.5 U	2.5 U	2.7 U	17 U	2.8 U	3 U	39 U	35 U	2.7 U	71 U	2.8 U	2.9 U
		mg/kg OC	0.2 U	0.3 U	0.3 U			0.4 U		1.1 U	0.3 U	0.2 U	1.0 U	1.2 U	0.2 U	1.6 U	0.3 U	0.1 U
1-Methylnaphthalene	EPA 8270C	ug/Kg	18 U UJ	16 U UJ	14 U UJ	13 U UJ	13 U UJ	14 U UJ	14 U UJ	90 U UJ	15 U UJ	20 J	210 U UJ	180 U UJ	14 U UJ	650 D J	17 J	19 J
2,4,5-Trichlorophenol	EPA 8270C	ug/Kg	5.3 U	4.6 U	4.2 U	3.8 U	3.9 U	4 U	4.2 U	27 U	4.4 U	4.7 U	62 U	54 U	4.2 U	120 U	4.4 U	4.5 U
2,4,6-Trichlorophenol	EPA 8270C	ug/Kg	3.2 U	2.8 U	2.6 U	2.3 U	2.4 U	2.4 U	2.6 U	17 U	2.7 U	2.8 U	37 U	33 U	2.6 U	67 U	2.6 U	2.7 U
2,4-Dichlorophenol	EPA 8270C	ug/Kg	3.2 U	2.8 U	2.6 U	2.3 U	2.4 U	2.4 U	2.6 U	17 U	2.7 U	2.8 U	37 U	33 U	2.6 U	67 U	2.6 U	2.7 U
2,4-Dimethylphenol	EPA 8270C	ug/Kg	9.6 U	8.3 U	7.7 U	7 U	7.2 U	7.2 U	7.7 U	50 U	8.1 U	8.5 U	120 U	99 U	7.7 U	210 U	8 U	8.3 U
2,4-Dinitrophenol	EPA 8270C	ug/Kg	63 U	55 U	51 U	46 U	47 U	47 U	51 U	330 U	53 U	56 U	740 U	650 U	51 U	1400 U	52 U	54 U
2,4-Dinitrotoluene	EPA 8270C	ug/Kg	4.9 U	4.3 U	4 U	3.6 U	3.7 U	3.7 U	3.9 U	25 U	4.1 U	4.4 U	58 U	51 U	4 U	110 U	4.1 U	4.2 U
2,6-Dinitrotoluene	EPA 8270C	ug/Kg	4.9 U	4.3 U	4 U	3.6 U	3.7 U	3.7 U	3.9 U	25 U	4.1 U	4.4 U	58 U	51 U	4 U	110 U	4.1 U	4.2 U
2-Chloronaphthalene	EPA 8270C	ug/Kg	6.3 U	5.5 U	5.1 U	4.6 U	4.7 U	4.7 U	5.1 U	33 U	5.3 U	5.6 U	74 U	65 U	5.1 U	140 U	5.2 U	5.4 U
2-Chlorophenol	EPA 8270C	ug/Kg	3 U	2.6 U	2.4 U	2.2 U	2.2 U	2.3 U	2.4 U	16 U	2.5 U	2.7 U	35 U	31 U	2.4 U	64 U	2.5 U	2.6 U
2-Methylnaphthalene	EPA 8270C	ug/Kg	2.7 J	1.9 U	1.7 U	2.2 J	1.6 U	1.6 U	5.7 J	65 D	23	28	200 D	120 D	14	600 D	28	26
		mg/kg OC	0.1 J	0.2 U	0.2 U			0.3 U		4.4 D	2.6	2.3	5.2 D	4.1 D	1.0	13.2 D	2.9	0.8
2-Methylphenol	EPA 8270C	ug/Kg	6 U	5.2 U	4.8 U	4.3 U	4.4 U	4.5 U	4.8 U	31 U	5 U	5.3 U	70 U	62 U	4.8 U	130 U	5 U	5.1 U
2-Nitroaniline	EPA 8270C	ug/Kg	4.8 U	4.1 U	3.8 U	3.4 U	3.5 U	3.6 U	3.8 U	25 U	4 U	4.2 U	55 U	49 U	3.8 U	110 U	3.9 U	4.1 U
2-Nitrophenol	EPA 8270C	ug/Kg	4.6 U	4 U	3.7 U	3.3 U	3.4 U	3.4 U	3.7 U	24 U	3.8 U	4.1 U	53 U	47 U	3.7 U	97 U	3.8 U	3.9 U
3,3'-Dichlorobenzidine	EPA 8270C	ug/Kg	6.5 U	5.6 U	5.2 U	4.7 U UJ	4.8 U UJ	4.9 U UJ	5.2 U	34 U	5.4 U	5.8 U	76 U	67 U	5.2 U	140 U	5.4 U	5.6 U
3-Nitroaniline	EPA 8270C	ug/Kg	4.6 U	4 U	3.7 U	3.3 U	3.4 U	3.4 U	3.7 U	24 U	3.8 U	4.1 U	53 U	47 U	3.7 U	97 U	3.8 U	3.9 U
4,6-Dinitro-o-cresol	EPA 8270C	ug/Kg	3 U	2.6 U	2.4 U	2.2 U	2.2 U	2.3 U	2.4 U	16 U	2.5 U	2.7 U	35 U	31 U	2.4 U	64 U	2.5 U	2.6 U
4-Bromophenyl phenyl ether	EPA 8270C	ug/Kg	2.5 U	2.2 U	2 U	1.8 U	1.9 U	1.9 U	2 U	13 U	2.1 U	2.2 U	29 U	26 U	2 U	53 U	2.1 U	2.1 U
4-Chloro-3-methylphenol	EPA 8270C	ug/Kg	3.7 U	3.2 U	3 U	2.7 U	2.8 U	2.8 U	3 U	19 U	3.1 U	3.3 U	43 U	38 U	3 U	79 U	3.1 U	3.2 U

Table A-1. 2007 Remedial Investigation Subsurface Cores Analytical Data

Location			22	22	22	23	23	23	24	24	24	24	25	25	25	25	26	26
Sample ID			TT22-CS-B	TT22-CS-C	TT22-CS-D	TT23-CS-B	TT23-CS-C	TT23-CS-H	TT24-CS-B	TT24-CS-C	TT24-CS-E	TT24-CS-H	TT25-CS-B	TT25-CS-C	TT25-CS-J	TT25-CS-L	TT26-CS-B	TT26-CS-C
Sample Date			1/12/2007	1/12/2007	1/12/2007	1/10/2007	1/10/2007	1/10/2007	1/10/2007	1/10/2007	1/10/2007	1/10/2007	1/12/2007	1/12/2007	1/12/2007	1/12/2007	1/12/2007	1/12/2007
Sample Depth (MLLW)			-44 To -45 ft	-45 To -46 ft	-46 To -47 ft	-44 To -45 ft	-45 To -46 ft	-50 To -51.2 ft	-27 To -28.6 ft	-28.6 To -29.9 ft	-30.8 To -32 ft	-34 To -35 ft	-25 To -26 ft	-26 To -27 ft	-33 To -34 ft	-35 To -36 ft	-31 To -32 ft	-32 To -33 ft
Parameter	**Method**	**Units**																
4-Chloroaniline	EPA 8270C	ug/Kg	3.7 U	3.2 U	3 U	2.7 U	2.8 U	2.8 U	3 U	19 U	3.1 U	3.3 U	43 U	38 U	3 U	79 U	3.1 U	3.2 U
4-Chlorophenyl phenyl ether	EPA 8270C	ug/Kg	3.5 U	3.1 U	2.8 U	2.6 U	2.6 U	2.7 U	2.8 U	18 U	3 U	3.1 U	41 U	36 U	2.8 U	75 U	2.9 U	3 U
4-Methylphenol	EPA 8270C	ug/Kg	5.1 U	4.4 U	4.1 U	3.7 U	3.8 U	3.8 U	4.1 U	40 JD	4.3 U	12	60 U	53 U	4.1 U	110 U	4.2 U	4.4 U
4-Nitroaniline	EPA 8270C	ug/Kg	6 U	5.2 U	4.8 U	4.3 U	4.4 U	4.5 U	4.8 U	31 U	5 U	5.3 U	70 U	62 U	4.8 U	130 U	5 U	5.1 U
4-Nitrophenol	EPA 8270C	ug/Kg	53 U	46 U	42 U	38 U	39 U	40 U	42 U	270 U	44 U	47 U	620 U	540 U	42 U	1200 U	44 U	45 U
Acenaphthene	EPA 8270C	ug/Kg	1.9 J	1.6 U	1.4 U	2.6 J	1.3 U	1.4 U	8.3 J	150 D	40	95	660 D	730 D	58	5900 D	60	61
		mg/kg OC	0.1 J	0.2 U	0.2 U			0.2 U		10.1 D	4.6	7.7	17.1 D	25.0 D	4.3	130.0 D	6.3	1.8
Acenaphthylene	EPA 8270C	ug/Kg	2.5 U	2.2 U	2 U	2.6 J	1.9 U	1.9 U	6.7 J J	130 D J	22 J	23 J	160 D	170 D	17 J	480 D J	90	140
		mg/kg OC	0.1 U	0.2 U	0.3 U			0.3 U	J	8.7 D J	2.5 J	1.9 J	4.2 D	5.8 D	1.3 J	10.6 D J	9.4	4.1
Aniline	EPA 8270C	ug/Kg	2.7 U	2.3 U	2.1 U	1.9 U	2 U	3.2 J	2.1 U	14 U	2.2 U	2.4 U	31 U	27 U	2.1 U	56 U	2.2 U	2.3 U
Anthracene	EPA 8270C	ug/Kg	6 J	4.1 J	3.1 J	5.3 J	1.9 U	1.9 U	20	290 D	62	120	650 D	760 D	52	6300 D	240	430
		mg/kg OC	0.3 J	0.4 J	0.4 J			0.3 U		19.5 D	7.1	9.7	16.9 D	26.0 D	3.9	138.8 D	25.0	12.5
Benzo(a)anthracene	EPA 8270C	ug/Kg	9.6 J	6.1 J	6.1 J	5.2 J	1.9 U	1.9 U	30 J	420 D J	66 J	140 J	670 D	1100 D	72 J	12000 D J	600	990 D
		mg/kg OC	0.4 J	0.6 J	0.8 J			0.3 U	J	28.2 D J	7.6 J	11.3 J	17.4 D	37.7 D	5.3 J	264.3 D J	62.5	28.8 D
Benzo(a)pyrene	EPA 8270C	ug/Kg	7.3 J	5.9 J	5 J	8.3 J	2.1 U	2.1 U	34	480 D	83	88	1100 D	1100 D	59	4100 D	650	1000 D
		mg/kg OC	0.3 J	0.6 J	0.6 J			0.4 U		32.2 D	9.5	7.1	28.6 D	37.7 D	4.4	90.3 D	67.7	29.1 D
Benzo(b)fluoranthene	EPA 8270C	ug/Kg	9.9 J	7.7 J	4.9 J	10	3.3 U	3.3 U	53	810 D	130	130	2000 D	2000 D	87	6500 D	1200 D	1900 D
Benzo(g,h,i)perylene	EPA 8270C	ug/Kg	4.3 J	4.4 J	3.3 U	4.7 J	3 U	3.1 U	21	270 D	49	50	400 D	460 D	35	1700 D	340	530
		mg/kg OC	0.2 J	0.4 J	0.4 U			0.5 U		18.1 D	5.6	4.0	10.4 D	15.8 D	2.6	37.4 D	35.4	15.4
Benzo(k)fluoranthene	EPA 8270C	ug/Kg	4.4 U	3.8 U	3.5 U	7.2 J	3.3 U	3.3 U	18	290 D	43	38	670 D	750 D	29	2400 D	320	460
Benzofluoranthenes (total)	TT calculated	ug/Kg	9.9	7.7	4.9	17.2	3.3 U	3.3 U	71	1100	173	168	2670	2750	116	8900	1520	2360
		mg/kg OC	0.4	0.8	0.6			0.6 U		73.8	19.9	13.5	69.4	94.2	8.6	196.0	158.3	68.6
Benzoic acid	EPA 8270C	ug/Kg	170 U UJ	150 U UJ	140 U UJ	130 U UJ	130 U UJ	130 U UJ	140 U	860 U	140 U	150 U	2000 U UJ	1800 U UJ	140 U	3600 U	140 U UJ	150 U UJ
Benzyl alcohol	EPA 8270C	ug/Kg	6.5 U	5.6 U	5.2 U	4.7 U	4.8 U	4.9 U	5.2 U	34 U	5.4 U	5.8 U	76 U	67 U	5.2 U	140 U	5.4 U	5.6 U
bis(2-chloroethoxy)methane	EPA 8270C	ug/Kg	2.3 U	2 U	1.9 U	1.7 U	1.7 U	1.7 U	1.9 U	12 U	1.9 U	2.1 U	27 U	24 U	1.9 U	49 U	1.9 U	2 U
bis(2-chloroethyl)ether	EPA 8270C	ug/Kg	4.2 U	3.7 U	3.4 U	3.1 U	3.2 U	3.2 U	3.4 U	22 U	3.5 U	3.8 U	49 U	44 U	3.4 U	90 U	3.5 U	3.6 U
bis(2-chloroisopropyl)ether	EPA 8270C	ug/Kg	2.1 U	1.9 U	1.7 U	1.6 U	1.6 U	1.6 U	1.7 U	11 U	1.8 U	1.9 U	25 U	22 U	1.7 U	45 U	1.8 U	1.8 U
bis(2-ethylhexyl)phthalate	EPA 8270C	ug/Kg	4.4 J U	8.6 J U	4.7 J U	12 J U	6.8 J U	5.4 J U	13 J	56 JD	19 J	2.7 U	48 JD U	58 JD U	2.4 U	64 U	410	840 JD
		mg/kg OC	0.2 J U	0.9 J U	0.6 J U	U	U	0.9 J U		3.8 JD	2.2 J	0.2 U	1.2 JD U	2.0 JD U	0.2 U	1.4 U	42.7	24.4 JD
Butyl benzyl phthalate	EPA 8270C	ug/Kg	2.7 U	2.3 U	2.1 U	1.9 U	2 U	2 U	2.1 U	14 U	2.2 U	2.4 U	31 U	27 U	2.1 U	56 U	32	2.3 U
		mg/kg OC	0.1 U	0.2 U	0.3 U			0.3 U		0.9 U	0.3 U	0.2 U	0.8 U	0.9 U	0.2 U	1.2 U	3.3	0.1 U
Chrysene	EPA 8270C	ug/Kg	6.9 J	4.5 J	5.9 J	6.3 J	1.9 U	1.9 U	34 J	560 D J	95 J	130 J	1100 D	1900 D	110 J	13000 D J	1200 D	2000 D
		mg/kg OC	0.3 J	0.5 J	0.7 J			0.3 U	J	37.6 D J	10.9 J	10.5 J	28.6 D	65.1 D	8.1 J	286.3 D J	125.0 D	58.1 D
Dibenzo(a,h)anthracene	EPA 8270C	ug/Kg	3.9 U	3.4 U	3.1 U	2.8 U	2.9 U	2.9 U	5.6 J	78 D	12	14	130 D	140 D	9.1 J	510 D	88	160
		mg/kg OC	0.2 U	0.3 U	0.4 U			0.5 U		5.2 D	1.4	1.1	3.4 D	4.8 D	0.7 J	11.2 D	9.2	4.7
Dibenzofuran	EPA 8270C	ug/Kg	2.3 U	2 U	1.9 U	2.7 J	1.7 U	1.7 U	6.2 J	88 D	26	65	450 D	310 D	20	1600 D	41	48
		mg/kg OC	0.1 U	0.2 U	0.2 U			0.3 U		5.9 D	3.0	5.2	11.7 D	10.6 D	1.5	35.2 D	4.3	1.4
Diethylphthalate	EPA 8270C	ug/Kg	6.1 U	5.3 U	4.9 U	4.4 U	4.6 U	4.6 U	4.9 U	32 U	5.2 U	5.5 U	72 U	63 U	4.9 U	140 U	5.1 U	5.3 U
		mg/kg OC	0.3 U	0.5 U	0.6 U			0.8 U		2.1 U	0.6 U	0.4 U	1.9 U	2.2 U	0.4 U	3.1 U	0.5 U	0.2 U
Dimethyl phthalate	EPA 8270C	ug/Kg	3.2 U	2.8 U	2.6 U	2.3 U	2.4 U	2.4 U	2.6 U	17 U	2.7 U	2.8 U	37 U	33 U	2.6 U	67 U	2.7 J	2.7 U
		mg/kg OC	0.1 U	0.3 U	0.3 U			0.4 U		1.1 U	0.3 U	0.2 U	1.0 U	1.1 U	0.2 U	1.5 U	0.3 J	0.1 U
Di-n-butyl phthalate	EPA 8270C	ug/Kg	4.6 U	4.5 J	4.2 J	3.3 U	3.4 U	3.4 U	5.1 J	24 U	5.6 J	4.1 U	53 U	47 U	4.5 J	97 U	20	18
		mg/kg OC	0.2 U	0.5 J	0.5 J			0.6 U		1.6 U	0.6 J	0.3 U	1.4 U	1.6 U	0.3 J	2.1 U	2.1	0.5
Di-n-octyl phthalate	EPA 8270C	ug/Kg	2.1 U	1.9 U	1.7 U	1.6 U	1.6 U	1.6 U	1.7 U	11 U	1.8 U	1.9 U	25 U	22 U	1.7 U	45 U	1.8 U	1.8 U
		mg/kg OC	0.1 U	0.2 U	0.2 U			0.3 U		0.7 U	0.2 U	0.2 U	0.6 U	0.8 U	0.1 U	1.0 U	0.2 U	0.1 U
Fluoranthene	EPA 8270C	ug/Kg	11	10	9.8 J	17	2.9 U	2.9 U	62	880 D	180	370	2000 D	2300 D	200	58000 D	1000 D	1800 D
		mg/kg OC	0.5	1.0	1.2 J			0.5 U		59.1 D	20.7	29.8	51.9 D	78.8 D	14.8	1277.5 D	104.2 D	52.3 D
Fluorene	EPA 8270C	ug/Kg	3 U	2.6 U	2.4 U	3 J	2.2 U	2.3 U	9.5 J	130 D	36	89	580 D	450 D	38	2700 D	83	110
		mg/kg OC	0.1 U	0.3 U	0.3 U			0.4 U		8.7 D	4.1	7.2	15.1 D	15.4 D	2.8	59.5 D	8.6	3.2
Hexachlorobenzene	EPA 8081A	ug/Kg	0.69 U	0.6 U	0.12 U	0.1 U	0.11 U	0.52 U	2.2 U	2.9 U	2.4 U	2.5 U	1.7 U	1.5 U	2.3 U	3.1 Ui	1.2 U	1.2 U
		mg/kg OC	0.03 U	0.1 U	0.02 U			0.1 U		0.2 U	0.3 U	0.2 U	0.04 U	0.1 U	0.2 U	0.1 Ui	0.1 U	0.0 U
Hexachlorobenzene	EPA 8270C	ug/Kg																
		mg/kg OC																
Hexachlorobutadiene	EPA 8081A	ug/Kg			0.69 U	0.62 U	0.64 U						10 U	8.8 U		19 U		
		mg/kg OC			0.1 U								0.3 U	0.3 U		0.4 U		
Hexachlorobutadiene	EPA 8270C	ug/Kg	2.5 U	2.2 U				1.9 U	2 U	13 U	2.1 U	2.2 U			2 U		2.1 U	2.1 U
		mg/kg OC	0.1 U	0.2 U	0.0			0.3 U		0.9 U	0.2 U	0.2 U	0.0	0.0	0.1 U	0.0	0.2 U	0.1 U
Hexachlorocyclopentadiene	EPA 8270C	ug/Kg	27 U	23 U	21 U	19 U	20 U	20 U	21 U UJ	140 U UJ	22 U UJ	24 U UJ	310 U	270 U	21 U UJ	560 U UJ	22 U	23 U
Hexachloroethane	EPA 8270C	ug/Kg	3.9 U	3.4 U	3.1 U	2.8 U	2.9 U	2.9 U	3.1 U UJ	20 U UJ	3.3 U UJ	3.4 U UJ	45 U	40 U	3.1 U UJ	82 U UJ	3.2 U	3.3 U
Indeno(1,2,3-cd)pyrene	EPA 8270C	ug/Kg	3.8 J	3.8 J	2.7 J	5.6 J	2.5 U	2.5 U	24	310 D	52	54	500 D	510 D	36	2100 D	410	650
		mg/kg OC	0.2 J	0.4 J	0.3 J			0.4 U		20.8 D	6.0	4.4	13.0 D	17.5 D	2.7	46.3 D	42.7	18.9
Isophorone	EPA 8270C	ug/Kg	2.8 U	2.5 U	2.3 U	2.1 U	2.1 U	2.1 U	2.3 U UJ	15 U UJ	2.4 U UJ	2.5 U UJ	33 U	29 U	2.3 U UJ	60 U UJ	2.4 U	2.4 U
Naphthalene	EPA 8270C	ug/Kg	3.8 J	3.1 J	3.2 J	7.2 J	2.3 J	1.7 U	16	180 D	130	64	660 D	330 D	48	2200 D	64	77
		mg/kg OC	0.2 J	0.3 J	0.4 J			0.3 U		12.1 D	14.9	5.2	17.1 D	11.3 D	3.6	48.5 D	6.7	2.2
Nitrobenzene	EPA 8270C	ug/Kg	3.5 U	3.1 U	2.8 U	2.6 U	2.6 U	2.7 U	2.8 U	18 U	3 U	3.1 U	41 U	36 U	2.8 U	75 U	2.9 U	3 U
N-Nitrosodimethylamine	EPA 8270C	ug/Kg	11 U	9.2 U	8.6 U	7.7 U	7.9 U	8 U	8.5 U	55 U	8.9 U	9.5 U	130 U	110 U	8.6 U	230 U	8.9 U	9.2 U
N-Nitroso-di-n-propylamine	EPA 8270C	ug/Kg	5.6 U	4.9 U	4.5 U	4.1 U	4.2 U	4.2 U	4.5 U	29 U	4.7 U	5 U	66 U	58 U	4.5 U	120 U	4.7 U	4.8 U
N-Nitrosodiphenylamine	EPA 8270C	ug/Kg	3.9 U	3.4 U	3.1 U	2.8 U	2.9 U	2.9 U	3.1 U	20 U	3.3 U	3.4 U	45 U	40 U	3.1 U	82 U	3.2 U	3.3 U
		mg/kg OC	0.2 U	0.3 U	0.4 U			0.5 U		1.3 U	0.4 U	0.3 U	1.2 U	1.4 U	0.2 U	1.8 U	0.3 U	0.1 U
Pentachlorophenol	EPA 8270C	ug/Kg	15 U	13 U	12 U	11 U	11 U	12 U	12 U	76 U	13 U	14 U	180 U	160 U	12 U	320 U	120	73 J
Phenanthrene	EPA 8270C	ug/Kg	8 J	7.8 J	6.7 J	14	2.2 J	1.7 U	34	370 D	110	210	1800 D	1300 D	100	12000 D	580	590
		mg/kg OC	0.4 J	0.8 J	0.8 J			0.3 U		24.8 D	12.6	16.9	46.8 D	44.5 D	7.4	264.3 D	60.4	17.2
Phenol	EPA 8270C	ug/Kg	3.4 U	2.9 U	2.7 U	3.1 J	2.8 J	3.2 J	2.7 U	17 U	2.8 U	3 U	39 U	35 U	2.7 U	71 U	49	2.9 U
Pyrene	EPA 8270C	ug/Kg	46	24	17	20	3 J	1.7 U	170	3600 D	530	970 D	19000 D	12000 D	370	39000 D	1900 D	3100 D
		mg/kg OC	2.1	2.4	2.2			0.3 U		241.6 D	60.9	78.2 D	493.5 D	411.0 D	27.4	859.0 D	197.9 D	90.1 D
Total HPAH	TT calculated	ug/Kg	98.8	66.4	51.4	84.3	3	3.3 U	451.6	7698	1240	1984	27570	22260	1007.1	139310	7708	12590
		mg/kg OC	4.5	6.7	6.5			0.6 U		516.6	142.5	160.0	716.1	762.3	74.6	3068.5	802.9	366.0
Total LPAH	TT calculated	ug/Kg	19.7	15	13	34.7	4.5	2.3 U	94.5	1250	400	601	4510	3740	313	29580	1117	1408
		mg/kg OC	0.9	1.5	1.6			0.4 U		83.9	46.0	48.5	117.1	128.1	23.2	651.5	116.4	40.9
Total PAH	TT calculated	ug/Kg	118.5	81.4	64.4	119	7.5	3.3 U	546.1	8948	1640	2585	32080	26000	1320.1	168890	8825	13998
Butyltin	KRONE	ug/Kg	0.053 U	0.046 U	0.042 U	0.038 U	0.039 U	0.04 U UJ	0.042 U	0.56 J	0.044 U	0.047 U	0.65 J	0.054 U	0.042 U		16	5.7
Dibutyltin	KRONE	ug/Kg	1.2 J U	1.1 J U	0.57 J U	1.3 J U	0.56 J U	0.51 J U	1.2 J U	6.5	0.88 J U	0.82 J U	6.4	2.8	0.77 J U		170 D	82
Tetrabutyltin	KRONE	ug/Kg	0.13 U	0.11 U	0.098 U	0.088 U	0.091 U	0.092 U	0.098 U	0.13 U	0.11 U	0.11 U	0.15 U	0.13 U	0.098 U		13	6.5
Tributyltin	KRONE	ug/Kg	1.6 J	1.6	0.21 Ui	1.8	0.4 Ui	0.074 U	1.5	8.8	0.98 J	0.087 U	19	3	0.079 U		710 D	290 D
		mg/kg OC	0.072 J	0.162	0.027 Ui			0.013 U		0.591	0.113 J	0.007 U	0.494	0.103	0.006 U		74.0 D	8.4 D
Total Solids	EPA 160.3	Percent	57.4	66.5	71.6	79.6	77.4	76.6	71.9	56	68.6	64.8	49.1	55.7	71.5	53.8	69.3	66.9

Table A-1. 2007 Remedial Investigation Subsurface Cores Analytical Data

Location			22	22	22	23	23	23	24	24	24	24	25	25	25	25	26	26
Sample ID			TT22-CS-B	TT22-CS-C	TT22-CS-D	TT23-CS-B	TT23-CS-C	TT23-CS-H	TT24-CS-B	TT24-CS-C	TT24-CS-E	TT24-CS-H	TT25-CS-B	TT25-CS-C	TT25-CS-J	TT25-CS-L	TT26-CS-B	TT26-CS-C
Sample Date			1/12/2007	1/12/2007	1/12/2007	1/10/2007	1/10/2007	1/10/2007	1/10/2007	1/10/2007	1/10/2007	1/10/2007	1/12/2007	1/12/2007	1/12/2007	1/12/2007	1/12/2007	1/12/2007
Sample Depth (MLLW)			-44 To -45 ft	-45 To -46 ft	-46 To -47 ft	-44 To -45 ft	-45 To -46 ft	-50 To -51.2 ft	-27 To -28.6 ft	-28.6 To -29.9 ft	-30.8 To -32 ft	-34 To -35 ft	-25 To -26 ft	-26 To -27 ft	-33 To -34 ft	-35 To -36 ft	-31 To -32 ft	-32 To -33 ft
Parameter	**Method**	**Units**																
Total Organic Carbon	ASTM D4129-98M	Percent	2.21	0.99	0.79	0.26	0.37	0.59	0.28	1.49	0.87	1.24	3.85	2.92	1.35	4.54	0.96	3.44
Fractional % phi >-1	PSEP Grain Size	Percent	0.57	0.22	0.38	0.25	0.35	0.31	0.2	1.36	0.35	0.62	2.45	2.81	0.37	4.57	6.14	7.13
Fractional % phi 0-1	PSEP Grain Size	Percent	0.6	0.23	0.22	1.3	1.02	5.96	0.37	2.03	0.69	0.68	1.8	1.55	0.32	3.83	3.94	5.32
Fractional % phi 1-2	PSEP Grain Size	Percent	1.05	0.89	1.46	12.8	19.7	11.2	3.08	5.54	4.49	1.27	3.74	2.2	0.53	4.75	13.1	13.3
Fractional % phi 2-3	PSEP Grain Size	Percent	4.46	11.2	16.1	36	38	29.3	35.7	21.6	32	6.03	9.79	5.4	5.19	11.2	21.4	19.6
Fractional % phi 3-4	PSEP Grain Size	Percent	6.17	26.6	28.8	22.4	16.4	19.1	36	21.8	36.8	19.2	14.9	12.9	24.6	18.6	14	12.2
Fractional % phi 4-5	PSEP Grain Size	Percent	5.01	17.6	20.2	11.5	8.6	15.8	14.1	14.3	11.6	23.8	15.1	16.5	21.8	13	6.53	5.63
Fractional % phi 5-6	PSEP Grain Size	Percent	19.2	13.6	12.2	5.57	6.79	10.3	4.46	13	5.44	16.5	16.5	18.8	17.7	13.4	4.03	7.21
Fractional % phi 6-7	PSEP Grain Size	Percent	21.9	11.2	7.94	2.84	3.28	5.26	2.28	8.39	2.31	11.1	9.23	12	10.7	7.54	3.48	2.98
Fractional % phi 7-8	PSEP Grain Size	Percent	15.7	5.9	3.8	1.82	1.78	2.93	1.37	5.3	1.88	6.4	5.89	6.85	5.92	3.83	1.54	1.19
Fractional % phi 8-9	PSEP Grain Size	Percent	9.78	3.77	2.11	0.92	0.86	1.48	1.11	3.71	1.16	4.12	4.08	5.33	4.49	3.05	1.15	0.73
Fractional % phi 9-10	PSEP Grain Size	Percent	6.72	2.85	1.55	0.97	0.62	1.07	0.73	2.86	1.02	2.87	3.1	3.52	3.15	1.92	1.17	0.66
Fractional % phi >10	PSEP Grain Size	Percent	9.49	4.14	2.87	1.42	1.25	1.51	1.67	4.06	1.94	4.24	5.02	5.08	4.66	4.26	2.27	2.14
Gravel	PSEP Grain Size	Percent	0.03	0.04	0.04	0.02	0.04	0.03	0.1	2.79	0.49	0.11	8.55	8.05	0.03	11.3	19.6	18.7

Notes:
0.14 U J = Result followed by laboratory data qualifier followed by data validator qualifier
Sample depth (MLLW) = the core increment elevation in mean lower low water
mg/kg = milligrams per kilogram
ug/kg = micrograms per kilogram
mg/L = milligrams per liter
ug/L = micrograms per liter
ng/L = nanograms per liter

Laboratory Data Qualifiers
U = result was not detected at or above the method detection limit
J (for organics) = result is an estimated concentration that is less than the reporting limit but greater than or equal to the detection limit
B (for metals) = result is an estimated concentration that is less than the reporting limit but greater than or equal to the detection limit
* (for metals) = duplicate analysis not within control limits. See case narrative (in laboratory report)
D (for organics) = result reported is from a dilution
P (for organics) = The GC or HPLC confirmation criteria was exceeded. The relative percent difference is greater than 40% between the two analytical results.
i (for organics) = the MRL/MDL has been elevated due to a chromatographic interference.

Data Validation Qualifiers
U = Result should be considered not-detected at the quantitation limit shown
J = Result is an estimated concentration
R = Rejected - Quality Control indicates the data is not usable
UJ = The compound was not detected and the sample detection limit should be considered an estimated value
N - Pesticide result is tentatively identified.

Table A-1. 2007 Remedial Investigation Subsurface Cores Analytical Data

Location			26	27	27	27	29	29	29	30	31	32	32	32	33	33	33	34
Sample ID			TT26-CS-G	TT27B-CS-B	TT27B-CS-C	TT27B-CS-D	TT29-CS-A	TT29-CS-B	TT29-CS-C	TT30-CS-A	TT31-CS-A	TT32-CS-B	TT32-CS-C	TT32-CS-H	TT33-CS-A	TT33-CS-B	TT33-CS-C	TT34-CS-A
Sample Date			1/12/2007	1/23/2007	1/23/2007	1/23/2007	1/18/2007	1/18/2007	1/18/2007	1/16/2007	1/17/2007	1/13/2007	1/13/2007	1/13/2007	1/23/2007	1/23/2007	1/23/2007	1/17/2007
Sample Depth (MLLW)			-36 To -37 ft	-29 To -30 ft	-30 To -31 ft	-31 To -32 ft	-40.95 To -42 ft	-42 To -43 ft	-43 To -44 ft	-52.19 To -53 ft	-51.8 To -52.9 ft	-42 To -43 ft	-43 To -44 ft	-48 To -49.4 ft	-50.6 To -51 ft	-51 To -52 ft	-52 To -53 ft	-51.3 To -52 ft
Parameter	**Method**	**Units**																
Antimony	EPA 6020	mg/Kg	44.6	1.03	0.353	0.179	0.094 * J	0.191 * J	0.415 * J	2.8 * J	5.09 * J	0.24	0.06 B	0.05 U	0.721	0.666	0.045 U	2 * J
Arsenic	EPA 6020	mg/Kg	123	3.69 J	4.43 J	6.23 J	1.65 J	1.56 J	2.47 J	8.42 J	14.7	3.29	3.17	2.95	4.84	4.47	2.67	6.96
Cadmium	EPA 6020	mg/Kg	1	0.113 J	0.214 J	0.273 J	0.033 B	0.034 B	0.087	0.25 J	0.273	0.079	0.074	0.099	0.142	0.129	0.172	0.216
Chromium	EPA 6010B	mg/Kg	396	13.9	17.6	21.5	9.3	10.4	13.6	24.7	36	15.9	18.8	16.9	19.1	21.2	14.8	19.6
Cobalt	EPA 6020	mg/Kg	11.8	3.44 J	4.76 J	5.82 J	2.29 J	2.45 J	2.87 J	4.05 J	5.37	4.13	5.28	5.08	4.72 J	4.17 J	4.1 J	4.37
Copper	EPA 6010B	mg/Kg	194	18.9	27.3	36.1	7.2 * J	6.7 * J	15.5 * J	122	1330	19	21.7	20.3	38.2	42.6	19.6	50.2
Lead	EPA 6020	mg/Kg	281	19.1 J	18 J	9.75 J	37.7	6.94	19.5	94.6	86.9	2.78	2.83	2.96	14.8 J	13.5 J	2.21 J	34.7
Mercury	EPA 7471A	mg/Kg	0.317	0.181 * J	0.364 * J	0.186 * J	0.018 B	0.014 B	0.099	1.14	0.803	0.023	0.026	0.022	0.176 * J	0.118 * J	0.025 * J	0.429
Molybdenum	EPA 6020	mg/Kg	8.5	0.49 J	1.24 J	1.44 J	0.39	0.4	0.42	0.85 J	1.27	0.53	0.46	0.41	0.73	0.63	0.73	0.78
Nickel	EPA 6020	mg/Kg	102	7.85 J	11.9 J	13.6 J	5.05 J	5.44 J	6.39 J	9.33 J	12.5	8.61	11.5	10.4	10.4 J	9.24 J	9.67 J	10.5
Selenium	EPA 6020	mg/Kg	0.7 B	0.5 U UJ	0.4 U UJ	0.4 U UJ	0.2 U	0.2 U	0.3 B	0.4 U UJ	0.4 U	0.2 B	0.4 B	0.3 B	0.5 U	0.4 U	0.4 U	0.5 B
Silver	EPA 6020	mg/Kg	0.264	0.07	0.118	0.146	0.023 B	0.015 B	0.098	0.314 * J	0.347	0.075	0.076	0.07	0.135	0.144	0.061	0.211
Thallium	EPA 6020	mg/Kg	0.15	0.048 J	0.073 J	0.123 J	0.023 B	0.023 B	0.034	0.064	0.08	0.06	0.07	0.08	0.071	0.063	0.081	0.084
Vanadium	EPA 6010B	mg/Kg	51.1	43	49	60.6	34.8	36.4	38.3	44.7	55.4	49.6	58	55	51.3	46.1	46.5	48.6
Zinc	EPA 6010B	mg/Kg	991	40.2	45.4	48	25.5	26	47.3	140	423	29.5	34.6	31.8	50.2	47.1	29.4	66.4
PCBs (total)	TT calculated	ug/Kg	690	20.3	11.2	2.7 U	2.3 U	2.2 U	40	660	1350	2.5 U	2.5 U	2.4 U	52	10.2	2.3 U	680
		mg/kg OC	52.3	2.9	1.0	0.2 U				93.0	166.7	0.4 U	0.2 U	0.3 U	4.6	1.4	0.3 U	90.7
PCB-1016	EPA 8082	ug/Kg	27 U UJ	2.4 U	2.5 U	2.7 U	2.1 U	2.2 U	2.2 U	47 U UJ	51 U	2.5 U	2.5 U	2.4 U UJ	2.4 U	2.4 U	2.3 U	48 U
PCB-1221	EPA 8082	ug/Kg	27 U UJ	2.4 U	2.5 U	2.7 U	2.1 U	2.2 U	2.2 U	47 U UJ	51 U	2.5 U	2.5 U	2.4 U UJ	2.4 U	2.4 U	2.3 U	48 U
PCB-1232	EPA 8082	ug/Kg	27 U UJ	2.4 U	2.5 U	2.7 U	2.1 U	2.2 U	2.2 U	47 U UJ	51 U	2.5 U	2.5 U	2.4 U UJ	2.4 U	2.4 U	2.3 U	48 U
PCB-1242	EPA 8082	ug/Kg	27 U UJ	2.4 U	2.5 U	2.7 U	2.1 U	2.2 U	2.2 U	47 U UJ	51 U	2.5 U UJ	2.5 U UJ	2.4 U UJ	2.4 U	2.4 U	2.3 U	48 U
PCB-1248	EPA 8082	ug/Kg	27 U UJ	2.4 U	2.5 U	2.7 U	2.1 U	2.2 U	2.2 U	47 U UJ	51 U	2.5 U UJ	2.5 U UJ	2.4 U UJ	2.4 U	2.4 U	2.3 U	48 U
PCB-1254	EPA 8082	ug/Kg	460 D J	12	6.7	2.7 U	2.3 Ui	2.2 U	22	450 D J	750 D	2.5 U UJ	2.5 U UJ	2.4 U UJ	29	5.7	2.3 U	390 D
PCB-1260	EPA 8082	ug/Kg	230 PD J	8.3	4.5	2.7 U	2.1 U	2.2 U	18	210 PD J	600 PD J	2.5 U UJ	2.5 U UJ	2.4 U UJ	23	4.5	2.3 U	290 PD J
PCB-1262	EPA 8082	ug/Kg	27 U UJ	2.4 U	2.5 U	2.7 U	2.1 U	2.2 U	2.2 U	47 U UJ	51 U	2.5 U UJ	2.5 U UJ	2.4 U UJ	2.4 U	2.4 U	2.3 U	48 U
PCB-1268	EPA 8082	ug/Kg	27 U UJ	2.4 U	2.5 U	2.7 U	2.1 U	2.2 U	2.2 U	47 U UJ	51 U	2.5 U UJ	2.5 U UJ	2.4 U UJ	2.4 U	2.4 U	2.3 U	48 U
Aldrin	EPA 8081A	ug/Kg	4.7 U UJ	0.21 U UJ	0.22 U UJ	0.24 U UJ	0.19 U UJ	0.19 U UJ	0.19 U UJ	4.1 U UJ	4.5 U UJ	1.1 U UJ	1.1 U UJ	1.1 U UJ	0.22 U UJ	0.21 U UJ	0.21 U UJ	4.3 U UJ
alpha-BHC	EPA 8081A	ug/Kg	8 U UJ	0.36 U UJ	0.38 U UJ	0.4 U UJ	0.32 U UJ	0.33 U UJ	0.33 U UJ	7.1 U UJ	7.8 U UJ	1.9 U UJ	1.9 U UJ	1.8 U UJ	0.37 U UJ	0.36 U UJ	0.35 U UJ	7.3 U UJ
alpha-Chlordane	EPA 8081A	ug/Kg	7.1 U UJ	0.32 U UJ	0.34 U UJ	0.36 U UJ	0.28 U UJ	0.29 U UJ	0.29 U UJ	6.3 U UJ	6.9 U UJ	1.7 U UJ	1.7 U UJ	1.6 U UJ	0.33 U UJ	0.32 U UJ	0.31 U UJ	6.5 U UJ
beta-BHC	EPA 8081A	ug/Kg	9.3 U UJ	0.42 U UJ	0.44 U UJ	0.47 U UJ	0.37 U UJ	0.38 U UJ	0.42 Ui UJ	8.2 U UJ	9 U UJ	2.2 U UJ	2.2 U UJ	2.1 U UJ	0.43 U UJ	0.41 U UJ	0.41 U UJ	8.5 U UJ
delta-BHC	EPA 8081A	ug/Kg	1.7 U UJ	0.076 U UJ	0.081 U UJ	0.099 Ui UJ	0.067 U UJ	0.069 U UJ	0.17 Ui UJ	1.5 U UJ	1.7 U UJ	0.4 U UJ	0.4 U UJ	0.38 U UJ	0.39 Ui UJ	0.075 U UJ	0.074 U UJ	1.6 U UJ
Dieldrin	EPA 8081A	ug/Kg	8.9 U UJ	0.58 Ui UJ	0.46 Ui UJ	0.45 U UJ	0.36 U UJ	0.37 U UJ	0.37 U UJ	7.9 U UJ	8.7 U UJ	2.1 U UJ	2.1 U UJ	2 U UJ	0.76 Ui UJ	0.4 U UJ	0.39 U UJ	8.2 U UJ
Endosulfan I	EPA 8081A	ug/Kg	5.3 U UJ	0.24 U UJ	0.25 U UJ	0.27 U UJ	0.21 U UJ	0.22 U UJ	0.22 U UJ	4.7 U UJ	5.1 U UJ	1.3 U UJ	1.3 U UJ	1.2 U UJ	0.62 JN	0.24 U UJ	0.23 U UJ	4.8 U UJ
Endosulfan II	EPA 8081A	ug/Kg	5.9 U UJ	0.27 U UJ	0.37 Ui UJ	0.3 U UJ	0.24 U UJ	0.24 U UJ	0.24 U UJ	5.2 U UJ	5.7 U UJ	1.4 U UJ	1.4 U UJ	1.4 U UJ	0.27 U UJ	0.26 U UJ	0.26 U UJ	5.4 U UJ
Endosulfan sulfate	EPA 8081A	ug/Kg	2.5 U UJ	0.11 U UJ	0.13 Ui UJ	0.13 U UJ	0.097 U UJ	0.11 Ui UJ	0.099 U UJ	2.2 U UJ	2.4 U UJ	0.57 U UJ	0.57 U UJ	0.55 U UJ	0.12 U UJ	0.11 U UJ	0.11 U UJ	2.3 U UJ
Endrin	EPA 8081A	ug/Kg	6.2 U UJ	0.28 U UJ	0.3 U UJ	0.31 U UJ	0.25 U UJ	0.25 U UJ	0.29 Ui UJ	5.5 U UJ	6 U UJ	1.5 U UJ	1.5 U UJ	1.4 U UJ	0.29 U UJ	0.28 U UJ	0.27 U UJ	5.7 U UJ
Endrin aldehyde	EPA 8081A	ug/Kg	3.4 JPD UJ	0.22 Ui UJ	0.55 Ui UJ	0.082 U UJ	0.068 Ui UJ	0.066 U UJ	0.48 Ui UJ	6.8 JPD JN	8.9 JPD JN	0.38 U UJ	0.38 U UJ	0.37 U UJ	0.56 Ui UJ	0.16 Ui UJ	0.079 Ui UJ	4.5 JD UJ
gamma-BHC	EPA 8081A	ug/Kg	4.7 U UJ	0.21 U UJ	0.81 Ui UJ	0.53 Ui UJ	0.19 U UJ	0.19 U UJ	0.19 U UJ	4.1 U UJ	4.5 U UJ	1.1 U UJ	1.1 U UJ	1.1 U UJ	0.5 Ui UJ	0.21 U UJ	0.21 U UJ	4.3 U UJ
gamma-Chlordane	EPA 8081A	ug/Kg	2 U UJ	0.31 JP JN	0.094 U UJ	0.12 Ui UJ	0.078 U UJ	0.08 U UJ	0.68 P JN	19 PD JN	24 D JN	0.46 U UJ	0.46 U UJ	0.44 U UJ	0.8 P JN	0.088 U UJ	0.086 U UJ	15 PD JN
Heptachlor	EPA 8081A	ug/Kg	2.5 U UJ	0.11 U UJ	0.5 Ui UJ	0.13 U UJ	0.098 U UJ	0.1 U UJ	0.1 U UJ	2.2 U UJ	2.4 U UJ	0.57 U UJ	0.58 U UJ	0.55 U UJ	0.12 U UJ	0.11 U UJ	0.11 U UJ	2.3 U UJ
Heptachlor epoxide	EPA 8081A	ug/Kg	6.9 Ui UJ	0.18 U UJ	0.19 U UJ	0.2 U UJ	0.16 U UJ	0.17 U UJ	0.17 U UJ	3.6 U UJ	3.9 U UJ	0.93 U UJ	0.93 U UJ	0.9 U UJ	0.19 U UJ	0.18 U UJ	0.18 U UJ	3.7 U UJ
Methoxychlor	EPA 8081A	ug/Kg	4.8 JD JN	0.14 U UJ	1.3 JN	0.16 U UJ	0.13 U UJ	0.13 U UJ	0.23 Ui UJ	2.8 U UJ	3.9 Ui UJ	0.71 U UJ	0.72 U UJ	0.69 U UJ	0.19 Ui UJ	0.14 U UJ	0.14 U UJ	2.9 U UJ
Mirex	EPA 8081A	ug/Kg	3.1 U UJ	0.14 U UJ	0.15 U UJ	0.16 U UJ	0.13 U UJ	0.13 U UJ	0.21 J JN	2.8 U UJ	3 U UJ	0.71 U UJ	0.72 U UJ	0.69 U UJ	0.15 U UJ	0.14 U UJ	0.14 U UJ	2.9 U UJ
Nonachlor (cis)	EPA 8081A	ug/Kg	8.3 Ui UJ	0.12 U UJ	0.2 Ui UJ	0.13 U UJ	0.5 Ui UJ	0.11 U UJ	0.35 JP JN	9.9 Ui UJ	10 Ui UJ	0.59 U UJ	0.6 U UJ	0.57 U UJ	0.41 Ui UJ	0.2 Ui UJ	0.12 U UJ	12 Ui UJ
Nonachlor (trans)	EPA 8081A	ug/Kg	8.3 Ui UJ	0.13 U UJ	0.29 Ui UJ	0.14 U UJ	0.11 U UJ	0.12 U UJ	0.12 U UJ	6.8 Ui UJ	8.8 Ui UJ	0.64 U UJ	0.64 U UJ	0.62 U UJ	0.55 Ui UJ	0.13 U UJ	0.12 U UJ	5.9 Ui UJ
Oxychlordane	EPA 8081A	ug/Kg	12 U UJ	0.51 U UJ	0.54 U UJ	0.57 U UJ	0.46 U UJ	0.47 U UJ	0.47 U UJ	11 U UJ	12 U UJ	2.7 U UJ	2.7 U UJ	2.6 U UJ	0.52 U UJ	0.51 U UJ	0.5 U UJ	11 U UJ
Toxaphene	EPA 8081A	ug/Kg	370 Ui UJ	18 Ui UJ	31 Ui UJ	18 Ui UJ	11 U UJ	12 U UJ	34 Ui UJ	250 U UJ	470 Ui UJ	64 U UJ	65 U UJ	62 U UJ	62 Ui UJ	13 U UJ	13 U UJ	260 U UJ
o,p'-DDD	EPA 8081A	ug/Kg	48 PD JN	0.86 JN	0.31 U UJ	0.33 U UJ	0.37 J JN	0.27 U UJ	1.2 JN	42 PD JN	15 Ui UJ	1.5 U UJ	1.5 U UJ	1.5 U UJ	2 P JN	0.46 J JN	0.29 U UJ	10 Ui UJ
o,p'-DDE	EPA 8081A	ug/Kg	30 Ui UJ	0.32 U UJ	0.59 Ui UJ	0.36 U UJ	0.28 U UJ	0.29 U UJ	0.29 U UJ	9.2 Ui UJ	16 Ui UJ	1.7 U UJ	1.7 U UJ	1.6 U UJ	0.33 U UJ	0.32 U UJ	0.31 U UJ	8.5 Ui UJ
o,p'-DDT	EPA 8081A	ug/Kg	28 D JN	0.39 Ui UJ	0.21 U UJ	0.22 U UJ	0.18 U UJ	0.18 U UJ	1.1 JN	25 D JN	41 D JN	1 U UJ	1 U UJ	0.97 U UJ	1.2 JN	0.34 J JN	0.19 U UJ	25 PD JN
p,p'-DDD	EPA 8081A	ug/Kg	9.5 D JN	0.17 U UJ	0.5 Ui UJ	0.5 Ui UJ	0.5 Ui UJ	0.15 U UJ	0.5 JN	6.1 JD JN	8.9 JD JN	2.8 Ui UJ	0.86 U UJ	1.7 Ui UJ	0.62 JN	0.28 Ui UJ	0.17 U UJ	3.4 U UJ
p,p'-DDE	EPA 8081A	ug/Kg	8.9 D JN	0.14 U UJ	0.15 U UJ	0.16 U UJ	0.13 U UJ	0.13 U UJ	0.22 JP JN	2.8 U UJ	3 U UJ	3.7 Ui UJ	0.72 U UJ	0.69 U UJ	0.36 JP JN	0.14 U UJ	0.14 U UJ	2.9 U UJ
p,p'-DDT	EPA 8081A	ug/Kg	36 Ui UJ	0.51 Ui UJ	0.48 J JN	0.099 U UJ	0.4 J JN	0.31 JP JN	1.8 JN	31 Ui UJ	59 D JN	0.46 U UJ	0.46 U UJ	0.44 U UJ	2.1 Ui UJ	0.58 JN	0.086 U UJ	27 Ui UJ
Total DDT	TT calculated	ug/Kg	94.4 JN	0.86 JN	0.48 JN	0.5 U UJ	0.77 JN	0.31 JN	4.82 JN	73.1 JN	108.9 JN	3.7 U UJ	1.7 U UJ	1.7 U UJ	4.18 JN	1.38 JN	0.31 U UJ	25 JN
Total chlordane	TT calculated	ug/Kg	12 U UJ	0.31 JN	0.54 U UJ	0.57 U UJ	0.5 U UJ	0.47 U UJ	1.03 JN	19 JN	24 JN	2.7 U UJ	2.7 U UJ	2.6 U UJ	0.8 JN	0.51 U UJ	0.5 U UJ	15 JN
1,2,4-Trichlorobenzene	EPA 8270C	ug/Kg	12 U	2.1 U	2.2 U	2.4 U	1.9 U	1.9 U	1.9 U	2.1 U	12 U	2.2 U	2.2 U	2.1 U	2.2 U	2.1 U	2.1 U	4.3 U
		mg/kg OC	0.9 U	0.3 U	0.2 U	0.1 U				0.3 U	1.5 U	0.3 U	0.2 U	0.3 U	0.2 U	0.3 U	0.2 U	0.6 U
1,2-Dichlorobenzene	EPA 8270C	ug/Kg	10 U	1.8 U	1.9 U	2 U	1.6 U	1.7 U	1.7 U	1.8 U	9.8 U	1.9 U	1.9 U	1.8 U	1.9 U	1.8 U	1.8 U	3.7 U
		mg/kg OC	0.8 U	0.3 U	0.2 U	0.1 U				0.3 U	1.2 U	0.3 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.5 U
1,3-Dichlorobenzene	EPA 8270C	ug/Kg	13 U	2.2 U	2.4 U	2.5 U	2 U	2 U	2 U	2.2 U	12 U	2.3 U	2.3 U	2.2 U	2.3 U	2.2 U	2.2 U	4.5 U
1,4-Dichlorobenzene	EPA 8270C	ug/Kg	15 U	2.7 U	2.8 U	3 U	2.4 U	2.4 U	2.4 U	2.6 U	15 U	2.7 U	2.8 U	2.7 U	2.7 U	2.6 U	2.6 U	5.4 U
		mg/kg OC	1.1 U	0.4 U	0.2 U	0.2 U				0.4 U	1.9 U	0.4 U	0.3 U	0.4 U	0.2 U	0.4 U	0.3 U	0.7 U
1-Methylnaphthalene	EPA 8270C	ug/Kg	77 U UJ	14 U UJ	18 J	16 U UJ	13 U UJ	13 U UJ	13 U UJ	14 U UJ	75 U UJ	15 U UJ	15 U UJ	14 U UJ	15 U UJ	14 U UJ	14 U UJ	29 U UJ
2,4,5-Trichlorophenol	EPA 8270C	ug/Kg	24 U	4.2 U	4.4 U	4.7 U	3.7 U	3.8 U	3.8 U	4.1 U	23 U	4.3 U	4.3 U	4.2 U	4.3 U	4.1 U	4.1 U	8.5 U
2,4,6-Trichlorophenol	EPA 8270C	ug/Kg	14 U	2.5 U	2.7 U	2.8 U	2.2 U	2.3 U	2.3 U	2.5 U	14 U	2.6 U	2.6 U	2.5 U	2.6 U	2.5 U	2.5 U	5.1 U
2,4-Dichlorophenol	EPA 8270C	ug/Kg	14 U	2.5 U	2.7 U	2.8 U	2.2 U	2.3 U	2.3 U	2.5 U	14 U	2.6 U	2.6 U	2.5 U	2.6 U	2.5 U	2.5 U	5.1 U
2,4-Dimethylphenol	EPA 8270C	ug/Kg	43 U	7.6 U	8.1 U	8.5 U	6.7 U	6.9 U	6.9 U	7.5 U	42 U	7.9 U	7.9 U	7.6 U	7.8 U	7.5 U	7.4 U	16 U
2,4-Dinitrophenol	EPA 8270C	ug/Kg	280 U	50 U	53 U	56 U	44 U	45 U	45 U	49 U UJ	270 U UJ	52 U	52 U	50 U	51 U	49 U	49 U	110 U
2,4-Dinitrotoluene	EPA 8270C	ug/Kg	22 U	3.9 U	4.1 U	4.3 U	3.5 U	3.5 U	3.5 U	3.8 U	21 U	4 U	4 U	3.9 U	4 U	3.9 U	3.8 U	7.9 U
2,6-Dinitrotoluene	EPA 8270C	ug/Kg	22 U	3.9 U	4.1 U	4.3 U	3.5 U	3.5 U	3.5 U	3.8 U	21 U	4 U	4 U	3.9 U	4 U	3.9 U	3.8 U	7.9 U
2-Chloronaphthalene	EPA 8270C	ug/Kg	28 U	5 U	5.3 U	5.6 U	4.4 U	4.5 U	4.5 U	4.9 U	27 U	5.2 U	5.2 U	5 U	5.1 U	4.9 U	4.9 U	11 U
2-Chlorophenol	EPA 8270C	ug/Kg	14 U	2.4 U	2.5 U	2.7 U	2.1 U	2.2 U	2.2 U	2.4 U	13 U	2.5 U	2.5 U	2.4 U	2.4 U	2.4 U	2.3 U	4.8 U
2-Methylnaphthalene	EPA 8270C	ug/Kg	50 D	6.7 J	38	18	1.5 U	1.5 U	6.3 J	14	25 JD	1.8 U	1.8 U	1.7 U	5.2 J	4.2 J	1.7 U	12 JD
		mg/kg OC	3.8 D	1.0 J	3.2	1.0				2.0	3.1 JD	0.3 U	0.2 U	0.2 U	0.5 J	0.6 J	0.2 U	1.6 JD
2-Methylphenol	EPA 8270C	ug/Kg	27 U	4.7 U	5 U	5.3 U	4.2 U	4.3 U	4.3 U	4.7 U	26 U	4.9 U	4.9 U	4.7 U	4.8 U	4.7 U	4.6 U	9.6 U
2-Nitroaniline	EPA 8270C	ug/Kg	21 U	3.8 U	4 U	4.2 U	3.3 U	3.4 U	3.4 U	3.7 U	21 U	3.9 U	3.9 U	3.8 U	3.8 U	3.7 U	3.7 U	7.6 U
2-Nitrophenol	EPA 8270C	ug/Kg	20 U	3.6 U	3.8 U	4 U	3.2 U	3.3 U	3.3 U	3.6 U	20 U	3.7 U	3.8 U	3.6 U	3.7 U	3.6 U	3.5 U	7.3 U
3,3'-Dichlorobenzidine	EPA 8270C	ug/Kg	29 U	5.1 U	5.4 U	5.7 U	4.6 U	4.7 U	4.7 U	5.1 U	28 U	5.3 U UJ	5.3 U UJ	5.1 U UJ	5.2 U	5.1 U	5 U	11 U
3-Nitroaniline	EPA 8270C	ug/Kg	20 U	3.6 U	3.8 U	4 U	3.2 U	3.3 U	3.3 U	3.6 U	20 U	3.7 U	3.8 U	3.6 U	3.7 U	3.6 U	3.5 U	7.3 U
4,6-Dinitro-o-cresol	EPA 8270C	ug/Kg	14 U	2.4 U	2.5 U	2.7 U	2.1 U	2.2 U	2.2 U	2.4 U	13 U	2.5 U	2.5 U	2.4 U	2.4 U	2.4 U	2.3 U	4.8 U
4-Bromophenyl phenyl ether	EPA 8270C	ug/Kg	11 U	2 U	2.1 U	2.2 U	1.8 U	1.8 U	1.8 U	1.9 U	11 U	2 U	2 U	2 U	2 U	2 U	1.9 U	4 U
4-Chloro-3-methylphenol	EPA 8270C	ug/Kg	17 U	2.9 U	3.1 U	3.3 U	2.6 U	2.7 U	2.7 U	2.9 U	16 U	3 U	3 U	2.9 U	3 U	2.9 U	2.9 U	5.9 U

Table A-1. 2007 Remedial Investigation Subsurface Cores Analytical Data

Location			26	27	27	27	29	29	29	30	31	32	32	32	33	33	33	34
Sample ID			TT26-CS-G	TT27B-CS-B	TT27B-CS-C	TT27B-CS-D	TT29-CS-A	TT29-CS-B	TT29-CS-C	TT30-CS-A	TT31-CS-A	TT32-CS-B	TT32-CS-C	TT32-CS-H	TT33-CS-A	TT33-CS-B	TT33-CS-C	TT34-CS-A
Sample Date			1/12/2007	1/23/2007	1/23/2007	1/23/2007	1/18/2007	1/18/2007	1/18/2007	1/16/2007	1/17/2007	1/13/2007	1/13/2007	1/13/2007	1/23/2007	1/23/2007	1/23/2007	1/17/2007
Sample Depth (MLLW)			-36 To -37 ft	-29 To -30 ft	-30 To -31 ft	-31 To -32 ft	-40.95 To -42 ft	-42 To -43 ft	-43 To -44 ft	-52.19 To -53 ft	-51.8 To -52.9 ft	-42 To -43 ft	-43 To -44 ft	-48 To -49.4 ft	-50.6 To -51 ft	-51 To -52 ft	-52 To -53 ft	-51.3 To -52 ft
Parameter	**Method**	**Units**																
4-Chloroaniline	EPA 8270C	ug/Kg	17 U	2.9 U	3.1 U	3.3 U	2.6 U	2.7 U	2.7 U	2.9 U UJ	16 U	3 U	3 U	2.9 U	3 U	2.9 U	2.9 U	5.9 U
4-Chlorophenyl phenyl ether	EPA 8270C	ug/Kg	16 U	2.8 U	3 U	3.1 U	2.5 U	2.5 U	2.5 U	2.8 U	15 U	2.9 U	2.9 U	2.8 U	2.9 U	2.8 U	2.7 U	5.7 U
4-Methylphenol	EPA 8270C	ug/Kg	23 U	4 U	6.7 J	7.8 J	3.6 U	3.7 U	3.7 U	4 U	22 U	4.2 U	4.2 U	4 U	12	4 U	3.9 U	8.2 U
4-Nitroaniline	EPA 8270C	ug/Kg	27 U	4.7 U	5 U	5.3 U	4.2 U	4.3 U	4.3 U	4.7 U	26 U	4.9 U	4.9 U	4.7 U	4.8 U	4.7 U	4.6 U	9.6 U
4-Nitrophenol	EPA 8270C	ug/Kg	240 U	42 U	44 U	47 U	37 U	38 U	38 U	41 U	230 U	43 U	43 U	42 U	43 U	41 U	41 U	85 U
Acenaphthene	EPA 8270C	ug/Kg	55 D	8.3 J	41	19	1.3 U	1.3 U	6.7 J	32	79 D	1.5 U	1.5 U	1.4 U	8.5 J	3.1 J	1.4 U	18 JD
		mg/kg OC	4.2 D	1.2 J	3.5	1.1				4.5	9.8 D	0.2 U	0.1 U	0.2 U	0.8 J	0.4 J	0.2 U	2.4 JD
Acenaphthylene	EPA 8270C	ug/Kg	80 D	9.4 J	50	37	1.8 U	1.8 U	7.8 J	66	73 D	2 U	2 U	2 U	8.7 J	5 J	1.9 U	20 D
		mg/kg OC	6.1 D	1.4 J	4.3	2.2				9.3	9.0 D	0.3 U	0.2 U	0.3 U	0.8 J	0.7 J	0.2 U	2.7 D
Aniline	EPA 8270C	ug/Kg	12 U	2.1 U	2.2 U	2.4 U	1.9 U	1.9 U	1.9 U	2.1 U	12 U	3.6 J	39	3.4 J	2.2 U	3.4 J	2.1 U	6.5 JD
Anthracene	EPA 8270C	ug/Kg	220 D	29	110	69	2.1 J	1.8 U	20	120	210 D	2 U	2 U	2 U	22	10	1.9 U	48 D
		mg/kg OC	16.7 D	4.2	9.4	4.0				16.9	25.9 D	0.3 U	0.2 U	0.3 U	2.0	1.4	0.2 U	6.4 D
Benzo(a)anthracene	EPA 8270C	ug/Kg	1000 D	28	96	83	4.4 J	2.6 J	50	230	570 D	2 U	2 U	2 U	39	15	1.9 U	110 D
		mg/kg OC	75.8 D	4.1	8.2	4.8				32.4	70.4 D	0.3 U	0.2 U	0.3 U	3.5	2.0	0.2 U	14.7 D
Benzo(a)pyrene	EPA 8270C	ug/Kg	670 D	41	110	91	8.6 J	5.1 J	72	410	750 D	2.3 U	2.3 U	2.2 U	49	20	2.2 U	140 D
		mg/kg OC	50.8 D	5.9	9.4	5.3				57.7	92.6 D	0.3 U	0.2 U	0.3 U	4.4	2.7	0.2 U	18.7 D
Benzo(b)fluoranthene	EPA 8270C	ug/Kg	1200 D	51	140	100	13	6.1 J	110	580	900 D	3.6 U	3.6 U	3.5 U	53	20	3.4 U	150 D
Benzo(g,h,i)perylene	EPA 8270C	ug/Kg	330 D	21	62	67	5.6 J	3.6 J	39	260	410 D	3.3 U	3.3 U	3.2 U	27	13	3.1 U	93 D
		mg/kg OC	25.0 D	3.0	5.3	3.9				36.6	50.6 D	0.5 U	0.3 U	0.4 U	2.4	1.8	0.3 U	12.4 D
Benzo(k)fluoranthene	EPA 8270C	ug/Kg	380 D	41	95	76	4.5 J	3.2 U	39	160	710 D	3.6 U	3.6 U	3.5 U	47	17	3.4 U	130 D
Benzofluoranthenes (total)	TT calculated	ug/Kg	1580	92	235	176	17.5	6.1	149	740	1610	3.6 U	3.6 U	3.5 U	100	37	3.4 U	280
		mg/kg OC	119.7	13.3	20.1	10.2				104.2	198.8	0.5 U	0.3 U	0.5 U	8.9	5.0	0.4 U	37.3
Benzoic acid	EPA 8270C	ug/Kg	740 U UJ	140 U	140 U	150 U	120 U	120 U	120 U	140 U	720 U	140 U UJ	140 U UJ	140 U UJ	140 U	140 U	130 U	270 U
Benzyl alcohol	EPA 8270C	ug/Kg	29 U	5.1 U	6.3 J	5.7 U	4.6 U	4.7 U	4.7 U	5.1 U	28 U	5.3 U	5.3 U	5.1 U	6.4 J	5.1 U	5 U	11 U
bis(2-chloroethoxy)methane	EPA 8270C	ug/Kg	10 U	1.8 U	1.9 U	2 U	1.6 U	1.7 U	1.7 U	1.8 U	9.8 U	1.9 U	1.9 U	1.8 U	1.9 U	1.8 U	1.8 U	3.7 U
bis(2-chloroethyl)ether	EPA 8270C	ug/Kg	19 U	3.3 U	3.5 U	3.7 U	3 U	3 U	3 U	3.3 U	18 U	3.5 U	3.5 U	3.3 U	3.4 U	3.3 U	3.3 U	6.8 U
bis(2-chloroisopropyl)ether	EPA 8270C	ug/Kg	9.3 U	1.7 U	1.8 U	1.9 U	1.5 U	1.5 U	1.5 U	1.7 U	9 U	1.8 U	1.8 U	1.7 U	1.7 U	1.7 U	1.7 U	3.4 U
bis(2-ethylhexyl)phthalate	EPA 8270C	ug/Kg	290 JD	20 J U	23 J U	9.1 J U	7.9 J U	13 J U	7.9 J U	140	430 JD	2.5 U	2.5 U	2.4 U	20 J U	8 J U	12 J U	41 JD U
		mg/kg OC	22.0 JD	2.9 J U	2.0 J U	0.5 J U	U	U	U	19.7	53.1 JD	0.4 U	0.2 U	0.3 U	1.8 J U	1.1 J U	1.3 J U	5.5 JD U
Butyl benzyl phthalate	EPA 8270C	ug/Kg	12 U	2.1 U	2.2 U	2.4 U	1.9 U	1.9 U	1.9 U	2.1 U	12 U	2.2 U	2.2 U	2.1 U	2.7 J	2.2 J	2.2 J	12 JD
		mg/kg OC	0.9 U	0.3 U	0.2 U	0.1 U				0.3 U	1.5 U	0.3 U	0.2 U	0.3 U	0.2 J	0.3 J	0.2 J	1.6 JD
Chrysene	EPA 8270C	ug/Kg	1300 D	41	120	93	6.7 J	3.1 J	81	290	700 D	2 U	2.2 J	2 U	48	18	1.9 U	130 D
		mg/kg OC	98.5 D	5.9	10.3	5.4				40.8	86.4 D	0.3 U	0.2 J	0.3 U	4.3	2.4	0.2 U	17.3 D
Dibenzo(a,h)anthracene	EPA 8270C	ug/Kg	110 D	5.3 J	17	14	2.7 U	2.8 U	11	56	120 D	3.2 U	3.2 U	3.1 U	7.1 J	3.6 J	3 U	26 D
		mg/kg OC	8.3 D	0.8 J	1.5	0.8				7.9	14.8 D	0.5 U	0.3 U	0.4 U	0.6 J	0.5 J	0.3 U	3.5 D
Dibenzofuran	EPA 8270C	ug/Kg	58 D	8.7 J	40	19	1.6 U	1.7 U	5.2 J	17	42 JD	1.9 U	1.9 U	1.8 U	6.3 J	3.8 J	1.8 U	14 JD
		mg/kg OC	4.4 D	1.3 J	3.4	1.1				2.4	5.2 JD	0.3 U	0.2 U	0.2 U	0.6 J	0.5 J	0.2 U	1.9 JD
Diethylphthalate	EPA 8270C	ug/Kg	27 U	4.9 U	5.2 U	5.4 U	4.3 U	4.4 U	4.4 U	4.8 U	27 U	5 U	5 U	4.9 U	5 U	4.8 U	4.7 U	9.9 U
		mg/kg OC	2.0 U	0.7 U	0.4 U	0.3 U				0.7 U	3.3 U	0.8 U	0.5 U	0.7 U	0.4 U	0.6 U	0.5 U	1.3 U
Dimethyl phthalate	EPA 8270C	ug/Kg	14 U	2.5 U	2.7 U	2.8 U	2.2 U	2.3 U	2.3 U	2.5 U	14 U	2.6 U	2.6 U	2.5 U	2.6 U	2.5 U	2.5 U	5.1 U
		mg/kg OC	1.1 U	0.4 U	0.2 U	0.2 U				0.4 U	1.7 U	0.4 U	0.2 U	0.3 U	0.2 U	0.3 U	0.3 U	0.7 U
Di-n-butyl phthalate	EPA 8270C	ug/Kg	22 JD	10 U	14 U	8.5 J U	5.7 J U	5.2 J U	6.2 J U	92	29 JD	3.7 U	3.8 U	3.6 U	8.9 J U	4.3 J U	5.9 J U	10 JD
		mg/kg OC	1.7 JD	1.4 U	1.2 U	0.5 J U	U	U	U	13.0	3.6 JD	0.6 U	0.4 U	0.5 U	0.8 J U	0.6 J U	0.6 J U	1.3 JD
Di-n-octyl phthalate	EPA 8270C	ug/Kg	9.3 U	1.7 U	1.8 U	1.9 U	1.5 U	1.5 U	1.5 U	1.7 U	9 U	1.8 U	1.8 U	1.7 U	1.7 U	1.7 U	1.7 U	3.4 U
		mg/kg OC	0.7 U	0.2 U	0.2 U	0.1 U				0.2 U	1.1 U	0.3 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.5 U
Fluoranthene	EPA 8270C	ug/Kg	640 D	77	290	220	5.5 J	4.1 J	93	420	1400 D	3.6 J	4.4 J	3.1 U	85	35	3 U	250 D
		mg/kg OC	48.5 D	11.2	24.8	12.8				59.2	172.8 D	0.5 J	0.4 J	0.4 U	7.6	4.7	0.3 U	33.3 D
Fluorene	EPA 8270C	ug/Kg	95 D	13	55	25	2.1 U	2.2 U	8.2 J	40	88 D	2.5 U	2.5 U	2.4 U	8.3 J	4.5 J	2.3 U	21 D
		mg/kg OC	7.2 D	1.9	4.7	1.5				5.6	10.9 D	0.4 U	0.2 U	0.3 U	0.7 J	0.6 J	0.3 U	2.8 D
Hexachlorobenzene	EPA 8081A	ug/Kg	2.5 U	0.11 U UJ	0.12 U UJ	0.13 U UJ	0.097 U	0.099 U	0.099 U	2.2 U	2.4 U	0.57 U	0.57 U	0.55 U	0.12 U UJ	0.11 U UJ	0.11 U UJ	2.3 U
		mg/kg OC	0.2 U	0.02 U UJ	0.01 U UJ	0.01 U UJ				0.3 U	0.3 U	0.1 U	0.1 U	0.1 U	0.01 U UJ	0.01 U UJ	0.01 U UJ	0.3 U
Hexachlorobenzene	EPA 8270C	ug/Kg																
		mg/kg OC																
Hexachlorobutadiene	EPA 8081A	ug/Kg		0.68 U UJ	0.72 U UJ	0.76 U UJ	0.6 U	0.61 U	0.62 U						0.69 U UJ	0.67 U UJ	0.66 U UJ	
		mg/kg OC		0.1 U UJ	0.1 U UJ	0.0 U UJ									0.1 U UJ	0.1 U UJ	0.1 U UJ	0.0
Hexachlorobutadiene	EPA 8270C	ug/Kg	11 U							1.9 U	11 U	2 U	2 U	2 U				4 U
		mg/kg OC	0.8 U	0.0	0.0	0.0				0.3 U	1.4 U	0.3 U	0.2 U	0.3 U	0.0	0.0	0.0	0.5 U
Hexachlorocyclopentadiene	EPA 8270C	ug/Kg	120 U	21 U UJ	22 U UJ	24 U UJ	19 U	19 U	19 U	21 U	120 U UJ	22 U	22 U	21 U	22 U UJ	21 U UJ	21 U UJ	43 U
Hexachloroethane	EPA 8270C	ug/Kg	17 U	3.1 U	3.3 U	3.4 U	2.7 U	2.8 U	2.8 U	3 U	17 U	3.2 U	3.2 U	3.1 U	3.1 U	3 U	3 U	6.2 U
Indeno(1,2,3-cd)pyrene	EPA 8270C	ug/Kg	400 D	22	59	62	5.7 J	2.9 J	41	270	460 D	2.7 U	2.8 U	2.7 U	29	14	2.6 U	98 D
		mg/kg OC	30.3 D	3.2	5.0	3.6				38.0	56.8 D	0.4 U	0.3 U	0.4 U	2.6	1.9	0.3 U	13.1 D
Isophorone	EPA 8270C	ug/Kg	13 U	2.2 U	2.4 U	2.5 U	2 U	2 U	2 U	2.2 U	12 U	2.3 U	2.3 U	2.2 U	2.3 U	2.2 U	2.2 U	4.5 U
Naphthalene	EPA 8270C	ug/Kg	120 D	17	140	90	1.7 J	1.7 U	13	30	62 D	1.9 U	1.9 U	1.8 U	15	9.9 J	1.8 U	29 D
		mg/kg OC	9.1 D	2.5	12.0	5.2				4.2	7.7 D	0.3 U	0.2 U	0.2 U	1.3	1.3 J	0.2 U	3.9 D
Nitrobenzene	EPA 8270C	ug/Kg	16 U	2.8 U	3 U	3.1 U	2.5 U	2.5 U	2.5 U	2.8 U	15 U	2.9 U	2.9 U	2.8 U	2.9 U	2.8 U	2.7 U	5.7 U
N-Nitrosodimethylamine	EPA 8270C	ug/Kg	47 U	8.4 U UJ	8.9 U UJ	9.4 U UJ	7.5 U	7.6 U	7.7 U	8.3 U	46 U	8.7 U	8.8 U	8.4 U	8.6 U	8.3 U	8.2 U	18 U
N-Nitroso-di-n-propylamine	EPA 8270C	ug/Kg	25 U	4.4 U	4.7 U	5 U	3.9 U	4 U	4 U	4.4 U	24 U	4.6 U	4.6 U	4.4 U	4.5 U	4.4 U	4.3 U	9 U
N-Nitrosodiphenylamine	EPA 8270C	ug/Kg	17 U	3.1 U	3.3 U	3.4 U	2.7 U	2.8 U	2.8 U	3 U	17 U	3.2 U	3.2 U	3.1 U	3.1 U	3 U	3 U	6.2 U
		mg/kg OC	1.3 U	0.4 U	0.3 U	0.2 U				0.4 U	2.1 U	0.5 U	0.3 U	0.4 U	0.3 U	0.4 U	0.3 U	0.8 U
Pentachlorophenol	EPA 8270C	ug/Kg	66 U	12 U	13 U	14 U	11 U	11 U	11 U	13 J	64 U	13 U	13 U	12 U	12 U	12 U	12 U	24 U
Phenanthrene	EPA 8270C	ug/Kg	300 D	55	240	120	4.2 J	2.2 J	27	260	730 D	3.2 J	5.6 J	1.8 U	56	24	3 J	160 D
		mg/kg OC	22.7 D	8.0	20.5	7.0				36.6	90.1 D	0.5 J	0.5 J	0.2 U	5.0	3.2	0.3 J	21.3 D
Phenol	EPA 8270C	ug/Kg	15 U	19 J	22 J	12 J	2.4 U	2.4 U	2.4 U	2.6 U	19 JD	6.9 J	3.3 J	4 J	8.2 J	4.6 J	4.5 J	13 JD
Pyrene	EPA 8270C	ug/Kg	2500 D	150	330	310	25	17	280	800 D	880 D	3.9 J	2.4 J	1.8 U	75	46	3.1 J	240 D
		mg/kg OC	189.4 D	21.7	28.2	18.0				112.7 D	108.6 D	0.6 J	0.2 J	0.2 U	6.7	6.2	0.3 J	32.0 D
Total HPAH	TT calculated	ug/Kg	8530	477.3	1319	1116	79	44.5	816	3476	6900	7.5	9	3.5 U	459.1	201.6	3.1	1367
		mg/kg OC	646.2	69.2	112.7	64.9				489.6	851.9	1.1	0.8	0.5 U	41.0	27.2	0.3	182.3
Total LPAH	TT calculated	ug/Kg	870	131.7	636	360	8	2.2	82.7	548	1242	3.2	5.6	2.4 U	118.5	56.5	3	296
		mg/kg OC	65.9	19.1	54.4	20.9				77.2	153.3	0.5	0.5	0.3 U	10.6	7.6	0.3	39.5
Total PAH	TT calculated	ug/Kg	9400	609	1955	1476	87	46.7	898.7	4024	8142	10.7	14.6	3.5 U	577.6	258.1	6.1	1663
Butyltin	KRONE	ug/Kg	1.3 J	0.042 U	0.38 J J	0.35 Ui	0.037 U	0.038 U	0.038 U	0.041 U	13	0.043 U	0.043 U	0.042 U	0.29 Ui	0.041 U	0.041 U	1.6
Dibutyltin	KRONE	ug/Kg	15	2.6	2	1.4 J	0.34 J U	0.18 Ui	0.37 J U	3.7	160 D	0.69 J U	0.47 J U	0.55 J U	7.2	0.8 J U	0.33 JP UJ	24
Tetrabutyltin	KRONE	ug/Kg	1.5 JP J	0.097 U	0.11 U	0.11 U	0.086 U	0.088 U	0.088 U	0.096 U	10	0.1 U	0.1 U	0.097 U	0.099 U	0.096 U	0.094 U	0.98 J
Tributyltin	KRONE	ug/Kg	50	5.3	3.6	3.2	0.47 J	0.23 Ui	0.07 U	14	480 D	0.55 J	0.08 U	0.26 Ui	16	2.4	0.075 U	63
		mg/kg OC	3.8	0.8	0.3	0.2				2.0	59.3 D	0.083 J	0.008 U	0.035 Ui	1.4	0.32	0.008 U	8.4
Total Solids	EPA 160.3	Percent	65.2	72.9	68.6	65.2	82.1	80.6	78.7	73.6	67	70.5	70.1	72.9	71.4	73.5	74.7	71.4

Table A-1. 2007 Remedial Investigation Subsurface Cores Analytical Data

Location			26	27	27	27	29	29	29	30	31	32	32	32	33	33	33	34
Sample ID			TT26-CS-G	TT27B-CS-B	TT27B-CS-C	TT27B-CS-D	TT29-CS-A	TT29-CS-B	TT29-CS-C	TT30-CS-A	TT31-CS-A	TT32-CS-B	TT32-CS-C	TT32-CS-H	TT33-CS-A	TT33-CS-B	TT33-CS-C	TT34-CS-A
Sample Date			1/12/2007	1/23/2007	1/23/2007	1/23/2007	1/18/2007	1/18/2007	1/18/2007	1/16/2007	1/17/2007	1/13/2007	1/13/2007	1/13/2007	1/23/2007	1/23/2007	1/23/2007	1/17/2007
Sample Depth (MLLW)			-36 To -37 ft	-29 To -30 ft	-30 To -31 ft	-31 To -32 ft	-40.95 To -42 ft	-42 To -43 ft	-43 To -44 ft	-52.19 To -53 ft	-51.8 To -52.9 ft	-42 To -43 ft	-43 To -44 ft	-48 To -49.4 ft	-50.6 To -51 ft	-51 To -52 ft	-52 To -53 ft	-51.3 To -52 ft
Parameter	**Method**	**Units**																
Total Organic Carbon	ASTM D4129-98M	Percent	1.32	0.69	1.17	1.72	0.09	0.09	0.26	0.71	0.81	0.66	1.06	0.75	1.12	0.74	0.92	0.75
Fractional % phi >-1	PSEP Grain Size	Percent	2.46	0.31	0.42	1.61	0.13	0.09	0.53	0.39	0.71	0.4	0.38	0.24	0.64	0.36	0.41	1.19
Fractional % phi 0-1	PSEP Grain Size	Percent	2.78	1.14	0.7	0.87	1.99	2.55	2.3	0.81	1.22	0.6	0.48	0.19	3.07	1.86	0.8	5.65
Fractional % phi 1-2	PSEP Grain Size	Percent	13.1	16.39	8.21	3.44	43.2	50.83	42.43	14.6	5.7	3.61	3.15	0.46	20.7	18.26	1.98	14.1
Fractional % phi 2-3	PSEP Grain Size	Percent	26.4	42.9	31.66	14.44	45.2	38.59	39.28	37.8	25	26.1	22.4	13.6	34.57	24.9	18.01	21.4
Fractional % phi 3-4	PSEP Grain Size	Percent	21.1	21.38	25.74	15.92	5.14	4.61	8.63	23.4	30.8	25	23.3	29.8	18.77	22.29	19.11	17.4
Fractional % phi 4-5	PSEP Grain Size	Percent	11	10.58	12.59	14.58	0.56	0.42	0.88	7.36	12.4	14.9	18.3	16.4	12.1	13.84	20.66	12.3
Fractional % phi 5-6	PSEP Grain Size	Percent	6.96	4.3	7.7	20.6	0.3	0.2	0.7	4.64	6.49	8.82	11.8	15.1	7	9.5	21.6	8.5
Fractional % phi 6-7	PSEP Grain Size	Percent	4.44	2.46	5.78	8.9	0	0.22	0.62	3.09	4.92	5.62	6.68	9.27	3.18	4.41	10.16	5.72
Fractional % phi 7-8	PSEP Grain Size	Percent	2.73	1.38	3.41	8.01	56.17	0.08	0.49	1.76	3.61	3.21	3.96	4.49	2.33	2.9	5.29	3.32
Fractional % phi 8-9	PSEP Grain Size	Percent	1.47	0.99	2.72	5.07	0.1	0.07	0.32	1.31	2.96	2.22	2.27	2.77	1.36	2.02	3.07	2.34
Fractional % phi 9-10	PSEP Grain Size	Percent	1.34	0	3.6	3.61	0	0	0.04	1.26	2.91	1.71	1.71	1.91	1.23	1.36	2.52	2.05
Fractional % phi >10	PSEP Grain Size	Percent	2.31	2.87	2.04	7.06	0.76	0.78	0.94	2.14	4.53	2.29	2.38	2.78	2.08	2.48	4.24	3.46
Gravel	PSEP Grain Size	Percent	2.57	0.37	0.74	2.36	0.28	0.13	0.94	0.29	0.45	0.21	0.04	0.02	0.87	0.55	0.62	0.88

Notes:
0.14 U J = Result followed by laboratory data qualifier followed by data validator qualifier
Sample depth (MLLW) = the core increment elevation in mean lower low water
mg/kg = milligrams per kilogram
ug/kg = micrograms per kilogram
mg/L = milligrams per liter
ug/L = micrograms per liter
ng/L = nanograms per liter

Laboratory Data Qualifiers
U = result was not detected at or above the method detection limit
J (for organics) = result is an estimated concentration that is less than the reporting limit but greater than or equal to the detection limit
B (for metals) = result is an estimated concentration that is less than the reporting limit but greater than or equal to the detection limit
* (for metals) = duplicate analysis not within control limits. See case narrative (in laboratory report)
D (for organics) = result reported is from a dilution
P (for organics) = The GC or HPLC confirmation criteria was exceeded. The relative percent difference is greater than 40% between the two analytical results.
i (for organics) = the MRL/MDL has been elevated due to a chromatographic interference.

Data Validation Qualifiers
U = Result should be considered not-detected at the quantitation limit shown
J = Result is an estimated concentration
R = Rejected - Quality Control indicates the data is not usable
UJ = The compound was not detected and the sample detection limit should be considered an estimated value
N - Pesticide result is tentatively identified.

Table A-1. 2007 Remedial Investigation Subsurface Cores Analytical Data

Location			34	35	35	35	37	37	37	39	39	39	42	42	42	RB	
Sample ID			TT34-CS-B	TT35-CS-B	TT35-CS-C	TT35-CS-D	TT37-CS-A	TT37-CS-B	TT37-CS-C	TT39-CS-A	TT39-CS-B	TT39-CS-C	TT42-CS-B	TT42-CS-C	TT42-CS-D	RB-CS-1	
Sample Date			1/17/2007	1/15/2007	1/15/2007	1/15/2007	1/13/2007	1/13/2007	1/13/2007	1/12/2007	1/12/2007	1/12/2007	1/23/2007	1/23/2007	1/23/2007	1/15/2007	
Sample Depth (MLLW)			-52 To -53 ft	-50 To -51 ft	-51 To -52 ft	-52 To -53 ft	-40.9 To -42 ft	-42 To -43 ft	-43 To -44 ft	-42.8 To -44 ft	-44 To -45 ft	-45 To -46 ft	-50 To -51 ft	-51 To -52 ft	-52 To -53 ft	To ft	
Parameter	**Method**	**Units**															**Units**
Antimony	EPA 6020	mg/Kg	0.31 * J	2.6 * J	0.19 * J	0.16 * J	5.89	0.64	0.13	1.23	1.26	0.28	1.02	0.357	0.145	0.02 U	ug/L
Arsenic	EPA 6020	mg/Kg	3.8	6.53	4.79	3.85	7.75	2.38	2.59	10.3 J	8.79 J	4.88	10.5	7.18	4.93	0.05 U	ug/L
Cadmium	EPA 6020	mg/Kg	0.132	0.304	0.229	0.176	0.066	0.041 B	0.089	0.607	0.468	0.242	0.43	0.378	0.204	0.02 U	ug/L
Chromium	EPA 6010B	mg/Kg	16.6	23	24.8	18.9	18.3	12.9	12.5	34.1	32.1	19.3	24.6	25.5	18.2	0.2 B	ug/L
Cobalt	EPA 6020	mg/Kg	4.14	5.57	5.74	4.71	3.55	3.14	3.52	7.2 J	6.69 J	4.9	6.05 J	6.85 J	5.56 J	0.008 U	ug/L
Copper	EPA 6010B	mg/Kg	25.4	39.6	30.7	23.7	23.6	10	13.4	71.5	75.1	31.2	63	48.7	30.1	0.18	ug/L
Lead	EPA 6020	mg/Kg	9.24	32.5	16.6	7.64	15.6	4.76	4.87	45.1	51.5	14.1	42.5 J	26.9 J	6.88 J	0.075	ug/L
Mercury	EPA 7471A	mg/Kg	0.148	0.456	0.296	0.139	0.032	0.019	0.075	0.332	0.446	0.151	1.03 * J	0.656 * J	0.146 * J	0.02 U	ug/L
Molybdenum	EPA 6020	mg/Kg	0.64	1.34	1.27	1.22	0.58	0.4	0.43	2.86	1.74	1.46	1.77	1.99	1.06	0.02 U	ug/L
Nickel	EPA 6020	mg/Kg	9.34	17.6	17.3	11.8	7.99	6.86	7.53	17.3 J	15.6 J	10.8	14.8 J	17.3 J	12.2 J	0.5	ug/L
Selenium	EPA 6020	mg/Kg	0.4 U	0.4 U	0.5 U	0.5 B	0.2 B	0.2 B	0.2 B	0.7 B	0.6 B	0.5 B	0.4 U	0.4 U	0.4 U	0.2 U	ug/L
Silver	EPA 6020	mg/Kg	0.1	0.241	0.148	0.134	0.064	0.043	0.071	0.292	0.361	0.135	0.338	0.225	0.104	0.007 U	ug/L
Thallium	EPA 6020	mg/Kg	0.066	0.093	0.095	0.088	0.05	0.03	0.05	0.17	0.16	0.1	0.11	0.115	0.1	0.008 U	ug/L
Vanadium	EPA 6010B	mg/Kg	47	51.6	55.7	53.7	36.5	39.8	39.8	65.2	63	51.5	55.9	63.5	51.2	0.04 B	ug/L
Zinc	EPA 6010B	mg/Kg	37.6	59	50.6	36.9	64	27.6	27.2	123	125	48.6	92.8	68.6	41.1	9.2	ug/L
PCBs (total)	TT calculated	ug/Kg	30	99	7.2	2.5 U	85	27	5.4	321	432	47	77	73	15.6	0.001 U	ug/L
		mg/kg OC	4.5	10.5	0.5	0.2 U				13.3	19.8	4.4	4.1	3.5	1.2		
PCB-1016	EPA 8082	ug/Kg	2.4 U UJ	2.5 U	2.4 U	2.5 U	2.3 U	2.3 U	2.3 U	15 U	15 U	2.6 U UJ	2.6 U	2.7 U	2.7 U	0.001 U UJ	ug/L
PCB-1221	EPA 8082	ug/Kg	2.4 U UJ	2.5 U	2.4 U	2.5 U	2.3 U	2.3 U	2.3 U	15 U	15 U	2.6 U UJ	2.6 U	2.7 U	2.7 U	0.001 U UJ	ug/L
PCB-1232	EPA 8082	ug/Kg	2.4 U UJ	2.5 U	2.4 U	2.5 U	2.3 U	2.3 U	2.3 U	15 U	15 U	2.6 U UJ	2.6 U	2.7 U	2.7 U	0.001 U UJ	ug/L
PCB-1242	EPA 8082	ug/Kg	2.4 U	2.5 U	2.4 U	2.5 U	2.3 U UJ	2.3 U	2.3 U	15 U	15 U	2.6 U UJ	2.6 U	2.7 U	2.7 U	0.001 U	ug/L
PCB-1248	EPA 8082	ug/Kg	2.4 U	2.5 U	2.4 U	2.5 U	2.3 U UJ	2.3 U	2.3 U	15 U	15 U	2.6 U UJ	2.6 U	2.7 U	2.7 U	0.001 U	ug/L
PCB-1254	EPA 8082	ug/Kg	15	53	3.7 J	2.5 U	85 J	27	5.4	190 D	240 D	26 J	39	49	7.6	0.001 U	ug/L
PCB-1260	EPA 8082	ug/Kg	15	46	3.5 J	2.5 U	2.3 U UJ	2.3 U	2.3 U	110 D	150 D	21 J	38	24	8	0.001 U	ug/L
PCB-1262	EPA 8082	ug/Kg	2.4 U	2.5 U	2.4 U	2.5 U	2.3 U UJ	2.3 U	2.3 U	15 U	15 U	2.6 U UJ	2.6 U	2.7 U	2.7 U		
PCB-1268	EPA 8082	ug/Kg	2.4 U	2.5 U	2.4 U	2.5 U	2.3 U UJ	2.3 U	2.3 U	21 D	42 D	2.6 U UJ	2.6 U	2.7 U	2.7 U		
Aldrin	EPA 8081A	ug/Kg	0.21 U UJ	0.22 U UJ	0.22 U UJ	0.22 U UJ	0.99 U UJ	0.98 U UJ	0.2 U UJ	5.2 U UJ	5.1 U UJ	4.5 U UJ	0.4 Ui UJ	0.24 U UJ	0.24 U UJ	0.054 U UJ	ng/L
alpha-BHC	EPA 8081A	ug/Kg	0.36 U UJ	0.38 U UJ	0.37 U UJ	0.38 U UJ	1.8 U UJ	1.7 U UJ	0.35 U UJ	8.9 U UJ	8.8 U UJ	7.8 U UJ	0.39 U UJ	0.4 U UJ	0.4 U UJ	0.06 U UJ	ng/L
alpha-Chlordane	EPA 8081A	ug/Kg	0.32 U UJ	0.34 U UJ	0.33 U UJ	0.34 U UJ	1.6 U UJ	1.5 U UJ	0.31 U UJ	7.9 U UJ	7.8 U UJ	6.9 U UJ	0.35 U UJ	0.36 U UJ	0.36 U UJ	0.41 J JN	ng/L
beta-BHC	EPA 8081A	ug/Kg	0.41 U UJ	0.44 U UJ	0.43 U UJ	0.66 Ui UJ	2 U UJ	2 U UJ	0.4 U UJ	11 U UJ	11 U UJ	9 U UJ	0.45 U UJ	0.47 U UJ	0.47 U UJ	0.9 Ui UJ	ng/L
delta-BHC	EPA 8081A	ug/Kg	0.075 U UJ	0.49 Ui UJ	0.16 Ui UJ	0.11 Ui UJ	0.37 U UJ	0.36 U UJ	0.072 U UJ	1.9 U UJ	1.9 U UJ	1.7 U UJ	0.58 JN	0.31 Ui UJ	0.085 U UJ	0.18 U UJ	ng/L
Dieldrin	EPA 8081A	ug/Kg	0.4 U UJ	0.42 U UJ	0.41 U UJ	0.43 U UJ	2 U UJ	1.9 U UJ	0.38 U UJ	9.9 U UJ	9.8 U UJ	8.7 U UJ	1.7 Ui UJ	2 Ui UJ	0.45 U UJ	0.4 U UJ	ng/L
Endosulfan I	EPA 8081A	ug/Kg	0.24 U UJ	0.25 U UJ	0.24 U UJ	0.25 U UJ	1.2 U UJ	1.2 U UJ	0.23 U UJ	5.8 U UJ	5.8 U UJ	5.1 U UJ	0.26 U UJ	0.27 U UJ	0.27 U UJ	0.067 U UJ	ng/L
Endosulfan II	EPA 8081A	ug/Kg	0.26 U UJ	0.28 U UJ	0.49 Ui UJ	0.28 U UJ	1.3 U UJ	1.3 U UJ	0.25 U UJ	6.5 U UJ	6.4 U UJ	5.7 U UJ	0.29 U UJ	0.3 U UJ	0.3 U UJ	0.5 Ui UJ	ng/L
Endosulfan sulfate	EPA 8081A	ug/Kg	0.37 Ui UJ	0.12 U UJ	0.3 Ui UJ	0.17 Ui UJ	0.53 U UJ	0.52 U UJ	0.11 U UJ	2.7 U UJ	2.7 U UJ	2.4 U UJ	0.68 Ui UJ	0.13 U UJ	0.19 Ui UJ	0.062 U UJ	ng/L
Endrin	EPA 8081A	ug/Kg	0.28 U UJ	0.29 U UJ	0.29 U UJ	0.3 U UJ	1.4 U UJ	1.4 U UJ	0.27 U UJ	6.9 U UJ	6.8 U UJ	6 U UJ	0.41 Ui UJ	0.31 U UJ	0.31 U UJ	0.083 U UJ	ng/L
Endrin aldehyde	EPA 8081A	ug/Kg	0.29 Ui UJ	0.5 Ui UJ	0.23 Ui UJ	0.15 J UJ	0.83 JPD UJ	0.35 U UJ	0.17 Ui UJ	2.5 Ui UJ	1.8 U UJ	1.6 U UJ	0.96 P UJ	0.57 UJ	0.25 Ui UJ	1.1 P JN	ng/L
gamma-BHC	EPA 8081A	ug/Kg	0.21 U UJ	0.86 Ui UJ	1.1 UJ	1.3 P JN	0.99 U UJ	0.98 U UJ	0.2 U UJ	5.2 U UJ	5.1 U UJ	4.5 U UJ	2.6 P UJ	2.7 P UJ	0.24 U UJ	1.7 B UJ	ng/L
gamma-Chlordane	EPA 8081A	ug/Kg	0.61 P JN	1.5 P JN	0.09 U UJ	0.16 JP JN	2.3 JPD JN	0.64 JPD JN	0.084 U UJ	2.2 U UJ	9.8 JPD JN	2 U UJ	0.76 P JN	1 P JN	0.16 J JN	0.15 U UJ	ng/L
Heptachlor	EPA 8081A	ug/Kg	0.2 Ui UJ	0.34 Ui UJ	0.26 Ui UJ	0.31 Ui UJ	0.53 U UJ	0.53 U UJ	0.11 U UJ	2.8 U UJ	2.7 U UJ	2.4 U UJ	0.12 U UJ	0.13 U UJ	0.13 U UJ	0.1 U UJ	ng/L
Heptachlor epoxide	EPA 8081A	ug/Kg	0.18 U UJ	0.5 Ui UJ	0.19 U UJ	0.19 U UJ	2.5 Ui UJ	0.85 U UJ	0.3 J JN	4.5 U UJ	4.4 U UJ	3.9 U UJ	0.2 U UJ	0.2 U UJ	0.2 U UJ	0.5 Ui UJ	ng/L
Methoxychlor	EPA 8081A	ug/Kg	0.14 U UJ	0.99 P JN	1.1 P JN	0.15 U UJ	0.66 U UJ	0.94 Ui UJ	0.14 U UJ	3.5 U UJ	3.4 U UJ	3 U UJ	0.58 Ui UJ	0.64 Ui UJ	0.16 U UJ	0.62 Ui UJ	ng/L
Mirex	EPA 8081A	ug/Kg	0.14 U UJ	0.15 U UJ	0.17 Ui UJ	0.15 U UJ	0.66 U UJ	0.66 U UJ	0.14 U UJ	3.5 U UJ	3.4 U UJ	3 U UJ	0.26 J JN	0.16 U UJ	0.16 U UJ	0.27 U UJ	ng/L
Nonachlor (cis)	EPA 8081A	ug/Kg	0.36 Ui UJ	0.54 Ui UJ	0.37 Ui UJ	0.13 U UJ	4.3 Ui UJ	1.3 Ui UJ	0.19 Ui UJ	3.5 Ui UJ	8.2 Ui UJ	2.5 U UJ	1.3 Ui UJ	0.81 Ui UJ	0.23 Ui UJ	0.5 Ui UJ	ng/L
Nonachlor (trans)	EPA 8081A	ug/Kg	0.13 U UJ	0.65 Ui UJ	0.13 U UJ	0.13 U UJ	2 Ui UJ	0.59 U UJ	0.12 U UJ	3.1 U UJ	3 U UJ	2.7 U UJ	0.14 U UJ	0.5 Ui UJ	0.14 U UJ	0.5 Ui UJ	ng/L
Oxychlordane	EPA 8081A	ug/Kg	0.51 U UJ	0.54 U UJ	0.52 U UJ	0.54 U UJ	2.5 U UJ	3.2 Ui UJ	0.66 Ui UJ	13 U UJ	13 U UJ	11 U UJ	0.55 U UJ	0.57 U UJ	0.57 U UJ	4 Ui UJ	ng/L
Toxaphene	EPA 8081A	ug/Kg	20 Ui UJ	36 Ui UJ	17 Ui UJ	14 U UJ	80 Ui UJ	59 U UJ	12 U UJ	310 U UJ	310 U UJ	270 U UJ	51 Ui UJ	31 Ui UJ	14 U UJ	52 Ui UJ	ng/L
o,p'-DDD	EPA 8081A	ug/Kg	1.6 P JN	3.8 P JN	0.41 JP JN	0.31 U UJ	3.3 Ui UJ	1.4 U UJ	0.78 JN	17 PD JN	24 D JN	6.3 U UJ	2.4 P JN	0.94 Ui UJ	0.45 J JN	0.94 U UJ	ng/L
o,p'-DDE	EPA 8081A	ug/Kg	0.84 Ui UJ	2.2 Ui UJ	0.33 U UJ	0.34 U UJ	2.5 Ui UJ	1.5 U UJ	0.31 U UJ	9.7 Ui UJ	7.8 U UJ	6.9 U UJ	0.59 Ui UJ	0.36 U UJ	0.36 U UJ	0.25 U UJ	ng/L
o,p'-DDT	EPA 8081A	ug/Kg	0.91 Ui UJ	2.2 JN	0.2 U UJ	0.21 U UJ	8.3 D JN	2.3 JD JN	0.33 J JN	10 D JN	14 D JN	4.2 U UJ	1.3 JN	1.5 JN	0.22 U UJ	0.2 U UJ	ng/L
p,p'-DDD	EPA 8081A	ug/Kg	0.54 JN	0.44 J JN	0.17 U UJ	0.18 U UJ	0.8 U UJ	1.7 Ui UJ	0.54 Ui UJ	4.1 U UJ	4.3 JD JN	3.6 U UJ	1.2 P JN	0.5 Ui UJ	0.5 Ui UJ	3.4 Ui UJ	ng/L
p,p'-DDE	EPA 8081A	ug/Kg	0.14 U UJ	1.1 P JN	0.15 U UJ	0.15 U UJ	0.66 U UJ	3.2 Ui UJ	0.5 Ui UJ	3.5 U UJ	3.4 U UJ	3 U UJ	0.15 U UJ	0.71 P JN	0.16 U UJ	2.3 Ui UJ	ng/L
p,p'-DDT	EPA 8081A	ug/Kg	1.6 Ui UJ	3.4 JN	0.37 Ui UJ	0.094 U UJ	10 D JN	3.4 D JN	0.28 JP JN	15 Ui UJ	19 D JN	2.9 JPD JN	3.2 JN	2.5 JN	0.47 J JN	0.33 U UJ	ng/L
Total DDT	TT calculated	ug/Kg	2.14 JN	10.94 JN	0.41 JN	0.34 U UJ	18.3 JN	5.7 JN	1.39 JN	27 JN	61.3 JN	2.9 JN	8.1 JN	4.71 JN	0.92 JN	3.4 U UJ	ng/L
Total chlordane	TT calculated	ug/Kg	0.61 JN	1.5 JN	0.52 U UJ	0.16 JN	2.3 JN	0.64 JN	0.66 U UJ	13 U UJ	9.8 JN	11 U UJ	0.76 JN	1 JN	0.16 JN	0.41 JN	ng/L
1,2,4-Trichlorobenzene	EPA 8270C	ug/Kg	2.1 U	4.4 U	2.2 U	2.2 U	2 U	2 U	2 U	2.6 U	2.6 U	2.3 U	2.3 U	2.4 U	2.4 U	0.016 U	ug/L
		mg/kg OC	0.3 U	0.5 U	0.2 U	0.2 U				0.1 U	0.1 U	0.2 U	0.1 U	0.1 U	0.2 U		
1,2-Dichlorobenzene	EPA 8270C	ug/Kg	1.8 U	3.8 U	1.9 U	1.9 U	1.8 U	1.7 U	1.8 U	2.3 U UJ	2.2 U UJ	2 U UJ	2 U	2 U	2 U	0.015 U	ug/L
		mg/kg OC	0.3 U	0.4 U	0.1 U	0.2 U				0.1 U UJ	0.1 U UJ	0.2 U UJ	0.1 U	0.1 U	0.1 U		
1,3-Dichlorobenzene	EPA 8270C	ug/Kg	2.2 U	4.6 U	2.3 U	2.4 U	2.2 U	2.1 U	2.1 U	2.8 U	2.7 U	2.4 U	2.4 U	2.5 U	2.5 U	0.011 U	ug/L
1,4-Dichlorobenzene	EPA 8270C	ug/Kg	2.6 U	5.5 U	2.7 U	2.8 U	2.6 U	2.5 U	2.5 U	3.3 U	3.2 U	2.9 U	2.9 U	3 U	3 U	0.014 U	ug/L
		mg/kg OC	0.4 U	0.6 U	0.2 U	0.2 U				0.1 U	0.1 U	0.3 U	0.2 U	0.1 U	0.2 U		
1-Methylnaphthalene	EPA 8270C	ug/Kg	14 U UJ	29 U UJ	15 U UJ	15 U UJ	14 U UJ	14 U UJ	14 U UJ	42 J	23 J	15 U UJ	21 J	28 J	16 U UJ	0.2 U UJ	ug/L
2,4,5-Trichlorophenol	EPA 8270C	ug/Kg	4.1 U	8.7 U	4.3 U	4.4 U	4 U	4 U	4 U	5.2 U	5.1 U	4.5 U	4.5 U	4.7 U	4.7 U	0.026 U	ug/L
2,4,6-Trichlorophenol	EPA 8270C	ug/Kg	2.5 U	5.2 U	2.6 U	2.7 U	2.4 U	2.4 U	2.4 U	3.1 U	3.1 U	2.7 U	2.7 U	2.8 U	2.8 U	0.037 U	ug/L
2,4-Dichlorophenol	EPA 8270C	ug/Kg	2.5 U	5.2 U	2.6 U	2.7 U	2.4 U	2.4 U	2.4 U	3.1 U	3.1 U	2.7 U	2.7 U	2.8 U	2.8 U	0.024 U	ug/L
2,4-Dimethylphenol	EPA 8270C	ug/Kg	7.5 U	16 U	7.8 U	8 U	7.3 U	7.2 U	7.2 U	9.4 U	9.3 U	8.2 U	8.2 U	8.5 U	8.5 U	0.32 U	ug/L
2,4-Dinitrophenol	EPA 8270C	ug/Kg	49 U UJ	110 U UJ	51 U UJ	53 U UJ	48 U	47 U	48 U	62 U	61 U	54 U	54 U	56 U	56 U	0.53 U UJ	ug/L
2,4-Dinitrotoluene	EPA 8270C	ug/Kg	3.8 U	8.1 U	4 U	4.1 U	3.7 U	3.7 U	3.7 U	4.8 U	4.8 U	4.2 U	4.2 U	4.4 U	4.3 U	0.02 U	ug/L
2,6-Dinitrotoluene	EPA 8270C	ug/Kg	3.8 U	8.1 U	4 U	4.1 U	3.7 U	3.7 U	3.7 U	4.8 U	4.8 U	4.2 U	4.2 U	4.4 U	4.3 U	0.0088 U	ug/L
2-Chloronaphthalene	EPA 8270C	ug/Kg	4.9 U	11 U	5.1 U	5.3 U	4.8 U	4.7 U	4.8 U	6.2 U	6.1 U	5.4 U	5.4 U	5.6 U	5.6 U	0.016 U	ug/L
2-Chlorophenol	EPA 8270C	ug/Kg	2.4 U	4.9 U	2.4 U	2.5 U	2.3 U	2.3 U	2.3 U	2.9 U	2.9 U	2.6 U	2.6 U	2.7 U	2.7 U	0.015 U	ug/L
2-Methylnaphthalene	EPA 8270C	ug/Kg	4 J	21 D	20	9.2 J	1.6 U	1.6 U	2.3 J	74	47	22	41	58	9 J	0.012 U	ug/L
		mg/kg OC	0.6 J	2.2 D	1.4	0.8 J				3.1	2.2	2.1	2.2	2.8	0.7 J		
2-Methylphenol	EPA 8270C	ug/Kg	4.7 U	9.8 U	4.8 U	5 U	4.5 U	4.5 U	4.5 U	5.8 U	5.8 U	5.1 U	5.1 U	5.3 U	5.3 U	0.06 U	ug/L
2-Nitroaniline	EPA 8270C	ug/Kg	3.7 U	7.8 U	3.8 U	4 U	3.6 U	3.6 U	3.6 U	4.6 U	4.6 U	4.1 U	4 U	4.2 U	4.2 U	0.015 U	ug/L
2-Nitrophenol	EPA 8270C	ug/Kg	3.6 U	7.5 U	3.7 U	3.8 U	3.5 U	3.4 U	3.5 U	4.5 U	4.4 U	3.9 U	3.9 U	4 U	4 U	0.014 U	ug/L
3,3'-Dichlorobenzidine	EPA 8270C	ug/Kg	5.1 U	11 U	5.2 U	5.4 U	4.9 U	4.9 U	4.9 U	6.4 U	6.3 U	5.5 U	5.5 U	5.7 U	5.7 U	0.43 U UJ	ug/L
3-Nitroaniline	EPA 8270C	ug/Kg	3.6 U	7.5 U	3.7 U	3.8 U	3.5 U	3.4 U	3.5 U	4.5 U	4.4 U	3.9 U	3.9 U	4 U	4 U	0.23 U	ug/L
4,6-Dinitro-o-cresol	EPA 8270C	ug/Kg	2.4 U	4.9 U	2.4 U	2.5 U	2.3 U	2.3 U	2.3 U	2.9 U	2.9 U	2.6 U	2.6 U	2.7 U	2.7 U	0.013 U UJ	ug/L
4-Bromophenyl phenyl ether	EPA 8270C	ug/Kg	1.9 U	4.1 U	2 U	2.1 U	1.9 U	1.9 U	1.9 U	2.4 U	2.4 U	2.1 U	2.1 U	2.2 U	2.2 U	0.018 U	ug/L
4-Chloro-3-methylphenol	EPA 8270C	ug/Kg	2.9 U	6.1 U	3 U	3.1 U	2.8 U	2.8 U	2.8 U	3.6 U	3.6 U	3.2 U	3.2 U	3.3 U	3.3 U	0.029 U	ug/L

Table A-1. 2007 Remedial Investigation Subsurface Cores Analytical Data

Location			34	35	35	35	37	37	37	39	39	39	42	42	42	RB	
Sample ID			TT34-CS-B	TT35-CS-B	TT35-CS-C	TT35-CS-D	TT37-CS-A	TT37-CS-B	TT37-CS-C	TT39-CS-A	TT39-CS-B	TT39-CS-C	TT42-CS-B	TT42-CS-C	TT42-CS-D	RB-CS-1	
Sample Date			1/17/2007	1/15/2007	1/15/2007	1/15/2007	1/13/2007	1/13/2007	1/13/2007	1/12/2007	1/12/2007	1/12/2007	1/23/2007	1/23/2007	1/23/2007	1/15/2007	
Sample Depth (MLLW)			-52 To -53 ft	-50 To -51 ft	-51 To -52 ft	-52 To -53 ft	-40.9 To -42 ft	-42 To -43 ft	-43 To -44 ft	-42.8 To -44 ft	-44 To -45 ft	-45 To -46 ft	-50 To -51 ft	-51 To -52 ft	-52 To -53 ft	To ft	
Parameter	**Method**	**Units**															**Units**
4-Chloroaniline	EPA 8270C	ug/Kg	2.9 U	6.1 U	3 U	3.1 U	2.8 U	2.8 U	2.8 U	3.6 U	3.6 U	3.2 U	3.2 U	3.3 U	3.3 U	0.018 U	ug/L
4-Chlorophenyl phenyl ether	EPA 8270C	ug/Kg	2.8 U	5.8 U	2.9 U	3 U	2.7 U	2.7 U	2.7 U	3.5 U	3.4 U	3 U	3 U	3.1 U	3.1 U	0.0085 U	ug/L
4-Methylphenol	EPA 8270C	ug/Kg	4 U	8.4 U	4.1 U	4.3 U	3.9 U	3.8 U	3.8 U	8.2 J	4.9 U	4.4 U	8.1 J	8.2 J	4.5 U	0.051 U	ug/L
4-Nitroaniline	EPA 8270C	ug/Kg	4.7 U	9.8 U	4.8 U	5 U	4.5 U	4.5 U	4.5 U	5.8 U	5.8 U	5.1 U	5.1 U	5.3 U	5.3 U	0.17 U	ug/L
4-Nitrophenol	EPA 8270C	ug/Kg	41 U	87 U	43 U	44 U	40 U	40 U	40 U	52 U	51 U	45 U	45 U	47 U	47 U	0.54 U	ug/L
Acenaphthene	EPA 8270C	ug/Kg	4.6 J	21 D	28	9 J	1.4 U	2.8 J	2.4 J	120	67	28	44	67	8.2 J	0.0088 U	ug/L
		mg/kg OC	0.7 J	2.2 D	2.0	0.8 J				5.0	3.1	2.6	2.3	3.2	0.6 J		
Acenaphthylene	EPA 8270C	ug/Kg	8.5 J	31 D	29	13	3.8 J	1.9 U	3.5 J	95 J	66 J	25 J	75	150	13	0.011 U	ug/L
		mg/kg OC	1.3 J	3.3 D	2.1	1.2				3.9 J	3.0 J	2.3 J	4.0	7.1	1.0		
Aniline	EPA 8270C	ug/Kg	6.3 J	6.6 JD	3.9 J	2.2 U	2 U	2 U	2 U	2.6 U	2.6 U	2.3 U	2.3 U	16 J	2.4 U	0.25 U R	ug/L
Anthracene	EPA 8270C	ug/Kg	20	76 D	54	30	7.6 J	8.3 J	5.7 J	290	180	50	180	210	27	0.015 U	ug/L
		mg/kg OC	3.0	8.1 D	3.8	2.7				12.0	8.3	4.7	9.5	10.0	2.0		
Benzo(a)anthracene	EPA 8270C	ug/Kg	41	69 D	44	30	15	14	7.9 J	330 J	200 J	52 J	160	190	56	0.012 U UJ	ug/L
		mg/kg OC	6.2	7.3 D	3.1	2.7				13.7 J	9.2 J	4.9 J	8.5	9.0	4.2		
Benzo(a)pyrene	EPA 8270C	ug/Kg	82	120 D	56	36	30	15	13	360	290	65	290	220	52	0.016 U	ug/L
		mg/kg OC	12.4	12.8 D	4.0	3.2				14.9	13.3	6.1	15.3	10.5	3.9		
Benzo(b)fluoranthene	EPA 8270C	ug/Kg	75	150 D	65	37	44	23	17	550	420	96	320	290	86	0.02 U	ug/L
Benzo(g,h,i)perylene	EPA 8270C	ug/Kg	40	67 D	31	21	15	11	8.8 J	210	170	42	170	150	27	0.017 U UJ	ug/L
		mg/kg OC	6.1	7.1 D	2.2	1.9				8.7	7.8	3.9	9.0	7.1	2.0		
Benzo(k)fluoranthene	EPA 8270C	ug/Kg	75	100 D	48	28	13	8.6 J	6.6 J	170	140	27	260	190	63	0.02 U UJ	ug/L
Benzofluoranthenes (total)	TT calculated	ug/Kg	150	250	113	65	57	31.6	23.6	720	560	123	580	480	149	0.02 U	ug/L
		mg/kg OC	22.7	26.6	8.0	5.8				29.9	25.7	11.5	30.7	22.9	11.1		
Benzoic acid	EPA 8270C	ug/Kg	140 U	280 U	140 U	140 U	130 U UJ	130 U UJ	130 U UJ	170 U	170 U	150 U	150 U	150 U	150 U	1.8 U UJ	ug/L
Benzyl alcohol	EPA 8270C	ug/Kg	5.1 U	11 U	5.2 U	5.4 U	4.9 U	4.9 U	4.9 U	6.4 U	6.3 U	5.5 U	5.5 J	5.7 U	5.7 U	0.98 U	ug/L
bis(2-chloroethoxy)methane	EPA 8270C	ug/Kg	1.8 U	3.8 U	1.9 U	1.9 U	1.8 U	1.7 U	1.8 U	2.3 U	2.2 U	2 U	2 U	2 U	2 U	0.012 U	ug/L
bis(2-chloroethyl)ether	EPA 8270C	ug/Kg	3.3 U	6.9 U	3.4 U	3.5 U	3.2 U	3.2 U	3.2 U	4.1 U	4.1 U	3.6 U	3.6 U	3.7 U	3.7 U	0.015 U	ug/L
bis(2-chloroisopropyl)ether	EPA 8270C	ug/Kg	1.7 U	3.5 U	1.7 U	1.8 U	1.6 U	1.6 U	1.6 U	2.1 U	2.1 U	1.8 U	1.8 U	1.9 U	1.9 U	0.017 U	ug/L
bis(2-ethylhexyl)phthalate	EPA 8270C	ug/Kg	12 J U	16 JD U	6.7 J U	5 J U	8 J U	6.5 J U	11 J U	82 J	58 J	15 J	22 J U	12 J U	6.7 J U	0.27 U	ug/L
		mg/kg OC	1.8 J U	1.7 JD U	0.5 J U	0.4 J U	U	U	U	3.4 J	2.7 J	1.4 J	1.2 J U	0.6 J U	0.5 J U		
Butyl benzyl phthalate	EPA 8270C	ug/Kg	2.1 U	4.4 U	2.2 U	2.2 U	2 U	2 U	2 U	2.6 U	2.6 U	2.3 U	2.3 U	2.4 U	2.7 J	0.026 U	ug/L
		mg/kg OC	0.3 U	0.5 U	0.2 U	0.2 U				0.1 U	0.1 U	0.2 U	0.1 U	0.1 U	0.2 J		
Chrysene	EPA 8270C	ug/Kg	45	82 D	48	33	23	20	13	380 J	240 J	65 J	200	210	120	0.014 U	ug/L
		mg/kg OC	6.8	8.7 D	3.4	2.9				15.8 J	11.0 J	6.1 J	10.6	10.0	9.0		
Dibenzo(a,h)anthracene	EPA 8270C	ug/Kg	13	17 JD	7.6 J	4.7 J	4.8 J	3 J	2.9 U	48	42	12	58	37	6.5 J	0.031 U UJ	ug/L
		mg/kg OC	2.0	1.8 JD	0.5 J	0.4 J				2.0	1.9	1.1	3.1	1.8	0.5 J		
Dibenzofuran	EPA 8270C	ug/Kg	3.8 J	22 D	23	9.3 J	1.8 U	1.8 J	2.2 J	130	56	21	49	72	9 J	0.014 U	ug/L
		mg/kg OC	0.6 J	2.3 D	1.6	0.8 J				5.4	2.6	2.0	2.6	3.4	0.7 J		
Diethylphthalate	EPA 8270C	ug/Kg	4.8 U	11 U	5 U	5.1 U	4.7 U	4.6 U	4.6 U	6 U	5.9 U	5.3 U	5.2 U	5.4 U	5.4 U	0.34	ug/L
		mg/kg OC	0.7 U	1.2 U	0.4 U	0.5 U				0.2 U	0.3 U	0.5 U	0.3 U	0.3 U	0.4 U		
Dimethyl phthalate	EPA 8270C	ug/Kg	2.5 U	5.2 U	2.6 U	2.7 U	2.4 U	2.4 U	2.4 U	3.1 U	3.1 U	2.7 U	2.7 U	2.8 U	2.8 U	0.013 U	ug/L
		mg/kg OC	0.4 U	0.6 U	0.2 U	0.2 U				0.1 U	0.1 U	0.3 U	0.1 U	0.1 U	0.2 U		
Di-n-butyl phthalate	EPA 8270C	ug/Kg	4.4 J	7.5 U	3.7 U	4.3 J	3.5 U	3.4 U	3.5 U	17	14	8.1 J	14 U	5.6 J U	7.9 J U	0.22 UJ	ug/L
		mg/kg OC	0.7 J	0.8 U	0.3 U	0.4 J				0.7	0.6	0.8 J	0.7 U	0.3 J U	0.6 J U		
Di-n-octyl phthalate	EPA 8270C	ug/Kg	1.7 U	3.5 U	1.7 U	1.8 U	1.6 U	1.6 U	1.6 U	2.1 U	2.1 U	1.8 U	1.8 U	1.9 U	1.9 U	0.032 U	ug/L
		mg/kg OC	0.3 U	0.4 U	0.1 U	0.2 U				0.1 U	0.1 U	0.2 U	0.1 U	0.1 U	0.1 U		
Fluoranthene	EPA 8270C	ug/Kg	67	180 D	130	100	24	31	24	840 D	480	120	370	640	360	0.013 U UJ	ug/L
		mg/kg OC	10.2	19.1 D	9.2	8.8				34.9 D	22.0	11.2	19.6	30.5	26.9		
Fluorene	EPA 8270C	ug/Kg	5.6 J	27 D	32	13	2.3 U	2.8 J	3.1 J	160	75	29	61	99	11	0.012 U	ug/L
		mg/kg OC	0.8 J	2.9 D	2.3	1.2				6.6	3.4	2.7	3.2	4.7	0.8		
Hexachlorobenzene	EPA 8081A	ug/Kg	0.11 U	0.12 U	0.12 U	0.12 U	0.53 U	0.52 U	0.11 U	2.7 U	2.7 U	2.4 U	0.12 U	0.13 U	0.13 U	0.5 Ui	ng/L
		mg/kg OC	0.02 U	0.01 U	0.01 U	0.01 U				0.1 U	0.1 U	0.2 U	0.01 U	0.01 U	0.01 U		
Hexachlorobenzene	EPA 8270C	ug/Kg															
		mg/kg OC															
Hexachlorobutadiene	EPA 8081A	ug/Kg	0.67 U	0.71 U	0.69 U	0.72 U			0.65 U				0.73 U	0.76 U	0.76 U	0.24 U	ng/L
		mg/kg OC	0.1 U	0.1 U	0.05 U	0.1 U							0.04 U	0.04 U	0.1 U		
Hexachlorobutadiene	EPA 8270C	ug/Kg					1.9 U	1.9 U		2.4 U	2.4 U	2.1 U					
		mg/kg OC	0.0	0.0	0.0	0.0				0.1 U	0.1 U	0.2 U	0.0	0.0	0.0		
Hexachlorocyclopentadiene	EPA 8270C	ug/Kg	21 U UJ	44 U UJ	22 U UJ	22 U UJ	20 U	20 U	20 U	26 U UJ	26 U UJ	23 U UJ	23 U UJ	24 U UJ	24 U UJ	0.041 U	ug/L
Hexachloroethane	EPA 8270C	ug/Kg	3 U	6.4 U	3.1 U	3.2 U	3 U	2.9 U	2.9 U	3.8 U UJ	3.7 U UJ	3.3 U UJ	3.3 U	3.4 U	3.4 U	0.019 U	ug/L
Indeno(1,2,3-cd)pyrene	EPA 8270C	ug/Kg	45	70 D	31	21	17	12	8.5 J	230	190	46	170	130	31	0.024 U UJ	ug/L
		mg/kg OC	6.8	7.4 D	2.2	1.9				9.5	8.7	4.3	9.0	6.2	2.3		
Isophorone	EPA 8270C	ug/Kg	2.2 U	4.6 U	2.3 U	2.4 U	2.2 U	2.1 U	2.1 U	2.8 U UJ	2.7 U UJ	2.4 U UJ	2.4 U	2.5 U	2.5 U	0.0085 U	ug/L
Naphthalene	EPA 8270C	ug/Kg	12	58 D	73	26	4.5 J	4.3 J	9.3 J	250	160	100	140	260	22	0.025 J U	ug/L
		mg/kg OC	1.8	6.2 D	5.2	2.3				10.4	7.3	9.3	7.4	12.4	1.6		
Nitrobenzene	EPA 8270C	ug/Kg	2.8 U	5.8 U	2.9 U	3 U	2.7 U	2.7 U	2.7 U	3.5 U	3.4 U	3 U	3 U	3.1 U	3.1 U	0.0074 U	ug/L
N-Nitrosodimethylamine	EPA 8270C	ug/Kg	8.3 U	18 U	8.6 U	8.9 U	8.1 U	8 U	8 U	11 U	11 U	9.1 U	9.1 U UJ	9.4 U UJ	9.4 U	0.42 U	ug/L
N-Nitroso-di-n-propylamine	EPA 8270C	ug/Kg	4.4 U	9.2 U	4.5 U	4.7 U	4.3 U	4.2 U	4.2 U	5.5 U	5.4 U	4.8 U	4.8 U	5 U	5 U	0.033 U UJ	ug/L
N-Nitrosodiphenylamine	EPA 8270C	ug/Kg	3 U	6.4 U	3.1 U	3.2 U	3 U	2.9 U	2.9 U	3.8 U	3.7 U	3.3 U	3.3 U	3.4 U	3.4 U	0.028 U UJ	ug/L
		mg/kg OC	0.5 U	0.7 U	0.2 U	0.3 U				0.2 U	0.2 U	0.3 U	0.2 U	0.2 U	0.3 U		
Pentachlorophenol	EPA 8270C	ug/Kg	12 U	25 U	12 U	13 U	12 U	12 U	12 U	37 J	33 J	13 U	13 U	14 U	14 U	0.029 U	ug/L
Phenanthrene	EPA 8270C	ug/Kg	34	120 D	120	64	8.1 J	18	15	580	310	110	260	410	54	0.011 U UJ	ug/L
		mg/kg OC	5.2	12.8 D	8.5	5.7				24.1	14.2	10.3	13.8	19.5	4.0		
Phenol	EPA 8270C	ug/Kg	6.1 J	10 JD	5.9 J	6.9 J	2.6 U	2.6 J	2.5 J	46	20 J	19 J	2.9 U	19 J	20 J	0.02 U	ug/L
Pyrene	EPA 8270C	ug/Kg	72	200 D	150	88	35	35	36	1900 D	890 D	200	560	780	270	0.022 J	ug/L
		mg/kg OC	10.9	21.3 D	10.6	7.8				78.8 D	40.8 D	18.7	29.6	37.1	20.1		
Total HPAH	TT calculated	ug/Kg	555	1055	610.6	398.7	220.8	172.6	134.8	5018	3062	725	2558	2837	1071.5	0.022	ug/L
		mg/kg OC	84.1	112.2	43.3	35.3				208.2	140.5	67.8	135.3	135.1	80.0		
Total LPAH	TT calculated	ug/Kg	84.7	333	336	155	24	36.2	39	1495	858	342	760	1196	135.2	0.025 U	ug/L
		mg/kg OC	12.8	35.4	23.8	13.7				62.0	39.4	32.0	40.2	57.0	10.1		
Total PAH	TT calculated	ug/Kg	639.7	1388	946.6	553.7	244.8	208.8	173.8	6513	3920	1067	3318	4033	1206.7	0.022	ug/L
Butyltin	KRONE	ug/Kg	0.39 J	0.044 U	0.043 U	0.044 U	0.38 JP UJ	0.04 U	0.04 U	2	1.4 J	0.66 J	1 J J	0.95 J J	0.047 U	0.0038 J U	ug/L
Dibutyltin	KRONE	ug/Kg	5.7	2.4	1.4 U	0.99 J U	3.6	2.4	0.66 J U	32	22	5.4	6.5	8.1	1.5 J U	0.0069 J U	ug/L
Tetrabutyltin	KRONE	ug/Kg	0.095 U	0.11 U	0.099 U	0.11 U	0.093 U	0.092 U	0.092 U	3	2.2	0.5 J	0.11 U	0.11 U	0.11 U	0.0015 U	ug/L
Tributyltin	KRONE	ug/Kg	18	5.4	3	1.4 J	6.3	4.3	1.5	63	52	6.7	84	22	4.9	0.0006 U	ug/L
		mg/kg OC	2.7	0.57	0.21	0.12 J				2.6	2.4	0.6	4.4	1.0	0.4		
Total Solids	EPA 160.3	Percent	73.8	69.6	71.4	68.8	75.8	76.7	76.4	58.7	59.5	67.3	67.5	65	65.2		

Table A-1. 2007 Remedial Investigation Subsurface Cores Analytical Data

Location			34	35	35	35	37	37	37	39	39	39	42	42	42	RB	
Sample ID			TT34-CS-B	TT35-CS-B	TT35-CS-C	TT35-CS-D	TT37-CS-A	TT37-CS-B	TT37-CS-C	TT39-CS-A	TT39-CS-B	TT39-CS-C	TT42-CS-B	TT42-CS-C	TT42-CS-D	RB-CS-1	
Sample Date			1/17/2007	1/15/2007	1/15/2007	1/15/2007	1/13/2007	1/13/2007	1/13/2007	1/12/2007	1/12/2007	1/12/2007	1/23/2007	1/23/2007	1/23/2007	1/15/2007	
Sample Depth (MLLW)			-52 To -53 ft	-50 To -51 ft	-51 To -52 ft	-52 To -53 ft	-40.9 To -42 ft	-42 To -43 ft	-43 To -44 ft	-42.8 To -44 ft	-44 To -45 ft	-45 To -46 ft	-50 To -51 ft	-51 To -52 ft	-52 To -53 ft	To ft	
Parameter	**Method**	**Units**															**Units**
Total Organic Carbon	ASTM D4129-98M	Percent	0.66	0.94	1.41	1.13	0.08	0.09	0.33	2.41	2.18	1.07	1.89	2.1	1.34	0.04 U	mg/L
Fractional % phi >-1	PSEP Grain Size	Percent	0.63	1.13	1.02	0.46	0.1	0.04	0.12	0.77	0.4	0.37	0.69	1.33	0.41		
Fractional % phi 0-1	PSEP Grain Size	Percent	2.25	4.79	4.68	1.41	0.87	0.43	1.07	0.51	0.53	0.45	1.15	1.56	0.3		
Fractional % phi 1-2	PSEP Grain Size	Percent	11.4	12.9	12.7	4.24	39.9	18.5	17.4	1.66	1.6	3.22	4.47	1.96	1.03		
Fractional % phi 2-3	PSEP Grain Size	Percent	23.7	10.8	9.93	4.53	45.3	59.7	32.6	7.24	8.53	27.9	10.65	7.44	5.12		
Fractional % phi 3-4	PSEP Grain Size	Percent	20.5	12.8	13.5	19.3	10.3	18.2	22.3	13.1	16.4	26.4	20.05	13.97	12.28		
Fractional % phi 4-5	PSEP Grain Size	Percent	13.3	12.8	12.1	22.2	0.74	1.44	11.2	10.9	13.5	12.6	23.42	15.27	22.79		
Fractional % phi 5-6	PSEP Grain Size	Percent	11	11.6	11.4	18.9	0.43	0.42	5.64	21.3	15.6	9.98	14.9	20.8	25.9		
Fractional % phi 6-7	PSEP Grain Size	Percent	5.62	7.72	7.81	13.1	0.22	0.15	2.62	17.4	14.8	8.22	8.4	15.05	13.68		
Fractional % phi 7-8	PSEP Grain Size	Percent	3.51	6	5.97	5.42	0.11	0.11	1.89	9.89	9.84	3.72	6.53	10.04	7.91		
Fractional % phi 8-9	PSEP Grain Size	Percent	2.42	4.31	2.91	2.77	0.11	0.2	1	6.33	6.21	2.93	3.81	6.27	4.16		
Fractional % phi 9-10	PSEP Grain Size	Percent	1.56	3.03	3.27	2.45	0.08	0.34	0.94	5.21	5.09	2.23	3.4	4.63	3.33		
Fractional % phi >10	PSEP Grain Size	Percent	3.1	5.66	5.22	5.48	1.13	0.83	1.34	6.77	7.08	3.8	6.16	9.64	6.48		
Gravel	PSEP Grain Size	Percent	0.51	14.4	1.7	0.01	0.06	0.06	0.01	0.03	0.11	0.08	5.24	1.23	0.52		

Notes:
0.14 U J = Result followed by laboratory data qualifier followed by data validator qualifier
Sample depth (MLLW) = the core increment elevation in mean lower low water
mg/kg = milligrams per kilogram
ug/kg = micrograms per kilogram
mg/L = milligrams per liter
ug/L = micrograms per liter
ng/L = nanograms per liter

Data Validation Qualifiers
U = Result should be considered not-detected at the quantitation limit shown
J = Result is an estimated concentration
R = Rejected - Quality Control indicates the data is not usable
UJ = The compound was not detected and the sample detection limit should be considered an estimated value
N - Pesticide result is tentatively identified.

Laboratory Data Qualifiers
U = result was not detected at or above the method detection limit
J (for organics) = result is an estimated concentration that is less than the reporting limit but greater than or equal to the detection limit
B (for metals) = result is an estimated concentration that is less than the reporting limit but greater than or equal to the detection limit
* (for metals) = duplicate analysis not within control limits. See case narrative (in laboratory report)
D (for organics) = result reported is from a dilution
P (for organics) = The GC or HPLC confirmation criteria was exceeded. The relative percent difference is greater than 40% between the two analytical results.
i (for organics) = the MRL/MDL has been elevated due to a chromatographic interference.

Table A-2. Remedial Investigation Round 2 Subsurface Cores Analytical Data

Location			4	4	5	5	6	6	6	7	7	8	8	9	9	9
Sample ID			TT04-CS-K	TT04-CS-M	TT05-CS-E	TT05-CS-G	TT06-CS-E	TT06-CS-G	TT06-CS-I	TT07-CS-F	TT07-CS-H	TT08-CS-K	TT08-CS-M	TT09-CS-G	TT09-CS-I	TT09-CS-K
Sample Date			1/22/2007	1/22/2007	1/12/2007	1/12/2007	1/17/2007	1/17/2007	1/17/2007	1/16/2007	1/16/2007	1/16/2007	1/16/2007	1/16/2007	1/16/2007	1/16/2007
Sample Depth (MLLW)			-33 To -34 ft	-35 To -36 ft	-10 To -11 ft	-12 To -12.9 ft	-47 To -48 ft	-49 To -50 ft	-51 To -52 ft	-10 To -11 ft	-12 To -12.7 ft	-50 To -51 ft	-51.8 To -53 ft	-46.3 To -47 ft	-48 To -49 ft	-50 To -51 ft
Parameter	**Method**	**Units**														
Antimony	EPA 6020	mg/Kg	0.27 J	0.326 J	0.175 J	0.082 J	0.147 J	0.137 J	0.09 J	41.7 J	5.37 J	69.6 J	12.7 J	3.04 J	0.715 J	0.526 J
Arsenic	EPA 6020	mg/Kg	6.61	6.1	1.9	1.11	2.79	2.42	2.98	48.4	14.4	105	21	5.36	2.4	10
Cadmium	EPA 6020	mg/Kg	0.4	0.38	0.11	0.04 B	0.09	0.08	0.11	1.03	0.41	1.13	0.61	0.12	0.06	0.3
Chromium	EPA 6020	mg/Kg	15	18.4	9	10.3	9.91	9.11	11	107	41.9	111	49.9	12	8.61	31.9
Cobalt	EPA 6020	mg/Kg	5.5	6.63	2.92	2.76	4	3.65	4.59	9.99	6.19	15.7	6.92	4.19	3.52	5.18
Copper	EPA 6020	mg/Kg	33	38.9	12.7	10.6	16.8	12.6	16.6	860	223	1530	1840	42.2	27.6	312
Lead	EPA 6020	mg/Kg	39.3	35.8	13.2	5.55	6.04	4.49	8.9	576	117	527	232	15.8	23.3	96.5
Mercury	EPA 7471A	mg/Kg	0.448 J	0.651 J	0.087	0.021	0.089	0.036	0.066	5.52	1.87	14.5	4.6 J	0.231 J	0.166 J	2.44
Molybdenum	EPA 6020	mg/Kg	2.22	1.75	0.29	0.23	0.56	0.51	0.62	4.81	2.47	7.37	1.78	0.79	0.51	0.95
Nickel	EPA 6020	mg/Kg	12.8	17.5	6.16 * J	6.28 * J	7.98 * J	7.06 * J	9.15 * J	39.7	15.9	41.6 * J	18.2	9.79	7.76	12.2 * J
Selenium	EPA 6020	mg/Kg	0.7 B	0.8 B	0.3 B	0.2 B	0.4 B	0.2 B	0.4 B	0.7 B	0.5 B	0.9 B	1 B	0.5 B	0.4 B	0.4 B
Silver	EPA 6020	mg/Kg	0.194	0.188	0.056 UJ	0.023 UJ	0.042 UJ	0.031 UJ	0.047 UJ	0.859	0.331	0.622 J	0.337	0.138	0.056 U	0.12 J
Thallium	EPA 6020	mg/Kg	0.14	0.14	0.07	0.04	0.07	0.05	0.08	0.12	0.08	0.14	0.1	0.07	0.06	0.1
Vanadium	EPA 6020	mg/Kg	36.4	46.7	26.8	23.4	30.8	28.8	36.9	40.1	38.9	40.1	34.2	24.7	21.9	45.7
Zinc	EPA 6020	mg/Kg	55.8	55.8	31	21	24.4	23.4	26.6	1060	211	1150	451	58.4	74.6	158
PCBs (total)	TT calculated	µg/Kg	4.1 U	2.7 U	10.5	2.2 U	6.4	2.3 U	2.3 U	3580	480	960	410	75	30	1300
		mg/kg OC	0.3 U	0.2 U			0.7			341.0	35.8	118.5	53.9	14.7	5.4	69.5
PCB-1016	EPA 8082	µg/Kg	2.7 U	2.7 U	2.2 U	2.2 U	2.4 U	2.3 U	2.3 U	25 U	24 U	23 U	23 U	2.4 U	2.3 U	25 U
PCB-1221	EPA 8082	µg/Kg	2.8 Ui	2.7 U	2.2 U	2.2 U	2.4 U	2.3 U	2.3 U	25 U	24 U	23 U	23 U	2.4 U	2.3 U	25 U
PCB-1232	EPA 8082	µg/Kg	4.1 Ui	2.7 U	2.2 U	2.2 U	2.4 U	2.3 U	2.3 U	25 U	24 U	23 U	23 U	2.4 U	2.3 U	25 U
PCB-1242	EPA 8082	µg/Kg	2.7 U	2.7 U	2.2 U	2.2 U	2.4 U	2.3 U	2.3 U	25 U	24 U	23 U	23 U	2.4 U	2.3 U	25 U
PCB-1248	EPA 8082	µg/Kg	2.7 U	2.7 U	2.2 U	2.2 U	2.4 U	2.3 U	2.3 U	25 U	24 U	400 D	23 U	2.4 U	2.3 U	25 U
PCB-1254	EPA 8082	µg/Kg	2.7 U	2.7 U	6.2	2.2 U	6.4	2.3 U	2.3 U	2300 D	320 D	560 D	410 D	51	30	1300 D
PCB-1260	EPA 8082	µg/Kg	2.7 U	2.7 U	4.3	2.2 U	2.4 U	2.3 U	2.3 U	960 D	160 D	23 U	23 U	24	2.3 U	25 U
PCB-1262	EPA 8082	µg/Kg	2.7 U	2.7 U	2.2 U	2.2 U	2.4 U	2.3 U	2.3 U	25 U	24 U	23 U	23 U	2.4 U	2.3 U	25 U
PCB-1268	EPA 8082	µg/Kg	2.7 U	2.7 U	2.2 U	2.2 U	2.4 U	2.3 U	2.3 U	320 D	24 U	23 U	23 U	2.4 U	2.3 U	25 U
Aldrin	EPA 8081A	µg/Kg	2.4 U UJ	2.4 U UJ	2 U UJ	2 U UJ	2.1 U UJ	2 U UJ	2 U UJ	2.2 U UJ	3.5 Ui UJ	2.1 U UJ	2.1 U UJ	2.1 U UJ	2 U UJ	2.2 U UJ
alpha-BHC	EPA 8081A	µg/Kg	4.1 U UJ	4 U UJ	3.4 U UJ	3.4 U UJ	3.6 U UJ	3.5 U UJ	3.4 U UJ	3.8 U UJ	3.6 U UJ	3.5 U UJ	3.5 U UJ	3.6 U UJ	3.5 U UJ	3.7 U UJ
alpha-Chlordane	EPA 8081A	µg/Kg	3.6 U UJ	3.6 U UJ	3 U UJ	3 U UJ	3.2 U UJ	3.1 U UJ	3 U UJ	3.4 U UJ	3.2 U UJ	3.1 U UJ	3.1 U UJ	3.2 U UJ	3.1 U UJ	3.3 U UJ
beta-BHC	EPA 8081A	µg/Kg	4.7 U UJ	4.7 U UJ	3.9 U UJ	3.9 U UJ	4.2 U UJ	4 U UJ	3.9 U UJ	4.4 U UJ	4.2 U UJ	4.1 U UJ	4.8 Ui UJ	4.1 U UJ	4 U UJ	4.3 U UJ
delta-BHC	EPA 8081A	µg/Kg	0.86 U UJ	0.85 U UJ	0.71 U UJ	0.71 U UJ	0.76 U UJ	0.73 U UJ	0.72 U UJ	3.4 Ui UJ	2.1 Ui UJ	6.9 PD JN	1.1 Ui UJ	0.75 U UJ	0.74 U UJ	3.5 Ui UJ
Dieldrin	EPA 8081A	µg/Kg	4.5 U UJ	4.5 U UJ	3.8 U UJ	3.8 U UJ	4 U UJ	3.9 U UJ	3.8 U UJ	4.3 U UJ	4 U UJ	3.9 U UJ	3.9 U UJ	4 U UJ	3.9 U UJ	4.2 U UJ
Endosulfan I	EPA 8081A	µg/Kg	2.7 U UJ	2.7 U UJ	2.2 U UJ	2.2 U UJ	2.4 U UJ	2.3 U UJ	2.3 U UJ	23 PD JN	2.4 U UJ	2.3 U UJ	2.3 U UJ	2.4 U UJ	2.3 U UJ	5.8 Ui UJ
Endosulfan II	EPA 8081A	µg/Kg	3 U UJ	3 U UJ	2.5 U UJ	2.5 U UJ	2.7 U UJ	2.6 U UJ	2.5 U UJ	5.1 Ui UJ	2.7 U UJ	2.6 U UJ	2.6 U UJ	2.6 U UJ	2.6 U UJ	2.7 U UJ
Endosulfan sulfate	EPA 8081A	µg/Kg	1.3 U UJ	1.3 U UJ	1.1 U UJ	1.1 U UJ	1.1 U UJ	1.1 U UJ	1.1 U UJ	3.7 Ui UJ	1.1 U UJ	1.1 U UJ	1.2 Ui UJ	1.1 U UJ	1.1 U UJ	3 Ui UJ
Endrin	EPA 8081A	µg/Kg	3.2 U UJ	3.1 U UJ	2.6 U UJ	2.6 U UJ	2.8 U UJ	2.7 U UJ	2.6 U UJ	10 PD JN	2.8 U UJ	2.7 U UJ	2.7 U UJ	2.8 U UJ	2.7 U UJ	3.9 Ui UJ
Endrin aldehyde	EPA 8081A	µg/Kg	0.83 U UJ	0.82 U UJ	0.68 U UJ	0.69 U UJ	0.73 U UJ	0.71 U UJ	0.69 U UJ	8.6 Ui UJ	0.73 U UJ	2.5 Ui UJ	2.6 JD UJ	0.73 U UJ	0.71 U UJ	10 PD JN
gamma-BHC	EPA 8081A	µg/Kg	2.4 U UJ	2.4 U UJ	2 U UJ	2 U UJ	2.1 U UJ	2 U UJ	2 U UJ	3.7 Ui UJ	12 PD JN	3.4 Ui UJ	2.1 U UJ	2.1 U UJ	2 U UJ	2.2 U UJ
gamma-Chlordane	EPA 8081A	µg/Kg	1 U UJ	0.99 U UJ	0.82 U UJ	0.83 U UJ	0.89 U UJ	0.85 U UJ	0.83 U UJ	39 PD JN	3.5 Ui UJ	15 PD JN	12 PD JN	1 JPI JN	0.85 U UJ	36 D JN
Heptachlor	EPA 8081A	µg/Kg	1.3 U UJ	1.3 U UJ	1.1 U UJ	1.1 U UJ	1.2 U UJ	1.1 U UJ	1.1 U UJ	1.2 U UJ	1.2 U UJ	1.1 U UJ	1.1 U UJ	1.1 U UJ	1.1 U UJ	1.2 U UJ
Heptachlor epoxide	EPA 8081A	µg/Kg	2.1 U UJ	2 U UJ	1.7 U UJ	1.7 U UJ	1.8 U UJ	1.8 U UJ	1.7 U UJ	1.9 U UJ	1.8 U UJ	9.8 D JN	3.8 Ui UJ	1.8 U UJ	1.8 U UJ	1.9 U UJ
Methoxychlor	EPA 8081A	µg/Kg	1.6 U UJ	1.6 U UJ	1.3 U UJ	1.3 U UJ	6.2 Ui UJ	1.4 U UJ	1.3 U UJ	9.1 D JN	18 D JN	8 Ui UJ	4.7 Ui UJ	1.4 U UJ	1.4 U UJ	2.6 Ui UJ
Mirex	EPA 8081A	µg/Kg	1.6 U UJ	1.6 U UJ	1.3 U UJ	1.3 U UJ	1.4 U UJ	1.4 U UJ	1.3 U UJ	3.7 Ui UJ	1.4 U UJ	3.4 Ui UJ	3.4 Ui UJ	1.4 U UJ	1.4 U UJ	3.5 Ui UJ
Nonachlor (cis)	EPA 8081A	µg/Kg	1.3 U UJ	1.3 U UJ	1.1 U UJ	1.1 U UJ	1.2 U UJ	1.1 U UJ	1.1 U UJ	6.2 Ui UJ	1.2 U UJ	3.4 Ui UJ	9.6 Ui UJ	1.2 U UJ	1.2 U UJ	3.6 Ui UJ
Nonachlor (trans)	EPA 8081A	µg/Kg	1.4 U UJ	1.4 U UJ	1.2 U UJ	1.2 U UJ	1.3 U UJ	1.2 U UJ	1.2 U UJ	8.8 Ui UJ	1.3 U UJ	1.2 U UJ	1.2 U UJ	1.3 U UJ	1.2 U UJ	3 Ui UJ
Oxychlordane	EPA 8081A	µg/Kg	5.8 U UJ	5.7 U UJ	4.8 U UJ	4.8 U UJ	5.1 U UJ	5 U UJ	4.8 U UJ	5.4 U UJ	5.1 U UJ	5 U UJ	5 U UJ	5.1 U UJ	5 U UJ	5.3 U UJ
Toxaphene	EPA 8081A	µg/Kg	140 U UJ	140 U UJ	120 U UJ	120 U UJ	130 U UJ	120 U UJ	120 U UJ	420 Ui UJ	280 Ui UJ	240 Ui UJ	150 Ui UJ	130 U UJ	120 U UJ	360 Ui UJ
o,p-DDD	EPA 8081A	µg/Kg	3.3 U UJ	3.3 U UJ	2.7 U UJ	2.8 U UJ	2.9 U UJ	2.8 U UJ	2.8 U UJ	29 Ui UJ	24 PD JN	22 PD JN	32 PD JN	5.2 D JN	2.8 U UJ	37 Ui UJ
o,p-DDE	EPA 8081A	µg/Kg	3.6 U UJ	3.6 U UJ	3 U UJ	3 U UJ	3.2 U UJ	3.1 U UJ	3 U UJ	3.4 U UJ	3.2 U UJ	3.1 U UJ	3.1 U UJ	3.2 U UJ	3.1 U UJ	4.1 Ui UJ
o,p-DDT	EPA 8081A	µg/Kg	2.2 U UJ	2.2 U UJ	1.8 U UJ	1.9 U UJ	2 U UJ	1.9 U UJ	1.9 U UJ	110 PD JN	12 PD JN	15 D JN	20 PD JN	3.4 Ui UJ	1.9 U UJ	44 Ui UJ
p,p-DDD	EPA 8081A	µg/Kg	1.9 U UJ	1.9 U UJ	1.6 U UJ	1.6 U UJ	1.7 U UJ	1.6 U UJ	1.6 U UJ	17 D JN	9.8 D JN	56 D JN	14 D UJ	2.4 JPI UJ	1.6 U UJ	65 D JN
p,p-DDE	EPA 8081A	µg/Kg	1.6 U UJ	1.6 U UJ	1.3 U UJ	1.3 U UJ	1.4 U UJ	1.4 U UJ	1.3 U UJ	4.9 Ui UJ	3.5 Ui UJ	13 PD JN	1.4 U UJ	1.4 U UJ	1.4 U UJ	1.5 U UJ
p,p-DDT	EPA 8081A	µg/Kg	1 U UJ	0.99 U UJ	0.82 U UJ	0.83 U UJ	0.89 U UJ	0.85 U UJ	0.83 U UJ	120 Ui UJ	9.6 Ui UJ	26 Ui UJ	20 D UJ	5.7 PD UJ	2 JPI UJ	56 Ui UJ
Total DDT	TT Calculated	µg/Kg	3.6 U UJ	3.6 U UJ	3 U UJ	3 U UJ	3.2 U UJ	3.1 U UJ	3 U UJ	127 JN	45.8 JN	106 JN	52 JN	5.2 JN	3.1 U UJ	65 JN
Total Chlordane	TT Calculated	ug/Kg	5.8 U UJ	5.7 U UJ	4.8 U UJ	4.8 U UJ	5.1 U UJ	5 U UJ	4.8 U UJ	39 JN	5.1 U UJ	15 JN	12 JN	1 JN	5 U UJ	36 JN
1,2,4-Trichlorobenzene	EPA 8270C	µg/Kg	24 U	12 U	2 U	2 U	4.2 U	2 U	2 U	110 U	110 U	110 U	41 U	2.1 U	2 U	43 U
		mg/kg OC	1.7 U	0.7 U			0.4 U			10.5 U	8.2 U	13.6 U	5.4 U	0.4 U	0.4 U	2.3 U
1,2-Dichlorobenzene	EPA 8270C	µg/Kg	21 U	10 U	1.7 U UJ	1.7 U UJ	3.6 U UJ	1.8 U UJ	1.7 U UJ	95 U UJ	90 U UJ	88 U UJ	35 U	1.8 U	1.8 U	37 U UJ
		mg/kg OC	1.5 U	0.6 U	UJ	UJ	0.4 U UJ	UJ	UJ	9.0 U UJ	6.7 U UJ	10.9 U UJ	4.6 U	0.4 U	0.3 U	2.0 U UJ
1,3-Dichlorobenzene	EPA 8270C	µg/Kg	25 U	13 U	2.1 U UJ	2.1 U UJ	4.5 U UJ	2.2 U UJ	2.1 U UJ	120 U UJ	120 U UJ	110 U UJ	43 U	2.2 U	2.2 U	46 U UJ
1,4-Dichlorobenzene	EPA 8270C	µg/Kg	30 U	15 U	2.5 U UJ	2.5 U UJ	5.3 U UJ	2.6 U UJ	2.5 U UJ	140 U UJ	140 U UJ	130 U UJ	52 U	2.6 U	2.6 U	54 U UJ
		mg/kg OC	2.1 U	0.9 U	UJ	UJ	0.6 U UJ	UJ	UJ	13.3 U UJ	10.4 U UJ	16.0 U UJ	6.8 U	0.5 U	0.5 U	2.9 U UJ
1-Methylnaphthalene	EPA 8270C	µg/Kg	35 U	40 D	6.4 J	2.9 U UJ	6.1 U UJ	3 U UJ	2.9 U UJ	160 U UJ	3600 D J	320 JD J	82 JD	24	3 U	120 JD J
2,4,5-Trichlorophenol	EPA 8270C	µg/Kg	47 U	24 U	3.9 U	3.9 U	8.3 U	4 U	3.9 U	220 U	210 U	210 U	81 U	4.1 U	4 U	85 U
2,4,6-Trichlorophenol	EPA 8270C	µg/Kg	28 U	14 U	2.3 U	2.4 U	5 U	2.4 U	2.4 U	140 U	130 U	130 U	49 U	2.5 U	2.4 U	51 U
2,4-Dichlorophenol	EPA 8270C	µg/Kg	28 U	14 U	2.3 U	2.4 U	5 U	2.4 U	2.4 U	140 U	130 U	130 U	49 U	2.5 U	2.4 U	51 U
2,4-Dimethylphenol	EPA 8270C	µg/Kg	86 U	43 U	7.1 U	7.1 U	16 U	7.3 U	7.2 U	400 U	380 U	370 U	150 U	7.5 U	7.4 U	160 U
2,4-Dinitrophenol	EPA 8270C	µg/Kg	560 U	280 U	46 U	47 U	100 U	48 U	47 U	2700 U	2500 U	2500 U	970 U	49 U	48 U	1100 U
2,4-Dinitrotoluene	EPA 8270C	µg/Kg	44 U	22 U	3.6 U	3.7 U	7.8 U	3.8 U	3.7 U	210 U	200 U	190 U	76 U	3.9 U	3.8 U	80 U

Table A-2. Remedial Investigation Round 2 Subsurface Cores Analytical Data

Location			4	4	5	5	6	6	6	7	7	8	8	9	9	9
Sample ID			TT04-CS-K	TT04-CS-M	TT05-CS-E	TT05-CS-G	TT06-CS-E	TT06-CS-G	TT06-CS-I	TT07-CS-F	TT07-CS-H	TT08-CS-K	TT08-CS-M	TT09-CS-G	TT09-CS-I	TT09-CS-K
Sample Date			1/22/2007	1/22/2007	1/12/2007	1/12/2007	1/17/2007	1/17/2007	1/17/2007	1/16/2007	1/16/2007	1/16/2007	1/16/2007	1/16/2007	1/16/2007	1/16/2007
Sample Depth (MLLW)			-33 To -34 ft	-35 To -36 ft	-10 To -11 ft	-12 To -12.9 ft	-47 To -48 ft	-49 To -50 ft	-51 To -52 ft	-10 To -11 ft	-12 To -12.7 ft	-50 To -51 ft	-51.8 To -53 ft	-46.3 To -47 ft	-48 To -49 ft	-50 To -51 ft
Parameter	**Method**	**Units**														
2,6-Dinitrotoluene	EPA 8270C	µg/Kg	44 U	22 U	3.6 U	3.7 U	7.8 U	3.8 U	3.7 U	210 U	200 U	190 U	76 U	3.9 U	3.8 U	80 U
2-Chloronaphthalene	EPA 8270C	µg/Kg	56 U	28 U	4.6 U	4.7 U	10 U	4.8 U	4.7 U	270 U	250 U	250 U	97 U	4.9 U	4.8 U	110 U
2-Chlorophenol	EPA 8270C	µg/Kg	27 U	14 U	2.2 U	2.2 U	4.7 U	2.3 U	2.3 U	130 U	120 U	120 U	46 U	2.4 U	2.3 U	49 U
2-Methylnaphthalene	EPA 8270C	µg/Kg	37 JD	80 D	10	1.6 U	5.8 JD	2.5 J	5.1 J	88 U	790 D	280 JD	97 JD	30	3.6 J	160 D
		mg/kg OC	2.6 JD	4.5 D			0.6 JD			8.4 U	59.0 D	34.6 JD	12.8 JD	5.9	0.6 J	8.6 D
2-Methylphenol	EPA 8270C	µg/Kg	53 U	27 U	4.4 U	4.4 U	9.4 U	4.6 U	4.5 U	250 U	240 U	230 U	92 U	4.7 U	4.6 U	97 U
2-Nitroaniline	EPA 8270C	µg/Kg	42 U	21 U	3.5 U	3.5 U	7.5 U	3.6 U	3.5 U	200 U	190 U	190 U	73 U	3.7 U	3.6 U	77 U
2-Nitrophenol	EPA 8270C	µg/Kg	41 U	20 U	3.4 U	3.4 U	7.2 U	3.5 U	3.4 U	190 U	180 U	180 U	70 U	3.6 U	3.5 U	74 U
3,3-Dichlorobenzidine	EPA 8270C	µg/Kg	58 U	29 U	4.8 U	4.8 U	11 U	5 U	4.8 U	270 U	260 U	250 U	100 U	5.1 U	5 U	110 U
3-Nitroaniline	EPA 8270C	µg/Kg	41 U	20 U	3.4 U	3.4 U	7.2 U	3.5 U	3.4 U	190 U	180 U	180 U	70 U	3.6 U	3.5 U	74 U
4,6-Dinitro-o-cresol	EPA 8270C	µg/Kg	27 U	14 U	2.2 U	2.2 U	4.7 U	2.3 U	2.3 U	130 U	120 U	120 U	46 U	2.4 U	2.3 U	49 U
4-Bromophenyl phenyl ether	EPA 8270C	µg/Kg	22 U	11 U	1.8 U	1.9 U	3.9 U	1.9 U	1.9 U	110 U	97 U	94 U	38 U	2 U	1.9 U	40 U
4-Chloro-3-methylphenol	EPA 8270C	µg/Kg	33 U	17 U	2.7 U	2.8 U	5.8 U	2.8 U	2.8 U	160 U	150 U	150 U	57 U	2.9 U	2.8 U	60 U
4-Chloroaniline	EPA 8270C	µg/Kg	33 U	17 U	2.7 U	2.8 U	5.8 U	2.8 U	2.8 U	160 U	150 U	150 U	57 U	2.9 U	2.8 U	60 U
4-Chlorophenyl phenyl ether	EPA 8270C	µg/Kg	32 U	16 U	2.6 U	2.6 U	5.6 U	2.7 U	2.6 U	150 U	140 U	140 U	54 U	2.8 U	2.7 U	57 U
4-Methylphenol	EPA 8270C	µg/Kg	45 U	23 U	3.8 U	3.8 U	8 U	3.9 U	3.8 U	220 U	200 U	200 U	78 U	4 U	3.9 U	83 U
4-Nitroaniline	EPA 8270C	µg/Kg	53 U	27 U	4.4 U	4.4 U	9.4 U	4.6 U	4.5 U	250 U	240 U	230 U	92 U	4.7 U	4.6 U	97 U
4-Nitrophenol	EPA 8270C	µg/Kg	470 U	240 U	39 U	39 U	83 U	40 U	39 U	2200 U	2100 U	2100 U	810 U	41 U	40 U	850 U
Acenaphthene	EPA 8270C	µg/Kg	58 JD	91 D	13	1.3 U	6.3 JD	4 J	2.6 J	460 D	20000 D	1400 D	300 D	87	3.1 J	710 D
		mg/kg OC	4.1 JD	5.2 D			0.7 JD			43.8 D	1492.5 D	172.8 D	39.5 D	17.1	0.6 J	38.0 D
Acenaphthylene	EPA 8270C	µg/Kg	170 D	110 D	24	1.9 U	4.1 JD	10	4.4 J	280 JD	620 D	570 D	110 JD	17	7.1	99 JD
		mg/kg OC	12.1 D	6.3 D			0.4 JD			26.7 JD	46.3 D	70.4 D	14.5 JD	3.3	1.3	5.3 JD
Aniline	EPA 8270C	µg/Kg	26 JD	12 U	2 U	2 U	4.2 U	2 U	2 U	110 U	110 U	110 U	41 U	2.1 U	2 U	43 U
Anthracene	EPA 8270C	µg/Kg	490 D	230 D	38	2.7 J	16 D	16	12	830 D	5400 D	1900 D	520 D	91	10	570 D
		mg/kg OC	35.0 D	13.1 D			1.7 D			79.0 D	403.0 D	234.6 D	68.4 D	17.8	1.8	30.5 D
Benzo(a)anthracene	EPA 8270C	µg/Kg	2400 D	210 D	63	3 J	29 D	54	14	4100 D	8400 D	4400 D	1400 D	110	26	940 D
		mg/kg OC	171.4 D	11.9 D			3.0 D			390.5 D	626.9 D	543.2 D	184.2 D	21.6	4.6	50.3 D
Benzo(a)pyrene	EPA 8270C	µg/Kg	2200 D	230 D	79	4.3 J	35 D	58	25	2300 D	2500 D	3800 D	1000 D	81	22	660 D
		mg/kg OC	157.1 D	13.1 D			3.6 D			219.0 D	186.6 D	469.1 D	131.6 D	15.9	3.9	35.3 D
Benzo(b)fluoranthene	EPA 8270C	µg/Kg	3300 D	340 D	120	7.3	44 D	65	37	3300 D	4400 D	5200 D	1500 D	100	25	990 D
Benzo(g,h,i)perylene	EPA 8270C	µg/Kg	1100 D	140 D	43	3.1 J	22 D	27	12	1100 D	800 D	2200 D	660 D	46	13	410 D
		mg/kg OC	78.6 D	8.0 D			2.3 D			104.8 D	59.7 D	271.6 D	86.8 D	9.0	2.3	21.9 D
Benzo(k)fluoranthene	EPA 8270C	µg/Kg	1100 D	120 D	46	3.3 U	17 D	26	15	1200 D	1500 D	1800 D	600 D	36	9.3	340 D
Benzofluoranthenes (total)	TT calculated	µg/Kg	4400	460	166	7.3	61	91	52	4500	5900	7000	2100	136	34.3	1330
		mg/kg OC	314.3	26.1			6.4			428.6	440.3	864.2	276.3	26.7	6.1	71.1
Benzoic acid	EPA 8270C	µg/Kg	1500 U	740 U	130 U	130 U	270 U	130 U	130 U	7000 U	6700 U	6500 U	2600 U	140 U	130 U	2800 U
Benzyl alcohol	EPA 8270C	µg/Kg	58 U	29 U	4.8 U	4.8 U	11 U	5 U	4.8 U	270 U	260 U	250 U	100 U	5.1 U	5 U	110 U
bis(2-chloroethoxy)methane	EPA 8270C	µg/Kg	21 U	10 U	1.7 U	1.7 U	3.6 U	1.8 U	1.7 U	95 U	90 U	88 U	35 U	1.8 U	1.8 U	37 U
bis(2-chloroethyl)ether	EPA 8270C	µg/Kg	38 U	19 U	3.1 U	3.1 U	6.7 U	3.2 U	3.2 U	180 U	170 U	170 U	65 U	3.3 U	3.2 U	68 U
bis(2-chloroisopropyl)ether	EPA 8270C	µg/Kg	19 U	9.3 U	1.6 U	1.6 U	3.4 U	1.6 U	1.6 U	88 U	83 U	81 U	33 U	1.7 U	1.6 U	34 U
bis(2-ethylhexyl)phthalate	EPA 8270C	µg/Kg	27 JD U	14 U U	6.6 J U	7.2 J U	4.9 JD U	5.1 J U	2.9 J U	1900 JD	280 JD U	780 JD U	130 JD U	8 J U	4.3 J U	71 JD U
		mg/kg OC	1.9 JD U	0.8 U U	U	U	0.5 JD U	U	U	181.0 JD	20.9 JD U	96.3 JD U	17.1 JD U	1.6 J U	0.8 J U	3.8 JD U
Butyl benzyl phthalate	EPA 8270C	µg/Kg	24 U	12 U	2 U	2 U	4.2 U	2 U	2 U	110 U	110 U	110 U	41 U	2.1 U	2 U	43 U
		mg/kg OC	1.7 U	0.7 U			0.4 U			10.5 U	8.2 U	13.6 U	5.4 U	0.4 U	0.4 U	2.3 U
Chrysene	EPA 8270C	µg/Kg	3300 D	290 D	110	3 J	33 D	55	16	4300 D	8600 D	4500 D	1500 D	120	30	1100 D
		mg/kg OC	235.7 D	16.5 D			3.4 D			409.5 D	641.8 D	555.6 D	197.4 D	23.5	5.4	58.8 D
Dibenzo(a,h)anthracene	EPA 8270C	µg/Kg	280 D	29 JD	11	2.9 U	6.1 U	7.6	3.4 J	330 JD	240 JD	590 D	180 D	12	3.4 J	120 JD
		mg/kg OC	20.0 D	1.6 JD			0.6 U			31.4 JD	17.9 JD	72.8 D	23.7 D	2.4	0.6 J	6.4 JD
Dibenzofuran	EPA 8270C	µg/Kg	41 JD	85 D	9.1	1.7 U	5.4 JD	3 J	3.6 J	180 JD	15000 D	670 D	180 D	41	2.7 J	210 D
		mg/kg OC	2.9 JD	4.8 D			0.6 JD			17.1 JD	1119.4 D	82.7 D	23.7 D	8.0	0.5 J	11.2 D
Diethylphthalate	EPA 8270C	µg/Kg	55 U	81 BD U	4.5 U	4.6 U	9.7 U	4.7 U	4.6 U	260 U	250 U	240 U	94 U	5.5 BJ U	4.7 U	100 U
		mg/kg OC	3.9 U	4.6 BD U			1.0 U			24.8 U	18.7 U	29.6 U	12.4 U	1.1 BJ U	0.8 U	5.3 U
Dimethyl phthalate	EPA 8270C	µg/Kg	28 U	14 U	2.3 U	2.4 U	5 U	2.4 U	2.4 U	140 U	130 U	130 U	49 U	2.5 U	2.4 U	51 U
		mg/kg OC	2.0 U	0.8 U			0.5 U			13.3 U	9.7 U	16.0 U	6.4 U	0.5 U	0.4 U	2.7 U
Di-n-butyl phthalate	EPA 8270C	µg/Kg	41 U	20 U	3.4 U	3.7 J	7.2 U	3.7 J	3.4 U	190 U	180 U	180 U	70 U	4.4 J	3.6 J	74 U
		mg/kg OC	2.9 U	1.1 U			0.8 U			18.1 U	13.4 U	22.2 U	9.2 U	0.9 J	0.6 J	4.0 U
Di-n-octyl phthalate	EPA 8270C	µg/Kg	19 U	9.3 U	1.6 U	1.6 U	3.4 U	1.6 U	1.6 U	88 U	83 U	81 U	33 U	1.7 U	1.6 U	34 U
		mg/kg OC	1.4 U	0.5 U			0.4 U			8.4 U	6.2 U	10.0 U	4.3 U	0.3 U	0.3 U	1.8 U
Fluoranthene	EPA 8270C	µg/Kg	1700 D	590 D	140	8.3	62 D	76	25	14000 D	38000 D	11000 D	2700 D	330	51	3000 D
		mg/kg OC	121.4 D	33.5 D			6.5 D			1333.3 D	2835.8 D	1358.0 D	355.3 D	64.7	9.1	160.4 D
Fluorene	EPA 8270C	µg/Kg	96 D	120 D	16	2.2 U	6.8 JD	5 J	3.9 J	380 D	20000 D	1300 D	310 D	68	4.1 J	490 D
		mg/kg OC	6.9 D	6.8 D			0.7 JD			36.2 D	1492.5 D	160.5 D	40.8 D	13.3	0.7 J	26.2 D
Hexachlorobenzene	EPA 8081A	µg/Kg	1.3 U	1.3 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.2 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.2 U
		mg/kg OC	0.1 U	0.1 U			0.1 U			0.1 U	0.1 U	0.1 U	0.1 U	0.2 U	0.2 U	0.1 U
Hexachlorobutadiene	EPA 8081A	µg/Kg	7.6 U	7.6 U						7.2 U	6.8 U	6.6 U	6.6 U			7 U
		mg/kg OC	0.5 U	0.4 U						0.7 U	0.5 U	0.8 U	0.9 U			0.4 U
Hexachlorobutadiene	EPA 8270C	µg/Kg			1.8 U	1.9 U	3.9 U	1.9 U	1.9 U					2 U	1.9 U	
		mg/kg OC					0.4 U							0.4 U	0.3 U	
Hexachlorocyclopentadiene	EPA 8270C	µg/Kg	240 U	120 U	20 U UJ	20 U UJ	42 U UJ	20 U UJ	20 U UJ	1100 U UJ	1100 U UJ	1100 U UJ	410 U	21 U	20 U	430 U UJ

Table A-2. Remedial Investigation Round 2 Subsurface Cores Analytical Data

Location			4	4	5	5	6	6	6	7	7	8	8	9	9	9
Sample ID			TT04-CS-K	TT04-CS-M	TT05-CS-E	TT05-CS-G	TT06-CS-E	TT06-CS-G	TT06-CS-I	TT07-CS-F	TT07-CS-H	TT08-CS-K	TT08-CS-M	TT09-CS-G	TT09-CS-I	TT09-CS-K
Sample Date			1/22/2007	1/22/2007	1/12/2007	1/12/2007	1/17/2007	1/17/2007	1/17/2007	1/16/2007	1/16/2007	1/16/2007	1/16/2007	1/16/2007	1/16/2007	1/16/2007
Sample Depth (MLLW)			-33 To -34 ft	-35 To -36 ft	-10 To -11 ft	-12 To -12.9 ft	-47 To -48 ft	-49 To -50 ft	-51 To -52 ft	-10 To -11 ft	-12 To -12.7 ft	-50 To -51 ft	-51.8 To -53 ft	-46.3 To -47 ft	-48 To -49 ft	-50 To -51 ft
Parameter	**Method**	**Units**														
Hexachloroethane	EPA 8270C	µg/Kg	35 U	17 U	2.9 U UJ	2.9 U UJ	6.1 U UJ	3 U UJ	2.9 U UJ	160 U UJ	160 U UJ	150 U UJ	60 U	3 U	3 U	63 U UJ
Indeno(1,2,3-cd)pyrene	EPA 8270C	µg/Kg	1100 D	140 D	43	3.2 J	23 D	31	12	1200 D	900 D	2300 D	700 D	49	13	430 D
		mg/kg OC	78.6 D	8.0 D			2.4 D			114.3 D	67.2 D	284.0 D	92.1 D	9.6	2.3	23.0 D
Isophorone	EPA 8270C	µg/Kg	25 U	13 U	2.1 U	2.1 U	4.5 U	2.2 U	2.1 U	170 JD	120 U	110 U	43 U	2.2 U	2.2 U	46 U
Naphthalene	EPA 8270C	µg/Kg	110 D	310 D	25	1.7 U	55 D	13	15	400 D	3400 D	1400 D	260 D	95	10	360 D
		mg/kg OC	7.9 D	17.6 D			5.7 D			38.1 D	253.7 D	172.8 D	34.2 D	18.6	1.8	19.3 D
Nitrobenzene	EPA 8270C	µg/Kg	32 U	16 U	2.6 U	2.6 U	5.6 U	2.7 U	2.6 U	150 U	140 U	140 U	54 U	2.8 U	2.7 U	57 U
N-Nitrosodimethylamine	EPA 8270C	µg/Kg	95 U	47 U	7.8 U	7.9 U	17 U	8.1 U	8 U	450 U	420 U	410 U	170 U	8.3 U	8.2 U	180 U
N-Nitroso-di-n-propylamine	EPA 8270C	µg/Kg	50 U	25 U	4.1 U	4.2 U	8.9 U	4.3 U	4.2 U	240 U	230 U	220 U	86 U	4.4 U	4.3 U	91 U
N-Nitrosodiphenylamine	EPA 8270C	µg/Kg	35 U	17 U	2.9 U	2.9 U	6.1 U	3 U	2.9 U	160 U	160 U	150 U	60 U	3 U	3 U	63 U
		mg/kg OC	2.5 U	1.0 U			0.6 U			15.2 U	11.9 U	18.5 U	7.9 U	0.6 U	0.5 U	3.4 U
Pentachlorophenol	EPA 8270C	µg/Kg	140 U	66 U	11 U	11 U	24 U	12 U	12 U	620 U	590 U	570 U	230 U	12 U	12 U	250 U
Phenanthrene	EPA 8270C	µg/Kg	440 D	440 D	82	5 J	49 D	29	16	1600 D	58000 D	5500 D	1400 D	370	27	2900 D
		mg/kg OC	31.4 D	25.0 D			5.1 D			152.4 D	4328.4 D	679.0 D	184.2 D	72.5	4.8	155.1 D
Phenol	EPA 8270C	µg/Kg	30 U	15 U	2.5 U	2.5 U	10 JD	8.7 J	7.1 J	140 U	140 U	190 JD	310 JD	2.6 U	2.6 U	860 D
Pyrene	EPA 8270C	µg/Kg	4400 D	870 D	240	19	93 D	110	46	11000 D	32000 D	14000 D	3900 D	310	63	2900 D
		mg/kg OC	314.3 D	49.4 D			9.7 D			1047.6 D	2388.1 D	1728.4 D	513.2 D	60.8	11.3	155.1 D
Total HPAH	TT calculated	µg/Kg	20880	2959	895	51.2	358	509.6	205.4	42830	97340	49790	14140	1194	255.7	10890
		mg/kg OC	1491.4	168.1			37.3			4079.0	7264.2	6146.9	1860.5	234.1	45.7	582.4
Total LPAH	TT calculated	µg/Kg	1364	1301	198	7.7	137.2	77	53.9	3950	107420	12070	2900	728	61.3	5129
		mg/kg OC	97.4	73.9			14.3			376.2	8016.4	1490.1	381.6	142.7	10.9	274.3
Total PAH	TT calculated	µg/Kg	22244	4260	1093	58.9	495.2	586.6	259.3	46780	204760	61860	17040	1922	317	16019
Butyltin	KRONE	µg/Kg	0.29 Ui	0.047 U	0.039 U	0.039 U	0.13 Ui	0.04 U	0.039 U	3.5 J	8.8 J	9.1 J	5.3 J	0.24 JP UJ	0.08 Ui	0.31 J UJ
Dibutyltin	KRONE	µg/Kg	0.6 J U	0.044 U	0.31 JP UJ	0.56 J U	0.9 J U	0.86 J U	0.44 J U	41	100 D	150 D	220 D	2.2 J	0.23 J U	0.94 J U
Tetrabutyltin	KRONE	µg/Kg	0.11 U	0.11 U	0.09 U	0.091 U	0.097 U	0.093 U	0.091 U	1.4 J	4.8	9.7	9	0.096 U	0.093 U	0.1 U
Tributyltin	KRONE	µg/Kg	0.087 U	0.087 U	0.072 U	0.24 Ui	1.2 J	1.8	0.073 U	200 D	360 D	1000 D	1900 D	11	0.78 J	0.08 U
		mg/kg OC	0.006 U	0.005 U			0.1 J			19.0 D	26.9 D	123.5 D	250.0 D	2.2	0.1 J	0.004 U
Total Solids	EPA 160.3	Percent	64.5	65.1	78.3	77.6	72.7	75.5	77.2	68.8	72.7	74.6	74.5	73.5	75.3	70.6
Total Organic Carbon	PSEP	Percent	1.4	1.76	0.25	0.05	0.96	0.45	0.45	1.05	1.34	0.81	0.76	0.51	0.56	1.87
Fractional % phi >-1	PSEP	Percent	0.52	0.49	0.37	0.53	0.36	0.61	1.08	6.83	4.67	5.56	3.35	0.45	0.38	2.15
Fractional % phi 0-1	PSEP	Percent	0.74	0.72	2.51	6.17	0.6	5.62	7.92	11	9.27	22.1	9.96	1.03	1.38	6.03
Fractional % phi 1-2	PSEP	Percent	3.03	2.85	21.7	54.6	11.7	33.5	29	12.5	16.6	24.1	11.1	1.29	2.96	15.4
Fractional % phi 2-3	PSEP	Percent	9.17	16.9	46.8	32.1	52.3	37.4	24	23.3	21.1	11.1	3.88	9.3	30.9	24.2
Fractional % phi 3-4	PSEP	Percent	20.1	20.5	19.2	4.43	25.3	13.4	17.4	17	23.8	5.7	12	34.7	40.9	25
Fractional % phi 4-5	PSEP	Percent	27.2	14.1	3.2	0.48	4.03	3.39	6.05	8.23	7.31	5.34	19.7	25.7	11.5	10.5
Fractional % phi 5-6	PSEP	Percent	13.9	11.8	0.72	0	1.55	1.43	4.43	5.53	3.5	4.59	16	11.9	3.6	4.81
Fractional % phi 6-7	PSEP	Percent	6.99	9.34	0.93	0.33	1.14	1.31	2.76	1.47	2.3	3.78	12.2	5.12	1.66	2.41
Fractional % phi 7-8	PSEP	Percent	4.76	6.9	0.48	0.21	0.86	0.97	1.73	0.92	1.45	2.73	3.79	2.79	1.14	1.65
Fractional % phi 8-9	PSEP	Percent	3.34	5.58	0.25	0.08	0.68	0.55	0.96	0.59	0.87	2.07	1.85	1.8	0.78	1.04
Fractional % phi 9-10	PSEP	Percent	2.76	4.14	0.09	0.08	0.48	0.47	0.77	0.41	0.98	1.9	1.23	1.31	0.69	0.88
Fractional % phi >10	PSEP	Percent	4.62	6.62	1.06	0.86	1.39	1.32	1.53	1.89	1.64	2.73	2.15	3.13	1.62	1.97
Gravel	PSEP	Percent	2.13	0.22	1.69	0.57	0.34	0.45	1.5	10.6	5.92	6.82	1.83	1.21	0.86	2.64

Notes:

0.14 U J = Result followed by laboratory data qualifier followed by data validator qualifier
Sample depth (MLLW) = the core increment elevation in mean lower low water
mg/kg = milligrams per kilogram
µg/kg = micrograms per kilogram

Data Validation Qualifiers:
U – Result should be considered not detected at the quantitation limit shown.
J – Result is an estimated concentration.
UJ – The compound was not detected and the sample detection limit should be considered an estimated value.
N - Pesticide result is tentatively identified.

Laboratory Data Qualifiers:
U – result was not detected at or above the method detection limit.
J (for organics) – result is an estimated concentration that is less than the reporting limit but greater than or equal to the detection limit.
B (for metals) – result is an estimated concentration that is less than the reporting limit but greater than or equal to the detection limit.
* (for metals) – duplicate analysis not within control limits. See case narrative (in laboratory report).
D (for organics) – result reported is from a dilution.
P (for organics) – The GC or HPLC confirmation criteria was exceeded. The relative percent difference is greater than 40 percent between the two analytical results.
i (for organics) – the MRL/MDL has been elevated due to a chromatographic interference.

Table A-2. Remedial Investigation Round 2 Subsurface Cores Analytical Data

Location			9	10	11	12	14	15	17	17	17	18	19	19	26	30	31
Sample ID			TT09-CS-L	TT10-CS-E	TT11-CS-E	TT12-CS-E	TT14-CS-L	TT15-CS-H	TT17-CS-F	TT17-CS-H	TT17-CS-J	TT18-CS-E	TT19-CS-D	TT19-CS-E	TT26-CS-I	TT30-CS-B	TT31-CS-B
Sample Date			1/16/2007	1/22/2007	1/19/2007	1/15/2007	1/13/2007	1/18/2007	1/12/2007	1/12/2007	1/12/2007	1/15/2007	1/15/2007	1/15/2007	1/12/2007	1/16/2007	1/17/2007
Sample Depth (MLLW)			-51 To -51.6 ft	-35 To -36 ft	-48 To -49 ft	-46 To -47 ft	-36 To -37 ft	-53 To -54 ft	-47 To -48 ft	-49 To -50 ft	-51 To -51.84 ft	-38 To -39 ft	-35.58 To -37 ft	-37 To -38 ft	-38 To -39 ft	-53 To -54 ft	-52.9 To -54 ft
Parameter	**Method**	**Units**															
Antimony	EPA 6020	mg/Kg	4.95 J	0.412 J	0.074 J	0.077 J	0.195 J	19.6 J	84 J	6.75 J	0.251 J	0.796 J	6.43 J	0.403 J	0.391 J	1.1 J	0.702 J
Arsenic	EPA 6020	mg/Kg	26.8	8.21	3.26	2.02	5.27	18.1	130	5.15	3.43	4.69	7.22	2.64	3.02	4.97	2.67
Cadmium	EPA 6020	mg/Kg	0.71	0.42	0.14	0.07	0.37	0.09	0.71	0.09	0.12	0.16	0.13	0.09	0.06	0.19	0.09
Chromium	EPA 6020	mg/Kg	44.9	21	11.9	9.36	16.6	16.4	116	12	13.1	11.3	27.7	10.9	13.1	15.3	10.9
Cobalt	EPA 6020	mg/Kg	6.45	8.72	4.75	3.69	5.55	5.59	20.7	3.85	4.44	4.14	4.83	4.04	4.26	4.05	3.8
Copper	EPA 6020	mg/Kg	865	46.3	19	13.2	30.2	61.3	1040	27.8	24.2	66.2	40.8	15.8	14.1	69.7	18.9
Lead	EPA 6020	mg/Kg	266	9.31	3.05	2.52	16.8	56.7	522	9.07	4.49	17.6	40.1	2.59	3.7	41.3	11.7
Mercury	EPA 7471A	mg/Kg	8.51	0.119 J	0.034 J	0.03	0.412	0.315	8.95	0.225	0.09	0.564	0.058 J	0.1 J	0.022	0.741	0.16
Molybdenum	EPA 6020	mg/Kg	1.54	1.47	0.75	0.43	5.11	3.16	10	0.51	0.58	0.65	0.92	0.4	0.4	0.79	0.54
Nickel	EPA 6020	mg/Kg	18.7 * J	17.8	9.84	7.79 * J	13.5 * J	12.9 * J	50.6 * J	8.36 * J	9.72 * J	7.84	12.7	8.63	9.11 * J	9.45	8.35 * J
Selenium	EPA 6020	mg/Kg	0.7 B	1.4	0.5 B	0.3 B	0.6 B	0.4 B	0.8 B	0.3 B	0.3 B	0.4 B	0.4 B	0.4 B	0.3 B	0.5 B	0.4 B
Silver	EPA 6020	mg/Kg	0.247 J	0.13	0.045 U	0.035 UJ	0.122 J	0.429 J	0.511 J	0.061 UJ	0.047 UJ	0.078 U	0.069 U	0.039 U	0.045 UJ	0.152	0.053 UJ
Thallium	EPA 6020	mg/Kg	0.1	0.19	0.11	0.07	0.17	0.07	0.25	0.07	0.09	0.09	0.06	0.08	0.07	0.07	0.07
Vanadium	EPA 6020	mg/Kg	37.9	54.6	33.9	31.8	43.8	26.8	33.1	23.3	35	26.3	30.6	31.8	35.1	28.4	31.1
Zinc	EPA 6020	mg/Kg	405	45.6	24.9	19.6	41.8	229	1250	41.3	28	45.5	77.5	22.2	26.9	71.6	33.8
PCBs (total)	TT calculated	µg/Kg	182	3.2 U	2.4 U	2.4 U	5.5 U	30	3600	23	15	44	131	2.3 U	2.3 U	90	19
		mg/kg OC	13.4	0.1 U	0.3 U	0.3 U	0.2 U		339.6		2.4	3.9	16.8				
PCB-1016	EPA 8082	µg/Kg	2.4 U	3.2 U	2.4 U	2.4 U	2.6 U	2.3 U	130 U	2.3 U	2.3 U	2.4 U	2.3 U	2.3 U	2.3 U	2.4 U	2.3 U
PCB-1221	EPA 8082	µg/Kg	2.4 U	3.2 U	2.4 U	2.4 U	2.6 U	2.3 U	130 U	2.3 U	2.3 U	2.4 U	2.3 U	2.3 U	2.3 U	2.4 U	2.3 U
PCB-1232	EPA 8082	µg/Kg	2.4 U	3.2 U	2.4 U	2.4 U	5.5 Ui	2.3 U	130 U	2.3 U	2.3 U	2.4 U	2.3 U	2.3 U	2.3 U	2.4 U	2.3 U
PCB-1242	EPA 8082	µg/Kg	2.4 U UJ	3.2 U	2.4 U	2.4 U	2.6 U	2.3 U	130 U	2.3 U	2.3 U	15	2.3 U	2.3 U	2.3 U	2.4 U	2.3 U
PCB-1248	EPA 8082	µg/Kg	2.4 U UJ	3.2 U	2.4 U	2.4 U	2.6 U	2.3 U	130 U	2.3 U	2.3 U	2.4 U	2.3 U	2.3 U	2.3 U	2.4 U	2.3 U
PCB-1254	EPA 8082	µg/Kg	120 J	3.2 U	2.4 U	2.4 U	2.6 U	30	3600 D	23	15	19	83	2.3 U	2.3 U	63	19
PCB-1260	EPA 8082	µg/Kg	62 J	3.2 U	2.4 U	2.4 U	2.6 U	2.3 U	130 U	2.3 U	2.3 U	10	48	2.3 U	2.3 U	27	2.3 U
PCB-1262	EPA 8082	µg/Kg	2.4 U J	3.2 U	2.4 U	2.4 U	2.6 U	2.3 U	130 U	2.3 U	2.3 U	2.4 U	2.3 U	2.3 U	2.3 U	2.4 U	2.3 U
PCB-1268	EPA 8082	µg/Kg	2.4 U J	3.2 U	2.4 U	2.4 U	2.6 U	2.3 U	130 U	2.3 U	2.3 U	2.4 U	2.3 U	2.3 U	2.3 U	2.4 U	2.3 U
Aldrin	EPA 8081A	µg/Kg	2.1 U UJ	2.8 U UJ	2.2 U UJ	2.1 U UJ	2.3 U UJ	2 U UJ	11 U UJ	2 U UJ	2 U UJ	2.1 U UJ	2 U UJ	2 U UJ	2.1 U UJ	2.1 U UJ	2 U UJ
alpha-BHC	EPA 8081A	µg/Kg	3.6 U UJ	4.8 U UJ	3.7 U UJ	3.6 U UJ	4 U UJ	3.4 U UJ	19 U UJ	3.4 U UJ	3.5 U UJ	3.6 U UJ	3.5 U UJ	3.5 U UJ	3.5 U UJ	3.6 U UJ	3.5 U UJ
alpha-Chlordane	EPA 8081A	µg/Kg	3.2 U UJ	4.2 U UJ	3.3 U UJ	3.2 U UJ	3.5 U UJ	3 U UJ	17 U UJ	3 U UJ	3.1 U UJ	3.2 U UJ	3.1 U UJ	3.1 U UJ	3.1 U UJ	3.2 U UJ	3.1 U UJ
beta-BHC	EPA 8081A	µg/Kg	4.1 U UJ	5.5 U UJ	4.3 U UJ	4.2 U UJ	4.6 U UJ	4 U UJ	22 U UJ	4 U UJ	4 U UJ	4.1 U UJ	4 U UJ	4 U UJ	4.1 U UJ	4.1 U UJ	4 U UJ
delta-BHC	EPA 8081A	µg/Kg	3.4 Ui UJ	1.1 U UJ	0.78 U UJ	0.76 U UJ	0.84 U UJ	0.72 U UJ	5.1 Ui UJ	0.72 U UJ	0.73 U UJ	0.75 U UJ	0.74 U UJ	0.73 U UJ	0.75 U UJ	1.3 Ui UJ	0.73 U UJ
Dieldrin	EPA 8081A	µg/Kg	4 U UJ	5.3 U UJ	4.1 U UJ	4 U UJ	4.4 U UJ	3.8 U UJ	21 U UJ	3.8 U UJ	3.9 U UJ	4 U UJ	3.9 U UJ	3.9 U UJ	4 U UJ	4 U UJ	3.9 U UJ
Endosulfan I	EPA 8081A	µg/Kg	2.4 U UJ	3.2 U UJ	2.4 U UJ	2.4 U UJ	2.6 U UJ	2.3 U UJ	83 PD JN	2.3 U UJ	2.3 U UJ	2.4 U UJ	2.3 U UJ	2.3 U UJ	2.3 U UJ	2.4 U UJ	2.3 U UJ
Endosulfan II	EPA 8081A	µg/Kg	4.8 D JN	3.5 U UJ	2.7 U UJ	2.7 U UJ	2.9 U UJ	2.5 U UJ	14 U UJ	2.5 U UJ	2.5 U UJ	2.6 U UJ	2.6 U UJ	2.5 U UJ	2.6 U UJ	2.6 U UJ	2.6 U UJ
Endosulfan sulfate	EPA 8081A	µg/Kg	1.8 Ui UJ	1.5 U UJ	1.2 U UJ	1.1 U UJ	1.2 U UJ	1.1 U UJ	5.7 U UJ	1.1 U UJ	1.1 U UJ	1.1 U UJ	1.6 Ui UJ	1.1 U UJ	1.1 U UJ	1.1 U UJ	1.1 U UJ
Endrin	EPA 8081A	µg/Kg	2.8 U UJ	3.7 U UJ	2.9 U UJ	2.8 U UJ	3.1 U UJ	2.7 U UJ	24 D JN	2.7 U UJ	2.7 U UJ	2.8 U UJ	2.7 U UJ	2.7 U UJ	2.7 U UJ	2.8 U UJ	2.7 U UJ
Endrin aldehyde	EPA 8081A	µg/Kg	2.4 JPI JN	0.97 U UJ	0.75 U UJ	0.74 U UJ	0.81 U UJ	0.7 U UJ	66 PD JN	0.69 U UJ	0.7 U UJ	0.72 U UJ	0.71 U UJ	0.7 U UJ	0.72 U UJ	0.72 U UJ	0.71 U UJ
gamma-BHC	EPA 8081A	µg/Kg	2.1 U UJ	2.8 U UJ	2.2 U UJ	2.1 U UJ	3.1 JD UJ	2 U UJ	11 U UJ	2 U UJ	2 U UJ	2.1 U UJ	2 U UJ	2 U UJ	2.1 U UJ	2.1 U UJ	2 U UJ
gamma-Chlordane	EPA 8081A	µg/Kg	2.7 Ui UJ	1.2 U UJ	0.9 U UJ	0.89 U UJ	0.97 U UJ	0.84 U UJ	200 PD JN	0.84 U UJ	0.85 U UJ	0.87 U UJ	2.2 JPI JN	0.85 U UJ	0.87 U UJ	3.3 JD JN	0.85 U UJ
Heptachlor	EPA 8081A	µg/Kg	1.1 U UJ	1.5 U UJ	1.2 U UJ	1.2 U UJ	1.3 U UJ	1.1 U UJ	5.8 U UJ	1.1 U UJ	1.1 U UJ	1.1 U UJ	1.1 U UJ	1.1 U UJ	1.1 U UJ	1.1 U UJ	1.1 U UJ
Heptachlor epoxide	EPA 8081A	µg/Kg	1.8 U UJ	2.4 U UJ	1.9 U UJ	1.8 U UJ	2 U UJ	1.7 U UJ	30 Ui UJ	1.7 U UJ	1.8 U UJ	1.8 U UJ	4.5 PD JN	1.8 U UJ	1.8 U UJ	1.8 U UJ	1.8 U UJ
Methoxychlor	EPA 8081A	µg/Kg	6.2 PD JN	1.9 U UJ	1.5 U UJ	1.4 U UJ	6.1 D JN	1.4 U UJ	26 Ui UJ	3.9 Ui UJ	1.4 U UJ	1.4 U UJ	1.8 Ui UJ	1.4 U UJ	1.4 U UJ	2.7 Ui UJ	1.4 U UJ
Mirex	EPA 8081A	µg/Kg	2.5 JPI JN	1.9 U UJ	1.5 U UJ	1.4 U UJ	1.6 U UJ	1.4 U UJ	7.2 U UJ	1.4 U UJ	1.4 U UJ	1.4 U UJ	1.4 U UJ	1.4 U UJ	1.4 U UJ	1.4 U UJ	1.4 U UJ
Nonachlor (cis)	EPA 8081A	µg/Kg	1.2 U UJ	1.6 U UJ	1.2 U UJ	1.2 U UJ	1.3 U UJ	1.1 U UJ	16 Ui UJ	1.1 U UJ	1.1 U UJ	2.2 JD JN	1.2 U UJ	1.1 U UJ	1.2 U UJ	1.2 U UJ	1.1 U UJ
Nonachlor (trans)	EPA 8081A	µg/Kg	1.3 U UJ	1.7 U UJ	1.3 U UJ	1.3 U UJ	1.4 U UJ	1.2 U UJ	30 Ui UJ	1.2 U UJ	1.2 U UJ	1.3 U UJ	1.2 U UJ	1.2 U UJ	1.2 U UJ	1.3 U UJ	1.2 U UJ
Oxychlordane	EPA 8081A	µg/Kg	5.1 U UJ	6.8 U UJ	5.2 U UJ	5.2 U UJ	5.7 U UJ	4.9 U UJ	27 U UJ	4.9 U UJ	4.9 U UJ	5.1 U UJ	5 U UJ	4.9 U UJ	5 U UJ	5.1 U UJ	4.9 U UJ
Toxaphene	EPA 8081A	µg/Kg	170 Ui UJ	170 U UJ	130 U UJ	130 U UJ	140 U UJ	120 U UJ	1600 Ui UJ	120 U UJ	120 U UJ	130 U UJ	120 U UJ	120 U UJ	130 U UJ	130 U UJ	120 U UJ
o,p-DDD	EPA 8081A	µg/Kg	11 PD JN	3.9 U UJ	3 U UJ	2.9 U UJ	3.2 U UJ	3.3 JD JN	99 Ui UJ	2.8 U UJ	2.8 U UJ	2.9 U UJ	3.4 Ui UJ	2.8 U UJ	2.9 U UJ	8.6 PD JN	2.8 U UJ
o,p-DDE	EPA 8081A	µg/Kg	3.2 U UJ	4.2 U UJ	3.3 U UJ	3.2 U UJ	3.5 U UJ	3 U UJ	17 U UJ	3 U UJ	3.1 U UJ	3.2 U UJ	3.1 U UJ	3.1 U UJ	3.1 U UJ	3.2 U UJ	3.1 U UJ
o,p-DDT	EPA 8081A	µg/Kg	7.3 D JN	2.6 U UJ	2 U UJ	2 U UJ	2.2 U UJ	2.6 JD JN	190 D JN	1.9 U UJ	1.9 U UJ	3.6 Ui UJ	1.9 U UJ	1.9 U UJ	1.9 U UJ	3.8 PD JN	1.9 U UJ
p,p-DDD	EPA 8081A	µg/Kg	4.5 D JN	2.2 U UJ	1.7 U UJ	1.7 U UJ	1.9 U UJ	2.4 Ui UJ	38 D JN	4.4 PD JN	2.7 JD JN	4.5 PD JN	1.6 U UJ	1.6 U UJ	1.7 U UJ	5.5 D JN	1.8 JD JN
p,p-DDE	EPA 8081A	µg/Kg	1.4 U UJ	1.9 U UJ	1.5 U UJ	1.4 U UJ	1.6 U UJ	1.4 U UJ	7.2 U UJ	2.7 JPI JN	1.4 U UJ	1.4 U UJ	1.4 U UJ	1.4 U UJ	1.4 U UJ	1.4 U UJ	1.4 U UJ
p,p-DDT	EPA 8081A	µg/Kg	7.6 PD JN	1.2 U UJ	0.9 U UJ	0.89 U UJ	0.97 U UJ	2.2 JD JN	310 Ui UJ	2.2 JD JN	1.1 Ui UJ	0.87 U UJ	7.9 D JN	0.85 U UJ	0.87 U UJ	7.9 D JN	0.85 U UJ
Total DDT	TT Calculated	µg/Kg	30.4 JN	4.2 U UJ	3.3 U UJ	3.2 U UJ	3.5 U UJ	8.1 JN	228 JN	9.3 JN	2.7 JN	4.5 JN	7.9 JN	3.1 U UJ	3.1 U UJ	25.8 JN	1.8 JN
Total Chlordane	TT Calculated	ug/Kg	5.1 U UJ	6.8 U UJ	5.2 U UJ	5.2 U UJ	5.7 U UJ	4.9 U UJ	200 JN	4.9 U UJ	4.9 U UJ	2.2 JN	2.2 JN	4.9 U UJ	5 U UJ	3.3 JN	4.9 U UJ
1,2,4-Trichlorobenzene	EPA 8270C	µg/Kg	110 U	5.5 U	2.2 U	2.1 U	2.3 U	9.8 U	44 U	2 U	2 U	21 U	2 U	2 U	2.1 U	4.1 U	2 U
		mg/kg OC	8.1 U	0.2 U	0.3 U	0.2 U	0.1 U		4.2 U	U	0.3 U	1.9 U	0.3 U			U	
1,2-Dichlorobenzene	EPA 8270C	µg/Kg	89 U UJ	4.8 U	1.9 U	1.8 U UJ	2 U UJ	8.5 U UJ	38 U UJ	1.7 U UJ	1.8 U UJ	18 U UJ	1.8 U	1.8 U	1.8 U UJ	3.6 U UJ	1.8 U UJ
		mg/kg OC	6.5 U UJ	0.2 U	0.2 U	0.2 U UJ	0.1 U UJ	UJ	3.6 U UJ	U UJ	0.3 U UJ	1.6 U UJ	0.2 U		UJ	U UJ	UJ
1,3-Dichlorobenzene	EPA 8270C	µg/Kg	110 U UJ	5.9 U	2.3 U	2.3 U UJ	2.5 U UJ	11 U UJ	46 U UJ	2.1 U UJ	2.2 U UJ	22 U UJ	2.2 U	2.2 U	2.2 U UJ	4.4 U UJ	2.2 U UJ
1,4-Dichlorobenzene	EPA 8270C	µg/Kg	130 U UJ	7 U	2.7 U	2.7 U UJ	2.9 U UJ	13 U UJ	55 U UJ	2.5 U UJ	2.5 U UJ	26 U UJ	2.6 U	2.5 U	2.6 U UJ	5.2 U UJ	2.6 U UJ
		mg/kg OC	9.6 U UJ	0.3 U	0.3 U	0.3 U UJ	0.1 U UJ	UJ	5.2 U UJ	U UJ	0.4 U UJ	2.3 U UJ	0.3 U		UJ	U UJ	UJ
1-Methylnaphthalene	EPA 8270C	µg/Kg	150 U UJ	8.1 U	3.1 U	3.1 U UJ	85 J	15 U UJ	250 D J	3.1 J J	2.9 U UJ	31 JD J	3.7 J	2.9 U	3 U UJ	6 U UJ	4.4 J J
2,4,5-Trichlorophenol	EPA 8270C	µg/Kg	210 U	11 U	4.3 U	4.2 U	4.6 U	20 U	87 U	4 U	4 U	41 U	4 U	4 U	4.1 U	8.2 U	4 U
2,4,6-Trichlorophenol	EPA 8270C	µg/Kg	130 U	6.6 U	2.6 U	2.5 U	2.8 U	12 U	52 U	2.4 U	2.4 U	25 U	2.4 U	2.4 U	2.5 U	4.9 U	2.4 U
2,4-Dichlorophenol	EPA 8270C	µg/Kg	130 U	6.6 U	2.6 U	2.5 U	2.8 U	12 U	52 U	2.4 U	2.4 U	25 U	2.4 U	2.4 U	2.5 U	4.9 U	2.4 U
2,4-Dimethylphenol	EPA 8270C	µg/Kg	380 U	21 U	7.8 U	7.6 U	8.4 U	36 U	160 U	7.2 U	7.3 U	75 U	7.4 U	7.3 U	7.5 U	15 U	7.3 U
2,4-Dinitrophenol	EPA 8270C	µg/Kg	2500 U	140 U	51 U	50 U	55 U	240 U	1100 U	47 U	48 U	490 U	48 U	48 U	49 U	98 U	48 U
2,4-Dinitrotoluene	EPA 8270C	µg/Kg	190 U	11 U	4 U	3.9 U	4.3 U	19 U	81 U	3.7 U	3.7 U	38 U	3.8 U	3.7 U	3.8 U	7.6 U	3.8 U

Table A-2. Remedial Investigation Round 2 Subsurface Cores Analytical Data

Location			9	10	11	12	14	15	17	17	17	18	19	19	26	30	31
Sample ID			TT09-CS-L	TT10-CS-E	TT11-CS-E	TT12-CS-E	TT14-CS-L	TT15-CS-H	TT17-CS-F	TT17-CS-H	TT17-CS-J	TT18-CS-E	TT19-CS-D	TT19-CS-E	TT26-CS-I	TT30-CS-B	TT31-CS-B
Sample Date			1/16/2007	1/22/2007	1/19/2007	1/15/2007	1/13/2007	1/18/2007	1/12/2007	1/12/2007	1/12/2007	1/15/2007	1/15/2007	1/15/2007	1/12/2007	1/16/2007	1/17/2007
Sample Depth (MLLW)			-51 To -51.6 ft	-35 To -36 ft	-48 To -49 ft	-46 To -47 ft	-36 To -37 ft	-53 To -54 ft	-47 To -48 ft	-49 To -50 ft	-51 To -51.84 ft	-38 To -39 ft	-35.58 To -37 ft	-37 To -38 ft	-38 To -39 ft	-53 To -54 ft	-52.9 To -54 ft
Parameter	**Method**	**Units**															
2,6-Dinitrotoluene	EPA 8270C	µg/Kg	190 U	11 U	4 U	3.9 U	4.3 U	19 U	81 U	3.7 U	3.7 U	38 U	3.8 U	3.7 U	3.8 U	7.6 U	3.8 U
2-Chloronaphthalene	EPA 8270C	µg/Kg	250 U	14 U	5.1 U	5 U	5.5 U	24 U	110 U	4.7 U	4.8 U	49 U	4.8 U	4.8 U	4.9 U	9.8 U	4.8 U
2-Chlorophenol	EPA 8270C	µg/Kg	120 U	6.3 U	2.4 U	2.4 U	2.6 U	12 U	49 U	2.3 U	2.3 U	24 U	2.3 U	2.3 U	2.3 U	4.7 U	2.3 U
2-Methylnaphthalene	EPA 8270C	µg/Kg	110 JD	4.4 U	1.8 J	2.6 J	150	7.9 U	240 D	6.7	1.6 U	39 JD	6.8	1.6 U	1.7 U	9 JD	5.5 J
		mg/kg OC	8.1 JD	0.2 U	0.2 J	0.3 J	6.3		22.6 D		0.3 U	3.5 JD	0.9			JD	
2-Methylphenol	EPA 8270C	µg/Kg	240 U	13 U	4.8 U	4.7 U	5.2 U	23 U	98 U	4.5 U	4.5 U	47 U	4.6 U	4.5 U	4.6 U	9.3 U	4.5 U
2-Nitroaniline	EPA 8270C	µg/Kg	190 U	9.9 U	3.8 U	3.8 U	4.1 U	18 U	78 U	3.6 U	3.6 U	37 U	3.6 U	3.6 U	3.7 U	7.4 U	3.6 U
2-Nitrophenol	EPA 8270C	µg/Kg	180 U	9.5 U	3.7 U	3.6 U	4 U	17 U	75 U	3.4 U	3.5 U	36 U	3.5 U	3.5 U	3.5 U	7.1 U	3.5 U
3,3-Dichlorobenzidine	EPA 8270C	µg/Kg	260 U	14 U	5.2 U	5.2 U	5.7 U	25 U	110 U	4.9 U	4.9 U	51 U	5 U	4.9 U	5 U	11 U	4.9 U
3-Nitroaniline	EPA 8270C	µg/Kg	180 U	9.5 U	3.7 U	3.6 U	4 U	17 U	75 U	3.4 U	3.5 U	36 U	3.5 U	3.5 U	3.5 U	7.1 U	3.5 U
4,6-Dinitro-o-cresol	EPA 8270C	µg/Kg	120 U	6.3 U	2.4 U	2.4 U	2.6 U	12 U	49 U	2.3 U	2.3 U	24 U	2.3 U	2.3 U	2.3 U	4.7 U	2.3 U
4-Bromophenyl phenyl ether	EPA 8270C	µg/Kg	95 U	5.2 U	2 U	2 U	2.2 U	9.2 U	41 U	1.9 U	1.9 U	19 U	1.9 U	1.9 U	1.9 U	3.8 U	1.9 U
4-Chloro-3-methylphenol	EPA 8270C	µg/Kg	150 U	7.7 U	3 U	2.9 U	3.2 U	14 U	61 U	2.8 U	2.8 U	29 U	2.8 U	2.8 U	2.9 U	5.7 U	2.8 U
4-Chloroaniline	EPA 8270C	µg/Kg	150 U	7.7 U	3 U	2.9 U	3.2 U	14 U	61 U	2.8 U	2.8 U	29 U	2.8 U	2.8 U	2.9 U	5.7 U	2.8 U
4-Chlorophenyl phenyl ether	EPA 8270C	µg/Kg	140 U	7.3 U	2.9 U	2.8 U	3.1 U	14 U	58 U	2.7 U	2.7 U	28 U	2.7 U	2.7 U	2.7 U	5.5 U	2.7 U
4-Methylphenol	EPA 8270C	µg/Kg	200 U	11 U	4.1 U	4 U	15	19 U	84 U	6.8	3.9 U	40 U	3.9 U	3.9 U	4 U	7.9 U	3.9 U
4-Nitroaniline	EPA 8270C	µg/Kg	240 U	13 U	4.8 U	4.7 U	5.2 U	23 U	98 U	4.5 U	4.5 U	47 U	4.6 U	4.5 U	4.6 U	9.3 U	4.5 U
4-Nitrophenol	EPA 8270C	µg/Kg	2100 U	110 U	43 U	42 U	46 U	200 U	870 U	40 U	40 U	410 U	40 U	40 U	41 U	82 U	40 U
Acenaphthene	EPA 8270C	µg/Kg	1300 D	4 JD	1.5 U	2 J	240	7.3 JD	580 D	5.6 J	4 J	97 D	6.6 J	1.4 U	4.4 J	14 D	9
		mg/kg OC	95.6 D	0.2 JD	0.2 U	0.2 J	10.0		54.7 D	J	0.6 J	8.6 D	0.8 J			D	
Acenaphthylene	EPA 8270C	µg/Kg	170 JD	5.2 U	2 U	2 U	150	30 JD	410 D	6.9	2.2 J	29 JD	6.7 J	1.9 U	1.9 U	43 D	7.7
		mg/kg OC	12.5 JD	0.2 U	0.3 U	0.2 U	6.3		38.7 D		0.4 J	2.6 JD	0.9 J			D	
Aniline	EPA 8270C	µg/Kg	110 U	5.5 U	2.2 U	2.1 U	2.3 U	9.8 U	44 U	2 U	2 U	21 U	2 U	2 U	2.1 U	4.1 U	2 U
Anthracene	EPA 8270C	µg/Kg	1800 D	13 JD	2.4 J	4 J	330	74 D	1500 D	15	5.7 J	120 D	18	1.9 U	1.9 U	67 D	24
		mg/kg OC	132.4 D	0.5 JD	0.3 J	0.4 J	13.8		141.5 D		0.9 J	10.6 D	2.3			D	
Benzo(a)anthracene	EPA 8270C	µg/Kg	2800 D	19 JD	5.2 J	4.4 J	270	340 D	5000 D	70	22	190 D	41	4.4 J	3.5 J	120 D	40
		mg/kg OC	205.9 D	0.7 JD	0.7 J	0.5 J	11.3		471.7 D		3.5	16.8 D	5.3			D	
Benzo(a)pyrene	EPA 8270C	µg/Kg	2400 D	15 JD	3.6 J	6.8 J	250	270 D	3400 D	48	18	140 D	45	4.1 J	2.5 J	230 D	44
		mg/kg OC	176.5 D	0.6 JD	0.5 J	0.7 J	10.5		320.8 D		2.9	12.4 D	5.8			D	
Benzo(b)fluoranthene	EPA 8270C	µg/Kg	2900 D	20 D	4 J	9.7	450	340 D	4800 D	68	24	210 D	69	7.1	4.1 J	320 D	52
Benzo(g,h,i)perylene	EPA 8270C	µg/Kg	1300 D	8.4 JD	3.3 U	4.7 J	120	140 D	2000 D	28	10	83 D	27	3.1 U	3.1 U	140 D	23
		mg/kg OC	95.6 D	0.3 JD	0.4 U	0.5 J	5.0		188.7 D		1.6	7.3 D	3.5			D	
Benzo(k)fluoranthene	EPA 8270C	µg/Kg	950 D	9.2 U	3.6 U	3.5 U	100	120 D	1500 D	23	9.4	83 D	25	3.3 U	3.4 U	110 D	20
Benzofluoranthenes (total)	TT calculated	µg/Kg	3850	20	4	9.7	550	460	6300	91	33.4	293	94	7.1	4.1	430	72
		mg/kg OC	283.1	0.8	0.5	1.1	23.0		594.3		5.4	25.9	12.1				
Benzoic acid	EPA 8270C	µg/Kg	6600 U	360 U	140 U	140 U	150 U	630 U	2800 U	130 U	130 U	1400 U	130 U	130 U	130 U	270 U	130 U
Benzyl alcohol	EPA 8270C	µg/Kg	260 U	14 U	5.2 U	5.2 U	5.7 U	25 U	110 U	4.9 U	4.9 U	51 U	5 U	4.9 U	5 U	11 U	4.9 U
bis(2-chloroethoxy)methane	EPA 8270C	µg/Kg	89 U	4.8 U	1.9 U	1.8 U	2 U	8.5 U	38 U	1.7 U	1.8 U	18 U	1.8 U	1.8 U	1.8 U	3.6 U	1.8 U
bis(2-chloroethyl)ether	EPA 8270C	µg/Kg	170 U	8.8 U	3.4 U	3.4 U	3.7 U	16 U	69 U	3.2 U	3.2 U	33 U	3.2 U	3.2 U	3.3 U	6.6 U	3.2 U
bis(2-chloroisopropyl)ether	EPA 8270C	µg/Kg	82 U	4.4 U	1.7 U	1.7 U	1.9 U	7.9 U	35 U	1.6 U	1.6 U	17 U	1.6 U	1.6 U	1.7 U	3.3 U	1.6 U
bis(2-ethylhexyl)phthalate	EPA 8270C	µg/Kg	120 JD U	6.3 U	3.6 J U	7.9 J U	2.6 U	21 JD U	1100 JD	9.5 J U	21 J	24 U	19 J U	2.9 J U	3.9 J U	37 JD	5.9 J U
		mg/kg OC	8.8 JD U	0.2 U	0.5 J U	0.9 J U	0.1 U	U	103.8 JD	J U	3.4 J	2.1 U	2.4 J U	U	U	JD	U
Butyl benzyl phthalate	EPA 8270C	µg/Kg	110 U	5.5 U	2.2 U	2.1 U	2.3 U	9.8 U	44 U	2 U	2 U	21 U	2 U	2 U	2.1 U	4.1 U	2 U
		mg/kg OC	8.1 U	0.2 U	0.3 U	0.2 U	0.1 U		4.2 U	U	0.3 U	1.9 U	0.3 U			U	
Chrysene	EPA 8270C	µg/Kg	3500 D	17 JD	3.6 J	5.6 J	290	420 D	5300 D	74	24	230 D	51	7.9	3.5 J	150 D	46
		mg/kg OC	257.4 D	0.7 JD	0.5 J	0.6 J	12.1		500.0 D		3.9	20.4 D	6.5			D	
Dibenzo(a,h)anthracene	EPA 8270C	µg/Kg	330 JD	8.1 U	3.1 U	3.1 U	31	37 D	550 D	7.3	2.9 J	30 U	7.6	2.9 U	3 U	33 D	6.1 J
		mg/kg OC	24.3 JD	0.3 U	0.4 U	0.3 U	1.3		51.9 D		0.5 J	2.7 U	1.0			D	
Dibenzofuran	EPA 8270C	µg/Kg	410 D	4.8 U	1.9 U	2 J	210	8.5 U	320 D	4.2 J	2.6 J	61 JD	8	1.8 U	1.8 U	12 JD	4.8 J
		mg/kg OC	30.1 D	0.2 U	0.2 U	0.2 J	8.8		30.2 D	J	0.4 J	5.4 JD	1.0			JD	
Diethylphthalate	EPA 8270C	µg/Kg	240 U	13 U	37 B U	4.9 U	5.4 U	23 U	110 U	4.6 U	4.7 U	48 U	4.7 U	4.7 U	4.8 U	9.5 U	4.7 U
		mg/kg OC	17.6 U	0.5 U	4.7 B U	0.5 U	0.2 U		10.4 U	U	0.8 U	4.2 U	0.6 U			U	
Dimethyl phthalate	EPA 8270C	µg/Kg	130 U	6.6 U	2.6 U	2.5 U	2.8 U	12 U	52 U	2.4 U	2.4 U	25 U	2.4 U	2.4 U	2.5 U	4.9 U	2.4 U
		mg/kg OC	9.6 U	0.3 U	0.3 U	0.3 U	0.1 U		4.9 U	U	0.4 U	2.2 U	0.3 U			U	
Di-n-butyl phthalate	EPA 8270C	µg/Kg	180 U	9.5 U	4.6 J	3.9 J	4 U	17 U	380 D	6.2 J	3.8 J	36 U	4.2 J	3.5 U	3.5 U	17 D	4.4 J
		mg/kg OC	13.2 U	0.4 U	0.6 J	0.4 J	0.2 U		35.8 D	J	0.6 J	3.2 U	0.5 J			D	
Di-n-octyl phthalate	EPA 8270C	µg/Kg	82 U	4.4 U	1.7 U	1.7 U	1.9 U	7.9 U	35 U	1.6 U	1.6 U	17 U	1.6 U	1.6 U	1.7 U	3.3 U	1.6 U
		mg/kg OC	6.0 U	0.2 U	0.2 U	0.2 U	0.1 U		3.3 U	U	0.3 U	1.5 U	0.2 U			U	
Fluoranthene	EPA 8270C	µg/Kg	8400 D	58 D	8.5	12	740	590 D	11000 D	160	57	1100 D	99	7.1	5.2 J	190 D	76
		mg/kg OC	617.6 D	2.2 D	1.1	1.3	31.0		1037.7 D		9.2	97.3 D	12.7			D	
Fluorene	EPA 8270C	µg/Kg	1100 D	6.3 U	2.4 U	2.4 U	270	14 JD	810 D	7.1	2.9 J	81 D	8.9	2.3 U	2.3 U	20 D	10
		mg/kg OC	80.9 D	0.2 U	0.3 U	0.3 U	11.3		76.4 D		0.5 J	7.2 D	1.1			D	
Hexachlorobenzene	EPA 8081A	µg/Kg	1.1 U	1.5 U	1.2 U	1.1 U	1.2 U	1.1 U	5.7 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
		mg/kg OC	0.1 U	0.1 U	0.2 U	0.1 U	0.1 U		0.5 U	U	0.2 U	0.1 U	0.1 U			U	
Hexachlorobutadiene	EPA 8081A	µg/Kg	6.7 U					6.4 U	36 U			6.7 U					
		mg/kg OC	0.5 U						3.4 U			0.6 U					
Hexachlorobutadiene	EPA 8270C	µg/Kg		5.2 U	2 U	2 U	2.2 U			1.9 U	1.9 U		1.9 U	1.9 U	1.9 U	3.8 U	1.9 U
		mg/kg OC		0.2 U	0.3 U	0.2 U	0.1 U				0.3 U		0.2 U				
Hexachlorocyclopentadiene	EPA 8270C	µg/Kg	1100 U UJ	55 U	22 U	21 U UJ	23 U UJ	98 U UJ	440 U UJ	20 U UJ	20 U UJ	210 U UJ	20 U	20 U	21 U UJ	41 U UJ	20 U UJ

Table A-2. Remedial Investigation Round 2 Subsurface Cores Analytical Data

Location			9	10	11	12	14	15	17	17	17	18	19	19	26	30	31
Sample ID			TT09-CS-L	TT10-CS-E	TT11-CS-E	TT12-CS-E	TT14-CS-L	TT15-CS-H	TT17-CS-F	TT17-CS-H	TT17-CS-J	TT18-CS-E	TT19-CS-D	TT19-CS-E	TT26-CS-I	TT30-CS-B	TT31-CS-B
Sample Date			1/16/2007	1/22/2007	1/19/2007	1/15/2007	1/13/2007	1/18/2007	1/12/2007	1/12/2007	1/12/2007	1/15/2007	1/15/2007	1/15/2007	1/12/2007	1/16/2007	1/17/2007
Sample Depth (MLLW)			-51 To -51.6 ft	-35 To -36 ft	-48 To -49 ft	-46 To -47 ft	-36 To -37 ft	-53 To -54 ft	-47 To -48 ft	-49 To -50 ft	-51 To -51.84 ft	-38 To -39 ft	-35.58 To -37 ft	-37 To -38 ft	-38 To -39 ft	-53 To -54 ft	-52.9 To -54 ft
Parameter	**Method**	**Units**															
Hexachloroethane	EPA 8270C	µg/Kg	150 U UJ	8.1 U	3.1 U	3.1 U UJ	3.4 U UJ	15 U UJ	64 U UJ	2.9 U UJ	2.9 U UJ	30 U UJ	3 U	2.9 U	3 U UJ	6 U UJ	3 U UJ
Indeno(1,2,3-cd)pyrene	EPA 8270C	µg/Kg	1300 D	8.2 JD	2.7 U	5.1 J	130	140 D	2200 D	31	11	80 D	29	2.8 J	2.6 U	150 D	23
		mg/kg OC	95.6 D	0.3 JD	0.3 U	0.6 J	5.4		207.5 D		1.8	7.1 D	3.7			D	
Isophorone	EPA 8270C	µg/Kg	110 U	5.9 U	2.3 U	2.3 U	2.5 U	11 U	46 U	2.1 U	2.2 U	22 U	2.2 U	2.2 U	2.2 U	4.4 U	2.2 U
Naphthalene	EPA 8270C	µg/Kg	290 JD	8.1 JD	2.8 J	6.9	370	11 JD	1100 D	75	1.8 U	240 D	12	1.8 U	1.8 U	22 D	13
		mg/kg OC	21.3 JD	0.3 JD	0.4 J	0.8	15.5		103.8 D		0.3 U	21.2 D	1.5			D	
Nitrobenzene	EPA 8270C	µg/Kg	140 U	7.3 U	2.9 U	2.8 U	3.1 U	14 U	58 U	2.7 U	2.7 U	28 U	2.7 U	2.7 U	2.7 U	5.5 U	2.7 U
N-Nitrosodimethylamine	EPA 8270C	µg/Kg	420 U	23 U	8.6 U	8.5 U	9.3 U	40 U	180 U	8 U	8.1 U	83 U	8.2 U	8.1 U	8.3 U	17 U	8.1 U
N-Nitroso-di-n-propylamine	EPA 8270C	µg/Kg	220 U	12 U	4.5 U	4.5 U	4.9 U	21 U	92 U	4.2 U	4.3 U	44 U	4.3 U	4.3 U	4.4 U	8.7 U	4.3 U
N-Nitrosodiphenylamine	EPA 8270C	µg/Kg	150 U	8.1 U	3.1 U	3.1 U	3.4 U	19 JD	190 D	4.2 J	2.9 U	30 U	3 U	2.9 U	3 U	6 U	3 U
		mg/kg OC	11.0 U	0.3 U	0.4 U	0.3 U	0.1 U		17.9 D	J	0.5 U	2.7 U	0.4 U			U	
Pentachlorophenol	EPA 8270C	µg/Kg	580 U	32 U	12 U	12 U	13 U	56 U	250 U	12 U	12 U	120 U	12 U	12 U	12 U	24 U	12 U
Phenanthrene	EPA 8270C	µg/Kg	8700 D	20 D	6.3 J	11	630	67 D	4100 D	37	27	170 D	38	3.3 J	3.6 J	120 D	68
		mg/kg OC	639.7 D	0.8 D	0.8 J	1.2	26.4		386.8 D		4.4	15.0 D	4.9			D	
Phenol	EPA 8270C	µg/Kg	240 JD	7.3 JD	2.7 U	9.2 J	18 J	13 U	55 U	2.5 U	5.5 J	26 U	2.6 U	2.5 U	2.6 U	5.2 U	8.6 J
Pyrene	EPA 8270C	µg/Kg	9600 D	67 D	15	22	2400 D	740 D	10000 D	170	61	1400 D	140	8.4	11	490 D	100
		mg/kg OC	705.9 D	2.6 D	1.9	2.4	100.4 D		943.4 D		9.8	123.9 D	17.9			D	
Total HPAH	TT calculated	µg/Kg	33480	212.6	39.9	70.3	4781	3137	45750	679.3	239.3	3516	533.6	41.8	29.8	1933	430.1
		mg/kg OC	2461.8	8.2	5.1	7.6	200.0		4316.0		38.6	311.2	68.4				
Total LPAH	TT calculated	µg/Kg	13360	45.1	11.5	23.9	1990	203.3	8500	146.6	41.8	737	90.2	3.3	8	286	131.7
		mg/kg OC	982.4	1.7	1.5	2.6	83.3		801.9		6.7	65.2	11.6				
Total PAH	TT calculated	µg/Kg	46840	257.7	51.4	94.2	6771	3340.3	54250	825.9	281.1	4253	623.8	45.1	37.8	2219	561.8
Butyltin	KRONE	µg/Kg	0.47 JP UJ	0.055 U	0.043 U	0.14 Ui	0.046 U	0.24 Ui	0.87 J	0.04 U	0.37 J	0.041 U	1.5 J	0.04 U	0.13 Ui	0.21 Ui	0.22 Ui
Dibutyltin	KRONE	µg/Kg	2.7 J	0.35 Ui	0.45 J U	0.57 J U	0.59 J U	1.7 U	10	0.87 J U	1.8	0.74 J U	16	1.4	0.68 J U	1.2 J U	1.4 U
Tetrabutyltin	KRONE	µg/Kg	0.095 U	0.13 U	0.099 U	0.097 U	0.11 U	0.092 U	0.87 JP J	0.092 U	0.093 U	0.095 U	0.45 Ui	0.093 U	0.095 U	0.095 U	0.093 U
Tributyltin	KRONE	µg/Kg	0.52 J	0.8 J	0.079 U	0.29 J	0.21 Ui	5.3	37	1.4	5.5	2.3	47	3	0.43 J	2	1.6
		mg/kg OC	0.038 J	0.031 J	0.010 U	0.032 J	0.009 Ui		3.5		0.9	0.2	6.0				
Total Solids	EPA 160.3	Percent	73.8	54.8	71.4	72.5	66	76.8	69.6	76.9	76	73.7	75.2	76	74.3	73.7	75.6
Total Organic Carbon	PSEP	Percent	1.36	2.59	0.78	0.92	2.39	0.47	1.06	0.5	0.62	1.13	0.78	0.46	0.36	0.5	0.46
Fractional % phi >-1	PSEP	Percent	2.66	0.59	0.37	0.4	1	1.93	2.09	0.79	0.59	1.56	0.71	0.25	0.14	0.35	0.18
Fractional % phi 0-1	PSEP	Percent	8.86	0.45	0.65	0.7	0.966	9.32	8.33	2.53	1.03	9.93	1.84	0.26	0.2	0.87	0.35
Fractional % phi 1-2	PSEP	Percent	13.9	0.38	7.76	1.6	2.48	24.8	22.2	20.1	3.97	31.5	22.3	1.09	5.28	9.94	5.15
Fractional % phi 2-3	PSEP	Percent	14.4	0.86	16.5	34.4	6.8	39.6	24.4	25.6	18.6	22.9	34.7	27.8	30.9	33.6	38.8
Fractional % phi 3-4	PSEP	Percent	21.4	1.57	25.2	44.8	23	12.7	14.5	19.4	30.6	11.2	15.7	30.9	34.4	31.3	33.8
Fractional % phi 4-5	PSEP	Percent	16.1	2.07	17.6	12.7	31.1	3.75	10.3	9.24	17.1	6.83	6.77	14.6	13.5	10.4	10.8
Fractional % phi 5-6	PSEP	Percent	9.04	14.6	13	2.17	9.5	2.77	8.5	5.83	7.1	4.98	5.22	8.64	5.31	4.88	2.7
Fractional % phi 6-7	PSEP	Percent	3.36	27.9	6.8	1.04	13.8	1.81	3.76	7.2	9.96	2.99	3.4	5.8	5.64	3.14	1.56
Fractional % phi 7-8	PSEP	Percent	1.68	18.5	3.78	0.63	4.05	0.93	1.43	2.76	3.3	1.6	1.72	3.66	2.21	2.01	0.96
Fractional % phi 8-9	PSEP	Percent	0.84	11.8	2.53	0.45	3.22	0.49	0.48	1.44	2.07	1.34	0.89	2.28	1.37	1.28	0.74
Fractional % phi 9-10	PSEP	Percent	0.35	9.68	1.72	0.39	2.31	0.31	0.52	1.22	1.44	0.85	0.51	1.61	0.54	0.95	0.54
Fractional % phi >10	PSEP	Percent	1.69	11.9	3.37	1.6	4.23	1.09	1.8	1.77	2.39	1.84	1.56	2.18	1.8	1.85	1.62
Gravel	PSEP	Percent	1.5	0.19	0.27	0.25	1.18	1.07	3.95	2.46	1.1	2.47	1.22	0.1	0.22	0.43	0.66

Laboratory Data Qualifiers:
U – result was not detected at or above the method detection limit.
J (for organics) – result is an estimated concentration that is less than the reporting limit but greater than or equal to the detection limit.
B (for metals) – result is an estimated concentration that is less than the reporting limit but greater than or equal to the detection limit.
* (for metals) – duplicate analysis not within control limits. See case narrative (in laboratory report).
D (for organics) – result reported is from a dilution.

P (for organics) – The GC or HPLC confirmation criteria was exceeded. The relative percent difference is greater than 40 percent between the two analytical results.
i (for organics) – the MRL/MDL has been elevated due to a chromatographic interference.

Table A-3. Remedial Investigation Subtidal Surface Sediment Analytical Data

Location			1	2	3	4	4	5	5	6	6	7	8	9	10	11	12
Sample ID			TT01-SS	TT02-SS	TT03-SS	TT04-SS	TT92-SS	TT94-SS	TT05-SS	TT93-SS	TT06-SS	TT07-SS	TT08-SS	TT09-SS	TT10-SS	TT11-SS	TT12-SS
Sample Date			1/24/2007	1/24/2007	1/24/2007	1/24/2007	1/24/2007	1/25/2007	1/25/2007	1/24/2007	1/24/2007	1/25/2007	1/24/2007	1/25/2007	1/25/2007	1/26/2007	1/26/2007
Parameter	**Method**	**Units**															
Antimony	EPA 6020	mg/Kg	2.01 * J	1.45 * J	2.17 * J	2.4 * J	1.66 * J	2.23 * J	2.19 * J	4.12 * J	3.35 * J	2.59 * J	15.3 * J	41.3 J	56.4 J	194 J	9.21 J
Arsenic	EPA 6020	mg/Kg	7.88 J	9.05 J	10.6 J	9.83 J	9.65 J	11.9 J	12.6 J	15.6 J	15.9 J	14 J	40.5 J	183	146	204	18.3
Cadmium	EPA 6020	mg/Kg	0.169 J	0.188 J	0.268	0.245 J	0.237	0.388	0.375	0.367	0.305	0.364	0.286	0.73	0.57	0.64	0.18
Chromium	EPA 6010B	mg/Kg	26.7	26.5	34.6	30.4	31.3	41	39.5	46.4	48.2	44.4	50.5	60.6	169	94.5	66.9
Cobalt	EPA 6020	mg/Kg	5.69 J	5.88 J	5.69 J	5.88 J	5.73 J	6.02 J	6 J	6.67 J	6.66 J	6.89 J	8.29 J	21	23	16.3	5.71
Copper	EPA 6010B	mg/Kg	64	71.4	97.1	79.2	78.3	114	118	146	146	143	230	483	894	514	111
Lead	EPA 6020	mg/Kg	39.8 J	51 J	59.2	56.3 J	48.6	72.4	68.4	89.8	87.6	77.1	123	258	395	483	80.9
Mercury	EPA 7471A	mg/Kg	0.299	0.374	0.471	0.437	0.443	0.572	0.707	0.685	0.682	0.796	1.46	0.525	0.631	1.04 *	0.636 *
Molybdenum	EPA 6020	mg/Kg	0.69 J	0.7 J	1.09	0.9 J	0.92	1.63	1.63	1.38	1.67	1.37	3.43	14.5	12	9.33	1.33
Nickel	EPA 6020	mg/Kg	12.4 J	12.4 J	13.5 J	13.8 J	13.7 J	15.8 J	16.3 J	16.4 J	16.9 J	16.6 J	15.9 J	22.9	58.1	29.9	16.6
Selenium	EPA 6020	mg/Kg	0.4 U UJ	0.4 U UJ	0.4 U	0.5 U UJ	0.5 U	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U	0.5 U	1.1	1 B	1.2	0.9 B
Silver	EPA 6020	mg/Kg	0.224	0.201	0.276	0.216	0.262	0.297	0.27	0.373	0.328	0.349	0.332	0.521	0.703	0.665	0.296
Thallium	EPA 6020	mg/Kg	0.079 J	0.083 J	0.096	0.096 J	0.092	0.11	0.113	0.11	0.122	0.117	0.103	0.19	0.18	0.24	0.09
Vanadium	EPA 6010B	mg/Kg	53.6	52	55.4	49.5	47.8	53.8	49.5	57	56.3	64	48.5	61	69	58.2	42.4
Zinc	EPA 6010B	mg/Kg	90.1	95.5	130	120	122	150	153	192	180	168	235	880	954	1430	163
PCBs (total)	TT calculation	ug/Kg	149	150	240	270	173	300	430	420	390	445	690	480	1310	1220	257
		mg/kg OC	15.7	13.9		21.6	13.4	16.5	21.5	21.0	25.5	23.1	54.3	35.0	128.4	108.9	20.9
PCB-1016	EPA 8082	ug/Kg	2.9 U	2.9 U	2.7 U	2.8 U	2.8 U	16 U	16 U	2.9 U	3 U	16 U	15 U	31 U	26 U	25 U	2.8 U
PCB-1221	EPA 8082	ug/Kg	2.9 U	2.9 U	2.7 U	2.8 U	2.8 U	16 U	16 U	2.9 U	3 U	16 U	15 U	31 U	26 U	25 U	2.8 U
PCB-1232	EPA 8082	ug/Kg	2.9 U	2.9 U	2.7 U	2.8 U	2.8 U	16 U	16 U	2.9 U	3 U	16 U	15 U	31 U	26 U	25 U	2.8 U
PCB-1242	EPA 8082	ug/Kg	2.9 U	2.9 U	2.7 U	2.8 U	2.8 U	16 U	16 U	2.9 U	3 U	16 U	15 U	31 U	26 U	25 U	2.8 U
PCB-1248	EPA 8082	ug/Kg	2.9 U	2.9 U	2.7 U	2.8 U	2.8 U	16 U	16 U	2.9 U	3 U	16 U	15 U	31 U	26 U	25 U	2.8 U
PCB-1254	EPA 8082	ug/Kg	85	91	140	140	100	160 D	230 D	250	220	220 D	380 D	260 D	740 D	710 D	170
PCB-1260	EPA 8082	ug/Kg	64	59	100	130	73	140 D	200 D	170	170	200 D	310 D	220 D	570 PD J	510 D	87
PCB-1262	EPA 8082	ug/Kg	2.9 U	2.9 U	2.7 U	2.8 U	2.8 U	16 U	16 U	2.9 U	3 U	16 U	15 U	31 U	26 U	25 U	2.8 U
PCB-1268	EPA 8082	ug/Kg	2.9 U	2.9 U	2.7 U	2.8 U	2.8 U	16 U	16 U	2.9 U	3 U	25 D	15 U	31 U	26 U	25 U	2.8 U
Aldrin	EPA 8081A	ug/Kg	2.6 U UJ	2.6 U UJ	2.4 U UJ	3.5 Ui UJ	2.5 U UJ	3 Ui UJ	2.7 U UJ	2.6 U UJ	2.6 U UJ	2.8 U UJ	2.5 U UJ	5.4 U UJ	4.5 U UJ	4.4 U UJ	4.8 U UJ
alpha-BHC	EPA 8081A	ug/Kg	4.4 U UJ	4.5 U UJ	4.1 U UJ	4.3 U UJ	4.3 U UJ	4.7 U UJ	4.7 U UJ	4.4 U UJ	4.5 U UJ	4.8 U UJ	4.4 U UJ	9.4 U UJ	7.8 U UJ	7.5 U UJ	8.4 U UJ
alpha-Chlordane	EPA 8081A	ug/Kg	3.9 U UJ	4 U UJ	3.7 U UJ	3.8 U UJ	3.8 U UJ	4.2 U UJ	4.2 U UJ	3.9 U UJ	4 U UJ	4.2 U UJ	3.9 U UJ	8.3 U UJ	6.9 U UJ	6.7 U UJ	7.4 U UJ
beta-BHC	EPA 8081A	ug/Kg	5.1 U UJ	5.1 U UJ	4.8 U UJ	4.9 U UJ	5 U UJ	5.5 U UJ	5.4 U UJ	5.1 U UJ	5.2 U UJ	5.5 U UJ	5 U UJ	11 U UJ	8.9 U UJ	8.7 U UJ	9.6 U UJ
delta-BHC	EPA 8081A	ug/Kg	0.93 U UJ	0.94 U UJ	0.87 U UJ	1.6 Ui UJ	1.1 Ui UJ	1 U UJ	3.4 Ui UJ	0.94 U UJ	0.95 U UJ	1.1 U UJ	0.92 U UJ	2 U UJ	1.7 U UJ	1.6 U UJ	1.8 U UJ
Dieldrin	EPA 8081A	ug/Kg	4.9 U UJ	5 U UJ	4.6 U UJ	5.5 Ui UJ	4.8 U UJ	5.3 U UJ	5.2 U UJ	5 U UJ	5 U UJ	5.3 U UJ	9.9 Ui UJ	11 U UJ	11 Ui UJ	8.4 U UJ	9.3 U UJ
Endosulfan I	EPA 8081A	ug/Kg	2.9 U UJ	2.9 U UJ	2.7 U UJ	2.8 U UJ	2.8 U UJ	3.1 U UJ	3.1 U UJ	2.9 U UJ	3 U UJ	3.2 U UJ	2.9 U UJ	6.1 U UJ	5.1 U UJ	4.9 U UJ	5.5 U UJ
Endosulfan II	EPA 8081A	ug/Kg	3.2 U UJ	3.3 U UJ	3 U UJ	3.1 U UJ	3.2 U UJ	3.5 U UJ	3.5 U UJ	3.3 U UJ	3.3 U UJ	3.5 U UJ	3.2 U UJ	8 Ui UJ	5.7 U UJ	5.5 U UJ	6.1 U UJ
Endosulfan sulfate	EPA 8081A	ug/Kg	1.4 U UJ	1.4 U UJ	1.3 U UJ	1.7 Ui UJ	1.3 U UJ	1.7 Ui UJ	2.1 Ui UJ	1.9 Ui UJ	1.4 U UJ	1.5 U UJ	1.4 U UJ	2.9 U UJ	2.4 U UJ	2.3 U UJ	2.6 U UJ
Endrin	EPA 8081A	ug/Kg	3.4 U UJ	3.4 U UJ	3.2 U UJ	3.3 U UJ	3.3 U UJ	3.7 U UJ	3.6 U UJ	3.4 U UJ	3.5 U UJ	3.7 U UJ	3.4 U UJ	7.2 U UJ	6 U UJ	5.8 U UJ	6.4 U UJ
Endrin aldehyde	EPA 8081A	ug/Kg	0.9 U UJ	0.9 U UJ	0.95 Ui UJ	0.87 U UJ	0.87 U UJ	0.96 U UJ	1.4 Ui UJ	6.4 PD JN	5 Ui UJ	0.97 U UJ	6.8 PD JN	1.9 U UJ	10 PD JN	8.4 JPD JN	1.7 U UJ
gamma-BHC	EPA 8081A	ug/Kg	2.6 U UJ	2.6 U UJ	2.4 U UJ	2.5 U UJ	2.5 U UJ	5 Ui UJ	4.9 Ui UJ	2.6 U UJ	2.6 U UJ	2.8 U UJ	2.5 U UJ	5.4 U UJ	4.5 U UJ	4.4 U UJ	4.8 U UJ
gamma-Chlordane	EPA 8081A	ug/Kg	5 Ui UJ	4.7 JPD JN	3.4 JPD JN	3 JPD JN	6 PD JN	2.5 Ui UJ	8.4 PD JN	14 PD JN	12 PD JN	2.9 JPD JN	7.4 PD JN	7.6 JPD JN	29 PD JN	11 PD JN	3.9 JPD JN
Heptachlor	EPA 8081A	ug/Kg	1.4 U UJ	1.4 U UJ	1.3 U UJ	1.3 U UJ	1.4 U UJ	1.5 U UJ	1.5 U UJ	1.4 U UJ	1.4 U UJ	1.5 U UJ	1.4 U UJ	2.9 U UJ	2.4 U UJ	2.4 U UJ	2.6 U UJ
Heptachlor epoxide	EPA 8081A	ug/Kg	2.2 U UJ	2.3 U UJ	5 Ui UJ	2.2 U UJ	2.2 U UJ	2.4 U UJ	2.4 U UJ	2.2 U UJ	2.3 U UJ	2.4 U UJ	5 Ui UJ	4.7 U UJ	10 Ui UJ	3.8 U UJ	4.2 U UJ
Methoxychlor	EPA 8081A	ug/Kg	1.7 U UJ	1.9 Ui UJ	1.6 U UJ	1.7 U UJ	1.7 U UJ	13 PD JN	1.8 U UJ	5 Ui UJ	5 Ui UJ	1.9 U UJ	11 PD JN	3.6 U UJ	3 U UJ	3.3 Ui UJ	3.2 U UJ
Mirex	EPA 8081A	ug/Kg	1.7 U UJ	1.7 U UJ	1.6 U UJ	1.7 U UJ	1.7 U UJ	1.9 U UJ	1.8 U UJ	1.8 JD JN	1.8 U UJ	1.9 U UJ	1.7 U UJ	3.6 U UJ	10 Ui UJ	2.9 U UJ	3.2 U UJ
Nonachlor (cis)	EPA 8081A	ug/Kg	1.4 U UJ	1.5 U UJ	1.4 U UJ	1.4 U UJ	1.4 U UJ	5 Ui UJ	1.5 U UJ	5 Ui UJ	1.5 U UJ	1.6 U UJ	15 PD JN	5.3 Ui UJ	10 Ui UJ	2.4 U UJ	2.7 U UJ
Nonachlor (trans)	EPA 8081A	ug/Kg	1.5 U UJ	1.6 U UJ	5.5 PD JN	7.5 PD JN	1.5 U UJ	1.7 U UJ	1.6 U UJ	5 Ui UJ	1.6 U UJ	1.7 U UJ	5 Ui UJ	3.2 U UJ	10 Ui UJ	10 Ui UJ	2.9 U UJ
Oxychlordane	EPA 8081A	ug/Kg	6.3 U UJ	6.3 U UJ	5.8 U UJ	6.1 U UJ	6.1 U UJ	6.7 U UJ	6.7 U UJ	6.3 U UJ	6.4 U UJ	6.8 U UJ	6.2 U UJ	14 U UJ	11 U UJ	11 U UJ	12 U UJ
Toxaphene	EPA 8081A	ug/Kg	160 U UJ	160 U UJ	190 Ui UJ	180 Ui UJ	150 U UJ	170 U UJ	210 Ui UJ	220 Ui UJ	320 Ui UJ	170 U UJ	280 Ui UJ	330 U UJ	380 Ui UJ	500 Ui UJ	290 U UJ
o,p'-DDD	EPA 8081A	ug/Kg	11 PD JN	12 PD JN	18 PD JN	15 PD JN	12 PD JN	15 D JN	18 PD JN	10 Ui UJ	27 PD JN	6.4 D JN	39 PD JN	20 PD JN	75 PD JN	14 Ui UJ	20 PD JN
o,p'-DDE	EPA 8081A	ug/Kg	3.9 U UJ	4 U UJ	3.7 U UJ	3.8 U UJ	3.8 U UJ	4.2 U UJ	4.2 U UJ	3.9 U UJ	4 U UJ	4.2 U UJ	3.9 U UJ	8.3 U UJ	12 Ui UJ	14 Ui UJ	7.4 U UJ
o,p'-DDT	EPA 8081A	ug/Kg	8.3 D JN	8.9 D JN	13 D JN	11 D JN	8.7 D JN	10 D JN	11 D JN	24 D JN	19 D JN	4.8 JD JN	20 D JN	18 D JN	54 D JN	43 D JN	25 PD JN
p,p'-DDD	EPA 8081A	ug/Kg	2.1 U UJ	2.1 U UJ	1.9 U UJ	2 U UJ	2 U UJ	3.8 JPD JN	2.2 U UJ	3.1 JD JN	2.1 U UJ	2.2 U UJ	9.4 D JN	7.7 JD JN	8.1 JD JN	3.5 U UJ	3.9 U UJ
p,p'-DDE	EPA 8081A	ug/Kg	1.7 U UJ	1.7 U UJ	1.6 U UJ	1.7 U UJ	1.7 U UJ	1.9 U UJ	1.8 JPD JN	1.7 U UJ	1.8 U UJ	1.9 U UJ	5 Ui UJ	3.6 U UJ	3 U UJ	2.9 U UJ	3.2 U UJ
p,p'-DDT	EPA 8081A	ug/Kg	11 D JN	13 D JN	19 D JN	19 D JN	17 D JN	16 D JN	19 Ui UJ	35 D JN	34 D JN	6.8 D JN	37 D JN	37 D JN	68 D JN	58 Ui UJ	21 D JN
Total DDT	TT calculation	ug/Kg	30.3 JN	33.9 JN	50 JN	45 JN	37.7 JN	44.8 JN	30.8 JN	62.1 JN	80 JN	18 JN	105.4 JN	82.7 JN	205.1 JN	43 JN	66 JN
Total Chlordane	TT Calculated	ug/Kg	6.3 U UJ	4.7 JN	8.9 JN	10.5 JN	6 JN	6.7 U UJ	8.4 JN	14 JN	12 JN	2.9 JN	22.4 JN	7.6 JN	29 JN	11 JN	3.9 JN
1,2,4-Trichlorobenzene	EPA 8270C	ug/Kg	2.6 U	2.6 U	7.1 U	2.5 U	2.5 U	14 U	14 U	13 U	7.8 U	14 U	13 U	14 U	12 U	11 U	2.4 U
		mg/kg OC	0.3 U	0.2 U		0.2 U	0.2 U	0.8 U	0.7 U	0.7 U	0.5 U	0.7 U	1.0 U	1.0 U	1.2 U	1.0 U	0.2 U
1,2-Dichlorobenzene	EPA 8270C	ug/Kg	2.2 U	2.3 U	6.2 U	2.2 U	2.2 U	12 U	12 U	11 U	6.7 U	12 U	11 U	12 U	9.7 U	9.4 U	2.1 U
		mg/kg OC	0.2 U	0.2 U		0.2 U	0.2 U	0.7 U	0.6 U	0.6 U	0.4 U	0.6 U	0.9 U	0.9 U	1.0 U	0.8 U	0.2 U
1,3-Dichlorobenzene	EPA 8270C	ug/Kg	2.7 U	2.8 U	7.6 U	2.6 U	2.7 U	15 U	15 U	14 U	8.3 U	15 U	14 U	15 U	12 U	12 U	2.6 U
1,4-Dichlorobenzene	EPA 8270C	ug/Kg	3.2 U	4 J	9 U	3.5 J	3.7 J	18 U	18 U	17 U	9.8 U	18 U	16 U	17 U	15 U	14 U	3.1 U
		mg/kg OC	0.3 U	0.4 J		0.3 J	0.3 J	1.0 U	0.9 U	0.9 U	0.6 U	0.9 U	1.3 U	1.2 U	1.5 U	1.3 U	0.3 U
1-Methylnaphthalene	EPA 8270C	ug/Kg	17 U UJ	17 U UJ	48 U UJ	17 U UJ	19 J	91 U UJ	90 U UJ	85 U UJ	52 U UJ	92 U UJ	83 U UJ	90 U UJ	75 U UJ	73 U UJ	16 U UJ
2,4,5-Trichlorophenol	EPA 8270C	ug/Kg	5.1 U	5.1 U	15 U	4.9 U	5 U	28 U	27 U	26 U	16 U	28 U	25 U	27 U	23 U	22 U	4.8 U
2,4,6-Trichlorophenol	EPA 8270C	ug/Kg	3.1 U	3.1 U	8.5 U	3 U	3 U	17 U	17 U	16 U	9.3 U	17 U	15 U	17 U	14 U	13 U	2.9 U
2,4-Dichlorophenol	EPA 8270C	ug/Kg	3.1 U	3.1 U	8.5 U	3 U	3 U	17 U	17 U	16 U	9.3 U	17 U	15 U	17 U	14 U	13 U	2.9 U
2,4-Dimethylphenol	EPA 8270C	ug/Kg	9.3 U	9.4 U	26 U	9 U	9.1 U	50 U	50 U	47 U	29 U	51 U	46 U	50 U UJ	41 U UJ	40 U	8.8 U
2,4-Dinitrophenol	EPA 8270C	ug/Kg	61 U	62 U	170 U	59 U	59 U	330 U	330 U	310 U	190 U	330 U	300 U	330 U	270 U	260 U	58 U
2,4-Dinitrotoluene	EPA 8270C	ug/Kg	4.8 U	4.8 U	14 U	4.6 U	4.6 U	26 U	26 U	24 U	15 U	26 U	24 U	26 U	21 U	21 U	4.5 U
2,6-Dinitrotoluene	EPA 8270C	ug/Kg	4.8 U	4.8 U	14 U	4.6 U	4.6 U	26 U	26 U	24 U	15 U	26 U	24 U	26 U	21 U	21 U	4.5 U
2-Chloronaphthalene	EPA 8270C	ug/Kg	6.1 U	6.2 U	17 U	5.9 U	5.9 U	33 U	33 U	31 U	19 U	33 U	30 U	33 U	27 U	26 U	5.8 U
2-Chlorophenol	EPA 8270C	ug/Kg	2.9 U	2.9 U	8 U	2.8 U	2.8 U	16 U	16 U	15 U	8.8 U	16 U	15 U	16 U	13 U	13 U	2.8 U
2-Methylnaphthalene	EPA 8270C	ug/Kg	29	25	31 D	25	30	40 JD	37 JD	48 JD	34 D	51 D	48 JD	41 JD	40 JD	22 JD	22
		mg/kg OC	3.1	2.3		2.0	2.3	2.2 JD	1.9 JD	2.4 JD	2.2 D	2.6 D	3.8 JD	3.0 JD	3.9 JD	2.0 JD	1.8
2-Methylphenol	EPA 8270C	ug/Kg	5.8 U	5.8 U	16 U	5.6 U	5.6 U	31 U	31 U	29 U	18 U	32 U	29 U	31 U	26 U	25 U	5.5 U
2-Nitroaniline	EPA 8270C	ug/Kg	4.6 U	4.6 U	13 U	4.4 U	4.5 U	25 U	25 U	23 U	14 U	25 U	23 U	25 U	20 U	20 U	4.4 U
2-Nitrophenol	EPA 8270C	ug/Kg	4.4 U	4.5 U	13 U	4.3 U	4.3 U	24 U	24 U	22 U	14 U	24 U	22 U	24 U	20 U	19 U	4.2 U
3,3'-Dichlorobenzidine	EPA 8270C	ug/Kg	6.3 U	6.3 U	18 U	6.1 U	6.1 U	34 U	34 U	32 U	20 U	34 U	31 U	34 U	28 U	27 U	6 U
3-Nitroaniline	EPA 8270C	ug/Kg	4.4 U	4.5 U	13 U	4.3 U	4.3 U	24 U	24 U	22 U	14 U	24 U	22 U	24 U	20 U	19 U	4.2 U

Table A-3. Remedial Investigation Subtidal Surface Sediment Analytical Data

Location			1	2	3	4	4	5	5	6	6	7	8	9	10	11	12
Sample ID			TT01-SS	TT02-SS	TT03-SS	TT04-SS	TT92-SS	TT94-SS	TT05-SS	TT93-SS	TT06-SS	TT07-SS	TT08-SS	TT09-SS	TT10-SS	TT11-SS	TT12-SS
Sample Date			1/24/2007	1/24/2007	1/24/2007	1/24/2007	1/24/2007	1/25/2007	1/25/2007	1/24/2007	1/24/2007	1/25/2007	1/24/2007	1/25/2007	1/25/2007	1/26/2007	1/26/2007
Parameter	**Method**	**Units**															
4,6-Dinitro-o-cresol	EPA 8270C	ug/Kg	2.9 U	2.9 U	8 U	2.8 U	2.8 U	16 U	16 U	15 U	8.8 U	16 U	15 U	16 U	13 U	13 U	2.8 U
4-Bromophenyl phenyl ether	EPA 8270C	ug/Kg	2.4 U	2.4 U	6.6 U	2.3 U	2.3 U	13 U	13 U	12 U	7.2 U	13 U	12 U	13 U	11 U	11 U	2.3 U
4-Chloro-3-methylphenol	EPA 8270C	ug/Kg	3.6 U	3.6 U	9.9 U	3.5 U	3.5 U	19 U	19 U	18 U	11 U	20 U	18 U	19 U	16 U	16 U	3.4 U
4-Chloroaniline	EPA 8270C	ug/Kg	3.6 U	3.6 U	9.9 U	3.5 U	3.5 U	19 U	19 U	18 U	11 U	20 U	18 U	19 U	16 U	16 U	3.4 U
4-Chlorophenyl phenyl ether	EPA 8270C	ug/Kg	3.4 U	3.4 U	9.5 U	3.3 U	3.3 U	19 U	18 U	17 U	11 U	19 U	17 U	18 U	15 U	15 U	3.2 U
4-Methylphenol	EPA 8270C	ug/Kg	12	16	14 U	13	15	27 U	26 U	25 U	17 JD	27 U	25 U	26 U	27 JD	28 JD	18
4-Nitroaniline	EPA 8270C	ug/Kg	5.8 U	5.8 U	16 U	5.6 U	5.6 U	31 U	31 U	29 U	18 U	32 U	29 U	31 U	26 U	26 JD	5.5 U
4-Nitrophenol	EPA 8270C	ug/Kg	51 U	51 U	150 U	49 U	50 U	280 U	270 U	260 U	160 U	280 U	250 U	270 U	230 U	220 U	48 U
Acenaphthene	EPA 8270C	ug/Kg	40	39	55 D	48	59	95 D	67 D	100 D	87 D	170 D	160 D	150 D	130 D	54 D	51
		mg/kg OC	4.2	3.6		3.8	4.6	5.2 D	3.4 D	5.0 D	5.7 D	8.8 D	12.6 D	10.9 D	12.7 D	4.8 D	4.1
Acenaphthylene	EPA 8270C	ug/Kg	54	44	61 D	66	82	120 D	110 D	110 D	94 D	150 D	190 D	93 D	110 D	130 D	70
		mg/kg OC	5.7	4.1		5.3	6.4	6.6 D	5.5 D	5.5 D	6.1 D	7.8 D	15.0 D	6.8 D	10.8 D	11.6 D	5.7
Aniline	EPA 8270C	ug/Kg	2.6 U	2.6 U	7.1 U	2.5 U	2.5 U	14 U	14 U	13 U	13 JD	14 U	13 U	14 U	12 U	11 U	2.4 U
Anthracene	EPA 8270C	ug/Kg	520	140	190 D	190	230	370 D	510 D	300 D	260 D	450 D	510 D	350 D	310 D	600 D	210
		mg/kg OC	54.7	13.0		15.2	17.8	20.3 D	25.5 D	15.0 D	17.0 D	23.3 D	40.2 D	25.5 D	30.4 D	53.6 D	17.1
Benzo(a)anthracene	EPA 8270C	ug/Kg	570	220	370 D	330	370	770 D	730 D	750 D	580 D	910 D	1300 D	910 D	840 D	1900 D	360
		mg/kg OC	60.0	20.4		26.4	28.7	42.3 D	36.5 D	37.5 D	37.9 D	47.2 D	102.4 D	66.4 D	82.4 D	169.6 D	29.3
Benzo(a)pyrene	EPA 8270C	ug/Kg	420	270	470 D	440	450 D	830 D	770 D	850 D	690 D	990 D	1300 D	930 D	1000 D	860 D	420
		mg/kg OC	44.2	25.0		35.2	34.9 D	45.6 D	38.5 D	42.5 D	45.1 D	51.3 D	102.4 D	67.9 D	98.0 D	76.8 D	34.1
Benzo(b)fluoranthene	EPA 8270C	ug/Kg	660 D	450 D	790 D	580 D	650 D	1400 D	1300 D	1400 D	1100 D	1600 D	2100 D	1400 D	1500 D	1200 D	550
Benzo(g,h,i)perylene	EPA 8270C	ug/Kg	190	140	310 D	230	280 D	480 D	450 D	540 D	450 D	640 D	860 D	560 D	630 D	320 D	220
		mg/kg OC	20.0	13.0		18.4	21.7 D	26.4 D	22.5 D	27.0 D	29.4 D	33.2 D	67.7 D	40.9 D	61.8 D	28.6 D	17.9
Benzo(k)fluoranthene	EPA 8270C	ug/Kg	220 D	150 D	250 D	190 D	210 D	460 D	420 D	470 D	360 D	560 D	710 D	510 D	570 D	820 D	300
Benzofluoranthenes (total)	TT calculation	ug/Kg	880	600	1040	770	860	1860	1720	1870	1460	2160	2810	1910	2070	2020	850
		mg/kg OC	92.6	55.6		61.6	66.7	102.2	86.0	93.5	95.4	111.9	221.3	139.4	202.9	180.4	69.1
Benzoic acid	EPA 8270C	ug/Kg	170 U R	170 U R	460 U R	160 U R	160 U R	870 U R	870 U R	820 U R	500 U R	880 U R	800 U R	860 U R	720 U R	700 U	160 U
Benzyl alcohol	EPA 8270C	ug/Kg	6.3 U	6.6 J	18 U	6.1 U	8 J	34 U	34 U	32 U	20 U	34 U	31 U	34 U	28 U	27 U	6.3 J
bis(2-chloroethoxy)methane	EPA 8270C	ug/Kg	2.2 U	2.3 U	6.2 U	2.2 U	2.2 U	12 U	12 U	11 U	6.7 U	12 U	11 U	12 U	9.7 U	9.4 U	2.1 U
bis(2-chloroethyl)ether	EPA 8270C	ug/Kg	4.1 U	4.1 U	12 U	3.9 U	4 U	22 U	22 U	21 U	13 U	22 U	20 U	22 U	18 U	18 U	3.9 U
bis(2-chloroisopropyl)ether	EPA 8270C	ug/Kg	2.1 U	2.1 U	5.7 U	2 U	2 U	11 U	11 U	11 U	6.2 U	11 U	10 U	11 U	8.9 U	8.7 U	2 U
bis(2-ethylhexyl)phthalate	EPA 8270C	ug/Kg	180	160	230 JD	190	210	370 JD	240 JD	330 JD	280 JD	350 JD	740 D	230 JD	450 JD	180 JD	190
		mg/kg OC	18.9	14.8		15.2	16.3	20.3 JD	12.0 JD	16.5 JD	18.3 JD	18.1 JD	58.3 D	16.8 JD	44.1 JD	16.1 JD	15.4
Butyl benzyl phthalate	EPA 8270C	ug/Kg	20	13	24 JD	9 J	18	38 JD	46 JD	42 JD	30 JD	33 JD	26 JD	30 JD	34 JD	11 U	15
		mg/kg OC	2.1	1.2		0.7 J	1.4	2.1 JD	2.3 JD	2.1 JD	2.0 JD	1.7 JD	2.0 JD	2.2 JD	3.3 JD	1.0 U	1.2
Chrysene	EPA 8270C	ug/Kg	690	390	540 D	540	670	1200 D	1200 D	1100 D	800 D	1500 D	1800 D	1200 D	1200 D	2200 D	530
		mg/kg OC	72.6	36.1		43.2	51.9	65.9 D	60.0 D	55.0 D	52.3 D	77.7 D	141.7 D	87.6 D	117.6 D	196.4 D	43.1
Dibenzo(a,h)anthracene	EPA 8270C	ug/Kg	70	47	82 D	43	86 JD	140 D	130 D	150 D	120 D	170 D	250 D	160 D	170 D	90 D	100
		mg/kg OC	7.4	4.4		3.4	6.7 JD	7.7 D	6.5 D	7.5 D	7.8 D	8.8 D	19.7 D	11.7 D	16.7 D	8.0 D	8.1
Dibenzofuran	EPA 8270C	ug/Kg	50	30	40 D	34	47	68 D	57 D	67 D	56 D	98 D	100 D	86 D	73 D	31 JD	32
		mg/kg OC	5.3	2.8		2.7	3.6	3.7 D	2.9 D	3.4 D	3.7 D	5.1 D	7.9 D	6.3 D	7.2 D	2.8 JD	2.6
Diethylphthalate	EPA 8270C	ug/Kg	5.9 U	6 U	17 U	5.7 U	5.8 U	32 U	32 U	30 U	18 U	32 U	30 U	32 U	26 U	26 U	12
		mg/kg OC	0.6 U	0.6 U		0.5 U	0.4 U	1.8 U	1.6 U	1.5 U	1.2 U	1.7 U	2.4 U	2.3 U	2.5 U	2.3 U	1.0
Dimethyl phthalate	EPA 8270C	ug/Kg	3.1 U	3.1 U	8.5 U	3 U	3 U	17 U	17 U	16 U	11 JD	17 U	15 U	17 U	14 U	13 U	5.3 J
		mg/kg OC	0.3 U	0.3 U		0.2 U	0.2 U	0.9 U	0.9 U	0.8 U	0.7 JD	0.9 U	1.2 U	1.2 U	1.4 U	1.2 U	0.4 J
Di-n-butyl phthalate	EPA 8270C	ug/Kg	31	17	26 JD	23	24	24 U	28 JD	35 JD	29 JD	33 JD	61 D	24 U	22 JD	22 JD	29
		mg/kg OC	3.3	1.6		1.8	1.9	1.3 U	1.4 JD	1.8 JD	1.9 JD	1.7 JD	4.8 D	1.8 U	2.2 JD	2.0 JD	2.4
Di-n-octyl phthalate	EPA 8270C	ug/Kg	2.1 U	2.1 U	5.7 U	2 U	2 U	11 U	11 U	11 U	6.2 U	11 U	10 U	11 U	8.9 U	8.7 U	2 U
		mg/kg OC	0.2 U	0.2 U		0.2 U	0.2 U	0.6 U	0.6 U	0.6 U	0.4 U	0.6 U	0.8 U	0.8 U	0.9 U	0.8 U	0.2 U
Fluoranthene	EPA 8270C	ug/Kg	1600 D	550	700 D	680	750 D	1300 D	1200 D	1400 D	1200 D	2000 D	3000 D	1800 D	1700 D	2900 D J	670 D J
		mg/kg OC	168.4 D	50.9		54.4	58.1 D	71.4 D	60.0 D	70.0 D	78.4 D	103.6 D	236.2 D	131.4 D	166.7 D	258.9 D J	54.5 D J
Fluorene	EPA 8270C	ug/Kg	150	48	64 D	58	75	120 D	110 D	120 D	110 D	160 D	200 D	170 D	140 D	88 D	56
		mg/kg OC	15.8	4.4		4.6	5.8	6.6 D	5.5 D	6.0 D	7.2 D	8.3 D	15.7 D	12.4 D	13.7 D	7.9 D	4.6
Hexachlorobenzene	EPA 8081A	ug/Kg	1.4 U	1.4 U	1.3 U	1.3 U	1.3 U	1.5 U	1.5 U	1.4 U	1.4 U	1.5 U	1.4 U	2.9 U	2.4 U	2.3 U	2.6 U
		mg/kg OC	0.1 U	0.1 U		0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.2 U	0.2 U	0.2 U	0.2 U
Hexachlorobutadiene	EPA 8081A	ug/Kg						8.9 U	8.8 U	8.3 U		9 U	8.2 U				
		mg/kg OC	0.0	0.0		0.0	0.0	0.5 U	0.4 U	0.4 U	0.0	0.5 U	0.6 U	0.0	0.0	0.0	0.0
Hexachlorobutadiene	EPA 8270C	ug/Kg	2.4 U	2.4 U	6.6 U	2.3 U	2.3 U				7.2 U			13 U	11 U	11 U	2.3 U
		mg/kg OC	0.3 U	0.2 U		0.2 U	0.2 U	0.0	0.0	0.0	0.5 U	0.0	0.0	0.9 U	1.1 U	1.0 U	0.2 U
Hexachlorocyclopentadiene	EPA 8270C	ug/Kg	26 U UJ	26 U UJ	71 U	25 U UJ	25 U UJ	140 U	140 U	130 U	78 U	140 U	130 U	140 U	120 U	110 U	24 U
Hexachloroethane	EPA 8270C	ug/Kg	3.8 U	3.8 U	11 U	3.6 U	3.7 U	20 U	20 U	19 U	12 U	21 U	19 U	20 U	17 U	16 U	3.6 U
Indeno(1,2,3-cd)pyrene	EPA 8270C	ug/Kg	210	160	310 D	220	350 D	530 D	500 D	570 D	460 D	710 D	970 D	610 D	660 D	370 D	240
		mg/kg OC	22.1	14.8		17.6	27.1 D	29.1 D	25.0 D	28.5 D	30.1 D	36.8 D	76.4 D	44.5 D	64.7 D	33.0 D	19.5
Isophorone	EPA 8270C	ug/Kg	2.7 U	2.8 U	7.6 U	2.6 U	2.7 U	15 U	15 U	14 U	8.3 U	15 U	14 U	15 U	12 U	12 U	2.6 U
Naphthalene	EPA 8270C	ug/Kg	83	57	67 D	77	81	94 D	89 D	100 D	89 D	100 D	120 D	65 D	62 D	58 D	50
		mg/kg OC	8.7	5.3		6.2	6.3	5.2 D	4.5 D	5.0 D	5.8 D	5.2 D	9.4 D	4.7 D	6.1 D	5.2 D	4.1
Nitrobenzene	EPA 8270C	ug/Kg	3.4 U	3.4 U	9.5 U	3.3 U	3.3 U	19 U	18 U	17 U	11 U	19 U	17 U	18 U	15 U	15 U	3.2 U
N-Nitrosodimethylamine	EPA 8270C	ug/Kg	11 U UJ	11 U UJ	29 U	10 U UJ	10 U UJ	56 U	55 U	52 U	32 U	56 U	51 U	55 U	46 U	44 U	9.8 U
N-Nitroso-di-n-propylamine	EPA 8270C	ug/Kg	5.4 U	5.5 U	16 U	5.2 U	5.3 U	29 U	29 U	28 U	17 U	30 U	27 U	29 U	24 U	24 U	5.2 U
N-Nitrosodiphenylamine	EPA 8270C	ug/Kg	3.8 U	3.8 U	11 U	3.6 U	3.7 U	20 U	20 U	19 U	12 U	21 U	19 U	20 U	17 U	16 U	3.6 U
		mg/kg OC	0.4 U	0.4 U		0.3 U	0.3 U	1.1 U	1.0 U	1.0 U	0.8 U	1.1 U	1.5 U	1.5 U	1.7 U	1.4 U	0.3 U
Pentachlorophenol	EPA 8270C	ug/Kg	20 J	18 J	43 JD	26 J	40 J	77 U	77 U	90 JD	80 JD	78 U	310 JD	220 JD	360 JD	62 U	43 J
Phenanthrene	EPA 8270C	ug/Kg	610	300	410 D	370	540	690 D	620 D	780 D	700 D	1100 D	1600 D	1200 D	1100 D	610 D	400
		mg/kg OC	64.2	27.8		29.6	41.9	37.9 D	31.0 D	39.0 D	45.8 D	57.0 D	126.0 D	87.6 D	107.8 D	54.5 D	32.5
Phenol	EPA 8270C	ug/Kg	21 J	22 J	45 JD	17 J	27 J	18 U	21 JD	76 JD	46 JD	65 JD	79 JD	42 JD	30 JD	120 JD	30 J
Pyrene	EPA 8270C	ug/Kg	1100 D	480	890 D	580	720	1800 D	1400 D	1600 D	1400 D	2100 D	3300 D	2000 D	2500 D	1400 D	510
		mg/kg OC	115.8 D	44.4		46.4	55.8	98.9 D	70.0 D	80.0 D	91.5 D	108.8 D	259.8 D	146.0 D	245.1 D	125.0 D	41.5

Table A-3. Remedial Investigation Subtidal Surface Sediment Analytical Data

Location			1	2	3	4	4	5	5	6	6	7	8	9	10	11	12
Sample ID			TT01-SS	TT02-SS	TT03-SS	TT04-SS	TT92-SS	TT94-SS	TT05-SS	TT93-SS	TT06-SS	TT07-SS	TT08-SS	TT09-SS	TT10-SS	TT11-SS	TT12-SS
Sample Date			1/24/2007	1/24/2007	1/24/2007	1/24/2007	1/24/2007	1/25/2007	1/25/2007	1/24/2007	1/24/2007	1/25/2007	1/24/2007	1/25/2007	1/25/2007	1/26/2007	1/26/2007
Parameter	**Method**	**Units**															
Total HPAH	TT calculation	ug/Kg	5730	2857	4712	3833	4536	8910	8100	8830	7160	11180	15590	10080	10770	12060	3900
		mg/kg OC	603.2	264.5		306.6	351.6	489.6	405.0	441.5	468.0	579.3	1227.6	735.8	1055.9	1076.8	317.1
Total LPAH	TT calculation	ug/Kg	1457	628	847	809	1067	1489	1506	1510	1340	2130	2780	2028	1852	1540	837
		mg/kg OC	153.4	58.1		64.7	82.7	81.8	75.3	75.5	87.6	110.4	218.9	148.0	181.6	137.5	68.0
Total PAH	TT calculation	ug/Kg	7187	3485	5559	4642	5603	10399	9606	10340	8500	13310	18370	12108	12622	13600	4737
Butyltin	KRONE	ug/Kg	5.4	10	29	14	21	15	26	36	33	27	73	64	67	22	11
Dibutyltin	KRONE	ug/Kg	58	80	130 D	120	98	150 D	150 D	240 D	270 D	280 D	200 D	1200 D	1100 D	95	68
Tetrabutyltin	KRONE	ug/Kg	3	4.3	7.3	5.6	6	9	7.6	17	14	17	41	120	94	4.8	3.2
Tributyltin	KRONE	ug/Kg	160 D	230 D	380 D	300 D	290 D	530 D	340 D	810 D	860 D	810 D	690 D	3500 D	4000 D	290 D	190 D
		mg/kg OC	16.8 D	21.3 D	D	24.0 D	22.5 D	29.1 D	17.0 D	40.5 D	56.2 D	42.0 D	54.3 D	255.5 D	392.2 D	25.9 D	15.4 D
Total Solids	EPA 160.3	Percent	59.4	58.9	63.8	61.6	61.1	55.4	55.8	59.1	58.4	54.8	60.3	55.9	67.5	69.4	62.5
Total Organic Carbon	ASTM D4129-98M	Percent	0.95	1.08	0.1	1.25	1.29	1.82	2	2	1.53	1.93	1.27				
Total Organic Carbon	EPA 9060M	Percent												1.37	1.02	1.12	1.23
Fractional % phi >-1	PSEP Grain Size	Percent	0.45	0.54	0.73	0.78	0.93	4.07	3.94	0.72	0.57	0.8	1.09	2.94	7.47	3.74	0.83
Fractional % phi 0-1	PSEP Grain Size	Percent	1.57	1.38	1.4	1.64	1.82	1.49	1.48	1.01	0.96	0.74	2.11	8.03	17.6	11.6	0.71
Fractional % phi 1-2	PSEP Grain Size	Percent	13	11.7	14.2	13	12.8	2.34	4.03	5.42	4.85	3.44	3.73	3.1	23.7	21.2	3.22
Fractional % phi 2-3	PSEP Grain Size	Percent	27.8	24.6	24.4	24	26	18	16.7	18.5	18.4	12.5	36.2	23.8	21.1	18.8	19.6
Fractional % phi 3-4	PSEP Grain Size	Percent	21.9	23.1	21.9	23.4	21.9	21.1	19.9	25.8	25.6	21.2	25.4	21.7	11	15.3	36.2
Fractional % phi 4-5	PSEP Grain Size	Percent	5.27	3.61	5.3	4.93	5.58	5.02	5.25	7.34	8.7	8.79	4.2	12.5	5.22	8.84	15.4
Fractional % phi 5-6	PSEP Grain Size	Percent	9.94	10.5	8.87	10.2	9.63	14	12.8	14.2	14.5	16.5	8.12	5.6	3.69	4.24	6.68
Fractional % phi 6-7	PSEP Grain Size	Percent	4.6	5.52	5.69	5	5.49	6.46	7.18	6.9	7.67	10.8	4.26	6.04	5.12	2.94	3.12
Fractional % phi 7-8	PSEP Grain Size	Percent	2.63	3.79	3.38	3.16	3.11	3.47	4.89	4.31	4.31	4.63	3.29	5.4	3.02	1.87	2.32
Fractional % phi 8-9	PSEP Grain Size	Percent	4.5	5.19	4.57	4.54	4.89	3.46	5.01	5.65	5.58	8.48	4.81	5.09	1.95	2.19	2.55
Fractional % phi 9-10	PSEP Grain Size	Percent	3.63	3.48	2.87	3.23	2.81	1.81	1.32	3.99	4.2	4.92	1.88	4.79	2.24	1.33	1.76
Fractional % phi >10	PSEP Grain Size	Percent	4.34	4.38	4.57	3.97	4.24	3	3.12	5.39	5.5	5.62	2.94	6.52	0	2.82	3.51
Gravel	PSEP Grain Size	Percent	0.08	0.42	0.82	0.67	1.32	14.4	13.3	0.2	0.1	1.54	1.13	2.97	2.46	5.37	0.61

Notes:

0.14 U J = Result followed by laboratory data qualifier followed by data validator qualifier
mg/kg = milligrams per kilogram
ug/kg = micrograms per kilogram
mg/L = milligrams per liter
ug/L = micrograms per liter
ng/L = nanograms per liter

Data Validation Qualifiers
U = Result should be considered not-detected at the quantitation limit shown
J = Result is an estimated concentration
R = Rejected - Quality Control indicates the data is not usable
UJ = The compound was not detected and the sample detection limit should be considered an estimated value
N = Pesticide result is tentatively identified

Laboratory Data Qualifiers
U = result was not detected at or above the method detection limit
J (for organics) = result is an estimated concentrations that is less than the reporting limit but greater than or equal to the detection limit
B (for metals) = result is an estimated concentrations that is less than the reporting limit but greater than or equal to the detection limit
* (for metals) = duplicate analysis not within control limits. See case narrative (in laboratory report)
D (for organics) = result reported is from a dilution
P (for organics) = The GC or HPLC confirmation criteria was exceeded. The relative percent difference is greater than 40% between the two analytical results.
i (for organics) = the MRL/MDL has been elevated due to a chromatographic interference.

Table A-3. Remedial Investigation Subtidal Surface Sediment Analytical Data

Location			13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Sample ID			TT13-SS	TT14-SS	TT15-SS	TT16-SS	TT17-SS	TT18-SS	TT19-SS	TT20-SS	TT21-SS	TT22-SS	TT23-SS	TT24-SS	TT25-SS	TT26-SS	TT27-SS
Sample Date			1/26/2007	1/25/2007	1/25/2007	1/25/2007	1/25/2007	1/25/2007	1/25/2007	1/25/2007	1/25/2007	1/25/2007	1/26/2007	1/25/2007	1/25/2007	1/25/2007	1/24/2007
Parameter	Method	Units															
Antimony	EPA 6020	mg/Kg	7.76 J	4.86 J	18.9 J	5.35 J	17.2 J	3.72 * J	5.75 * J	12.7 J	10.5 J	0.98 J	0.45 J	0.43 * J	1.73 * J	3.11 * J	3.54 * J
Arsenic	EPA 6020	mg/Kg	14.7	12.4	74.1	21.4	71.5	4.87 J	12.8 J	30.4	23.6	7.23	4.66	5.58 J	11.1 J	13 J	9.45 J
Cadmium	EPA 6020	mg/Kg	0.18	0.48	0.5	0.44	0.56	0.175	0.386	0.34	0.55	0.2	0.1	0.258	0.619	0.59	0.204
Chromium	EPA 6010B	mg/Kg	34.6	20.2	59.1	57.3	129	504	45.7	81.1	87.3	26.1	17	23.8	70	48.6	26.2
Cobalt	EPA 6020	mg/Kg	5.53	5.16	17.9	8.91	13.8	4.13 J	6.87 J	9.87	7.38	5.63	4.03	6.07 J	6.47 J	3.9 J	4.98 J
Copper	EPA 6010B	mg/Kg	107	73.2	1900	222	661	66.6	115	173	127	64.7	33.4	33.5	90.1	114	75.1
Lead	EPA 6020	mg/Kg	83.9	46.5	132	128	248	20.3	73.5	106	76.8	32.7	15.9	17	50.7	61.3	45.9
Mercury	EPA 7471A	mg/Kg	0.71 *	0.14	0.675	0.993	2.94	0.117	0.306	0.325	0.215	0.308	0.138 *	0.22	0.094	0.094	0.343
Molybdenum	EPA 6020	mg/Kg	1.08	1.67	9.92	2.06	4.71	1.01	1.3	2.52	2.17	0.96	0.47	0.99	2.11	2.55	0.83
Nickel	EPA 6020	mg/Kg	12.9	20	24.8	21.6	32.8	13.7 J	16.8 J	27.1	22.7	14.1	10.6	18.7 J	20.7 J	14.7 J	12.2 J
Selenium	EPA 6020	mg/Kg	0.9 B	1.2	1.2	1.1	1.1	0.5 U	0.5 U	0.8 B	1 B	0.7 B	0.6 B	0.5 U	0.4 U	0.5 B	0.4 U
Silver	EPA 6020	mg/Kg	0.292	0.185	0.489	0.348	0.413	0.115	0.264	0.223	0.278	0.191	0.147	0.143	0.321	0.143	0.217
Thallium	EPA 6020	mg/Kg	0.08	0.07	0.14	0.16	0.16	0.033	0.108	0.13	0.15	0.1	0.07	0.078	0.136	0.089	0.082
Vanadium	EPA 6010B	mg/Kg	47.2	28.4	72.4	67.5	66.4	95.6	52.4	53.3	56.7	50.3	38.5	46.2	53.5	33.1	47.6
Zinc	EPA 6010B	mg/Kg	165	111	721	255	617	128	177	244	257	80.1	48.5	71.4	171	117	104
PCBs (total)	TT calculation	ug/Kg	311	134	520	470	2240	114	220	217	205	460	54	48	202	71	217
		mg/kg OC	29.3	4.1	30.6	29.7	112.6	14.1	16.8	12.0	15.2	34.3	6.2	2.6	7.5	3.6	10.5
PCB-1016	EPA 8082	ug/Kg	2.7 U	31 U	33 U	32 U	33 U	2.4 U	14 U	27 Ui	32 Ui	28 U	2.5 U	2.6 U	3 U	2.6 U	2.6 U
PCB-1221	EPA 8082	ug/Kg	2.7 U	31 U	33 U	32 U	33 U	2.4 U	14 U	16 Ui	17 Ui	28 U	2.5 U	2.6 U	3 U	2.6 U	2.6 U
PCB-1232	EPA 8082	ug/Kg	2.7 U	31 U	33 U	32 U	33 U	2.4 U	14 U	28 Ui	32 Ui	28 U	2.5 U	2.6 U	3 U	2.6 U	2.6 U
PCB-1242	EPA 8082	ug/Kg	2.7 U	31 U	33 U	32 U	33 U	2.4 U	14 U	36 Ui	37 Ui	28 U	2.5 U	2.6 U	3 U	2.6 U	2.6 U
PCB-1248	EPA 8082	ug/Kg	2.7 U	31 U	33 U	32 U	33 U	2.4 U	14 U	48 Ui	50 Ui	28 U	2.5 U	2.6 U	3 U	2.6 U	2.6 U
PCB-1254	EPA 8082	ug/Kg	170	73 D	280 D	270 D	1200 D	64	120 D	110	100	100 D	29	27	110	41	130
PCB-1260	EPA 8082	ug/Kg	110	61 PD J	240 D	200 D	900 PD J	50	100 D	80	82	200 D	25	21	92	30	87
PCB-1262	EPA 8082	ug/Kg	2.7 U	31 U	33 U	32 U	33 U	2.4 U	14 U	2.7 U	2.9 U	28 U	2.5 U	2.6 U	3 U	2.6 U	2.6 U
PCB-1268	EPA 8082	ug/Kg	31	31 U	33 U	32 U	140 D	2.4 U	14 U	27	23	160 D	2.5 U	2.6 U	3 U	2.6 U	2.6 U
Aldrin	EPA 8081A	ug/Kg	4.7 U UJ	5.4 U UJ	5.8 U UJ	5.6 U UJ	5.9 U UJ	2.1 U UJ	2.4 U UJ	4.7 U UJ	5 U UJ	4.9 U UJ	4.5 U UJ	2.3 U UJ	2.7 U UJ	2.3 U UJ	2.3 U UJ
alpha-BHC	EPA 8081A	ug/Kg	8.1 U UJ	9.4 U UJ	10 U UJ	9.7 U UJ	11 U UJ	3.6 U UJ	4.2 U UJ	8.1 U UJ	8.6 U UJ	8.4 U UJ	7.7 U UJ	4 U UJ	4.6 U UJ	3.9 U UJ	4 U UJ
alpha-Chlordane	EPA 8081A	ug/Kg	7.1 U UJ	8.3 U UJ	8.9 U UJ	8.6 U UJ	9 U UJ	3.2 U UJ	3.7 U UJ	7.2 U UJ	7.6 U UJ	7.4 U UJ	6.8 U UJ	3.5 U UJ	4.1 U UJ	3.5 U UJ	3.6 U UJ
beta-BHC	EPA 8081A	ug/Kg	9.3 U UJ	11 U UJ	12 U UJ	12 U UJ	12 U UJ	4.1 U UJ	4.8 U UJ	9.3 U UJ	10 U UJ	9.7 U UJ	8.9 U UJ	4.6 U UJ	5.3 U UJ	4.5 U UJ	4.6 U UJ
delta-BHC	EPA 8081A	ug/Kg	1.7 U UJ	2 U UJ	2.2 U UJ	2.1 U UJ	2.2 U UJ	0.75 U UJ	1.1 Ui UJ	1.8 U UJ	1.9 U UJ	2.5 Ui UJ	1.7 U UJ	0.84 U UJ	0.98 U UJ	2.2 Ui UJ	0.84 U UJ
Dieldrin	EPA 8081A	ug/Kg	9 U UJ	11 U UJ	12 U UJ	11 U UJ	21 Ui UJ	4 U UJ	4.7 U UJ	9 U UJ	9.6 U UJ	9.4 U UJ	8.6 U UJ	4.5 U UJ	5.2 U UJ	4.4 U UJ	5.2 Ui UJ
Endosulfan I	EPA 8081A	ug/Kg	5.3 U UJ	6.1 U UJ	6.6 U UJ	6.3 U UJ	8 Ui UJ	2.4 U UJ	2.8 U UJ	5.3 U UJ	5.7 U UJ	5.5 U UJ	5 U UJ	2.6 U UJ	3 U UJ	2.6 U UJ	2.6 U UJ
Endosulfan II	EPA 8081A	ug/Kg	5.9 U UJ	6.9 U UJ	7.4 U UJ	7.1 U UJ	7.4 U UJ	2.6 U UJ	3.4 Ui UJ	5.9 U UJ	6.3 U UJ	6.1 U UJ	5.6 U UJ	2.9 U UJ	3.4 U UJ	2.9 U UJ	3 U UJ
Endosulfan sulfate	EPA 8081A	ug/Kg	2.5 U UJ	2.9 U UJ	3.1 U UJ	3 U UJ	3.1 U UJ	1.1 U UJ	1.3 U UJ	2.5 U UJ	2.7 U UJ	24 Ui UJ	2.4 U UJ	1.2 U UJ	1.4 U UJ	1.2 U UJ	1.3 U UJ
Endrin	EPA 8081A	ug/Kg	6.2 U UJ	7.2 U UJ	7.7 U UJ	7.4 U UJ	7.8 U UJ	2.8 U UJ	3.2 U UJ	6.2 U UJ	6.7 U UJ	6.5 U UJ	5.9 U UJ	3.1 U UJ	3.6 U UJ	3 U UJ	3.1 U UJ
Endrin aldehyde	EPA 8081A	ug/Kg	4.2 JPD JN	1.9 U UJ	2.1 U UJ	2 U UJ	10 Ui UJ	0.73 U UJ	2 Ui UJ	1.7 U UJ	4 JPD JN	1.8 U UJ	1.6 U UJ	0.81 U UJ	5 JPD JN	2.3 JD UJ	1.1 Ui UJ
gamma-BHC	EPA 8081A	ug/Kg	4.7 U UJ	5.4 U UJ	5.8 U UJ	5.6 U UJ	25 PD JN	2.1 U UJ	2.4 U UJ	4.7 U UJ	5 U UJ	4.9 U UJ	4.5 U UJ	2.3 U UJ	5 Ui UJ	5 Ui UJ	2.3 U UJ
gamma-Chlordane	EPA 8081A	ug/Kg	4.8 JPD JN	2.3 U UJ	11 PD JN	10 JPD JN	46 PD JN	3.7 JPD JN	1.1 U UJ	2 U UJ	2.2 U UJ	4.9 JPD JN	1.9 U UJ	0.98 U UJ	1.2 U UJ	1.3 Ui UJ	8 PD JN
Heptachlor	EPA 8081A	ug/Kg	2.5 U UJ	2.9 U UJ	3.1 U UJ	3 U UJ	3.2 U UJ	1.1 U UJ	1.3 U UJ	2.5 U UJ	2.7 U UJ	2.6 U UJ	2.4 U UJ	1.3 U UJ	1.5 U UJ	1.2 U UJ	1.3 U UJ
Heptachlor epoxide	EPA 8081A	ug/Kg	4.1 U UJ	4.7 U UJ	5 U UJ	4.9 U UJ	10 Ui UJ	1.8 U UJ	2.1 U UJ	4.1 U UJ	4.3 U UJ	4.2 U UJ	3.9 U UJ	2 U UJ	2.3 U UJ	2 U UJ	2 U UJ
Methoxychlor	EPA 8081A	ug/Kg	5.2 Ui UJ	3.6 U UJ	3.9 U UJ	3.7 U UJ	3.9 U UJ	5 Ui UJ	1.6 U UJ	3.1 U UJ	3.7 Ui UJ	5.1 Ui UJ	3 U UJ	2.3 Ui UJ	15 PD JN	5.5 Ui UJ	1.6 U UJ
Mirex	EPA 8081A	ug/Kg	3.1 U UJ	3.6 U UJ	3.9 U UJ	3.7 U UJ	7.7 Ui UJ	1.6 JPD JN	1.6 U UJ	3.1 U UJ	3.4 U UJ	3.3 U UJ	3 U UJ	1.6 U UJ	2.8 JD JN	1.5 U UJ	1.6 U UJ
Nonachlor (cis)	EPA 8081A	ug/Kg	2.6 U UJ	3 U UJ	10 Ui UJ	3.1 U UJ	10 Ui UJ	1.2 U UJ	1.4 U UJ	2.6 U UJ	2.8 U UJ	2.7 U UJ	2.5 U UJ	1.3 U UJ	1.5 U UJ	1.3 U UJ	1.3 U UJ
Nonachlor (trans)	EPA 8081A	ug/Kg	2.8 U UJ	10 Ui UJ	3.5 U UJ	3.3 U UJ	10 Ui UJ	1.3 U UJ	1.5 U UJ	2.8 U UJ	3 U UJ	2.9 U UJ	2.7 U UJ	1.4 U UJ	3.3 Ui UJ	5 Ui UJ	1.4 U UJ
Oxychlordane	EPA 8081A	ug/Kg	12 U UJ	14 U UJ	15 U UJ	14 U UJ	15 U UJ	5.1 U UJ	5.9 U UJ	12 U UJ	13 U UJ	12 U UJ	11 U UJ	5.7 U UJ	6.6 U UJ	5.6 U UJ	5.7 U UJ
Toxaphene	EPA 8081A	ug/Kg	280 U UJ	330 U UJ	350 U UJ	340 U UJ	780 Ui UJ	130 U UJ	150 U UJ	280 U UJ	300 U UJ	390 Ui UJ	270 U UJ	140 U UJ	160 U UJ	140 U UJ	190 Ui UJ
o,p'-DDD	EPA 8081A	ug/Kg	11 PD JN	7.6 U UJ	23 PD JN	23 PD JN	110 PD JN	8.6 D JN	7.8 D JN	10 PD JN	9.4 JD JN	10 Ui UJ	6.2 U UJ	3.2 U UJ	11 D JN	4.7 JPD JN	6.1 Ui UJ
o,p'-DDE	EPA 8081A	ug/Kg	7.1 U UJ	8.3 U UJ	8.9 U UJ	8.6 U UJ	9 U UJ	3.2 U UJ	3.7 U UJ	7.2 U UJ	7.6 U UJ	7.4 U UJ	6.8 U UJ	3.5 U UJ	4.1 U UJ	3.5 U UJ	3.6 U UJ
o,p'-DDT	EPA 8081A	ug/Kg	18 D JN	5.5 JD JN	19 PD JN	16 D JN	73 D JN	6.4 D JN	4.8 JD JN	6.9 JD JN	8.3 JD JN	20 PD JN	4.2 U UJ	2.2 U UJ	6.1 D JN	2.1 U UJ	12 D JN
p,p'-DDD	EPA 8081A	ug/Kg	3.7 U UJ	4.4 U UJ	4.7 U UJ	4.5 U UJ	14 D JN	1.7 U UJ	2 U UJ	3.8 U UJ	4 U UJ	3.9 U UJ	3.6 U UJ	1.9 U UJ	4 JD JN	2 Ui UJ	1.9 U UJ
p,p'-DDE	EPA 8081A	ug/Kg	3.1 U UJ	3.6 U UJ	3.9 U UJ	3.7 U UJ	10 Ui UJ	1.4 U UJ	1.6 U UJ	3.1 U UJ	3.4 U UJ	3.3 U UJ	3 U UJ	1.6 U UJ	1.8 U UJ	1.5 U UJ	1.6 U UJ
p,p'-DDT	EPA 8081A	ug/Kg	28 D JN	8.6 JD JN	26 D JN	22 D JN	97 D JN	11 D JN	8.1 D JN	11 Ui UJ	10 D JN	15 D JN	4.5 JD JN	3.2 JD JN	11 D JN	4.4 JD JN	19 Ui UJ
Total DDT	TT calculation	ug/Kg	57 JN	14.1 JN	68 JN	61 JN	294 JN	26 JN	20.7 JN	16.9 JN	27.7 JN	35 JN	4.5 JN	3.2 JN	32.1 JN	9.1 JN	12 JN
Total Chlordane	TT Calculated	ug/Kg	4.8 JN	14 U UJ	11 JN	10 JN	46 JN	3.7 JN	5.9 U UJ	12 U UJ	13 U UJ	4.9 JN	11 U UJ	5.7 U UJ	6.6 U UJ	5.6 U UJ	8 JN
1,2,4-Trichlorobenzene	EPA 8270C	ug/Kg	2.4 U	54 U	2.9 U	2.8 U	30 U	2.1 U	12 U	2.4 U	2.5 U	2.5 U	2.3 U	2.3 U	14 U	12 U	6.9 U
		mg/kg OC	0.2 U	1.7 U	0.2 U	0.2 U	1.5 U	0.3 U	0.9 U	0.1 U	0.2 U	0.2 U	0.3 U	0.1 U	0.5 U	0.6 U	0.3 U
1,2-Dichlorobenzene	EPA 8270C	ug/Kg	2.1 U	47 U	2.7 J	2.5 U	26 U	1.8 U	11 U	2.1 U	2.2 U	2.1 U	2 U	2 U	12 U	9.7 U	6 U
		mg/kg OC	0.2 U	1.5 U	0.2 J	0.2 U	1.3 U	0.2 U	0.8 U	0.1 U	0.2 U	0.2 U	0.2 U	0.1 U	0.4 U	0.5 U	0.3 U
1,3-Dichlorobenzene	EPA 8270C	ug/Kg	2.5 U	58 U	3.1 U	3 U	32 U	2.2 U	13 U	2.5 U	2.7 U	2.6 U	2.4 U	2.5 U	15 U	12 U	7.4 U
1,4-Dichlorobenzene	EPA 8270C	ug/Kg	3 U	69 U	9.9 J	3.6 U	37 U	2.6 U	16 U	3.8 J	3.2 U	3.1 U	2.8 U	2.9 U	17 U	15 U	8.8 U
		mg/kg OC	0.3 U	2.1 U	0.6 J	0.2 U	1.9 U	0.3 U	1.2 U	0.2 J	0.2 U	0.2 U	0.3 U	0.2 U	0.6 U	0.8 U	0.4 U
1-Methylnaphthalene	EPA 8270C	ug/Kg	16 U UJ	360 U UJ	32 J	19 U UJ	200 U UJ	14 U UJ	80 U UJ	16 U UJ	25 J	17 U UJ	15 U UJ	23 J	160 D J	75 U UJ	46 U UJ
2,4,5-Trichlorophenol	EPA 8270C	ug/Kg	4.7 U	110 U	5.8 U	5.6 U	59 U	4.1 U	24 U	4.7 U	5 U	4.9 U	4.5 U	4.6 U	27 U	23 U	14 U
2,4,6-Trichlorophenol	EPA 8270C	ug/Kg	2.8 U	65 U	3.5 U	3.4 U	35 U	2.5 U	15 U	2.8 U	3 U	2.9 U	2.7 U	2.8 U	16 U	14 U	8.3 U
2,4-Dichlorophenol	EPA 8270C	ug/Kg	2.8 U	65 U	3.5 U	3.4 U	35 U	2.5 U	15 U	2.8 U	3 U	2.9 U	2.7 U	2.8 U	16 U	14 U	8.3 U
2,4-Dimethylphenol	EPA 8270C	ug/Kg	8.5 U	200 U UJ	11 U UJ	11 U UJ	110 U UJ	7.5 U	44 U	8.6 U UJ	9.1 U UJ	8.9 U UJ	8.1 U	8.4 U	49 U	41 U	26 U
2,4-Dinitrophenol	EPA 8270C	ug/Kg	56 U	1300 U	70 U	67 U	700 U	49 U	290 U	56 U	60 U	58 U	53 U	55 U	320 U	270 U	170 U
2,4-Dinitrotoluene	EPA 8270C	ug/Kg	4.4 U	110 U	5.4 U	5.2 U	55 U	3.9 U	23 U	4.4 U	4.7 U	4.5 U	4.2 U	4.3 U	25 U	21 U	13 U
2,6-Dinitrotoluene	EPA 8270C	ug/Kg	4.4 U	110 U	5.4 U	5.2 U	55 U	3.9 U	23 U	4.4 U	4.7 U	4.5 U	4.2 U	4.3 U	25 U	21 U	13 U
2-Chloronaphthalene	EPA 8270C	ug/Kg	5.6 U	130 U	7 U	6.7 U	70 U	4.9 U	29 U	5.6 U	6 U	5.8 U	5.3 U	5.5 U	32 U	27 U	17 U
2-Chlorophenol	EPA 8270C	ug/Kg	2.7 U	61 U	3.3 U	3.2 U	33 U	2.4 U	14 U	2.7 U	2.9 U	2.8 U	2.5 U	2.6 U	15 U	13 U	7.8 U
2-Methylnaphthalene	EPA 8270C	ug/Kg	21	44 U	39	25	81 JD	13	42 JD	22	43	30	15	30	190 D	84 D	17 JD
		mg/kg OC	2.0	1.4 U	2.3	1.6	4.1 JD	1.6	3.2 JD	1.2	3.2	2.2	1.7	1.6	7.0 D	4.3 D	0.8 JD
2-Methylphenol	EPA 8270C	ug/Kg	5.3 U	130 U	16	6.3 U	66 U	4.7 U	28 U	5.3 U	5.7 U	5.5 U	5 U	5.2 U	30 U	26 U	16 U
2-Nitroaniline	EPA 8270C	ug/Kg	4.2 U	97 U	5.2 U	5 U	53 U	3.7 U	22 U	4.2 U	4.5 U	4.4 U	4 U	4.1 U	24 U	21 U	13 U
2-Nitrophenol	EPA 8270C	ug/Kg	4.1 U	94 U	5 U	4.9 U	51 U	3.6 U	21 U	4.1 U	4.3 U	4.2 U	3.9 U	4 U	23 U	20 U	12 U
3,3'-Dichlorobenzidine	EPA 8270C	ug/Kg	5.8 U	140 U	7.2 U	6.9 U	72 U	5.1 U	30 U	5.8 U	6.2 U	6 U	5.5 U	5.7 U	33 U	28 U	17 U
3-Nitroaniline	EPA 8270C	ug/Kg	4.1 U	94 U	5 U	4.9 U	51 U	3.6 U	21 U	4.1 U	4.3 U	4.2 U	3.9 U	4 U	23 U	20 U	12 U

Table A-3. Remedial Investigation Subtidal Surface Sediment Analytical Data

Location			13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Sample ID			TT13-SS	TT14-SS	TT15-SS	TT16-SS	TT17-SS	TT18-SS	TT19-SS	TT20-SS	TT21-SS	TT22-SS	TT23-SS	TT24-SS	TT25-SS	TT26-SS	TT27-SS
Sample Date			1/26/2007	1/25/2007	1/25/2007	1/25/2007	1/25/2007	1/25/2007	1/25/2007	1/25/2007	1/25/2007	1/25/2007	1/26/2007	1/25/2007	1/25/2007	1/25/2007	1/24/2007
Parameter	**Method**	**Units**															
4,6-Dinitro-o-cresol	EPA 8270C	ug/Kg	2.7 U	61 U	3.3 U	3.2 U	33 U	2.4 U	14 U	2.7 U	2.9 U	2.8 U	2.5 U	2.6 U	15 U	13 U	7.8 U
4-Bromophenyl phenyl ether	EPA 8270C	ug/Kg	2.2 U	51 U	2.7 U	2.6 U	28 U	2 U	12 U	2.2 U	2.4 U	2.3 U	2.1 U	2.2 U	13 U	11 U	6.5 U
4-Chloro-3-methylphenol	EPA 8270C	ug/Kg	3.3 U	76 U	4.1 U	3.9 U	41 U	2.9 U	17 U	3.3 U	3.5 U	3.4 U	3.1 U	3.2 U	19 U	16 U	9.7 U
4-Chloroaniline	EPA 8270C	ug/Kg	3.3 U	76 U	4.1 U	3.9 U	41 U	2.9 U	17 U	3.3 U	3.5 U	3.4 U	3.1 U	3.2 U	19 U	16 U	9.7 U
4-Chlorophenyl phenyl ether	EPA 8270C	ug/Kg	3.1 U	72 U	3.9 U	3.7 U	39 U	2.8 U	16 U	3.1 U	3.4 U	3.3 U	3 U	3.1 U	18 U	15 U	9.2 U
4-Methylphenol	EPA 8270C	ug/Kg	83	110 U	45	15	57 U	4.4 J	24 U	4.5 U	4.8 U	5.9 J	5 J	9.8 J	26 U	26 JD	14 U
4-Nitroaniline	EPA 8270C	ug/Kg	5.3 U	130 U	6.6 U	6.3 U	66 U	4.7 U	28 U	5.3 U	5.7 U	5.5 U	5 U	5.2 U	30 U	26 U	16 U
4-Nitrophenol	EPA 8270C	ug/Kg	47 U	1100 U	58 U	56 U	590 U	41 U	240 U	47 U	50 U	49 U	45 U	46 U	270 U	230 U	140 U
Acenaphthene	EPA 8270C	ug/Kg	44	74 JD	110	79	270 D	25	100 D	55	71	41	22	73	450 D	100 D	26 JD
		mg/kg OC	4.2	2.3 JD	6.5	5.0	13.6 D	3.1	7.6 D	3.0	5.3	3.1	2.5	4.0	16.7 D	5.1 D	1.3 JD
Acenaphthylene	EPA 8270C	ug/Kg	78	650 D	150	110	230 D	54	130 D	44	71	51	28	42	210 D	260 D	35 D
		mg/kg OC	7.4	20.1 D	8.8	7.0	11.6 D	6.7	9.9 D	2.4	5.3	3.8	3.2	2.3	7.8 D	13.3 D	1.7 D
Aniline	EPA 8270C	ug/Kg	2.4 U	54 U	2.9 U	2.8 U	30 U	2.1 U	12 U	2.4 U	2.5 U	2.5 U	2.3 U	2.3 U	14 U	12 U	6.9 U
Anthracene	EPA 8270C	ug/Kg	180	890 D	360	310	640 D	290	350 D	240	370	250	89	170	860 D	2500 D	97 D
		mg/kg OC	17.0	27.6 D	21.2	19.6	32.2 D	35.8	26.7 D	13.3	27.4	18.7	10.2	9.3	31.9 D	127.6 D	4.7 D
Benzo(a)anthracene	EPA 8270C	ug/Kg	390	1900 D	830	680	1800 D	270	690 D	460	520	300	120	190	1000 D	2700 D	210 D
		mg/kg OC	36.8	58.8 D	48.8	43.0	90.5 D	33.3	52.7 D	25.4	38.5	22.4	13.8	10.4	37.0 D	137.8 D	10.2 D
Benzo(a)pyrene	EPA 8270C	ug/Kg	450	1100 D	810	700	2000 D	220	810 D	390	440	280	130	270	1200 D	1700 D	250 D
		mg/kg OC	42.5	34.1 D	47.6	44.3	100.5 D	27.2	61.8 D	21.5	32.6	20.9	14.9	14.8	44.4 D	86.7 D	12.1 D
Benzo(b)fluoranthene	EPA 8270C	ug/Kg	570	3400 D	1400 D	1200 D	3200 D	340 D	1400 D	680	860	500	170	430 D	2200 D	3100 D	420 D
Benzo(g,h,i)perylene	EPA 8270C	ug/Kg	240	530 D	460	430	1300 D	110	500 D	230	240	160	63	130	590 D	610 D	170 D
		mg/kg OC	22.6	16.4 D	27.1	27.2	65.3 D	13.6	38.2 D	12.7	17.8	11.9	7.2	7.1	21.9 D	31.1 D	8.3 D
Benzo(k)fluoranthene	EPA 8270C	ug/Kg	330	1200 D	310	330	1100 D	110 D	480 D	200	260	170	120	150 D	760 D	1100 D	140 D
Benzofluoranthenes (total)	TT calculation	ug/Kg	900	4600	1710	1530	4300	450	1880	880	1120	670	290	580	2960	4200	560
		mg/kg OC	84.9	142.4	100.6	96.8	216.1	55.6	143.5	48.6	83.0	50.0	33.3	31.9	109.6	214.3	27.2
Benzoic acid	EPA 8270C	ug/Kg	150 U	3500 U R	190 U R	180 U R	1900 U R	140 U R	770 U R	150 U R	160 U R	160 U R	150 U	150 U R	850 U R	720 U R	440 U R
Benzyl alcohol	EPA 8270C	ug/Kg	6.4 J	140 U	14 J	6.9 U	72 U	5.1 U	30 U	5.8 U	6.2 U	6 U	5.5 U	8.1 J	33 U	28 U	17 U
bis(2-chloroethoxy)methane	EPA 8270C	ug/Kg	2.1 U	47 U	2.5 U	2.5 U	26 U	1.8 U	11 U	2.1 U	2.2 U	2.1 U	2 U	2 U	12 U	9.7 U	6 U
bis(2-chloroethyl)ether	EPA 8270C	ug/Kg	3.7 U	87 U	4.7 U	4.5 U	47 U	3.3 U	20 U	3.8 U	4 U	3.9 U	3.6 U	3.7 U	22 U	18 U	11 U
bis(2-chloroisopropyl)ether	EPA 8270C	ug/Kg	1.9 U	44 U	2.4 U	2.3 U	24 U	1.7 U	9.6 U	1.9 U	2 U	2 U	1.8 U	1.9 U	11 U	9 U	5.5 U
bis(2-ethylhexyl)phthalate	EPA 8270C	ug/Kg	170	230 JD U	430	280	700 JD	80 J	230 JD	70 J	190	66 J	43 J	110	220 JD	110 JD	140 JD
		mg/kg OC	16.0	7.1 JD U	25.3	17.7	35.2 JD	9.9 J	17.6 JD	3.9 J	14.1	4.9 J	4.9 J	6.0	8.1 JD	5.6 JD	6.8 JD
Butyl benzyl phthalate	EPA 8270C	ug/Kg	10	54 U	55	20	96 JD	2.1 U	20 JD	7.3 J	2.5 U	14	5.5 J	15	30 JD	12 U	22 JD
		mg/kg OC	0.9	1.7 U	3.2	1.3	4.8 JD	0.3 U	1.5 JD	0.4 J	0.2 U	1.0	0.6 J	0.8	1.1 JD	0.6 U	1.1 JD
Chrysene	EPA 8270C	ug/Kg	540	5800 D	1200 D	1100 D	2500 D	520	1100 D	700	1000 D	520	230	350	1600 D	4500 D	310 D
		mg/kg OC	50.9	179.6 D	70.6 D	69.6 D	125.6 D	64.2	84.0 D	38.7	74.1 D	38.8	26.4	19.2	59.3 D	229.6 D	15.0 D
Dibenzo(a,h)anthracene	EPA 8270C	ug/Kg	84	130 JD	110	120	340 D	40	140 D	66	72	45	19	48	180 D	210 D	45 D
		mg/kg OC	7.9	4.0 JD	6.5	7.6	17.1 D	4.9	10.7 D	3.6	5.3	3.4	2.2	2.6	6.7 D	10.7 D	2.2 D
Dibenzofuran	EPA 8270C	ug/Kg	30	47 U	62	48	150 D	25	71 D	43	69	40	20	60	400 D	110 D	19 JD
		mg/kg OC	2.8	1.5 U	3.6	3.0	7.5 D	3.1	5.4 D	2.4	5.1	3.0	2.3	3.3	14.8 D	5.6 D	0.9 JD
Diethylphthalate	EPA 8270C	ug/Kg	5.4 U	130 U	6.8 U	6.5 U	68 U	4.8 U	28 U	5.5 U	5.8 U	5.7 U	5.2 U	5.4 U	31 U	27 U	17 U
		mg/kg OC	0.5 U	4.0 U	0.4 U	0.4 U	3.4 U	0.6 U	2.1 U	0.3 U	0.4 U	0.4 U	0.6 U	0.3 U	1.1 U	1.4 U	0.8 U
Dimethyl phthalate	EPA 8270C	ug/Kg	2.8 U	65 U	3.5 U	4.3 J	35 U	2.5 U	15 U	2.8 U	3 U	2.9 U	2.7 U	2.8 U	16 U	14 U	8.3 U
		mg/kg OC	0.3 U	2.0 U	0.2 U	0.3 J	1.8 U	0.3 U	1.1 U	0.2 U	0.2 U	0.2 U	0.3 U	0.2 U	0.6 U	0.7 U	0.4 U
Di-n-butyl phthalate	EPA 8270C	ug/Kg	23	94 U	22	30	69 JD	10	22 JD	8.4 J	23	7 J	13	12	23 U	27 JD	22 JD
		mg/kg OC	2.2	2.9 U	1.3	1.9	3.5 JD	1.2	1.7 JD	0.5 J	1.7	0.5 J	1.5	0.7	0.9 U	1.4 JD	1.1 JD
Di-n-octyl phthalate	EPA 8270C	ug/Kg	1.9 U	44 U	2.4 U	2.3 U	24 U	1.7 U	9.6 U	1.9 U	2 U	2 U	1.8 U	1.9 U	11 U	9 U	5.5 U
		mg/kg OC	0.2 U	1.4 U	0.1 U	0.1 U	1.2 U	0.2 U	0.7 U	0.1 U	0.1 U	0.1 U	0.2 U	0.1 U	0.4 U	0.5 U	0.3 U
Fluoranthene	EPA 8270C	ug/Kg	820 D J	33000 D	1600 D	1200 D	4500 D	760	1500 D	950 D	990	480	310 J	190	2100 D	4300 D	440 D
		mg/kg OC	77.4 D J	1021.7 D	94.1 D	75.9 D	226.1 D	93.8	114.5 D	52.5 D	73.3	35.8	35.6 J	10.4	77.8 D	219.4 D	21.4 D
Fluorene	EPA 8270C	ug/Kg	54	120 JD	130	110	330 D	57	130 D	79	130	70	29	77	470 D	340 D	30 JD
		mg/kg OC	5.1	3.7 JD	7.6	7.0	16.6 D	7.0	9.9 D	4.4	9.6	5.2	3.3	4.2	17.4 D	17.3 D	1.5 JD
Hexachlorobenzene	EPA 8081A	ug/Kg	2.5 U	2.9 U	3.1 U	3 U	3.1 U	2.9 JD	1.3 U	2.5 U	2.7 U	2.6 U	2.4 U	1.2 U	1.4 U	1.2 U	1.3 U
		mg/kg OC	0.2 U	0.1 U	0.2 U	0.2 U	0.2 U	0.4 JD	0.1 U	0.1 U	0.2 U	0.2 U	0.3 U	0.1 U	0.1 U	0.1 U	0.1 U
Hexachlorobutadiene	EPA 8081A	ug/Kg		18 U			19 U		7.9 U						8.7 U	7.4 U	
		mg/kg OC	0.0	0.6 U	0.0	0.0	1.0 U	0.0	0.6 U	0.0	0.0	0.0	0.0	0.0	0.3 U	0.4 U	0.0
Hexachlorobutadiene	EPA 8270C	ug/Kg	2.2 U		2.7 U	2.6 U		2 U		2.2 U	2.4 U	2.3 U	2.1 U	2.2 U			6.5 U
		mg/kg OC	0.2 U	0.0	0.2 U	0.2 U	0.0	0.2 U	0.0	0.1 U	0.2 U	0.2 U	0.2 U	0.1 U	0.0	0.0	0.3 U
Hexachlorocyclopentadiene	EPA 8270C	ug/Kg	24 U	540 U	29 U	28 U	300 U	21 U	120 U	24 U	25 U	25 U	23 U	23 U UJ	140 U	120 U	69 U
Hexachloroethane	EPA 8270C	ug/Kg	3.4 U	79 U	4.3 U	4.1 U	43 U	3 U	18 U	3.5 U	3.7 U	3.6 U	3.3 U	3.4 U	20 U	17 U	11 U
Indeno(1,2,3-cd)pyrene	EPA 8270C	ug/Kg	260	680 D	560	460	1400 D	120	510 D	250	280	170	72	140	690 D	810 D	170 D
		mg/kg OC	24.5	21.1 D	32.9	29.1	70.4 D	14.8	38.9 D	13.8	20.7	12.7	8.3	7.7	25.6 D	41.3 D	8.3 D
Isophorone	EPA 8270C	ug/Kg	2.5 U	58 U	3.1 U	3 U	32 U	2.2 U	13 U	2.5 U	2.7 U	2.6 U	2.4 U	2.5 U	15 U	12 U	7.4 U
Naphthalene	EPA 8270C	ug/Kg	44	47 U	77	53	95 JD	9.1 J	99 D	43	120	79	44	110	610 D	170 D	41 D
		mg/kg OC	4.2	1.5 U	4.5	3.4	4.8 JD	1.1 J	7.6 D	2.4	8.9	5.9	5.1	6.0	22.6 D	8.7 D	2.0 D
Nitrobenzene	EPA 8270C	ug/Kg	3.1 U	72 U	3.9 U	3.7 U	39 U	2.8 U	16 U	3.1 U	3.4 U	3.3 U	3 U	3.1 U	18 U	15 U	9.2 U
N-Nitrosodimethylamine	EPA 8270C	ug/Kg	9.4 U	220 U	38 J	12 U	120 U	8.3 U	49 U	9.5 U	11 U	9.8 U	9 U	9.3 U UJ	54 U	46 U	28 U
N-Nitroso-di-n-propylamine	EPA 8270C	ug/Kg	5 U	120 U	6.2 U	6 U	63 U	4.4 U	26 U	5 U	5.3 U	5.2 U	4.8 U	4.9 U	29 U	24 U	15 U
N-Nitrosodiphenylamine	EPA 8270C	ug/Kg	3.4 U	79 U	4.3 U	4.1 U	43 U	3 U	18 U	3.5 U	3.7 U	3.6 U	3.3 U	3.4 U	20 U	17 U	11 U
		mg/kg OC	0.3 U	2.4 U	0.3 U	0.3 U	2.2 U	0.4 U	1.4 U	0.2 U	0.3 U	0.3 U	0.4 U	0.2 U	0.7 U	0.9 U	0.5 U
Pentachlorophenol	EPA 8270C	ug/Kg	35 J	340 JD	540	80 J	330 JD	12 U	68 U	16 J	15 U	14 U	13 U	13 U	75 U	64 U	39 U
Phenanthrene	EPA 8270C	ug/Kg	420	450 D	810	710	3200 D	300	720 D	550	720	320	140	290	1700 D	1100 D	210 D
		mg/kg OC	39.6	13.9 D	47.6	44.9	160.8 D	37.0	55.0 D	30.4	53.3	23.9	16.1	15.9	63.0 D	56.1 D	10.2 D
Phenol	EPA 8270C	ug/Kg	130	69 U	47	33	38 JD	17 J	25 JD	75	59	23 J	10 J	27 J	38 JD	55 JD	18 JD
Pyrene	EPA 8270C	ug/Kg	530	23000 D	1900 D	1400 D	5300 D	420	1600 D	970	950	590	210	520	3000 D	2600 D	540 D
		mg/kg OC	50.0	712.1 D	111.8 D	88.6 D	266.3 D	51.9	122.1 D	53.6	70.4	44.0	24.1	28.6	111.1 D	132.7 D	26.2 D

Table A-3. Remedial Investigation Subtidal Surface Sediment Analytical Data

Location			13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Sample ID			TT13-SS	TT14-SS	TT15-SS	TT16-SS	TT17-SS	TT18-SS	TT19-SS	TT20-SS	TT21-SS	TT22-SS	TT23-SS	TT24-SS	TT25-SS	TT26-SS	TT27-SS
Sample Date			1/26/2007	1/25/2007	1/25/2007	1/25/2007	1/25/2007	1/25/2007	1/25/2007	1/25/2007	1/25/2007	1/25/2007	1/26/2007	1/25/2007	1/25/2007	1/25/2007	1/24/2007
Parameter	**Method**	**Units**															
Total HPAH	TT calculation	ug/Kg	4214	70740	9180	7620	23440	2910	8730	4896	5612	3215	1444	2418	13320	21630	2695
		mg/kg OC	397.5	2190.1	540.0	482.3	1177.9	359.3	666.4	270.5	415.7	239.9	166.0	132.9	493.3	1103.6	130.8
Total LPAH	TT calculation	ug/Kg	820	2184	1637	1372	4765	735.1	1529	1011	1482	811	352	762	4300	4470	439
		mg/kg OC	77.4	67.6	96.3	86.8	239.4	90.8	116.7	55.9	109.8	60.5	40.5	41.9	159.3	228.1	21.3
Total PAH	TT calculation	ug/Kg	5034	72924	10817	8992	28205	3645.1	10259	5907	7094	4026	1796	3180	17620	26100	3134
Butyltin	KRONE	ug/Kg	5.7	2.4	97	53	66	2.2	9.1	5.6	7.7	5.3	2.7	0.54 J	5.2	4.5	12
Dibutyltin	KRONE	ug/Kg	38	25	770 D	550 D	1000 D	9.7	94	46	82	63	16	3.1	69	18	96
Tetrabutyltin	KRONE	ug/Kg	1.8	2.9	57	37	77	0.31 J	5.7	4.4	4.8	3.6	1 J	0.11 U	7.3	1.1 J	6.8
Tributyltin	KRONE	ug/Kg	110	100	2800 D	1900 D	4100 D	28	250 D	160 D	180 D	200 D	42	8.9	140	52	240 D
		mg/kg OC	10.4	3.1	164.7 D	120.3 D	206.0 D	3.5	19.1 D	8.8 D	13.3 D	14.9 D	4.8	0.5	5.2	2.7	11.7 D
Total Solids	EPA 160.3	Percent	64.9	55.8	52	54.1	51.6	73.5	62.8	64.6	60.6	62.3	68	65.9	56.7	67.1	65.5
Total Organic Carbon	ASTM D4129-98M	Percent						0.81	1.31					1.82	2.7	1.96	2.06
Total Organic Carbon	EPA 9060M	Percent	1.06	3.23	1.7	1.58	1.99			1.81	1.35	1.34	0.87				
Fractional % phi >-1	PSEP Grain Size	Percent	0.82	15.7	6.11	1.04	2.99	8.24	0.55	1.36	1.07	0.84	0.36	6.87	1.12	3.34	0.36
Fractional % phi 0-1	PSEP Grain Size	Percent	0.9	5.31	9.64	2.03	3.85	6.74	1.42	3.98	2.27	1.75	0.8	13.6	0.97	1.7	0.74
Fractional % phi 1-2	PSEP Grain Size	Percent	3.24	5.6	8.42	3.74	9.67	20.9	11.4	16.9	12.7	1.12	14.6	15.8	4.2	1.87	3.23
Fractional % phi 2-3	PSEP Grain Size	Percent	14	9.34	11.9	25.5	15.4	13.1	24.2	32	23.4	31.3	34.5	10.1	13.9	2.03	31.4
Fractional % phi 3-4	PSEP Grain Size	Percent	31	6.3	17.1	22.5	17.9	4.91	19.7	19.2	21.3	27.8	22.8	9.82	20.5	2.3	34
Fractional % phi 4-5	PSEP Grain Size	Percent	23.4	3.73	12.6	13.4	11.7	0.528	4.66	10.6	13	15.7	10.1	3.69	6.25	0.75	3.41
Fractional % phi 5-6	PSEP Grain Size	Percent	8.52	4.72	7.49	8.19	11.2	1.36	11.6	5.29	9.24	8.4	5.14	12.8	21.7	4.01	6.3
Fractional % phi 6-7	PSEP Grain Size	Percent	4.05	4.27	7.03	6.81	8.08	0.91	6.5	3.01	5.69	0	2.71	6.45	7.6	1.89	3.63
Fractional % phi 7-8	PSEP Grain Size	Percent	3.19	3.1	6.19	6.35	5.55	0.8	3.95	3.03	4.44	4.15	2.11	2.76	4.75	1.06	2.48
Fractional % phi 8-9	PSEP Grain Size	Percent	2.31	2.83	5.62	5.48	4.99	0.99	5.31	2.64	3.59	3.12	1.85	2.98	4.81	1.38	3.78
Fractional % phi 9-10	PSEP Grain Size	Percent	1.69	1.91	4.83	5.11	4.2	0.31	3.48	2.6	3.61	3.49	1.18	1.52	4.1	0.31	2.69
Fractional % phi >10	PSEP Grain Size	Percent	4.74	3.22	8.14	6.84	6.08	1.04	4.77	4.21	4.77	4.56	2.33	2.88	4.53	1.06	2.61
Gravel	PSEP Grain Size	Percent	0.91	41.1	3.61	0.93	6.54	42.3	1.44	2.17	0.34	0.77	0.49	8.86	3.96	72	0.38

Notes:

0.14 U J = Result followed by laboratory data qualifier followed by data validator qualifier
mg/kg = milligrams per kilogram
ug/kg = micrograms per kilogram
mg/L = milligrams per liter
ug/L = micrograms per liter
ng/L = nanograms per liter

Data Validation Qualifiers
U = Result should be considered not-detected at the quantitation limit shown
J = Result is an estimated concentration
R = Rejected - Quality Control indicates the data is not usable
UJ = The compound was not detected and the sample detection limit should be considered an estimated value
N = Pesticide result is tentatively identified

Laboratory Data Qualifiers
U = result was not detected at or above the method detection limit
J (for organics) = result is an estimated concentrations that is less than the reporting limit but greater than or equal to the detection limit
B (for metals) = result is an estimated concentrations that is less than the reporting limit but greater than or equal to the detection limit
* (for metals) = duplicate analysis not within control limits. See case narrative (in laboratory report)
D (for organics) = result reported is from a dilution
P (for organics) = The GC or HPLC confirmation criteria was exceeded. The relative percent difference is greater than 40% between the two analytical results.
i (for organics) = the MRL/MDL has been elevated due to a chromatographic interference.

Table A-3. Remedial Investigation Subtidal Surface Sediment Analytical Data

Location			28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	RB	
Sample ID			TT28-SS	TT29-SS	TT30-SS	TT31-SS	TT32-SS	TT33-SS	TT34-SS	TT35-SS	TT36-SS	TT37-SS	TT38-SS	TT39-SS	TT40-SS	TT41-SS	TT42-SS	RB-SS-2	
Sample Date			1/24/2007	1/24/2007	1/24/2007	1/26/2007	1/26/2007	1/26/2007	1/26/2007	1/25/2007	1/25/2007	1/25/2007	1/25/2007	1/25/2007	1/26/2007	1/25/2007	1/26/2007	1/25/2007	
Parameter	**Method**	**Units**																	**Units**
Antimony	EPA 6020	mg/Kg	3.85 * J	1.14 * J	9.02 * J	7.46 J	3.5 J	2.73 J	1.17 J	1.08 J	1.09 J	1.54 J	2.68 J	1.02 J	58.1 J	8.51 J	9.19 J	0.02 B	ug/L
Arsenic	EPA 6020	mg/Kg	8.58 J	6.08 J	30.1 J	32	8.58	13.8	6.38	4.56	5.08	7.37	8.76	6.41	114	21.1	23.3	0.1 B	ug/L
Cadmium	EPA 6020	mg/Kg	0.083 J	0.061	0.388	0.36	0.23	0.24	0.1	0.12	0.04 B	0.08	0.11	0.13	0.47	0.18	0.39	0.02 U	ug/L
Chromium	EPA 6010B	mg/Kg	16.6	17.7	49.2	57.3	24.5	31.6	16.2	19	14.9	17.1	14.4	16.1	202	32.6	39.9	0.17 B	ug/L
Cobalt	EPA 6020	mg/Kg	4.67 J	3.18 J	8.82 J	9.78	6.37	6.86	4.93	4.85	3.66	4.47	4.33	4.26	15.6	6.72	6.96	0.007 U	ug/L
Copper	EPA 6010B	mg/Kg	34.5	28.2	388	409	54.5	101	840	39.3	28.3	39.8	31.2	34.6	442	148	132	0.11	ug/L
Lead	EPA 6020	mg/Kg	22.5	19.8	154	192	26.5	80.9	31.1	20.5	18.5	22.4	25.4	20.5	350	80.5	142	0.289	ug/L
Mercury	EPA 7471A	mg/Kg	0.178	0.376	0.754	0.83 *	0.253 *	0.54 *	0.758 *	0.176	0.084	0.121	0.122	0.158	1.57 *	0.837	0.998	0.02 U	ug/L
Molybdenum	EPA 6020	mg/Kg	0.63 J	0.41	2.79	2.63	1.07	0.97	0.58	0.46	0.36	0.46	0.67	0.68	8.24	1.24	1.71	0.026 B U	ug/L
Nickel	EPA 6020	mg/Kg	9.69 J	7.29 J	18.2 J	19.4	14.6	15.9	10.5	10.8	7.98	9.65	15.1	21	84.9	14.6	16.6	1.21	ug/L
Selenium	EPA 6020	mg/Kg	0.5 U UJ	0.5 U	0.5 U	1.1	1.1 B	0.8 B	0.6 B	0.6 B	0.3 B	0.5 B	0.5 B	0.4 B	1 B	0.6 B	1 B	0.2 U	ug/L
Silver	EPA 6020	mg/Kg	0.1	0.077	0.374	0.339	0.178	0.256	0.143	0.113	0.071	0.106	0.1	0.11	0.641	0.176	0.412	0.004 B U	ug/L
Thallium	EPA 6020	mg/Kg	0.056	0.035	0.107	0.12	0.13	0.1	0.07	0.08	0.06	0.09	0.08	0.06	0.16	0.08	0.12	0.005 U	ug/L
Vanadium	EPA 6010B	mg/Kg	44.3	45	54.7	61	55.3	48.9	43	45.7	36.9	38.2	32.5	27.9	59.2	44.1	50.1	0.04 B	ug/L
Zinc	EPA 6010B	mg/Kg	66.6	48.1	298	304	68.3	128	167	64.4	47.5	56.6	66	53.1	795	310	210	7.6	ug/L
PCBs (total)	TT calculation	ug/Kg	72	104	490	1410	139	490	62	60	47	121	106	85	2050	866	1110	0.005 U	ug/L
		mg/kg OC	10.1		30.2	104.4	7.6	38.3	6.6	7.6		16.8	3.7	1.6	201.0	93.1	73.5		
PCB-1016	EPA 8082	ug/Kg	2.4 U	2.4 U	2.8 U	31 U	2.8 U	13 U	2.5 U	2.6 U	2.4 U	2.5 U	2.5 U	2.5 U	26 U	25 U	27 U	0.005 U UJ	ug/L
PCB-1221	EPA 8082	ug/Kg	2.4 U	2.4 U	2.8 U	31 U	2.8 U	13 U	2.5 U	2.6 U	2.4 U	2.5 U	2.5 U	2.5 U	26 U	25 U	27 U	0.005 U	ug/L
PCB-1232	EPA 8082	ug/Kg	2.4 U	2.4 U	2.8 U	31 U	2.8 U	13 U	2.5 U	2.6 U	2.4 U	2.5 U	2.5 U	2.5 U	26 U	25 U	27 U	0.005 U	ug/L
PCB-1242	EPA 8082	ug/Kg	2.4 U	2.4 U	2.8 U	31 U	2.8 U	13 U	2.5 U	2.6 U	2.4 U	2.5 U	2.5 U	2.5 U	26 U	25 U	27 U	0.005 U	ug/L
PCB-1248	EPA 8082	ug/Kg	2.4 U	2.4 U	2.8 U	31 U	2.8 U	13 U	2.5 U	2.6 U	2.4 U	2.5 U	2.5 U	2.5 U	26 U	25 U	27 U	0.005 U	ug/L
PCB-1254	EPA 8082	ug/Kg	38	63	270	820 D	90	260 D	35	34	23	67	69	48	1400 D	440 D	700 D	0.005 U	ug/L
PCB-1260	EPA 8082	ug/Kg	34	41	220	590 D	49	230 D	27	26	24	54 P J	37	37	650 D	330 D	410 D	0.005 U	ug/L
PCB-1262	EPA 8082	ug/Kg	2.4 U	2.4 U	2.8 U	31 U	2.8 U	13 U	2.5 U	2.6 U	2.4 U	2.5 U	2.5 U	2.5 U	26 U	25 U	27 U	0.005 U	ug/L
PCB-1268	EPA 8082	ug/Kg	2.4 U	2.4 U	2.8 U	31 U	2.8 U	13 U	2.5 U	2.6 U	2.4 U	2.5 U	2.5 U	2.5 U	26 U	96 D	27 U	0.005 U	ug/L
Aldrin	EPA 8081A	ug/Kg	2.1 U UJ	2.2 U UJ	2.5 U UJ	5.4 U UJ	5 U UJ	4.6 U UJ	4.4 U UJ	4.5 U UJ	4.2 U UJ	4.4 U UJ	4.3 U UJ	4.4 U UJ	4.6 U UJ	4.4 U UJ	4.7 U UJ	0.054 U UJ	ng/L
alpha-BHC	EPA 8081A	ug/Kg	3.7 U UJ	3.7 U UJ	4.3 U UJ	9.3 U UJ	8.6 U UJ	7.9 U UJ	7.5 U UJ	7.8 U UJ	7.3 U UJ	7.6 U UJ	7.5 U UJ	7.5 U UJ	8 U UJ	7.6 U UJ	8.1 U UJ	0.06 U UJ	ng/L
alpha-Chlordane	EPA 8081A	ug/Kg	3.3 U UJ	3.3 U UJ	3.8 U UJ	8.2 U UJ	7.6 U UJ	7 U UJ	6.7 U UJ	6.9 U UJ	6.5 U UJ	6.7 U UJ	6.6 U UJ	6.7 U UJ	7.1 U UJ	6.8 U UJ	7.2 U UJ	0.072 U UJ	ng/L
beta-BHC	EPA 8081A	ug/Kg	4.2 U UJ	4.3 U UJ	5 U UJ	11 U UJ	9.9 U UJ	9.1 U UJ	8.7 U UJ	9 U UJ	8.4 U UJ	8.8 U UJ	8.6 U UJ	8.7 U UJ	9.2 U UJ	8.8 U UJ	9.4 U UJ	0.63 Ui UJ	ng/L
delta-BHC	EPA 8081A	ug/Kg	0.77 U UJ	0.78 U UJ	0.91 U UJ	3.6 Ui UJ	1.9 U UJ	1.7 U UJ	1.6 U UJ	1.7 U UJ	1.6 U UJ	1.6 U UJ	1.6 U UJ	1.6 U UJ	1.7 U UJ	1.7 U UJ	1.8 U UJ	0.18 U UJ	ng/L
Dieldrin	EPA 8081A	ug/Kg	4.1 U UJ	4.1 U UJ	4.8 U UJ	11 U UJ	9.6 U UJ	8.8 U UJ	8.4 U UJ	8.7 U UJ	8.2 U UJ	8.5 U UJ	8.3 U UJ	8.4 U UJ	8.9 U UJ	8.5 U UJ	9.1 U UJ	0.4 U UJ	ng/L
Endosulfan I	EPA 8081A	ug/Kg	2.4 U UJ	2.4 U UJ	2.8 U UJ	6.1 U UJ	5.6 U UJ	5.2 U UJ	4.9 U UJ	5.1 U UJ	4.8 U UJ	5 U UJ	4.9 U UJ	4.9 U UJ	16 PD JN	5 U UJ	5.3 U UJ	0.067 U UJ	ng/L
Endosulfan II	EPA 8081A	ug/Kg	2.7 U UJ	2.7 U UJ	3.2 U UJ	6.8 U UJ	6.3 U UJ	5.8 U UJ	5.5 U UJ	5.7 U UJ	5.4 U UJ	5.6 U UJ	5.5 U UJ	5.5 U UJ	5.8 U UJ	5.6 U UJ	6 U UJ	0.14 Ui UJ	ng/L
Endosulfan sulfate	EPA 8081A	ug/Kg	1.2 U UJ	1.2 U UJ	2.8 Ui UJ	2.9 U UJ	2.6 U UJ	2.4 U UJ	2.3 U UJ	2.4 U UJ	2.3 U UJ	2.3 U UJ	2.3 U UJ	2.3 U UJ	2.5 U UJ	2.4 U UJ	2.5 U UJ	0.062 U UJ	ng/L
Endrin	EPA 8081A	ug/Kg	2.8 U UJ	2.9 U UJ	3.3 U UJ	7.2 U UJ	6.6 U UJ	6.1 U UJ	5.8 U UJ	6 U UJ	5.6 U UJ	5.9 U UJ	5.7 U UJ	5.8 U UJ	6.1 U UJ	5.9 U UJ	6.3 U UJ	0.083 U UJ	ng/L
Endrin aldehyde	EPA 8081A	ug/Kg	0.74 U UJ	0.75 U UJ	5 Ui UJ	10 Ui UJ	1.8 U UJ	1.7 U UJ	1.6 U UJ	1.6 U UJ	1.5 U UJ	1.6 U UJ	1.6 U UJ	1.6 U UJ	17 PD JN	5.1 JPD JN	9.6 JPD JN	0.59 P JN	ng/L
gamma-BHC	EPA 8081A	ug/Kg	2.1 U UJ	2.2 U UJ	5 Ui UJ	5.4 U UJ	5 U UJ	4.6 U UJ	4.4 U UJ	4.5 U UJ	4.2 U UJ	4.4 U UJ	4.3 U UJ	4.4 U UJ	4.6 U UJ	4.4 U UJ	4.7 U UJ	0.91 P UJ	ng/L
gamma-Chlordane	EPA 8081A	ug/Kg	0.9 U UJ	3.7 JPD JN	15 PD JN	10 PD JN	2.2 U UJ	4.6 JPD JN	1.9 U UJ	1.9 U UJ	1.8 U UJ	1.9 U UJ	1.9 U UJ	1.9 U UJ	25 PD JN	15 PD JN	14 PD JN	0.15 U UJ	ng/L
Heptachlor	EPA 8081A	ug/Kg	1.2 U UJ	1.2 U UJ	1.4 U UJ	2.9 U UJ	2.7 U UJ	2.5 U UJ	2.4 U UJ	2.4 U UJ	2.3 U UJ	2.4 U UJ	2.3 U UJ	2.3 U UJ	2.5 U UJ	2.4 U UJ	2.5 U UJ	0.1 U UJ	ng/L
Heptachlor epoxide	EPA 8081A	ug/Kg	1.9 U UJ	1.9 U UJ	5 Ui UJ	4.7 U UJ	4.3 U UJ	4 U UJ	3.8 U UJ	3.9 U UJ	3.7 U UJ	3.8 U UJ	3.8 U UJ	3.8 U UJ	10 Ui UJ	3.8 U UJ	4.1 U UJ	0.065 U UJ	ng/L
Methoxychlor	EPA 8081A	ug/Kg	1.4 U UJ	1.5 U UJ	15 PD JN	6.3 Ui UJ	3.3 U UJ	3.1 U UJ	2.9 U UJ	3 U UJ	2.8 U UJ	3 U UJ	2.9 U UJ	2.9 U UJ	3.4 Ui UJ	3.7 Ui UJ	3.2 U UJ	1.4 Ui UJ	ng/L
Mirex	EPA 8081A	ug/Kg	1.4 U UJ	1.5 U UJ	3 JD JN	10 Ui UJ	3.3 U UJ	3.1 U UJ	2.9 U UJ	3 U UJ	2.8 U UJ	3 U UJ	2.9 U UJ	2.9 U UJ	10 Ui UJ	3 U UJ	3.2 U UJ	0.27 U UJ	ng/L
Nonachlor (cis)	EPA 8081A	ug/Kg	1.2 U UJ	1.2 U UJ	1.4 U UJ	10 Ui UJ	3.3 Ui UJ	2.6 U UJ	2.4 U UJ	2.5 U UJ	2.4 U UJ	2.5 U UJ	2.4 U UJ	2.4 U UJ	10 Ui UJ	2.5 U UJ	10 Ui UJ	0.31 U UJ	ng/L
Nonachlor (trans)	EPA 8081A	ug/Kg	5 Ui UJ	1.3 U UJ	1.5 U UJ	10 Ui UJ	3 U UJ	2.7 U UJ	2.6 U UJ	2.7 U UJ	2.5 U UJ	2.6 U UJ	2.6 U UJ	2.6 U UJ	10 Ui UJ	2.6 U UJ	10 Ui UJ	0.22 U UJ	ng/L
Oxychlordane	EPA 8081A	ug/Kg	5.2 U UJ	5.3 U UJ	6.1 U UJ	14 U UJ	13 U UJ	12 U UJ	11 U UJ	11 U UJ	11 U UJ	11 U UJ	11 U UJ	11 U UJ	12 U UJ	11 U UJ	12 U UJ	3.4 Ui UJ	ng/L
Toxaphene	EPA 8081A	ug/Kg	130 U UJ	130 U UJ	290 Ui UJ	390 Ui UJ	300 U UJ	340 Ui UJ	500 Ui UJ	270 U UJ	260 U UJ	270 U UJ	260 U UJ	260 U UJ	970 Ui UJ	270 U UJ	470 Ui UJ	22 Ui UJ	ng/L
o,p'-DDD	EPA 8081A	ug/Kg	3.8 JD JN	3 U UJ	34 PD JN	60 PD JN	6.9 U UJ	25 PD JN	6.1 U UJ	6.3 U UJ	5.9 U UJ	6.2 U UJ	6 U UJ	6.1 U UJ	29 Ui UJ	39 PD JN	17 Ui UJ	0.94 U UJ	ng/L
o,p'-DDE	EPA 8081A	ug/Kg	3.3 U UJ	3.3 U UJ	3.8 U UJ	8.2 U UJ	7.6 U UJ	7 U UJ	6.7 U UJ	6.9 U UJ	6.5 U UJ	6.7 U UJ	6.6 U UJ	6.7 U UJ	27 Ui UJ	9.5 Ui UJ	14 Ui UJ	0.25 U UJ	ng/L
o,p'-DDT	EPA 8081A	ug/Kg	2.8 JD JN	5.3 D JN	22 D JN	41 D JN	4.6 U UJ	17 D JN	4.1 U UJ	4.2 U UJ	4 U UJ	6 JD JN	5.5 JD JN	4.1 U UJ	90 D JN	28 D JN	44 D JN	0.2 U UJ	ng/L
p,p'-DDD	EPA 8081A	ug/Kg	1.7 U UJ	1.7 U UJ	7.5 D JN	6 JD JN	4 U UJ	5.6 JD JN	3.5 U UJ	3.6 U UJ	3.4 U UJ	3.5 U UJ	3.5 U UJ	3.5 U UJ	11 D JN	3.5 U UJ	13 D JN	3 Ui UJ	ng/L
p,p'-DDE	EPA 8081A	ug/Kg	1.4 U UJ	1.5 U UJ	1.7 U UJ	3.6 U UJ	3.3 U UJ	3.1 U UJ	2.9 U UJ	3 U UJ	2.8 U UJ	3 U UJ	2.9 U UJ	2.9 U UJ	3.1 U UJ	3 U UJ	3.2 U UJ	3 Ui UJ	ng/L
p,p'-DDT	EPA 8081A	ug/Kg	4.5 JD JN	9.1 D JN	40 D JN	58 Ui UJ	8.6 JD JN	29 Ui UJ	4.9 Ui UJ	4.5 JD JN	3 Ui UJ	8.4 Ui UJ	7 Ui UJ	5.6 JD JN	120 Ui UJ	37 D JN	62 D JN	0.33 U UJ	ng/L
Total DDT	TT calculation	ug/Kg	11.1 JN	14.4 JN	103.5 JN	107 JN	8.6 JN	47.6 JN	6.7 U UJ	4.5 JN	6.5 U UJ	6 JN	5.5 JN	5.6 JN	101 JN	104 JN	119 JN	3 U UJ	ng/L
Total Chlordane	TT Calculated	ug/Kg	5.2 U UJ	3.7 JN	15 JN	10 JN	13 U UJ	4.6 JN	11 U UJ	11 U UJ	11 U UJ	11 U UJ	11 U UJ	11 U UJ	25 JN	15 JN	14 JN	3.4 U UJ	ng/L
1,2,4-Trichlorobenzene	EPA 8270C	ug/Kg	2.1 U	2.2 U	25 U	14 U	2.5 U	12 U	2.2 U	2.3 U	2.1 U	2.2 U	2.2 U	2.2 U	12 U	2.2 U	12 U	0.016 U	ug/L
		mg/kg OC	0.3 U		1.5 U	1.0 U	0.1 U	0.9 U	0.2 U	0.3 U		0.3 U	0.1 U	0.0 U	1.2 U	0.2 U	0.8 U		
1,2-Dichlorobenzene	EPA 8270C	ug/Kg	1.9 U	1.9 U	22 U	12 U	2.2 U	9.9 U	1.9 U	2 U	1.9 U	1.9 U	1.9 U	1.9 U	10 U	1.9 U	11 U	0.015 U UJ	ug/L
		mg/kg OC	0.3 U		1.4 U	0.9 U	0.1 U	0.8 U	0.2 U	0.3 U		0.3 U	0.1 U	0.0 U	1.0 U	0.2 U	0.7 U		
1,3-Dichlorobenzene	EPA 8270C	ug/Kg	2.3 U	2.3 U	27 U	15 U	2.7 U	13 U	2.4 U	2.4 U	2.3 U	2.4 U	2.3 U	2.3 U	13 U	2.4 U	13 U	0.011 U UJ	ug/L
1,4-Dichlorobenzene	EPA 8270C	ug/Kg	2.7 U	2.7 U	32 U	17 U	3.2 U	15 U	2.8 U	2.9 U	2.7 U	2.8 U	2.8 U	2.8 U	15 U	2.8 U	15 U	0.014 U UJ	ug/L
		mg/kg OC	0.4 U		2.0 U	1.3 U	0.2 U	1.2 U	0.3 U	0.4 U		0.4 U	0.1 U	0.1 U	1.5 U	0.3 U	1.0 U		
1-Methylnaphthalene	EPA 8270C	ug/Kg	14 U UJ	15 U UJ	170 U UJ	90 U UJ	17 U UJ	76 U UJ	15 U UJ	15 U UJ	14 U UJ	15 U UJ	15 U UJ	15 U UJ	77 U UJ	15 U UJ	78 U UJ	0.2 U UJ	ug/L
2,4,5-Trichlorophenol	EPA 8270C	ug/Kg	4.2 U	4.3 U	50 U	27 U	5 U	23 U	4.4 U	4.5 U	4.2 U	4.4 U	4.3 U	4.4 U	23 U	4.4 U	24 U	0.026 U UJ	ug/L
2,4,6-Trichlorophenol	EPA 8270C	ug/Kg	2.6 U	2.6 U	30 U	17 U	3 U	14 U	2.6 U	2.7 U	2.6 U	2.7 U	2.6 U	2.6 U	14 U	2.7 U	14 U	0.037 U	ug/L
2,4-Dichlorophenol	EPA 8270C	ug/Kg	2.6 U	2.6 U	30 U	17 U	3 U	14 U	2.6 U	2.7 U	2.6 U	2.7 U	2.6 U	2.6 U	14 U	2.7 U	14 U	0.024 U	ug/L
2,4-Dimethylphenol	EPA 8270C	ug/Kg	7.7 U	7.8 U	91 U	50 U	9.1 U	42 U	8 U	8.2 U UJ	7.7 U UJ	8 U UJ	7.9 U UJ	8 U UJ	42 U	8.1 U UJ	43 U	0.32 U	ug/L
2,4-Dinitrophenol	EPA 8270C	ug/Kg	51 U	51 U	600 U	330 U	60 U	280 U	52 U	54 U	51 U UJ	53 U	52 U	52 U	280 U	53 U	280 U	0.53 U	ug/L
2,4-Dinitrotoluene	EPA 8270C	ug/Kg	4 U	4 U	46 U	25 U	4.6 U	22 U	4.1 U	4.2 U	4 U	4.1 U	4 U	4.1 U	22 U	4.1 U	22 U	0.02 U UJ	ug/L
2,6-Dinitrotoluene	EPA 8270C	ug/Kg	4 U	4 U	46 U	25 U	4.6 U	22 U	4.1 U	4.2 U	4 U	4.1 U	4 U	4.1 U	22 U	4.1 U	22 U	0.0088 U UJ	ug/L
2-Chloronaphthalene	EPA 8270C	ug/Kg	5.1 U	5.1 U	60 U	33 U	6 U	28 U	5.2 U	5.4 U	5.1 U	5.3 U	5.2 U	5.2 U	28 U	5.3 U	28 U	0.016 U	ug/L
2-Chlorophenol	EPA 8270C	ug/Kg	2.4 U	2.4 U	28 U	16 U	2.8 U	13 U	2.5 U	2.6 U	2.4 U	2.5 U	2.5 U	2.5 U	13 U	2.5 U	14 U	0.015 U UJ	ug/L
2-Methylnaphthalene	EPA 8270C	ug/Kg	7.2 J	3.6 J	74 JD	60 D	12	22 JD	10	5.2 J	1.7 U	7.9 J	8.4 J	22	31 JD	12	24 JD	0.012 U	ug/L
		mg/kg OC	1.0 J		4.6 JD	4.4 D	0.7	1.7 JD	1.1	0.7 J		1.1 J	0.3 J	0.4	3.0 JD	1.3	1.6 JD		
2-Methylphenol	EPA 8270C	ug/Kg	4.8 U	4.8 U	56 U	31 U	5.6 U	26 U	4.9 U	5.1 U	4.8 U	5 U	4.9 U	4.9 U	26 U	5 U	27 U	0.06 U	ug/L
2-Nitroaniline	EPA 8270C	ug/Kg	3.8 U	3.8 U	45 U	25 U	4.5 U	21 U	3.9 U	4.1 U	3.8 U	4 U	3.9 U	3.9 U	21 U	4 U	21 U	0.015 U	ug/L
2-Nitrophenol	EPA 8270C	ug/Kg	3.7 U	3.7 U	43 U	24 U	4.3 U	20 U	3.8 U	3.9 U	3.7 U	3.8 U	3.8 U	3.8 U	20 U	3.8 U	21 U	0.014 U	ug/L
3,3'-Dichlorobenzidine	EPA 8270C	ug/Kg	5.2 U	5.3 U	61 U	33 U	6.1 U	29 U	5.4 U	5.5 U	5.2 U	5.4 U	5.3 U	5.4 U	29 U	5.4 U	29 U	0.43 U R	ug/L
3-Nitroaniline	EPA 8270C	ug/Kg	3.7 U	3.7 U	43 U	24 U	4.3 U	20 U	3.8 U	3.9 U	3.7 U	3.8 U	3.8 U	3.8 U	20 U	3.8 U	21 U	0.23 U UJ	ug/L

Table A-3. Remedial Investigation Subtidal Surface Sediment Analytical Data

Location			28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	RB	
Sample ID			TT28-SS	TT29-SS	TT30-SS	TT31-SS	TT32-SS	TT33-SS	TT34-SS	TT35-SS	TT36-SS	TT37-SS	TT38-SS	TT39-SS	TT40-SS	TT41-SS	TT42-SS	RB-SS-2	
Sample Date			1/24/2007	1/24/2007	1/24/2007	1/26/2007	1/26/2007	1/26/2007	1/26/2007	1/25/2007	1/25/2007	1/25/2007	1/25/2007	1/25/2007	1/26/2007	1/25/2007	1/26/2007	1/25/2007	
Parameter	**Method**	**Units**																	**Units**
4,6-Dinitro-o-cresol	EPA 8270C	ug/Kg	2.4 U	2.4 U	28 U	16 U	2.8 U	13 U	2.5 U	2.6 U	2.4 U	2.5 U	2.5 U	2.5 U	13 U	2.5 U	14 U	0.013 U	ug/L
4-Bromophenyl phenyl ether	EPA 8270C	ug/Kg	2 U	2 U	23 U	13 U	2.3 U	11 U	2.1 U	2.1 U	2 U	2.1 U	2 U	2.1 U	11 U	2.1 U	11 U	0.018 U UJ	ug/L
4-Chloro-3-methylphenol	EPA 8270C	ug/Kg	3 U	3 U	35 U	19 U	3.5 U	16 U	3.1 U	3.2 U	3 U	3.1 U	3 U	3.1 U	17 U	3.1 U	17 U	0.029 U	ug/L
4-Chloroaniline	EPA 8270C	ug/Kg	3 U	3 U	35 U	19 U	3.5 U	16 U	3.1 U	3.2 U	3 U	3.1 U	3 U	3.1 U	17 U	3.1 U	17 U	0.018 U R	ug/L
4-Chlorophenyl phenyl ether	EPA 8270C	ug/Kg	2.8 U	2.9 U	33 U	18 U	3.3 U	16 U	2.9 U	3 U	2.8 U	3 U	2.9 U	2.9 U	16 U	3 U	16 U	0.0085 U UJ	ug/L
4-Methylphenol	EPA 8270C	ug/Kg	4.1 J	4.1 U	48 U	80 D	8.3 J	22 U	4.2 U	4.4 U	4.1 U	4.3 U	4.2 U	4.2 U	23 JD	5.8 J	23 U	0.051 U	ug/L
4-Nitroaniline	EPA 8270C	ug/Kg	4.8 U	4.8 U	56 U	31 U	5.6 U	26 U	4.9 U	5.1 U	4.8 U	5 U	4.9 U	4.9 U	55 JD	5 U	27 U	0.17 U	ug/L
4-Nitrophenol	EPA 8270C	ug/Kg	42 U	43 U	500 U	270 U	50 U	230 U	44 U	45 U	42 U	44 U	43 U	44 U	230 U	44 U	240 U	0.54 U	ug/L
Acenaphthene	EPA 8270C	ug/Kg	14	14	210 D	270 D	23	37 JD	31	9.5 J	6.5 J	14	11	30	150 D	30	47 JD	0.0088 U UJ	ug/L
		mg/kg OC	2.0		13.0 D	20.0 D	1.3	2.9 JD	3.3	1.2 J		1.9	0.4	0.6	14.7 D	3.2	3.1 JD		
Acenaphthylene	EPA 8270C	ug/Kg	13	11	160 D	190 D	22	44 JD	27	11	4.4 J	12	13	23	96 D	80	59 D	0.011 U	ug/L
		mg/kg OC	1.8		9.9 D	14.1 D	1.2	3.4 JD	2.9	1.4		1.7	0.5	0.4	9.4 D	8.6	3.9 D		
Aniline	EPA 8270C	ug/Kg	2.1 U	2.2 U	25 U	14 U	2.5 U	12 U	2.2 U	2.3 U	2.1 U	2.2 U	2.2 U	2.2 U	12 U	2.2 U	12 U	0.25 U R	ug/L
Anthracene	EPA 8270C	ug/Kg	41	30	540 D	580 D	60	120 D	110	24	15	39	32	67	430 D	110	150 D	0.015 U UJ	ug/L
		mg/kg OC	5.8		33.3 D	43.0 D	3.3	9.4 D	11.7	3.0		5.4	1.1	1.3	42.2 D	11.8	9.9 D		
Benzo(a)anthracene	EPA 8270C	ug/Kg	86	75	1400 D	1500 D	90	320 D	200	50	37	86	56	95	820 D	230	300 D	0.012 U UJ	ug/L
		mg/kg OC	12.1		86.4 D	111.1 D	4.9	25.0 D	21.3	6.3		11.9	2.0	1.8	80.4 D	24.7	19.9 D		
Benzo(a)pyrene	EPA 8270C	ug/Kg	100	100	1700 D	1800 D	110	360 D	180	60	40	77	63	100	800 D	360	460 D	0.016 U	ug/L
		mg/kg OC	14.1		104.9 D	133.3 D	6.0	28.1 D	19.1	7.6		10.7	2.2	1.9	78.4 D	38.7	30.5 D		
Benzo(b)fluoranthene	EPA 8270C	ug/Kg	120	120	2700 D	2100 D	130	430 D	170	92	58	130	92	160	940 D	530	480 D	0.02 U UJ	ug/L
Benzo(g,h,i)perylene	EPA 8270C	ug/Kg	62	61	1100 D	960 D	63	190 D	85	39	27	48	42	66	390 D	230	270 D	0.017 U UJ	ug/L
		mg/kg OC	8.7		67.9 D	71.1 D	3.4	14.8 D	9.0	4.9		6.7	1.5	1.2	38.2 D	24.7	17.9 D		
Benzo(k)fluoranthene	EPA 8270C	ug/Kg	85	96	950 D	1500 D	98	300 D	120	32	21	47	35	54	780 D	170	340 D	0.02 U UJ	ug/L
Benzofluoranthenes (total)	TT calculation	ug/Kg	205	216	3650	3600	228	730	290	124	79	177	127	214	1720	700	820	0.02 U	ug/L
		mg/kg OC	28.9		225.3	266.7	12.4	57.0	30.9	15.7		24.6	4.5	4.0	168.6	75.3	54.3		
Benzoic acid	EPA 8270C	ug/Kg	140 U R	140 U R	1600 U R	860 U	160 U	730 U	140 U	150 U R	140 U R	140 U R	140 U R	140 U R	740 U	140 U R	750 U	1.8 U UJ	ug/L
Benzyl alcohol	EPA 8270C	ug/Kg	5.2 U	5.3 U	61 U	33 U	6.1 U	29 U	5.4 U	5.5 U	5.2 U	5.4 U	5.3 U	5.4 U	29 U	5.4 U	29 U	0.98 U	ug/L
bis(2-chloroethoxy)methane	EPA 8270C	ug/Kg	1.9 U	1.9 U	22 U	12 U	2.2 U	9.9 U	1.9 U	2 U	1.9 U	1.9 U	1.9 U	1.9 U	10 U	1.9 U	11 U	0.012 U UJ	ug/L
bis(2-chloroethyl)ether	EPA 8270C	ug/Kg	3.4 U	3.4 U	40 U	22 U	4 U	19 U	3.5 U	3.6 U	3.4 U	3.5 U	3.5 U	3.5 U	19 U	3.5 U	19 U	0.015 U UJ	ug/L
bis(2-chloroisopropyl)ether	EPA 8270C	ug/Kg	1.7 U	1.7 U	20 U	11 U	2 U	9.1 U	1.8 U	1.8 U	1.7 U	1.8 U	1.8 U	1.8 U	9.2 U	1.8 U	9.4 U	0.017 U	ug/L
bis(2-ethylhexyl)phthalate	EPA 8270C	ug/Kg	55 J	56 J	700 JD	650 D	66 J	99 JD U	140	29 J	28 J	31 J	33 J	44 J	610 D	120	160 JD	0.27 U	ug/L
		mg/kg OC	7.7 J		43.2 JD	48.1 D	3.6 J	7.7 JD U	14.9	3.7 J		4.3 J	1.2 J	0.8 J	59.8 D	12.9	10.6 JD		
Butyl benzyl phthalate	EPA 8270C	ug/Kg	2.1 U	2.2 U	53 JD	38 JD	2.5 U	12 U	7 J	3.3 J	2.1 U	5.1 J	2.2 U	10	69 D	6.2 J	12 U	0.026 U	ug/L
		mg/kg OC	0.3 U		3.3 JD	2.8 JD	0.1 U	0.9 U	0.7 J	0.4 J		0.7 J	0.1 U	0.2	6.8 D	0.7 J	0.8 U		
Chrysene	EPA 8270C	ug/Kg	130	97	1800 D	1900 D	120	340 D	280	70	56	130	88	140	1100 D	310	400 D	0.014 U UJ	ug/L
		mg/kg OC	18.3		111.1 D	140.7 D	6.5	26.6 D	29.8	8.9		18.1	3.1	2.6	107.8 D	33.3	26.5 D		
Dibenzo(a,h)anthracene	EPA 8270C	ug/Kg	19	18	300 D	280 D	18	59 D	27	11	6.5 J	14	11	18	130 D	60	78 D	0.031 U UJ	ug/L
		mg/kg OC	2.7		18.5 D	20.7 D	1.0	4.6 D	2.9	1.4		1.9	0.4	0.3	12.7 D	6.5	5.2 D		
Dibenzofuran	EPA 8270C	ug/Kg	8.6 J	7.6 J	120 D	130 D	18	24 JD	9.7 J	7.2 J	3.1 J	16	10	30	81 D	19	34 JD	0.014 U UJ	ug/L
		mg/kg OC	1.2 J		7.4 D	9.6 D	1.0	1.9 JD	1.0 J	0.9 J		2.2	0.4	0.6	7.9 D	2.0	2.3 JD		
Diethylphthalate	EPA 8270C	ug/Kg	4.9 U	5 U	58 U	32 U	5.8 U	27 U	5.1 U	5.2 U	4.9 U	5.1 U	5 U	5.1 U	27 U	5.2 U	28 U	0.026 U UJ	ug/L
		mg/kg OC	0.7 U		3.6 U	2.4 U	0.3 U	2.1 U	0.5 U	0.7 U		0.7 U	0.2 U	0.1 U	2.6 U	0.6 U	1.9 U		
Dimethyl phthalate	EPA 8270C	ug/Kg	2.6 U	2.6 U	30 U	17 U	3 U	14 U	2.6 U	2.7 U	2.6 U	2.7 U	2.6 U	2.6 U	14 U	2.7 U	14 U	0.013 U UJ	ug/L
		mg/kg OC	0.4 U		1.9 U	1.3 U	0.2 U	1.1 U	0.3 U	0.3 U		0.4 U	0.1 U	0.0 U	1.4 U	0.3 U	0.9 U		
Di-n-butyl phthalate	EPA 8270C	ug/Kg	15	8.5 J	52 JD	40 JD	7.7 J	20 U	14	4.4 J	7.5 J	7.8 J	6.6 J	6.8 J	27 JD	18	29 JD	0.067 J UJ	ug/L
		mg/kg OC	2.1		3.2 JD	3.0 JD	0.4 J	1.6 U	1.5	0.6 J		1.1 J	0.2 J	0.1 J	2.6 JD	1.9	1.9 JD		
Di-n-octyl phthalate	EPA 8270C	ug/Kg	1.7 U	1.7 U	20 U	11 U	2 U	9.1 U	1.8 U	1.8 U	1.7 U	1.8 U	1.8 U	1.8 U	9.2 U	1.8 U	9.4 U	0.032 U	ug/L
		mg/kg OC	0.2 U		1.2 U	0.8 U	0.1 U	0.7 U	0.2 U	0.2 U		0.3 U	0.1 U	0.0 U	0.9 U	0.2 U	0.6 U		
Fluoranthene	EPA 8270C	ug/Kg	190	170	3100 D	3800 D J	250 J	670 D J	430 J	88	90	170	130	220	2900 D J	400	610 D J	0.013 U UJ	ug/L
		mg/kg OC	26.8		191.4 D	281.5 D J	13.6 J	52.3 D J	45.7 J	11.1		23.6	4.6	4.1	284.3 D J	43.0	40.4 D J		
Fluorene	EPA 8270C	ug/Kg	15	15	240 D	270 D	26	42 JD	34	11	5.1 J	20	14	37	170 D	37	55 D	0.012 U UJ	ug/L
		mg/kg OC	2.1		14.8 D	20.0 D	1.4	3.3 JD	3.6	1.4		2.8	0.5	0.7	16.7 D	4.0	3.6 D		
Hexachlorobenzene	EPA 8081A	ug/Kg	1.2 U	1.2 U	1.3 U	2.9 U	2.6 U	2.4 U	2.3 U	2.4 U	2.3 U	2.3 U	2.3 U	2.3 U	2.5 U	2.4 U	2.5 U	0.014 U	ng/L
		mg/kg OC	0.2 U		0.1 U	0.2 U	0.1 U	0.2 U	0.2 U	0.3 U		0.3 U	0.1 U	0.0 U	0.2 U	0.3 U	0.2 U		
Hexachlorobutadiene	EPA 8081A	ug/Kg			8.1 U													0.24 U	ng/L
		mg/kg OC	0.0		0.5 U	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0		
Hexachlorobutadiene	EPA 8270C	ug/Kg	2 U	2 U		13 U	2.3 U	11 U	2.1 U	2.1 U	2 U	2.1 U	2 U	2.1 U	11 U	2.1 U	11 U		
		mg/kg OC	0.3 U		0.0	1.0 U	0.1 U	0.9 U	0.2 U	0.3 U		0.3 U	0.1 U	0.0 U	1.1 U	0.2 U	0.7 U		
Hexachlorocyclopentadiene	EPA 8270C	ug/Kg	21 U UJ	22 U UJ	250 U	140 U	25 U	120 U UJ	22 U	23 U	21 U	22 U	22 U	22 U	120 U	22 U	120 U UJ	0.041 U	ug/L
Hexachloroethane	EPA 8270C	ug/Kg	3.1 U	3.1 U	37 U	20 U	3.7 U	17 U	3.2 U	3.3 U	3.1 U	3.2 U	3.2 U	3.2 U	17 U	3.3 U	18 U	0.019 U	ug/L
Indeno(1,2,3-cd)pyrene	EPA 8270C	ug/Kg	64	64	1200 D	1000 D	69	210 D	85	43	28	54	42	69	440 D	250	280 D	0.024 U UJ	ug/L
		mg/kg OC	9.0		74.1 D	74.1 D	3.8	16.4 D	9.0	5.4		7.5	1.5	1.3	43.1 D	26.9	18.5 D		
Isophorone	EPA 8270C	ug/Kg	2.3 U	2.3 U	27 U	15 U	2.7 U	13 U	2.4 U	2.4 U	2.3 U	2.4 U	2.3 U	2.3 U	13 U	2.4 U	13 U	0.0085 U UJ	ug/L
Naphthalene	EPA 8270C	ug/Kg	28	9.6 J	120 D	130 D	34	51 D	23	15	4.2 J	18	26	66	56 D	23	76 D	0.012 U UJ	ug/L
		mg/kg OC	3.9		7.4 D	9.6 D	1.8	4.0 D	2.4	1.9		2.5	0.9	1.2	5.5 D	2.5	5.0 D		
Nitrobenzene	EPA 8270C	ug/Kg	2.8 U	2.9 U	33 U	18 U	3.3 U	16 U	2.9 U	3 U	2.8 U	3 U	2.9 U	2.9 U	16 U	3 U	16 U	0.0074 U UJ	ug/L
N-Nitrosodimethylamine	EPA 8270C	ug/Kg	8.6 U UJ	8.6 U UJ	110 U	55 U	11 U	47 U	8.8 U	9.1 U	8.6 U	8.9 U	8.7 U	8.8 U	47 U	8.9 U	48 U	0.42 U	ug/L
N-Nitroso-di-n-propylamine	EPA 8270C	ug/Kg	4.5 U	4.6 U	53 U	29 U	5.3 U	25 U	4.7 U	4.8 U	4.5 U	4.7 U	4.6 U	4.6 U	25 U	4.7 U	25 U	0.033 U UJ	ug/L
N-Nitrosodiphenylamine	EPA 8270C	ug/Kg	3.1 U	3.1 U	37 U	20 U	3.7 U	17 U	3.2 U	3.3 U	3.1 U	3.2 U	3.2 U	3.2 U	17 U	3.3 U	18 U	0.028 U UJ	ug/L
		mg/kg OC	0.4 U		2.3 U	1.5 U	0.2 U	1.3 U	0.3 U	0.4 U		0.4 U	0.1 U	0.1 U	1.7 U	0.4 U	1.2 U		
Pentachlorophenol	EPA 8270C	ug/Kg	12 U	12 U	570 JD	440 JD	14 U	65 U	13 U	23 J	12 U	13 U	13 U	13 U	90 JD	44 J	67 U	0.029 U	ug/L
Phenanthrene	EPA 8270C	ug/Kg	97	110	2000 D	2300 D	150	330 D	480	57	46	120	82	160	1400 D	240	370 D	0.011 U UJ	ug/L
		mg/kg OC	13.7		123.5 D	170.4 D	8.2	25.8 D	51.1	7.2		16.7	2.9	3.0	137.3 D	25.8	24.5 D		
Phenol	EPA 8270C	ug/Kg	16 J	5.4 J	47 JD	84 JD	20 J	40 JD	11 J	64	2.7 U	30 J	10 J	13 J	27 JD	21 J	47 JD	0.02 U	ug/L
Pyrene	EPA 8270C	ug/Kg	190	120	4000 D	2800 D	180	390 D	370	100	85	170	170	250	1800 D	580	740 D	0.015 U UJ	ug/L
		mg/kg OC	26.8		246.9 D	207.4 D	9.8	30.5 D	39.4	12.7		23.6	6.0	4.7	176.5 D	62.4	49.0 D		

Table A-3. Remedial Investigation Subtidal Surface Sediment Analytical Data

Location			28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	RB	
Sample ID			TT28-SS	TT29-SS	TT30-SS	TT31-SS	TT32-SS	TT33-SS	TT34-SS	TT35-SS	TT36-SS	TT37-SS	TT38-SS	TT39-SS	TT40-SS	TT41-SS	TT42-SS	RB-SS-2	
Sample Date			1/24/2007	1/24/2007	1/24/2007	1/26/2007	1/26/2007	1/26/2007	1/26/2007	1/25/2007	1/25/2007	1/25/2007	1/25/2007	1/25/2007	1/26/2007	1/25/2007	1/26/2007	1/25/2007	
Parameter	**Method**	**Units**																	**Units**
Total HPAH	TT calculation	ug/Kg	1046	921	18250	17640	1128	3269	1947	585	448.5	926	729	1172	10100	3120	3958	0.031 U	ug/L
		mg/kg OC	147.3		1126.5	1306.7	61.3	255.4	207.1	74.1		128.6	25.8	22.0	990.2	335.5	262.1		
Total LPAH	TT calculation	ug/Kg	208	189.6	3270	3740	315	624	705	127.5	81.2	223	178	383	2302	520	757	0.015 U	ug/L
		mg/kg OC	29.3		201.9	277.0	17.1	48.8	75.0	16.1		31.0	6.3	7.2	225.7	55.9	50.1		
Total PAH	TT calculation	ug/Kg	1254	1110.6	21520	21380	1443	3893	2652	712.5	529.7	1149	907	1555	12402	3640	4715	0.031 U	ug/L
Butyltin	KRONE	ug/Kg	3.5	0.88 J	160 D	200 D	2.8	9.2 J	1.4 J	7.1	0.2 Ui	3 J	0.7 JP J	1.8	23	10	6.1	0.0033 J U	ug/L
Dibutyltin	KRONE	ug/Kg	21	23	1300 D	1400 D	20	86	7.4	130 D	9.1	17	5.6	18	360 D	130 D	51	0.0066 J U	ug/L
Tetrabutyltin	KRONE	ug/Kg	0.77 J	2	93	86	2.4 P J	4.2	0.46 Ui	11	0.89 J	0.81 JP J	0.1 U	1.2 J	21	9	2.8	0.0015 U	ug/L
Tributyltin	KRONE	ug/Kg	52	130 D	4500 D	4200 D	71	160 D	22	520 D	30	33	18	61	1200 D	470 D	130	0.0025 JP J	ug/L
		mg/kg OC	7.3	D	277.8 D	311.1 D	3.9	12.5 D	2.3	65.8 D		4.6	0.6	1.1	117.6 D	50.5 D	8.6		
Total Solids	EPA 160.3	Percent	71.7	71.1	60.9	56.1	60.9	66	69.4	67.4	71.6	68.8	70.2	69.6	65.6	68.6	64.3		
Total Organic Carbon	ASTM D4129-98M	Percent	0.71	0.22	1.62													0.11 a J	mg/L
Total Organic Carbon	EPA 9060M	Percent				1.35	1.84	1.28	0.94	0.79	0.2	0.72	2.83	5.33	1.02	0.93	1.51		
Fractional % phi >-1	PSEP Grain Size	Percent	1.75	0.33	2.06	1.51	0.91	1.98	1.95	0.58	0.38	0.5	0.41	1.71	3.68	1.16	1.62		
Fractional % phi 0-1	PSEP Grain Size	Percent	13	0.66	4.48	2.53	2.28	6.33	9.92	0.87	2.64	0.74	1.5	3.34	9.4	4.32	4.25		
Fractional % phi 1-2	PSEP Grain Size	Percent	37.8	9.58	11.8	8.27	7.16	13.2	22.5	4.91	40	17.4	9.72	11.9	24.69	21.4	11.8		
Fractional % phi 2-3	PSEP Grain Size	Percent	25.4	68.4	20.7	19.1	9.84	13	22.8	22.5	43.5	48	31.42	24.13	25	28.7	14.2		
Fractional % phi 3-4	PSEP Grain Size	Percent	8.93	14.8	18.8	19.7	10.8	15.4	15.4	34.4	12	21.9	38.12	25.99	13	19.1	15.3		
Fractional % phi 4-5	PSEP Grain Size	Percent	1.41	0.98	5.18	7.65	12.5	17.1	8.67	20.1	2.91	9.58	13	14.28	5.79	8.85	15.5		
Fractional % phi 5-6	PSEP Grain Size	Percent	2.64	0.97	9.49	6.5	16.1	9.21	5.06	9.61	0.73	0	4.2	7.2	3.02	4.11	11.5		
Fractional % phi 6-7	PSEP Grain Size	Percent	1.68	0.85	7.24	6.1	12.2	6.12	3.48	2.84	0.45	1.4	1.73	3.69	2.63	3.23	7.25		
Fractional % phi 7-8	PSEP Grain Size	Percent	1.81	0.62	4.23	5.76	8.43	3.75	2.13	2.35	0.66	1.86	1.64	2.43	2.31	11.3	4.31		
Fractional % phi 8-9	PSEP Grain Size	Percent	2.18	1.02	5.7	6.46	4.92	2.54	1.78	2.04	0.34	1.48	1.33	2	2.39	0	3.67		
Fractional % phi 9-10	PSEP Grain Size	Percent	1.26	0.42	3.58	4.69	3.42	2.4	1.6	2.45	0.55	0.86	1.35	1.51	1.33	2.14	2.46		
Fractional % phi >10	PSEP Grain Size	Percent	1.87	1.35	5.1	9.38	8.52	4.93	3.05	2.83	1.37	1.91	2.33	0	2.74	3.41	5.87		
Gravel	PSEP Grain Size	Percent	0.52	0.27	4.58	1.75	1.35	3.76	1.18	0.55	0.3	0.76	0.26	4.4	3.98	1.83	1.99		

Notes:
0.14 U J = Result followed by laboratory data qualifier followed by data validator qualifier
mg/kg = milligrams per kilogram
ug/kg = micrograms per kilogram
mg/L = milligrams per liter
ug/L = micrograms per liter
ng/L = nanograms per liter

Data Validation Qualifiers
U = Result should be considered not-detected at the quantitation limit shown
J = Result is an estimated concentration
R = Rejected - Quality Control indicates the data is not usable
UJ = The compound was not detected and the sample detection limit should be considered an estimated value
N = Pesticide result is tentatively identified

Laboratory Data Qualifiers
U = result was not detected at or above the method detection limit
J (for organics) = result is an estimated concentrations that is less than the reporting limit but greater than or equal to the detection limit
B (for metals) = result is an estimated concentrations that is less than the reporting limit but greater than or equal to the detection limit
* (for metals) = duplicate analysis not within control limits. See case narrative (in laboratory report)
D (for organics) = result reported is from a dilution
P (for organics) = The GC or HPLC confirmation criteria was exceeded. The relative percent difference is greater than 40% between the two analytical results.
i (for organics) = the MRL/MDL has been elevated due to a chromatographic interference.

Table A-4. Remedial Investigation Intertidal Sediment Analytical Data

Location			IT-01	IT-02	IT-03	IT-04	IT-05	IT-06	IT-07	IT-08	IT-09	RB	
Sample ID			TT-IT-01	TT-IT-02	TT-IT-03	TT-IT-04	TT-IT-05	TT-IT-06	TT-IT-07	TT-IT-08	TT-IT-09	RB-IT-03	
Sample Date			4/20/2007	4/20/2007	4/20/2007	4/20/2007	4/20/2007	4/20/2007	4/20/2007	4/20/2007	4/20/2007	4/19/2007	
Parameter	**Method**	**Units**											**Units**
Antimony	EPA 6020	mg/Kg	25.4 J	14.9 J	15.2 J	5.1 J	126 J	112 J	62.1 J	61.5 J	70.3 J	0.03 U	µg/L
Arsenic	EPA 6020	mg/Kg	45.4	20.7	44.6	5.86	185	330	152	158	197	0.06 U	µg/L
Cadmium	EPA 6020	mg/Kg	0.132	0.145	0.183	0.089	0.422	0.646	0.398	0.456	0.48	0.007 U	µg/L
Chromium	EPA 6010B	mg/Kg	49.6 * J	39.2 * J	139 * J	40.6 * J	78.1 * J	129 * J	289 * J	253 * J	225 * J	0.22 U	µg/L
Cobalt	EPA 6020	mg/Kg	5.63	3.91	8.72	4.15	17	38.6	28.1	34	21.8	0.007 B	µg/L
Copper	EPA 6010B	mg/Kg	73.5	44.6	207	93.6	266	1060	975	1310	774	0.05 B	µg/L
Lead	EPA 6010B	mg/Kg	91.5	1420	152	164	346	399	213	251	268	0.014 B U	µg/L
Mercury	EPA 7471A	mg/Kg	0.032 *	0.046 *	0.16 * J	0.266 *	0.423 *	0.021 *	0.049 * J	0.05 *	0.022 *	0.03 U	µg/L
Molybdenum	EPA 6020	mg/Kg	4.05	1.54	7.16	2.01	15.8	23.8	15.2	13.6	14.4	0.08	µg/L
Nickel	EPA 6020	mg/Kg	37.6	13.6	51	9.37	32.9	142	101	151	111	0.21	µg/L
Selenium	EPA 6020	mg/Kg	0.2 B	0.2 B	0.3 B	0.3 B	0.4 B	0.7 B	0.4 B	0.5 B	0.5 B	0.2 U	µg/L
Silver	EPA 6020	mg/Kg	0.1	0.088	0.25 J	0.446	0.348	0.625	0.555 J	0.674	0.516	0.009 U	µg/L
Thallium	EPA 6020	mg/Kg	0.087	0.07	0.064	0.059	0.187	0.314	0.208	0.211	0.223	0.003 U	µg/L
Vanadium	EPA 6020	mg/Kg	23.1	23.7	33.2	22	41.7	65.6	47.1	68.6	43.8	0.04 U*	µg/L
Zinc	EPA 6010B	mg/Kg	272	174	645	818	1140	1360	768	894	851	1.1	µg/L
PCBs (total)	TT calculated	µg/Kg	17	77	47	28	34	4.2	17	12	14	0.001 U	µg/L
		mg/kg OC											
PCB-1016	EPA 8082	µg/Kg	2.2 U	2.3 U	2 U	2.3 U	2 U	2 U	2.2 U	2.3 U	2.3 U	0.001 U	µg/L
PCB-1221	EPA 8082	µg/Kg	2.2 U	2.3 U	2 U	2.3 U	2 U	2 U	2.2 U	2.3 U	2.3 U	0.001 U	µg/L
PCB-1232	EPA 8082	µg/Kg	2.2 U	2.3 U	2 U	2.3 U	2 U	2 U	2.2 U	2.3 U	2.3 U	0.001 U	µg/L
PCB-1242	EPA 8082	µg/Kg	2.2 U	2.3 U	2 U	2.3 U	2 U	2 U	2.2 U	2.3 U	2.3 U	0.001 U UJ	µg/L
PCB-1248	EPA 8082	µg/Kg	2.2 U	2.3 U	2 U	2.3 U	2 U	2 U	2.2 U	2.3 U	2.3 U	0.001 U UJ	µg/L
PCB-1254	EPA 8082	µg/Kg	9.4	77	27	28	19	4.2	17	12	14	0.001 U UJ	µg/L
PCB-1260	EPA 8082	µg/Kg	7.6	2.3 U	20	15 Ui	15	2.6 U	2.2 U	2.3 U	2.3 U	0.001 U UJ	µg/L
PCB-1262	EPA 8082	µg/Kg	2.2 U	2.3 U	2 U	2.3 U	2 U	2 U	2.2 U	2.3 U	2.3 U	0.001 U	µg/L
PCB-1268	EPA 8082	µg/Kg	2.2 U	2.3 U	2 U	2.3 U	2 U	2 U	2.2 U	2.3 U	2.3 U	0.001 U	µg/L
Aldrin	EPA 8081A	µg/Kg	0.19 U UJ	0.2 U UJ	0.18 U UJ	0.21 U UJ	0.18 U UJ	0.18 U UJ	0.2 U UJ	0.2 U UJ	0.2 U UJ	0.054 U UJ	µg/L
alpha-BHC	EPA 8081A	µg/Kg	0.33 U UJ	0.35 U UJ	0.3 U UJ	0.35 U UJ	0.31 U UJ	0.31 U UJ	0.34 U UJ	0.34 U UJ	0.35 U UJ	0.17 Ui UJ	µg/L
alpha-Chlordane	EPA 8081A	µg/Kg	0.29 U UJ	0.31 U UJ	0.27 U UJ	0.31 U UJ	0.27 U UJ	0.27 U UJ	0.3 U UJ	0.3 U UJ	0.31 U UJ	0.089 Ui UJ	µg/L
beta-BHC	EPA 8081A	µg/Kg	0.38 U UJ	0.4 U UJ	0.35 U UJ	0.41 U UJ	0.36 U UJ	0.36 U UJ	0.39 U UJ	0.39 U UJ	0.4 U UJ	0.46 J JN	µg/L
delta-BHC	EPA 8081A	µg/Kg	0.07 U UJ	0.073 U UJ	0.064 U UJ	0.075 U UJ	0.17 Ui UJ	0.065 U UJ	0.072 U UJ	0.072 U UJ	0.074 U UJ	0.18 U UJ	µg/L
Dieldrin	EPA 8081A	µg/Kg	0.37 U UJ	0.51 Ui UJ	0.34 U UJ	0.4 U UJ	0.64 Ui UJ	0.34 U UJ	0.38 U UJ	0.38 U UJ	0.39 U UJ	0.4 U UJ	µg/L
Endosulfan I	EPA 8081A	µg/Kg	0.22 U UJ	0.5 Ui UJ	0.2 U UJ	0.23 U UJ	0.2 U UJ	0.2 U UJ	0.86 Ui UJ	0.5 Ui UJ	0.31 Ui UJ	0.067 U UJ	µg/L
Endosulfan II	EPA 8081A	µg/Kg	0.24 U UJ	0.26 U UJ	0.22 U UJ	0.26 U UJ	0.23 U UJ	0.23 U UJ	0.25 U UJ	0.43 Ui UJ	0.44 Ui UJ	0.087 U UJ	µg/L
Endosulfan sulfate	EPA 8081A	µg/Kg	0.1 U UJ	0.11 U UJ	0.091 U UJ	0.11 U UJ	0.093 U UJ	0.093 U UJ	0.11 U UJ	0.11 U UJ	0.11 U UJ	0.062 U UJ	µg/L
Endrin	EPA 8081A	µg/Kg	0.26 U UJ	0.5 Ui UJ	0.23 U UJ	0.5 Ui UJ	0.24 U UJ	0.24 U UJ	0.42 Ui UJ	0.26 U UJ	0.29 Ui UJ	0.083 U UJ	µg/L
Endrin aldehyde	EPA 8081A	µg/Kg	0.067 U UJ	0.82 P JN	0.5 Ui UJ	0.072 U UJ	0.67 Ui UJ	0.062 U UJ	0.069 U UJ	0.2 Ui UJ	0.12 Ui UJ	0.13 U UJ	µg/L
gamma-BHC	EPA 8081A	µg/Kg	0.19 U UJ	0.2 U UJ	0.18 U UJ	0.21 U UJ	0.55 Ui UJ	0.18 U UJ	0.2 U UJ	0.2 U UJ	0.2 U UJ	0.45 JP UJ	µg/L
gamma-Chlordane	EPA 8081A	µg/Kg	0.14 JP JN	1.1 P JN	0.75 P JN	0.087 U UJ	0.39 Ui UJ	0.075 U UJ	0.67 JN	0.13 Ui UJ	0.086 U UJ	0.15 U UJ	µg/L
Heptachlor	EPA 8081A	µg/Kg	0.11 U UJ	0.11 U UJ	0.092 U UJ	0.11 U UJ	0.094 U UJ	0.094 U UJ	0.11 U UJ	0.11 U UJ	0.11 U UJ	0.49 Ui UJ	µg/L
Heptachlor epoxide	EPA 8081A	µg/Kg	0.17 U UJ	0.5 Ui UJ	0.15 U UJ	0.18 U UJ	0.16 U UJ	0.16 U UJ	0.5 P JN	0.17 U UJ	0.18 U UJ	0.25 Ui UJ	µg/L
Methoxychlor	EPA 8081A	µg/Kg	0.13 U UJ	0.14 U UJ	0.5 Ui UJ	0.14 U UJ	0.12 U UJ	0.12 U UJ	0.59 Ui UJ	0.5 Ui UJ	0.5 Ui UJ	0.29 Ui UJ	µg/L
Mirex	EPA 8081A	µg/Kg	0.13 U UJ	0.14 U UJ	0.2 J JN	0.5 Ui UJ	0.12 Ui UJ	0.12 U UJ	0.5 Ui UJ	0.13 U UJ	0.14 U UJ	0.23 U UJ	µg/L
Nonachlor (cis)	EPA 8081A	µg/Kg	0.11 U UJ	0.5 Ui UJ	0.096 U UJ	0.12 U UJ	0.5 Ui UJ	0.097 U UJ	0.11 U UJ	0.4 Ui UJ	0.3 Ui UJ	0.21 U UJ	µg/L
Nonachlor (trans)	EPA 8081A	µg/Kg	0.12 U UJ	0.92 Ui UJ	0.26 Ui UJ	0.27 Ui UJ	0.11 U UJ	0.11 U UJ	0.5 Ui UJ	0.16 Ui UJ	0.18 Ui UJ	0.11 J JN	µg/L
Oxychlordane	EPA 8081A	µg/Kg	0.47 U UJ	0.5 U UJ	0.43 U UJ	0.5 U UJ	0.44 U UJ	0.44 U UJ	0.48 U UJ	0.48 U UJ	0.5 U UJ	0.97 Ui UJ	µg/L
Toxaphene	EPA 8081A	µg/Kg	16 Ui UJ	33 Ui UJ	28 Ui UJ	25 Ui UJ	33 Ui UJ	11 U UJ	18 Ui UJ	15 Ui UJ	21 Ui UJ	8.4 Ui UJ	µg/L

Table A-4. Remedial Investigation Intertidal Sediment Analytical Data

Location			IT-01	IT-02	IT-03	IT-04	IT-05	IT-06	IT-07	IT-08	IT-09	RB	
Sample ID			TT-IT-01	TT-IT-02	TT-IT-03	TT-IT-04	TT-IT-05	TT-IT-06	TT-IT-07	TT-IT-08	TT-IT-09	RB-IT-03	
Sample Date			4/20/2007	4/20/2007	4/20/2007	4/20/2007	4/20/2007	4/20/2007	4/20/2007	4/20/2007	4/20/2007	4/19/2007	
Parameter	**Method**	**Units**											**Units**
o,p-DDD	EPA 8081A	µg/Kg	0.27 U UJ	0.9 Ui UJ	0.5 Ui UJ	2.1 Ui UJ	0.25 Ui UJ	0.48 Ui UJ	1.3 Ui UJ	1.4 P JN	1.1 JN	0.11 U UJ	µg/L
o,p-DDE	EPA 8081A	µg/Kg	0.29 U UJ	0.82 Ui UJ	0.27 U UJ	0.31 U UJ	0.27 U UJ	0.27 U UJ	1.2 Ui UJ	0.3 U UJ	0.31 U UJ	0.22 U UJ	µg/L
o,p-DDT	EPA 8081A	µg/Kg	0.67 JN	4.2 JN	1.8 P JN	1.1 JN	0.53 P JN	0.17 U UJ	0.72 JN	0.36 J JN	0.69 P JN	0.12 U UJ	µg/L
p,p-DDD	EPA 8081A	µg/Kg	0.16 U UJ	0.5 Ui UJ	0.14 U UJ	0.17 U UJ	0.44 Ui UJ	0.23 Ui UJ	0.5 Ui UJ	0.16 U UJ	0.16 U UJ	0.49 Ui UJ	µg/L
p,p-DDE	EPA 8081A	µg/Kg	0.13 U UJ	0.14 U UJ	0.12 U UJ	0.14 U UJ	0.12 U UJ	0.12 U UJ	0.13 U UJ	0.13 U UJ	0.14 U UJ	0.16 U UJ	µg/L
p,p-DDT	EPA 8081A	µg/Kg	1 JN	5.2 JN	2.3 JN	3 P JN	0.98 JN	0.28 J JN	0.9 JN	0.67 JN	0.8 JN	0.33 U UJ	µg/L
Total DDT	TT Calculated	µg/Kg	1.67 JN	9.4 JN	4.1 JN	4.1 JN	1.51 JN	0.28 JN	1.62 JN	2.43 JN	2.59 JN	0.49 U UJ	µg/L
Total chlordane	TT calculated	ug/Kg	0.14 JN	1.1 JN	0.75 JN	0.5 U UJ	0.5 U UJ	0.44 U UJ	0.67 JN	0.48 U UJ	0.5 U UJ	0.11 JN	µg/L
1,2,4-Trichlorobenzene	EPA 8270C	µg/Kg	1.9 U	2 U	1.8 U	2.1 U	1.8 U	1.8 U	2 U	2 U	2 U	0.016 U	µg/L
		mg/kg OC											
1,2-Dichlorobenzene	EPA 8270C	µg/Kg	1.7 U	1.8 U	1.5 U	1.8 U	1.6 U	1.6 U	1.7 U	1.7 U	1.8 U	0.015 U	µg/L
		mg/kg OC											
1,3-Dichlorobenzene	EPA 8270C	µg/Kg	2.1 U	2.2 U	1.9 U	2.2 U	1.9 U	1.9 U	2.1 U	2.1 U	2.2 U	0.011 U	µg/L
1,4-Dichlorobenzene	EPA 8270C	µg/Kg	2.4 U	2.6 U	2.2 U	2.6 U	2.3 U	2.3 U	2.5 U	2.5 U	2.6 U	0.014 U	µg/L
		mg/kg OC											
1-Methylnaphthalene	EPA 8270C	µg/Kg	2.8 U	3 U	2.6 U	3 U	2.6 U	40	3.3 J	4 J	3 U	0.2 U	µg/L
2,4,5-Trichlorophenol	EPA 8270C	µg/Kg	3.8 U	4 U	3.5 U	4.1 U	3.6 U	3.6 U	3.9 U	3.9 U	4 U	0.026 U	µg/L
2,4,6-Trichlorophenol	EPA 8270C	µg/Kg	2.3 U	2.4 U	2.1 U	2.5 U	2.2 U	2.2 U	2.4 U	2.4 U	2.4 U	0.037 U	µg/L
2,4-Dichlorophenol	EPA 8270C	µg/Kg	2.3 U	2.4 U	2.1 U	2.5 U	2.2 U	2.2 U	2.4 U	2.4 U	2.4 U	0.024 U	µg/L
2,4-Dimethylphenol	EPA 8270C	µg/Kg	7 U	7.3 U	6.4 U	7.5 U	6.5 U	6.5 U	7.2 U	7.2 U	7.4 U	0.32 U	µg/L
2,4-Dinitrophenol	EPA 8270C	µg/Kg	46 U	48 U	42 U	49 U	43 U	43 U	47 U	47 U	48 U	0.53 U R	µg/L
2,4-Dinitrotoluene	EPA 8270C	µg/Kg	3.6 U	3.8 U	3.3 U	3.8 U	3.3 U	3.3 U	3.7 U	3.7 U	3.8 U	0.02 U	µg/L
2,6-Dinitrotoluene	EPA 8270C	µg/Kg	3.6 U	3.8 U	3.3 U	3.8 U	3.3 U	3.3 U	3.7 U	3.7 U	3.8 U	0.0088 U	µg/L
2-Chloronaphthalene	EPA 8270C	µg/Kg	4.6 U	4.8 U	4.2 U	4.9 U	4.3 U	4.3 U	4.7 U	4.7 U	4.8 U	0.016 U	µg/L
2-Chlorophenol	EPA 8270C	µg/Kg	2.2 U	2.3 U	2 U	2.3 U	2 U	2 U	2.2 U	2.3 U	2.3 U	0.015 U	µg/L
2-Methylnaphthalene	EPA 8270C	µg/Kg	1.6 U	1.6 U	1.4 U	1.7 U	1.5 U	1.5 U	1.6 U	4.5 J	1.6 J	0.012 U	µg/L
		mg/kg OC											
2-Methylphenol	EPA 8270C	µg/Kg	4.3 U	4.6 U	4 U	4.6 U	4 U	4 U	4.4 U	4.5 U	4.6 U	0.06 U	µg/L
2-Nitroaniline	EPA 8270C	µg/Kg	3.5 U	3.6 U	3.2 U	3.7 U	3.2 U	3.2 U	3.5 U	3.5 U	3.6 U	0.015 U	µg/L
2-Nitrophenol	EPA 8270C	µg/Kg	3.3 U	3.5 U	3 U	3.5 U	3.1 U	3.1 U	3.4 U	3.4 U	3.5 U	0.014 U	µg/L
3,3-Dichlorobenzidine	EPA 8270C	µg/Kg	4.7 U	5 U	4.3 U	5 U	4.4 U	4.4 U	4.8 U	4.8 U	5 U	0.43 U R	µg/L
3-Nitroaniline	EPA 8270C	µg/Kg	3.3 U	3.5 U	3 U	3.5 U	3.1 U	3.1 U	3.4 U	3.4 U	3.5 U	0.23 U UJ	µg/L
4,6-Dinitro-o-cresol	EPA 8270C	µg/Kg	2.2 U	2.3 U	2 U	2.3 U	2 U	2 U	2.2 U	2.3 U	2.3 U	0.013 U	µg/L
4-Bromophenyl phenyl ether	EPA 8270C	µg/Kg	1.8 U	1.9 U	1.7 U	1.9 U	1.7 U	1.7 U	1.9 U	1.9 U	1.9 U	0.018 U	µg/L
4-Chloro-3-methylphenol	EPA 8270C	µg/Kg	2.7 U	2.8 U	2.5 U	2.9 U	2.5 U	2.5 U	2.8 U	2.8 U	2.8 U	0.029 U	µg/L
4-Chloroaniline	EPA 8270C	µg/Kg	2.7 U	2.8 U	2.5 U	2.9 U	2.5 U	2.5 U	2.8 U	2.8 U	2.8 U	0.018 U R	µg/L
4-Chlorophenyl phenyl ether	EPA 8270C	µg/Kg	2.6 U	2.7 U	2.3 U	2.7 U	2.4 U	2.4 U	2.6 U	2.6 U	2.7 U	0.0085 U	µg/L
4-Methylphenol	EPA 8270C	µg/Kg	3.7 U	3.9 U	3.4 U	4 U	3.4 U	3.4 U	3.8 U	3.8 U	3.9 U	0.051 U	µg/L
4-Nitroaniline	EPA 8270C	µg/Kg	4.3 U	4.6 U	4 U	4.6 U	4 U	4 U	4.4 U	4.5 U	4.6 U	0.17 U	µg/L
4-Nitrophenol	EPA 8270C	µg/Kg	38 U	40 U	35 U	41 U	36 U	36 U	39 U	39 U	40 U	0.54 U	µg/L
Acenaphthene	EPA 8270C	µg/Kg	1.3 U	1.4 U	1.2 U	2.8 J	5.1 J	280	18	22	10	0.0088 U	µg/L
		mg/kg OC											
Acenaphthylene	EPA 8270C	µg/Kg	1.8 U UJ	3.6 J J	3 J J	5.1 J J	10 J	21 J	8.2 J J	8.1 J	12	0.011 U	µg/L
		mg/kg OC											
Aniline	EPA 8270C	µg/Kg	1.9 U	2 U	1.8 U	2.1 U	1.8 U	1.8 U	2 U	2 U	2 U	0.25 U R	µg/L
Anthracene	EPA 8270C	µg/Kg	1.8 U	4.2 J	3.9 J	8.1 J	19	66	24	37	37	0.015 U	µg/L
		mg/kg OC											
Benzo(a)anthracene	EPA 8270C	µg/Kg	2.6 J	17	14	24	62	120	170	150	160	0.012 U	µg/L
		mg/kg OC											
Benzo(a)pyrene	EPA 8270C	µg/Kg	2.6 J	16	15	20	48	260	110	110	120	0.016 U	µg/L
		mg/kg OC											
Benzo(b)fluoranthene	EPA 8270C	µg/Kg	5 J	19	21	31	110	340	230	180	250	0.02 U	µg/L
Benzo(g,h,i)perylene	EPA 8270C	µg/Kg	4.3 J	11	17	15	29	110	42	53	46	0.017 U	µg/L
		mg/kg OC											

Table A-4. Remedial Investigation Intertidal Sediment Analytical Data

Location			IT-01	IT-02	IT-03	IT-04	IT-05	IT-06	IT-07	IT-08	IT-09	RB	
Sample ID			TT-IT-01	TT-IT-02	TT-IT-03	TT-IT-04	TT-IT-05	TT-IT-06	TT-IT-07	TT-IT-08	TT-IT-09	RB-IT-03	
Sample Date			4/20/2007	4/20/2007	4/20/2007	4/20/2007	4/20/2007	4/20/2007	4/20/2007	4/20/2007	4/20/2007	4/19/2007	
Parameter	**Method**	**Units**											**Units**
Benzo(k)fluoranthene	EPA 8270C	µg/Kg	3.2 U	7.3 J	7.3 J	11	33	120	68	59	80	0.02 U	µg/L
Benzofluoranthenes (total)	TT calculated	µg/Kg	5	26.3	28.3	42	143	460	298	239	330	0.02 U	µg/L
		mg/kg OC											
Benzoic acid	EPA 8270C	µg/Kg	130 U	130 U	120 U	130 U	120 U	120 U	130 U	130 U	130 U	1.8 U	µg/L
Benzyl alcohol	EPA 8270C	µg/Kg	4.7 U	5 U	4.3 U	5 U	4.4 U	4.4 U	4.8 U	4.8 U	5 U	0.98 U	µg/L
bis(2-chloroethoxy)methane	EPA 8270C	µg/Kg	1.7 U	1.8 U	1.5 U	1.8 U	1.6 U	1.6 U	1.7 U	1.7 U	1.8 U	0.012 U	µg/L
bis(2-chloroethyl)ether	EPA 8270C	µg/Kg	3.1 U	3.2 U	2.8 U	3.3 U	2.9 U	2.9 U	3.2 U	3.2 U	3.2 U	0.015 U	µg/L
bis(2-chloroisopropyl)ether	EPA 8270C	µg/Kg	1.6 U	1.6 U	1.4 U	1.7 U	1.5 U	1.5 U	1.6 U	1.6 U	1.6 U	0.017 U	µg/L
bis(2-ethylhexyl)phthalate	EPA 8270C	µg/Kg	3.3 J U	60 J	7.4 J U	3.2 J U	9.6 J U	16 J U	14 J U	670	35 J	0.27 U	µg/L
		mg/kg OC											
Butyl benzyl phthalate	EPA 8270C	µg/Kg	1.9 U	2 U	1.8 U	2.1 U	1.8 U	1.8 U	2 U	2 U	2 U	0.026 U	µg/L
		mg/kg OC											
Chrysene	EPA 8270C	µg/Kg	3.1 J	21	17	28	92	62	190	150	200	0.014 U	µg/L
		mg/kg OC											
Dibenzo(a,h)anthracene	EPA 8270C	µg/Kg	2.8 U	3 U	3.6 J	4.2 J	8.4 J	28	14	13	17	0.031 U	µg/L
		mg/kg OC											
Dibenzofuran	EPA 8270C	µg/Kg	1.7 U	1.8 U	1.5 U	2.7 J	2.2 J	67	15	15	6.2 J	0.014 U	µg/L
		mg/kg OC											
Diethylphthalate	EPA 8270C	µg/Kg	4.5 U	4.7 U	4.1 U	4.8 U	4.1 U	4.1 U	4.6 U	4.6 U	4.7 U	0.043 J	µg/L
		mg/kg OC											
Dimethyl phthalate	EPA 8270C	µg/Kg	2.3 U	2.4 U	2.1 U	2.5 U	2.2 U	2.2 U	2.4 U	2.4 U	2.4 U	0.013 U	µg/L
		mg/kg OC											
Di-n-butyl phthalate	EPA 8270C	µg/Kg	5.3 J	6.4 J	3.5 J	4.3 J	4.7 J	4.5 J	4.4 J	5.5 J	6.3 J	0.078 J U	µg/L
		mg/kg OC											
Di-n-octyl phthalate	EPA 8270C	µg/Kg	1.6 U	1.6 U	1.4 U	1.7 U	1.5 U	1.5 U	1.6 U	2600 D	1.6 U	0.032 U	µg/L
		mg/kg OC											
Fluoranthene	EPA 8270C	µg/Kg	4.5 J	30	31	80	240	350	610	460	290	0.013 U	µg/L
		mg/kg OC											
Fluorene	EPA 8270C	µg/Kg	2.2 U	2.3 U	2 U	2.8 J	4.9 J	140	21	22	16	0.012 U	µg/L
		mg/kg OC											
Hexachlorobenzene	EPA 8081A	µg/Kg	0.1 U	0.11 U	0.091 U UJ	2 B	0.093 U	0.093 U	0.2 BJ U	1.8 B U	0.11 U	0.014 U UJ	µg/L
		mg/kg OC											
Hexachlorobutadiene	EPA 8081A	µg/Kg	0.62 U	0.65 U	0.57 U	0.66 U	0.58 U	0.58 U	0.64 U	0.64 U	0.66 U	0.14 U	µg/L
		mg/kg OC											
Hexachlorocyclopentadiene	EPA 8270C	µg/Kg	19 U	20 U	18 U	21 U	18 U	18 U	20 U	20 U	20 U	0.041 U R	µg/L
Hexachloroethane	EPA 8270C	µg/Kg	2.8 U	3 U	2.6 U	3 U	2.6 U	2.6 U	2.9 U	2.9 U	3 U	0.019 U	µg/L
Indeno(1,2,3-cd)pyrene	EPA 8270C	µg/Kg	2.9 J	11	14	15	30	140	54	62	59	0.024 U	µg/L
		mg/kg OC											
Isophorone	EPA 8270C	µg/Kg	2.1 U	2.2 U	1.9 U	2.2 U	1.9 U	1.9 U	2.1 U	2.1 U	2.2 U	0.0085 U	µg/L
Naphthalene	EPA 8270C	µg/Kg	1.7 U	2 J	1.5 U	1.8 U	1.6 U	4.2 J	5.1 J	41	3.9 J	0.038 J	µg/L
		mg/kg OC											
Nitrobenzene	EPA 8270C	µg/Kg	2.6 U	2.7 U	2.3 U	2.7 U	2.4 U	2.4 U	2.6 U	2.6 U	2.7 U	0.0074 U	µg/L
N-Nitrosodimethylamine	EPA 8270C	µg/Kg	7.7 U	8.1 U	7.1 U	8.3 U	7.2 U	7.2 U	7.9 U	8 U	8.2 U	0.42 U	µg/L
N-Nitroso-di-n-propylamine	EPA 8270C	µg/Kg	4.1 U	4.3 U	3.7 U	4.4 U	3.8 U	3.8 U	4.2 U	4.2 U	4.3 U	0.033 U	µg/L
N-Nitrosodiphenylamine	EPA 8270C	µg/Kg	2.8 U	3 U	2.6 U	3 U	2.6 U	2.6 U	2.9 U	2.9 U	3 U	0.028 U	µg/L
		mg/kg OC											
Pentachlorophenol	EPA 8270C	µg/Kg	11 U	12 U	9.8 U	12 U	10 U	10 U	11 U	12 U	12 U	0.029 U	µg/L
Phenanthrene	EPA 8270C	µg/Kg	1.7 U	4.5 J	6 J	32	39	240	190	170	84	0.011 U	µg/L
		mg/kg OC											
Phenol	EPA 8270C	µg/Kg	12 J	9.7 J	2.2 U	17 J	2.3 U	2.3 U	2.5 U	2.5 U	21 J	0.055 J	µg/L
Pyrene	EPA 8270C	µg/Kg	3.8 J	34	20 J	48	140	180	520	300	190	0.015 U	µg/L
		mg/kg OC											

Table A-4. Remedial Investigation Intertidal Sediment Analytical Data

Location			IT-01	IT-02	IT-03	IT-04	IT-05	IT-06	IT-07	IT-08	IT-09	RB	
Sample ID			TT-IT-01	TT-IT-02	TT-IT-03	TT-IT-04	TT-IT-05	TT-IT-06	TT-IT-07	TT-IT-08	TT-IT-09	RB-IT-03	
Sample Date			4/20/2007	4/20/2007	4/20/2007	4/20/2007	4/20/2007	4/20/2007	4/20/2007	4/20/2007	4/20/2007	4/19/2007	
Parameter	**Method**	**Units**											**Units**
Total HPAH	TT calculated	µg/Kg	28.8	166.3	159.9	276.2	792.4	1710	2008	1537	1412	0.031 U	µg/L
		mg/kg OC											
Total LPAH	TT calculated	µg/Kg	2.2 U	14.3	12.9	50.8	78	751.2	266.3	300.1	162.9	0.038	µg/L
		mg/kg OC											
Total PAH	TT calculated	µg/Kg	28.8	180.6	172.8	327	870.4	2461.2	2274.3	1837.1	1574.9	0.038	µg/L
Butyltin	KRONE	µg/Kg	0.72 J UJ	0.96 J J	3 J	4.6 J	6 J	1.6 J	2.6 J	3.1 J	2.4 J	0.042 J	µg/L
Dibutyltin	KRONE	µg/Kg	4.7	8.1	7.6	7 J	34	9.7	15	13	16	0.029 J U	µg/L
Tetrabutyltin	KRONE	µg/Kg	0.089 U	0.093 U	0.081 U	0.095 U UJ	0.082 U	0.72 J	0.94 J	0.51 J	0.54 J	0.022 U	µg/L
Tributyltin	KRONE	µg/Kg	0.81 J	13	3.8	1 J	2.6	28	57	56	36	0.041 U	
		mg/kg OC											
Total Solids	EPA 160.3	Percent	79.4	75.5	87	74.3	85.5	85.7	77.3	77.2	75.1		mg/L
Total Organic Carbon	EPA 9060M	Percent	0.1	0.41	0.24	0.34	0.29	0.49	0.34	0.32	0.19	0.09 J	
Fractional % phi >-1	PSEP	Percent	4.72	2.32	5.69	1.98	11.5	4.68	8.56	4.86	6.02		
Fractional % phi 0-1	PSEP	Percent	4.88	4.29	14.6	11.4	19.5	14.7	15.1	10.4	20.2		
Fractional % phi 1-2	PSEP	Percent	35.8	25.9	48.8	56.5	45.1	53.6	33.5	37.4	28		
Fractional % phi 2-3	PSEP	Percent	21.5	19.7	12.3	26	8.81	10.9	23.2	40.8	17.6		
Fractional % phi 3-4	PSEP	Percent	0.4	2.09	12.6	2.07	0.17	0.01	1.98	1.15	0.72		
Fractional % phi 4-5	PSEP	Percent	0	0.98	0.06	0.19	0	0	0.02	0	0		
Fractional % phi 5-6	PSEP	Percent	0.02	0.34	0.04	0.08	0.05	0.02	0.21	0.02	0		
Fractional % phi 6-7	PSEP	Percent	0.06	0.23	0.01	0	0.03	0.02	0.25	0	0.14		
Fractional % phi 7-8	PSEP	Percent	0.02	0.22	0.05	0	0.03	0.07	0.09	0.07	0.02		
Fractional % phi 8-9	PSEP	Percent	0.09	0.16	0.01	2.18	0.05	0	0.04	0.03	0.12		
Fractional % phi 9-10	PSEP	Percent	0	0.15	0.05	0	0	0	0.06	0.05	0.09		
Fractional % phi >10	PSEP	Percent	0.41	0.58	0.47	0.94	0.54	0.41	0.8	0.82	0.85		
Gravel	PSEP	Percent	42.5	54.1	16.1	4.16	13.2	19.8	19	8.69	32.6		

Notes:

IT – Intertidal sediment sample
RB – Rinsate Blank (QA/QC sample)
0.14 U J = Result followed by laboratory data qualifier followed by data validator qualifier
mg/kg – milligrams per kilogram
µg/kg – micrograms per kilogram
mg/L – milligrams per liter
µg/L – micrograms per liter
ng/L – nanograms per liter

Data Validation Qualifiers:
U – Result should be considered not-detected at the quantitation limit shown.
J – Result is an estimated concentration.
UJ – The compound was not detected and the sample detection limit should be considered an estimated value.
R – Rejected - Quality Control indicates the data are not usable.
N - Pesticide result is tentatively identified

Laboratory Data Qualifiers:
U – result was not detected at or above the method detection limit.
J (for organics) – result is an estimated concentrations that is less than the reporting limit but greater than or equal to the detection limit.
B (for metals) – result is an estimated concentrations that is less than the reporting limit but greater than or equal to the detection limit.
* (for metals) – duplicate analysis not within control limits. See case narrative (in laboratory report).
P (for organics) – The GC or HPLC confirmation criteria was exceeded. The relative percent difference is greater than 40 percent between the two analytical results.
i (for organics) – the MRL/MDL has been elevated due to a chromatographic interference.
D (for organics) – result reported is from a dilution

Table A-5. Clam Tissue Analytical Data

Location			Intertidal			3A			4B			5A		
Matrix			Tissue			Tissue			Tissue			Tissue		
Sample ID			A1-IT			3A-C			4B-C			5A-C		
Sample Date			4/8/2008			5/14/2008			5/13/2008			5/13/2008		
Parameter	**Method**	**Units**	**Result**	**Lab Q**	**Val Q**	**Result**	**Lab Q**	**Val Q**	**Result**	**Lab Q**	**Val Q**	**Result**	**Lab Q**	**Val Q**
Lipids	NOAA LIPID	Percent	0.92			1.1			1.2			1		
Total Solids	Freeze Dry	Percent	12.4			13.9			14.1			13.3		
PCB Aroclors														
Aroclor 1016	EPA 8082	µg/kg (ww)	2.4	U		2.4	U		2.4	U		2.4	U	
Aroclor 1221	EPA 8082	µg/kg (ww)	2.6	U		2.6	U		2.6	U		2.6	U	
Aroclor 1232	EPA 8082	µg/kg (ww)	2.3	U		2.3	U		2.3	U		2.3	U	
Aroclor 1242	EPA 8082	µg/kg (ww)	2.2	U		2.2	U		2.2	U		2.2	U	
Aroclor 1248	EPA 8082	µg/kg (ww)	0.51	U		18			13			7.5	J	
Aroclor 1254	EPA 8082	µg/kg (ww)	17			48			42			21		
Aroclor 1260	EPA 8082	µg/kg (ww)	1.9	U		1.9	U		1.9	U		1.9	U	
Total PCBs	TtEC Calculated	µg/kg (ww)	17			66			55			28.5		
PAHs														
Acenaphthene	EPA 8270C	µg/kg (ww)	0.91			n/a			13			7.5		
Anthracene	EPA 8270C	µg/kg (ww)	4			n/a			35			40		
Acenaphthylene	EPA 8270C	µg/kg (ww)	0.96			n/a			2.5			3.1		
Fluorene	EPA 8270C	µg/kg (ww)	1.6			n/a			23			11		
Naphthalene	EPA 8270C	µg/kg (ww)	0.74	J		n/a			1.6			6.2		
Phenanthrene	EPA 8270C	µg/kg (ww)	17			n/a			180			88		
Total LPAH	TtEC Calculated	µg/kg (ww)	25.21			n/a			255.1			155.8		
Benzo(a)anthracene	EPA 8270C	µg/kg (ww)	17			n/a			170			120		
Benzo(a)pyrene	EPA 8270C	µg/kg (ww)	12			n/a			99			140		
Benzo(b)fluoranthene	EPA 8270C	µg/kg (ww)	20			n/a			170			210		
Benzo(k)fluoranthene	EPA 8270C	µg/kg (ww)	7			n/a			54			65		
Total Benzofluoranthenes	TtEC Calculated	µg/kg (ww)	27			n/a			224			275		
Benzo(g,h,i)perylene	EPA 8270C	µg/kg (ww)	7.1			n/a			24			29		
Chrysene	EPA 8270C	µg/kg (ww)	30			n/a			190			170		
Dibenzo(a,h)anthracene	EPA 8270C	µg/kg (ww)	1.5			n/a			8.7			11		
Fluoranthene	EPA 8270C	µg/kg (ww)	78			n/a			590	D		300		
Indeno(1,2,3-cd)pyrene	EPA 8270C	µg/kg (ww)	7.7			n/a			32			36		
Pyrene	EPA 8270C	µg/kg (ww)	58			n/a			440			230		
2-Methylnaphthalene	EPA 8270C	µg/kg (ww)	0.61	J		n/a			2.4			2.7		
Dibenzofuran	EPA 8270C	µg/kg (ww)	0.7			n/a			11	D		5.8		
Total HPAH	TtEC Calculated	µg/kg (ww)	238.3			n/a			1777.7			1311		
Total PAH	TtEC Calculated	µg/kg (ww)	263.51			n/a			2032.8			1466.8		
Dioxin/Furans														
2,3,7,8-TCDD	EPA 8290	ng/kg (ww)	0.0343	U		n/a			0.025	U		0.0275	U	
1,2,3,7,8-PeCDD[1/]	EPA 8290	ng/kg (ww)	0.0624	U		n/a			0.051	U		0.0607	U	
1,2,3,4,7,8-HxCDD[1/]	EPA 8290	ng/kg (ww)	0.253	U		n/a			0.076	U		0.12	U	
1,2,3,6,7,8-HxCDD[1/]	EPA 8290	ng/kg (ww)	0.252	U		n/a			0.335	J		0.24	J	
1,2,3,7,8,9-HxCDD[1/]	EPA 8290	ng/kg (ww)	0.254	U		n/a			0.143	JK		0.121	U	
1,2,3,4,6,7,8-HpCDD[1/]	EPA 8290	ng/kg (ww)	4.67	BJ	U	n/a			7.83	B	U	8.26	B	U
OCDD[1/]	EPA 8290	ng/kg (ww)	38.4	UJ		n/a			58.2	B	UJ	68.4	B	UJ
2,3,7,8-TCDF[1/]	EPA 8290	ng/kg (ww)	0.0225	U		n/a			0.0363	U		0.0315	U	
1,2,3,7,8-PeCDF[1/]	EPA 8290	ng/kg (ww)	0.0372	U		n/a			0.0383	U		0.0326	U	
2,3,4,7,8-PeCDF[1/]	EPA 8290	ng/kg (ww)	0.0359	U		n/a			0.037	U		0.0316	U	
1,2,3,4,7,8-HxCDF[1/]	EPA 8290	ng/kg (ww)	0.136	U		n/a			0.0454	U		0.11	U	
1,2,3,6,7,8-HxCDF[1/]	EPA 8290	ng/kg (ww)	0.138	U		n/a			0.0465	U		0.112	U	
1,2,3,7,8,9-HxCDF[1/]	EPA 8290	ng/kg (ww)	0.162	U		n/a			0.0544	U		0.131	U	

Table A-5. Clam Tissue Analytical Data

Location			Intertidal			3A			4B			5A		
Matrix			Tissue			Tissue			Tissue			Tissue		
Sample ID			A1-IT			3A-C			4B-C			5A-C		
Sample Date			4/8/2008			5/14/2008			5/13/2008			5/13/2008		
Parameter	**Method**	**Units**	**Result**	**Lab Q**	**Val Q**	**Result**	**Lab Q**	**Val Q**	**Result**	**Lab Q**	**Val Q**	**Result**	**Lab Q**	**Val Q**
2,3,4,6,7,8-HxCDF[1/]	EPA 8290	ng/kg (ww)	0.146	U		n/a			0.0492	U		0.119	U	
1,2,3,4,6,7,8-HpCDF[1/]	EPA 8290	ng/kg (ww)	3.13	BJ	U	n/a			4.47	BJ	U	2.79	BJ	U
1,2,3,4,7,8,9-HpCDF[1/]	EPA 8290	ng/kg (ww)	0.169	U		n/a			0.125	U		0.201	U	
OCDF[1/]	EPA 8290	ng/kg (ww)	6.26	BJ	UJ	n/a			8.94	BJ	UJ	0.209	U	UJ
Total Hepta-Dioxins	EPA 8291	ng/kg (ww)	12.1		U	n/a			34.6		U	36.3		U
Total Hepta-Furans	EPA 8292	ng/kg (ww)	3.73		U	n/a			4.47	J	U	4.4		U
Total Hexa-Dioxins	EPA 8293	ng/kg (ww)	0.64	J		n/a			3.22	J		2.52	J	
Total Hexa-Furans	EPA 8294	ng/kg (ww)	1.34	J		n/a			1.72	J		2.23	J	
Total Penta-Dioxins	EPA 8295	ng/kg (ww)	0.0624	U		n/a			0.051	U		0.0607	U	
Total Penta-Furans	EPA 8296	ng/kg (ww)	3.13	J	U	n/a			4.47	J	U	2.79	J	U
Total Tetra-Dioxins	EPA 8297	ng/kg (ww)	0.0343	U		n/a			0.025	U		0.0275	U	
Total Tetra-Furans	EPA 8298	ng/kg (ww)	0.0225	U		n/a			0.0363	U		0.0315	U	
TBT														
Di-n-butyltin	GC-FPD	µg/kg (ww)	9.9			n/a			20			15		
n-Butyltin	GC-FPD	µg/kg (ww)	1.8			n/a			4.6			3.4		
Tri-n-butyltin	GC-FPD	µg/kg (ww)	71			n/a			72			49		
Tetrabutyltin	GC-FPD	µg/kg (ww)	0.44	U		n/a			0.47	U		0.47	U	
Metals														
Antimony	EPA 6020	mg/kg (dw)	0.771	N	J	0.433	N	J	0.33	N	J	0.423	N	J
Arsenic	EPA 6020	mg/kg (dw)	17			21			18.2			22.7		
Cadmium	EPA 6020	mg/kg (dw)	0.37			1.2			0.25			0.17		
Chromium	EPA 6010B	mg/kg (dw)	7.71			4.32			4.79			6.72		
Cobalt	EPA 6020	mg/kg (dw)	1.93			2.18			2.11			2.34		
Copper	EPA 6010B	mg/kg (dw)	252			264			171			122		
Lead	EPA 6020	mg/kg (dw)	27			15.8			13.5			17.2		
Molybdenum	EPA 6020	mg/kg (dw)	2.53			5.92			2.56			3.77		
Nickel	EPA 6020	mg/kg (dw)	6			3.52			6.14			8.66		
Selenium	EPA 7742	mg/kg (dw)	3.35			3.4			3.47			4.2		
Silver	EPA 6020	mg/kg (dw)	0.946	N	J	1.3	N	J	1.1	N	J	0.518	N	J
Thallium	EPA 6020	mg/kg (dw)	0.027			0.081			0.016	B		0.07		
Vanadium	EPA 6010B	mg/kg (dw)	7.4			5.11			5.39			6.9		
Zinc	EPA 6010B	mg/kg (dw)	324			423			419			198		
Mercury	EPA 7471A	mg/kg (dw)	0.076	N	J	0.027	BN	J	0.116	N	J	0.151	N	J
Pesticides														
4,4'-DDD	EPA 8081A	µg/kg (ww)	0.13	JP	J	n/a			0.36	Ui		0.5	JP	J
4,4'-DDE	EPA 8081A	µg/kg (ww)	0.24	Ui		n/a			0.69	J		0.4	JP	J
4,4'-DDT	EPA 8081A	µg/kg (ww)	1.5	Ui		n/a			3	Ui		2	Ui	
2,4'-DDD	EPA 8081A	µg/kg (ww)	0.97	Ui		n/a			1.7	Ui		1.2	Ui	
2,4'-DDE	EPA 8081A	µg/kg (ww)	0.21	U		n/a			1	Ui		0.21	U	
2,4'-DDT	EPA 8081A	µg/kg (ww)	0.97	Ui		n/a			1.7	Ui		1	Ui	
Total DDT	TtEC Calculated	µg/kg (ww)	0.13	JN		n/a			0.69	JN		0.9	JN	
Aldrin	EPA 8081A	µg/kg (ww)	0.51	Ui		n/a			0.23	U		0.23	U	
alpha-BHC	EPA 8081A	µg/kg (ww)	0.27	U		n/a			0.27	U		0.27	U	
beta-BHC	EPA 8081A	µg/kg (ww)	1.7	Ui		n/a			1.2	Ui		0.98	Ui	
delta-BHC	EPA 8081A	µg/kg (ww)	0.16	U		n/a			0.16	U		1	Ui	
alpha-Chlordane	EPA 8081A	µg/kg (ww)	0.15	U		n/a			1	Ui		0.22	Ui	
gamma-Chlordane	EPA 8081A	µg/kg (ww)	0.75	Ui		n/a			2.1	P	J	1.4	P	J
Total Chlordane[2/]	TtEC Calculated	µg/kg (ww)	0.97	U		n/a			2.1			1.4	U	

Table A-5. Clam Tissue Analytical Data

Location			Intertidal			3A			4B			5A		
Matrix			Tissue			Tissue			Tissue			Tissue		
Sample ID			A1-IT			3A-C			4B-C			5A-C		
Sample Date			4/8/2008			5/14/2008			5/13/2008			5/13/2008		
Parameter	**Method**	**Units**	**Result**	**Lab Q**	**Val Q**	**Result**	**Lab Q**	**Val Q**	**Result**	**Lab Q**	**Val Q**	**Result**	**Lab Q**	**Val Q**
Dieldrin	EPA 8081A	µg/kg (ww)	0.97	Ui		n/a			1	Ui		1	Ui	
Endosulfan I	EPA 8081A	µg/kg (ww)	0.12	U		n/a			0.27	Ui		0.17	Ui	
Endosulfan II	EPA 8081A	µg/kg (ww)	0.22	U		n/a			1	Ui		0.22	U	
Endosulfan Sulfate	EPA 8081A	µg/kg (ww)	0.97	Ui	UJ	n/a			0.13	U	UJ	1	Ui	UJ
Endrin	EPA 8081A	µg/kg (ww)	0.22	U		n/a			0.22	U		0.22	U	
Endrin aldehyde	EPA 8081A	µg/kg (ww)	0.25	U		n/a			0.25	U		0.25	U	
gamma-BHC (Lindane)	EPA 8081A	µg/kg (ww)	0.55	J		n/a			0.24	U		0.24	U	
Heptachlor	EPA 8081A	µg/kg (ww)	0.66	U		n/a			1	Ui		0.73	Ui	
Heptachlor epoxide	EPA 8081A	µg/kg (ww)	0.78	J		n/a			0.86	Ui		0.88	J	
Hexachlorobenzene	EPA 8081A	µg/kg (ww)	0.97	Ui		n/a			0.31	U		0.31	U	
Hexachlorobutadiene	EPA 8081A	µg/kg (ww)	0.84	Ui		n/a			2.2	Ui		0.91	Ui	
Oxy-chlordane	EPA 8081A	µg/kg (ww)	0.19	U		n/a			0.19	U		0.19	U	
Nonachlor (trans)	EPA 8081A	µg/kg (ww)	0.14	U		n/a			0.27	Ui		0.21	Ui	
Nonachlor (cis)	EPA 8081A	µg/kg (ww)	0.97	Ui	UJ	n/a			1	Ui	UJ	1.1	Ui	UJ
Methoxychlor	EPA 8081A	µg/kg (ww)	1	U		n/a			3.3	Ui		1	U	
Mirex	EPA 8081A	µg/kg (ww)	0.4	U	UJ	n/a			0.4	U	UJ	0.4	U	UJ
Toxaphene	EPA 8081A	µg/kg (ww)	21	U		n/a			50	Ui		25	Ui	

Footnotes:

1/ Dioxin-like PCB and dioxin/furan congeners will be evaluated as toxic equivalents (TEQs) in the risk assessments, rather than as individual congeners. However, because TEQs are calculated, rather than measured by the laboratory, RBCs for individual congeners are presented to facilitate comparison with RLs for those congeners. In reality, risks will be assessed based on sums of these congeners (normalized per their realtive toxicity to TCDD), and thus comparison to RLs on a congener-specific basis is somewhat uncertain.

2/ Total Chlordane calculated by TtEC. Total chlordane is the sum of oxychlordane, alpha- and gamma-chlordane, and cis- and trans-nonachlor. RL and MDL are the highest RL and MDL for the chlordane-related compounds. Lab reports as individual analytes.

Notes:
IT - Intertidal tissue sample
mg/kg= milligrams per kilogram
µg/kg= micrograms per kilogram
ww= wet weight
dw= dry weight
n/a= not available

Laboratory Qualifiers (Lab Q):
For Metals:
N- The Matrix Spike sample recovery is not within control limits. See case narative.
For Organics:
B - The analyte was found in the associated method blank at a level that is significant relative to the sample result.
D - Result reported from a dilution.
J - Result is an estimated concentration that is less than the MRL but greater than or equal to the MDL.
N - The result is presumptive. The analyte was tentatively identified, but a confirmation analysis was not performed.
P - The GC or HPLC confirmation criteria was exceeded. The relative percent difference is greater than 40% between the two analytical results.
U - Result was not detected at or above the MRL/MDL.
i - The MRL/MDL has been elevated due to a chromatographic interference.
For Dioxins/Furans:
B- Indicates the associated analyte is found in the method blank, as well as in the sample.
J- Indicated an estimated value that is less than the MRL but greater than or equal to the EDL.
K- Indicates an estimated maximum possible concentration for the associated compounds.
U- Indicates the compound was analyzed and not detected.

Data Validation Qualifiers (Val Q):
U - Result should be considered not detected at the quntitation limit shown.
J - Result is an estimated concentration.
UJ - The compound was not detected and the sample detection limit should be considered an estimated value.

Table A-6. Clam Tissue Co-Located Sediment Analytical Data

Location			Intertidal			3A			3A (Duplicate)			4B			5A			Rinse Blank			
Matrix			Sediment			Sediment			Sediment			Sediment			Sediment			Water			
Sample ID			A1-IT			3A-S			3D-S			4B-S			5A-S			RB-S			
Sample Date			4/8/2008			5/14/2008			5/14/2008			5/13/2008			5/13/2008			5/14/2008			
Parameter	**Method**	**Units**	**Result**	**Lab Q**	**Val Q**	**Result**	**Lab Q**	**Val Q**	**Result**	**Lab Q**	**Val Q**	**Result**	**Lab Q**	**Val Q**	**Result**	**Lab Q**	**Val Q**	**Result**	**Unit**	**Lab Q**	**Val Q**
PCB Aroclors																					
Aroclor 1016	EPA 8082	µg/kg (dw)	1.7	U		1.7	U		1.7	U		1.7	U		1.7	U		0.0064	ug/L	Ui	
Aroclor 1221	EPA 8082	µg/kg (dw)	1.7	U		1.7	U		1.7	U		1.7	U		1.7	U		0.001	ug/L	U	
Aroclor 1232	EPA 8082	µg/kg (dw)	1.7	U		1.7	U		1.7	U		1.7	U		1.7	U		0.012	ug/L	Ui	
Aroclor 1242	EPA 8082	µg/kg (dw)	1.7	U		1.7	U		1.7	U		1.7	U		1.7	U		0.0078	ug/L	Ui	UJ
Aroclor 1248	EPA 8082	µg/kg (dw)	1.7	U		130			140			58			60			0.0076	ug/L	Ui	UJ
Aroclor 1254	EPA 8082	µg/kg (dw)	17			360			330			130			97			0.001	ug/L	U	UJ
Aroclor 1260	EPA 8082	µg/kg (dw)	13			120			110			77			69			0.001	ug/L	U	UJ
Total PCBs	TtEC Calculated	µg/kg (dw)	30			610			580			265			226			0.012	ug/L	U	
PAHs																					
Acenaphthylene	EPA 8270C	µg/kg (dw)	1.7	J		100	D		110	D		160	D		83	D		0.02	ug/L	U	
Acenaphthene	EPA 8270C	µg/kg (dw)	1.6	J		140	D		160	D		53	D		81	D		0.034	ug/L	U	
Anthracene	EPA 8270C	µg/kg (dw)	5.2			320	D		380	D		410	D		280	D		0.031	ug/L	U	
Fluorene	EPA 8270C	µg/kg (dw)	2.1	J		160	D		170	D		88	D		120	D		0.035	ug/L	U	
Naphthalene	EPA 8270C	µg/kg (dw)	4.9			55	D		57	D		21	JD		96	D		0.029	ug/L	U	
Phenanthrene	EPA 8270C	µg/kg (dw)	17			1200	D		1200	D		620	D		540	D		0.029	ug/L	U	
Total LPAH	TtEC Calculated	µg/kg (dw)	32.5			1975			2077			1352			1200			0.035	ug/L	U	
Benzo(a)anthracene	EPA 8270C	µg/kg (dw)	21			930	D		970	D		1700	D		540	D		0.024	ug/L	U	
Benzo(a)pyrene	EPA 8270C	µg/kg (dw)	24			1200	D		1200	D		1100	D		680	D		0.04	ug/L	U	
Benzo(b)fluoranthene	EPA 8270C	µg/kg (dw)	38			1700	D		1700	D		2300	D		1100	D		0.022	ug/L	U	
Benzo(k)fluoranthene	EPA 8270C	µg/kg (dw)	12			610	D		560	D		750	D		390	D		0.031	ug/L	U	
Total Benzofluoranthenes	TtEC Calculated	µg/kg (dw)	50			2310			2260			3050			1490			0.031	ug/L	U	
Benzo(g,h,i)perylene	EPA 8270C	µg/kg (dw)	18			660	D		680	D		450	D		340	D		0.025	ug/L	U	
Chrysene	EPA 8270C	µg/kg (dw)	21			1500	D		1500	D		2600	D		1000	D		0.036	ug/L	U	
Dibenzo(a,h)anthracene	EPA 8270C	µg/kg (dw)	4.2	J		190	D		200	D		150	D		110	D		0.022	ug/L	U	
Fluoranthene	EPA 8270C	µg/kg (dw)	49			2000	D		2000	D		12000	D		920	D		0.026	ug/L	U	
Indeno(1,2,3-cd)pyrene	EPA 8270C	µg/kg (dw)	17			760	D		780	D		580	D		400	D		0.027	ug/L	U	
Pyrene	EPA 8270C	µg/kg (dw)	79			2100	D		2000	D		6800	D		970	D		0.025	ug/L	U	
2-Methylnaphthalene	EPA 8270C	µg/kg (dw)	1.8	J		34	JD		37	JD		14	JD		35	JD		0.034	ug/L	U	
Dibenzofuran	EPA 8270C	µg/kg (dw)	1.7	J		76	D		79	D		36	JD		68	D		0.024	ug/L	U	
Total HPAH	TtEC Calculated	µg/kg (dw)	283.2			11650			11590			28430			6450			0.04	ug/L	U	
Total PAH	TtEC Calculated	µg/kg (dw)	315.7			13625			13667			29782			7650			0.04	ug/L	U	
Dioxin/Furans																					
2,3,7,8-TCDD	EPA 8290	ng/kg (dw)	0.053	U		0.0742	JK		0.15	JK		0.264	J		0.0572	J		0.65	pg/L	U	
1,2,3,7,8-PeCDD[1/]	EPA 8290	ng/kg (dw)	0.1	J		0.297	J		0.692	J		0.86	J		0.169	J		0.534	pg/L	U	
1,2,3,4,7,8-HxCDD[1/]	EPA 8290	ng/kg (dw)	0.134	J		0.416	J		1.2	J		1.85			0.192	J		0.231	pg/L	U	
1,2,3,6,7,8-HxCDD[1/]	EPA 8290	ng/kg (dw)	0.583	J		4.29	B	J	12.5	B	J	14.9	B	J	2.58	B	J	0.257	pg/L	U	
1,2,3,7,8,9-HxCDD[1/]	EPA 8290	ng/kg (dw)	0.495	J		1.19	J		3.36			3.96			1.37			0.23	pg/L	U	
1,2,3,4,6,7,8-HpCDD[1/]	EPA 8290	ng/kg (dw)	18.4	B		231	B		655	BE	J	698	BE	J	106	B		0.617	pg/L	U	
OCDD[1/]	EPA 8290	ng/kg (dw)	192	B		1960	BE	J	6300	BE	J	4840	BE	J	872	BE	J	104	pg/L	BJ	U
2,3,7,8-TCDF[1/]	EPA 8290	ng/kg (dw)	0.176	U		0.184	U		0.645	K		1.3			0.177	U		0.754	pg/L	U	
1,2,3,7,8-PeCDF[1/]	EPA 8290	ng/kg (dw)	0.163	J		0.225	J		0.683	J		1.19	J		0.236	J		0.361	pg/L	U	
2,3,4,7,8-PeCDF[1/]	EPA 8290	ng/kg (dw)	0.229	J		1.54	BJ	U	0.968	BJ		1.68	B		1.13	BJ	U	0.343	pg/L	U	
1,2,3,4,7,8-HxCDF[1/]	EPA 8290	ng/kg (dw)	0.576	J		1.54	BJ	U	3.41	B		4.9	B		1.13	BJ	U	0.294	pg/L	U	
1,2,3,6,7,8-HxCDF[1/]	EPA 8290	ng/kg (dw)	0.256	J		0.371	JK		1.1	J		1.74			0.392	J		0.318	pg/L	U	
1,2,3,7,8,9-HxCDF[1/]	EPA 8290	ng/kg (dw)	0.085	U		0.107	U		0.223	U		0.178	J		0.141	U		0.31	pg/L	U	
2,3,4,6,7,8-HxCDF[1/]	EPA 8290	ng/kg (dw)	0.223	J		0.0916	U		0.891	J		1.48			0.628	J		0.313	pg/L	U	
1,2,3,4,6,7,8-HpCDF[1/]	EPA 8290	ng/kg (dw)	3.71			20	B	J	55.9	B	J	59.7	B	J	12.7	B	J	0.446	pg/L	U	
1,2,3,4,7,8,9-HpCDF[1/]	EPA 8290	ng/kg (dw)	0.34	J		1.84			6.04			5.09			0.83	J		0.599	pg/L	U	
OCDF[1/]	EPA 8290	ng/kg (dw)	15.6			94.1	B		337	B		186	B		35.8	B		0.886	pg/L	U	
Total Hepta-Dioxins	EPA 8291	ng/kg (dw)	44.5			697			1810			3430			453			0.617	pg/L	U	
Total Hepta-Furans	EPA 8292	ng/kg (dw)	13.6			103			293			267			51.8			0.446	pg/L	U	
Total Hexa-Dioxins	EPA 8293	ng/kg (dw)	4.35			50.8			138			237			37.8			0.231	pg/L	U	
Total Hexa-Furans	EPA 8294	ng/kg (dw)	6.38			22.9			69.2			101			22.4			0.294	pg/L	U	

Table A-6. Clam Tissue Co-Located Sediment Analytical Data

Location			Intertidal			3A			3A (Duplicate)			4B			5A			Rinse Blank			
Matrix			Sediment			Sediment			Sediment			Sediment			Sediment			Water			
Sample ID			A1-IT			3A-S			3D-S			4B-S			5A-S			RB-S			
Sample Date			4/8/2008			5/14/2008			5/14/2008			5/13/2008			5/13/2008			5/14/2008			
Parameter	**Method**	**Units**	**Result**	**Lab Q**	**Val Q**	**Result**	**Lab Q**	**Val Q**	**Result**	**Lab Q**	**Val Q**	**Result**	**Lab Q**	**Val Q**	**Result**	**Lab Q**	**Val Q**	**Result**	**Unit**	**Lab Q**	**Val Q**
Total Penta-Dioxins	EPA 8295	ng/kg (dw)	0.158	J		1.8			8.66			13			1.17		U	0.534	pg/L	U	
Total Penta-Furans	EPA 8296	ng/kg (dw)	1.85	J		4.65			15.1			26.4			4.85			0.343	pg/L	U	
Total Tetra-Dioxins	EPA 8297	ng/kg (dw)	0.0526	U		0.821			2.12			4.78			1.53			0.65	pg/L	U	
Total Tetra-Furans	EPA 8298	ng/kg (dw)	2			3.55			10.2			17.6			1.71			0.754	pg/L	U	
TBT																					
Di-n-butyltin	Krone	μg/kg (dw)	3.4			630	D		600	D		91			88			0.0081	ug/L	U	
n-Butyltin	Krone	μg/kg (dw)	0.36	J		110		J	140		J	22		J	36		J	0.029	ug/L	U	UJ
Tri-n-butyltin	Krone	μg/kg (dw)	15			1800	D		2000	D		180			170			0.012	ug/L	U	
Tetrabutyltin	Krone	μg/kg (dw)	0.089	U		23			29			3.3	P	J	3.6			0.038	ug/L	U	
Metals																					
Antimony	EPA 6020	mg/kg (dw)	7.77			5.35	*	J	6.14	*	J	14.2	*	J	12.2	*	J	0.02	ug/L	U	
Arsenic	EPA 6020	mg/kg (dw)	7.92			30.6			29.5			31.6			44.3			0.07	ug/L	U	
Cadmium	EPA 6020	mg/kg (dw)	0.222			0.526			0.519			0.528			0.647			0.012	ug/L	B	U
Chromium	EPA 6010B	mg/kg (dw)	23.8			63			55.8			93			67			0.11	ug/L	B	U
Cobalt	EPA 6020	mg/kg (dw)	3.46			9.28		J	8.59		J	9.33		J	7.38		J	0.004	ug/L	U	
Copper	EPA 6010B	mg/kg (dw)	28.3	N	J	252			278			299			174			0.02	ug/L	B	
Lead	EPA 6020	mg/kg (dw)	48.6	*	J	133	*	J	115	*	J	135	*	J	121	*	J	0.01	ug/L	B	U
Molybdenum	EPA 6020	mg/kg (dw)	2.11			3.77			3.67			3.75			5.28			0.02	ug/L	U	
Nickel	EPA 6020	mg/kg (dw)	11.3			20.1	*	J	19	*	J	29.9	*	J	18.7	*	J	0.07	ug/L	U	
Selenium	EPA 7742	mg/kg (dw)	0.3	B		1	B		1.1	B		0.9	U		0.9	U		0.2	ug/L	U	
Silver	EPA 6020	mg/kg (dw)	0.072			0.397			0.38			0.502			0.3			0.003	ug/L	U	
Thallium	EPA 6020	mg/kg (dw)	0.041			0.159			0.151			0.144			0.267			0.003	ug/L	U	
Vanadium	EPA 6010B	mg/kg (dw)	24.5			65			64			57			56			0.06	ug/L	B	
Zinc	EPA 6010B	mg/kg (dw)	115	*	J	259			258			290			238			0.59	ug/L		U
Mercury	EPA 7471A	mg/kg (dw)	0.117			0.873			0.688			0.224			0.249			0.05	ug/L	U	
Pesticides																					
4,4'-DDD	EPA 8081A	μg/kg (dw)	0.12	U		3.4			4.2			1.4			1.5	Ui		0.21	ng/L	U	UJ
4,4'-DDE	EPA 8081A	μg/kg (dw)	0.1	U		1	Ui		1	Ui		0.95	Ui		0.51	JP	J	0.19	ng/L	U	UJ
4,4'-DDT	EPA 8081A	μg/kg (dw)	1.8	Ui		27	Ui		24			9.1			5.5			0.17	ng/L	U	
2,4'-DDD	EPA 8081A	μg/kg (dw)	0.94	Ui		7.5	Ui		6.2	Ui		2.1	Ui		2.6	Ui		0.068	ng/L	U	
2,4'-DDE	EPA 8081A	μg/kg (dw)	0.23	U		4.6	Ui		1	Ui		1.7	Ui		1	Ui		0.12	ng/L	U	UJ
2,4'-DDT	EPA 8081A	μg/kg (dw)	1.3			19			19			6.1	Ui		4.5			0.13	ng/L	U	
Total DDT	TtEC Calculated	μg/kg (dw)	1.3	JN		22.4	JN		47.2	JN		10.5	JN		10.51	JN		0.21	ng/L	U	UJ
Aldrin	EPA 8081A	μg/kg (dw)	0.15	U		0.15	U		0.15	U		1	Ui		0.15	U		0.11	ng/L	U	UJ
alpha-BHC	EPA 8081A	μg/kg (dw)	0.26	U		0.26	U		0.26	U		1	Ui		0.26	U		0.21	ng/L	U	
beta-BHC	EPA 8081A	μg/kg (dw)	0.3	U		1.9	Ui		1.4	Ui		1	Ui		1	Ui		0.41	ng/L	U	
delta-BHC	EPA 8081A	μg/kg (dw)	0.38	Ui		1.8	Ui		1.8	P	J	1.2	Ui		1.8	Ui		0.14	ng/L	U	
alpha-Chlordane	EPA 8081A	μg/kg (dw)	0.23	U		0.48	J		0.68	J		0.23	U		0.32	JP	J	0.27	ng/L	U	
gamma-Chlordane	EPA 8081A	μg/kg (dw)	0.064	U		11	P	J	11	Ui		3.9	Ui		2.7	Ui		0.31	ng/L	U	
Total chlordane[2/]	TtEC Calculated	μg/kg (dw)	0.79	U		11.48			0.68			3.9	U		0.32			0.31	ng/L	U	
Dieldrin	EPA 8081A	μg/kg (dw)	0.29	U		16	Ui		0.29	U		6.3	Ui		4	Ui		0.37	ng/L	U	
Endosulfan I	EPA 8081A	μg/kg (dw)	0.2	Ui		1.2	Ui		1.2	Ui		0.17	U		0.17	U		0.25	ng/L	U	
Endosulfan II	EPA 8081A	μg/kg (dw)	0.19	U		1	Ui		1	Ui		1	Ui		1	Ui		0.35	ng/L	U	
Endosulfan Sulfate	EPA 8081A	μg/kg (dw)	0.079	U		1	Ui		1	Ui		0.079	U		1	Ui		0.28	ng/L	U	
Endrin	EPA 8081A	μg/kg (dw)	0.2	U		1			1	P	J	0.39	JP	J	0.2	U		0.49	ng/L	U	
Endrin aldehyde	EPA 8081A	μg/kg (dw)	0.063	Ui		1.4	Ui		1.3	Ui		1	Ui		1	Ui	UJ	0.21	ng/L	U	
gamma-BHC (Lindane)	EPA 8081A	μg/kg (dw)	0.15	U		3.1	Ui		4.5	Ui		0.15	U		4.4	Ui		1.2	ng/L		
Heptachlor	EPA 8081A	μg/kg (dw)	0.08	U		0.08	U		0.22	Ui		0.08	U		0.85	Ui	UJ	0.18	ng/L	U	
Heptachlor epoxide	EPA 8081A	μg/kg (dw)	0.76	Ui		1.9	Ui		2	Ui		1	Ui		1.2	Ui		0.21	ng/L	U	
Hexachlorobenzene	EPA 8081A	μg/kg (dw)	0.64	J		1	Ui		0.079	U		1	Ui		0.14	Ui		0.27	ng/L	Ui	
Hexachlorobutadiene	EPA 8081A	μg/kg (dw)	2.8			1.5	Ui		2	Ui		0.94	Ui		0.55	Ui		0.095	ng/L	U	
Oxy-chlordane	EPA 8081A	μg/kg (dw)	0.058	U		1	Ui		1	Ui		1.5	Ui		3.5	Ui		0.069	ng/L	U	
Nonachlor (trans)	EPA 8081A	μg/kg (dw)	0.22	Ui		1	Ui		1.2	Ui		0.066	U		0.066	U		0.11	ng/L	U	
Nonachlor (cis)	EPA 8081A	μg/kg (dw)	0.79	Ui		2.8	Ui		2.4	Ui		1.3	Ui		1.3	Ui		0.14	ng/L	Ui	

Table A-6. Clam Tissue Co-Located Sediment Analytical Data

Location			Intertidal			3A			3A (Duplicate)			4B			5A			Rinse Blank			
Matrix			Sediment			Sediment			Sediment			Sediment			Sediment			Water			
Sample ID			A1-IT			3A-S			3D-S			4B-S			5A-S			RB-S			
Sample Date			4/8/2008			5/14/2008			5/14/2008			5/13/2008			5/13/2008			5/14/2008			
Parameter	**Method**	**Units**	**Result**	**Lab Q**	**Val Q**	**Result**	**Lab Q**	**Val Q**	**Result**	**Lab Q**	**Val Q**	**Result**	**Lab Q**	**Val Q**	**Result**	**Lab Q**	**Val Q**	**Result**	**Unit**	**Lab Q**	**Val Q**
Methoxychlor	EPA 8081A	µg/kg (dw)	0.46	Ui		1.4	Ui		1.6	Ui		0.74	Ui		0.93	Ui	UJ	0.28	ng/L	Ui	
Mirex	EPA 8081A	µg/kg (dw)	0.063	U		0.063	U		1	Ui		0.063	U		0.063	U		0.19	ng/L	U	
Toxaphene	EPA 8081A	µg/kg (dw)	18	Ui	UJ	110	Ui		430	Ui		66	Ui		76	Ui		9	ng/L	U	UJ
Total Solids	EPA 160.3	Percent (dw)	75.8			51.9			52			64.8			64.7			n/a			
Total Organic Carbon	EPA 9060M	Percent (dw)	0.2			1.96			2.07			1.41			1.82			n/a			
Grain Size																					
Fractional % phi >-1	PSEP	Percent (dw)	5.48			1.2			1.04			2.52			1.41			n/a			
Fractional % phi 0-1	PSEP	Percent (dw)	8.38			1.31			1.3			3.68			1.62			n/a			
Fractional % phi 1-2	PSEP	Percent (dw)	35.6			5.58			5.27			13.7			5.58			n/a			
Fractional % phi 2-3	PSEP	Percent (dw)	32			11.4			10.4			26.2			24			n/a			
Fractional % phi 3-4	PSEP	Percent (dw)	6.71			18.9			19.5			19.1			22.7			n/a			
Fractional % phi 4-5	PSEP	Percent (dw)	1.17			13.4			15.3			9.71			13.6			n/a			
Fractional % phi 5-6	PSEP	Percent (dw)	0.36			14.5			13.4			4.75			8.12			n/a			
Fractional % phi 6-7	PSEP	Percent (dw)	0.32			10.9			10.7			4.21			6.15			n/a			
Fractional % phi 7-8	PSEP	Percent (dw)	0.34			5.07			6.16			3.46			4.15			n/a			
Fractional % phi 8-9	PSEP	Percent (dw)	0.16			4.32			5.1			3.73			4.34			n/a			
Fractional % phi 9-10	PSEP	Percent (dw)	0.05			3.66			4.54			2.26			2.82			n/a			
Fractional % phi >10	PSEP	Percent (dw)	0.52			8.41			8.13			3.59			3.9			n/a			
Gravel	PSEP	Percent (dw)	15.5			0.84			0.91			8.24			1.46			n/a			

Footnotes:

1/ Dioxin-like PCB and dioxin/furan congeners will be evaluated as toxic equivalents (TEQs) in the risk assessments, rather than as individual congeners. However, because TEQs are calculated, rather than measured by the laboratory, RBCs for individual congeners are presented to facilitate comparison with RLs for those congeners. In reality, risks will be assessed based on sums of these congeners (normalized per their realtive toxicity to TCDD), and thus comparison to RLs on a congener-specific basis is somewhat uncertain.

2/ Total Chlordane calculated by TtEC. Total chlordane is the sum of oxychlordane, alpha- and gamma-chlordane, and cis- and trans-nonachlor. RL and MDL are the highest RL and MDL for the cholrdane-related compounds. Lab reports as individual analytes.

Notes:

IT - Intertidal sediment sample
mg/kg= milligrams per kilogram
µg/kg= microgram per kilogram
ww= wet weight
dw= dry weight

Laboratory Qualifiers (Lab Q):

For Metals:
B - Result is an estimated concentration that is less than the MRL but greater than or equal to the MDL.
N- The Matrix Spike sample recovery is not within control limits. See case narative.
U- The compound was analyzed for, but was not detected ("Non-detect") at or above the MRL/MDL.
*- The duplicate was not within control limits. See case narrative.
For Oranics:
B - The analyte was found in the associated method blank at a level that is significant relative to the sample result.
D - Result reported from a dilution.
J - Result is an estimated concentration that is less than the MRL but greater than or equal to the MDL.
N - The result is presumptive. The analyte was tentatively identified, but a confirmation analysis was not performed.
P - The GC or HPLC confirmation criteria was exceeded. The relative percent difference is greater than 40% between the two analytical results.
U - Result was not detected at or above the MRL/MDL.
i - The MRL/MDL has been elevated due to a chromatographic interference.
For Dioxins/Furans:
B- Indicates the associated analyte is found in the method blank, as well as in the sample.
E- Indicates an estimated value-used when the analyte concentration exceeds the upper end of the linear calibration range.
J- Indicated an estimated value that is less than the MRL but greater than or equal to the EDL.
K- Indicates an estimated maximum possible concentration for the associated compounds.
U- Indicates the compound was analyzed and not detected.

Data Validation Qualifiers (Val Q):

U - Result should be considered not detected at the quantitation limit shown.
J - Result is an estimated concentration.
UJ - The compound was not detected and the sample detection limit should be considered an estimated value.

Table A-7. Composite Sediment for Elutriate Testing Analytical Data

Location			Sediment Composite	Sediment Composite
Sample ID			TT-Comp1	TT-Comp2
Parameter	**Method**	**Units**		
Antimony	EPA 6020	mg/Kg	4.63 J	31.5 J
Arsenic	EPA 6020	mg/Kg	15.6	145
Cadmium	EPA 6020	mg/Kg	0.282	0.515
Chromium	EPA 6020	mg/Kg	71.5	233
Cobalt	EPA 6020	mg/Kg	7.37	20.4
Copper	EPA 6020	mg/Kg	237	1840
Lead	EPA 6020	mg/Kg	157 N J	1010 N J
Mercury	EPA 7471A	mg/Kg	1.11 * J	3.58 * J
Molybdenum	EPA 6020	mg/Kg	1.81	12.3
Nickel	EPA 6020	mg/Kg	30.5 J	66 J
Selenium	EPA 6020	mg/Kg	0.5 B	0.7 B
Silver	EPA 6020	mg/Kg	0.187 J	0.35 J
Thallium	EPA 6020	mg/Kg	0.093	0.142
Vanadium	EPA 6020	mg/Kg	48.4	40.4
Zinc	EPA 6020	mg/Kg	220	850
PCBs (total)	TT calculated	µg/Kg	490	1780
PCB-1016	EPA 8082	µg/Kg	2.5 U	23 U
PCB-1221	EPA 8082	µg/Kg	2.5 U	23 U
PCB-1232	EPA 8082	µg/Kg	2.5 U	23 U
PCB-1242	EPA 8082	µg/Kg	2.5 U	23 U
PCB-1248	EPA 8082	µg/Kg	2.5 U	23 U
PCB-1254	EPA 8082	µg/Kg	370	1200 D
PCB-1260	EPA 8082	µg/Kg	120	580 D
PCB-1262	EPA 8082	µg/Kg	2.5 U	23 U
PCB-1268	EPA 8082	µg/Kg	2.5 U	23 U
Aldrin	EPA 8081A	µg/Kg	1.3 Ui	0.21 U
alpha-BHC	EPA 8081A	µg/Kg	0.38 U	0.35 U
alpha-Chlordane	EPA 8081A	µg/Kg	0.46 J	2.1 Ui
beta-BHC	EPA 8081A	µg/Kg	1	0.41 U
delta-BHC	EPA 8081A	µg/Kg	0.36 Ui	2.5 Ui
Dieldrin	EPA 8081A	µg/Kg	0.42 U	7.4 Ui
Endosulfan I	EPA 8081A	µg/Kg	0.93 Ui	14 Ui
Endosulfan II	EPA 8081A	µg/Kg	0.28 U	0.26 U
Endosulfan sulfate	EPA 8081A	µg/Kg	0.13 Ui	0.5 Ui
Endrin	EPA 8081A	µg/Kg	1.5 Ui	4 Ui
Endrin aldehyde	EPA 8081A	µg/Kg	3.4 P	12 P J
gamma-BHC	EPA 8081A	µg/Kg	0.22 U	0.92 Ui
gamma-Chlordane	EPA 8081A	µg/Kg	6.5 P J	1.3 Ui
Heptachlor	EPA 8081A	µg/Kg	0.22 Ui	0.5 Ui
Heptachlor epoxide	EPA 8081A	µg/Kg	1.7 Ui	7 Ui
Methoxychlor	EPA 8081A	µg/Kg	0.15 U	3.3 Ui
Mirex	EPA 8081A	µg/Kg	0.15 U	0.14 U
Nonachlor (cis)	EPA 8081A	µg/Kg	7.6 Ui UJ	3.3 Ui
Nonachlor (trans)	EPA 8081A	µg/Kg	0.21 JP J	1.9 Ui
Oxychlordane	EPA 8081A	µg/Kg	0.53 U	0.5 U
Toxaphene	EPA 8081A	µg/Kg	110 Ui UJ	610 Ui UJ
o,p-DDD	EPA 8081A	µg/Kg	7.2 Ui	36 Ui UJ
o,p-DDE	EPA 8081A	µg/Kg	1.2 Ui	1.4 Ui
o,p-DDT	EPA 8081A	µg/Kg	18 P J	83 D J
p,p-DDD	EPA 8081A	µg/Kg	16 J	56 D
p,p-DDE	EPA 8081A	µg/Kg	0.65 Ui	45 PD J
p,p-DDT	EPA 8081A	µg/Kg	17 Ui	130 D
Total DDT	TT Calculated	µg/Kg	16	231
1,2,4-Trichlorobenzene	EPA 8270C	µg/Kg	11 U	41 U
1,2-Dichlorobenzene	EPA 8270C	µg/Kg	9.3 U	36 JD
1,3-Dichlorobenzene	EPA 8270C	µg/Kg	12 U	43 U
1,4-Dichlorobenzene	EPA 8270C	µg/Kg	14 U	51 U
1-Methylnaphthalene	EPA 8270C	µg/Kg	30 JD J	430 D J
2,4,5-Trichlorophenol	EPA 8270C	µg/Kg	22 U	81 U
2,4,6-Trichlorophenol	EPA 8270C	µg/Kg	13 U	49 U
2,4-Dichlorophenol	EPA 8270C	µg/Kg	13 U	49 U
2,4-Dimethylphenol	EPA 8270C	µg/Kg	40 U	150 U
2,4-Dinitrophenol	EPA 8270C	µg/Kg	260 U	970 U
2,4-Dinitrotoluene	EPA 8270C	µg/Kg	20 U	75 U
2,6-Dinitrotoluene	EPA 8270C	µg/Kg	20 U	75 U
2-Chloronaphthalene	EPA 8270C	µg/Kg	26 U	97 U
2-Chlorophenol	EPA 8270C	µg/Kg	13 U	46 U
2-Methylnaphthalene	EPA 8270C	µg/Kg	27 JD	320 D
2-Methylphenol	EPA 8270C	µg/Kg	25 U	91 U
2-Nitroaniline	EPA 8270C	µg/Kg	20 U	73 U
2-Nitrophenol	EPA 8270C	µg/Kg	19 U	70 U
3,3-Dichlorobenzidine	EPA 8270C	µg/Kg	27 U	99 U
3-Nitroaniline	EPA 8270C	µg/Kg	19 U	70 U
4,6-Dinitro-o-cresol	EPA 8270C	µg/Kg	13 U	46 U
4-Bromophenyl phenyl ether	EPA 8270C	µg/Kg	10 U	38 U
4-Chloro-3-methylphenol	EPA 8270C	µg/Kg	15 U	57 U
4-Chloroaniline	EPA 8270C	µg/Kg	15 U	57 U
4-Chlorophenyl phenyl ether	EPA 8270C	µg/Kg	15 U	54 U
4-Methylphenol	EPA 8270C	µg/Kg	21 U	95 JD
4-Nitroaniline	EPA 8270C	µg/Kg	40 JD	91 U
4-Nitrophenol	EPA 8270C	µg/Kg	220 U	810 U
Acenaphthene	EPA 8270C	µg/Kg	150 D	1400 D
Acenaphthylene	EPA 8270C	µg/Kg	58 D	210 D
Aniline	EPA 8270C	µg/Kg	11 U	41 U
Anthracene	EPA 8270C	µg/Kg	250 D	1300 D
Benzo(a)anthracene	EPA 8270C	µg/Kg	690 D	3100 D
Benzo(a)pyrene	EPA 8270C	µg/Kg	700 D	2400 D
Benzo(b)fluoranthene	EPA 8270C	µg/Kg	960 D	3400 D
Benzo(g,h,i)perylene	EPA 8270C	µg/Kg	380 D	1400 D
Benzo(k)fluoranthene	EPA 8270C	µg/Kg	360 D	1200 D
Benzofluoranthenes (total)	TT calculated	µg/Kg	1320	4600
Benzoic acid	EPA 8270C	µg/Kg	690 U R	2600 U R
Benzyl alcohol	EPA 8270C	µg/Kg	27 U	99 U
bis(2-chloroethoxy)methane	EPA 8270C	µg/Kg	9.3 U	35 U
bis(2-chloroethyl)ether	EPA 8270C	µg/Kg	18 U	65 U
bis(2-chloroisopropyl)ether	EPA 8270C	µg/Kg	8.6 U	33 U
bis(2-ethylhexyl)phthalate	EPA 8270C	µg/Kg	220 JD	2800 JD
Butyl benzyl phthalate	EPA 8270C	µg/Kg	11 U	41 U
Chrysene	EPA 8270C	µg/Kg	860 D	3400 D
Dibenzo(a,h)anthracene	EPA 8270C	µg/Kg	110 D	370 D
Dibenzofuran	EPA 8270C	µg/Kg	94 D	890 D
Diethylphthalate	EPA 8270C	µg/Kg	25 U	94 U
Dimethyl phthalate	EPA 8270C	µg/Kg	13 U	49 U
Di-n-butyl phthalate	EPA 8270C	µg/Kg	31 JD	71 JD
Di-n-octyl phthalate	EPA 8270C	µg/Kg	8.6 U	33 U
Fluoranthene	EPA 8270C	µg/Kg	1700 D	8600 D
Fluorene	EPA 8270C	µg/Kg	160 D	1400 D
Hexachlorobenzene	EPA 8081A	µg/Kg	0.16 J	0.81 P J
Hexachlorobutadiene	EPA 8081A	µg/Kg	0.7 U UJ	0.66 U
Hexachlorocyclopentadiene	EPA 8270C	µg/Kg	110 U	410 U
Hexachloroethane	EPA 8270C	µg/Kg	16 U	59 U
Indeno(1,2,3-cd)pyrene	EPA 8270C	µg/Kg	420 D	1500 D
Isophorone	EPA 8270C	µg/Kg	12 U	43 U
Naphthalene	EPA 8270C	µg/Kg	69 D	1900 D
Nitrobenzene	EPA 8270C	µg/Kg	15 U	54 U
N-Nitrosodimethylamine	EPA 8270C	µg/Kg	44 U	170 U
N-Nitroso-di-n-propylamine	EPA 8270C	µg/Kg	23 U	86 U
N-Nitrosodiphenylamine	EPA 8270C	µg/Kg	16 U	59 U
Pentachlorophenol	EPA 8270C	µg/Kg	61 U	230 U
Phenanthrene	EPA 8270C	µg/Kg	960 D	5900 D
Phenol	EPA 8270C	µg/Kg	24 JD	52 JD
Pyrene	EPA 8270C	µg/Kg	1900 D	7800 D
Total HPAH	TT calculated	µg/Kg	6760	28570
Total LPAH	TT calculated	µg/Kg	1647	12110
Total PAH	TT calculated	µg/Kg	8407	40680
Butyltin	KRONE	µg/Kg	4	22 J
Dibutyltin	KRONE	µg/Kg	90	550 D
Tetrabutyltin	KRONE	µg/Kg	6.2	41
Tributyltin	KRONE	µg/Kg	390 D	2400 D
Total Solids	EPA 160.3	Percent	70.2	74.8
Total Organic Carbon	PSEP	Percent	0.97	0.7
Fractional % phi >-1	PSEP Grain Size	Percent	2.09	7.92
Fractional % phi 0-1	PSEP Grain Size	Percent	5.59	17.6
Fractional % phi 1-2	PSEP Grain Size	Percent	19.5	16.6
Fractional % phi 2-3	PSEP Grain Size	Percent	23	18.3
Fractional % phi 3-4	PSEP Grain Size	Percent	14.8	14.8
Gravel	PSEP Grain Size	Percent	3.17	4.12
.98 µm	PSEP Grain Size	Percent	3.5	1.52
1.95 µm	PSEP Grain Size	Percent	1.79	0.71
3.9 µm	PSEP Grain Size	Percent	2.25	1
7.8 µm	PSEP Grain Size	Percent	3.19	1.64
15.6 µm	PSEP Grain Size	Percent	5.75	3.45
31.3 µm	PSEP Grain Size	Percent	6.93	5.55
62.5 µm	PSEP Grain Size	Percent	7.04	5.77

Notes:
0.14 U J – Result followed by laboratory data qualifier followed by data validator qualifi
mg/kg – milligrams per kilogram
µg/Kg – micrograms per kilogram

Laboratory Data Qualifiers
U – result was not detected at or above the method detection lim
J (for organics) – result is an estimated concentrations that is less than the reporting limit but greater than or equal to the detection li
B (for metals) – result is an estimated concentrations that is less than the reporting limit but greater than or equal to the detection li
* (for metals) – duplicate analysis not within control limits. See case narrative (in laboratory repo
D (for organics) – result reported is from a dilutio
P (for organics) – The GC or HPLC confirmation criteria was exceeded. The relative percent difference is greater than 40% between the two analytical resu
i (for organics) – the MRL/MDL has been elevated due to a chromatographic interferenc
N (for metals) – The Matrix Spike recovery is not within control limits. See case narrative in laboratory repo

Data Validation Qualifiers
U – Result should be considered not-detected at the quantitation limit show
J – Result is an estimated concentratio
UJ – The compound was not detected and the sample detection limit should be considered an estimated val
R – Rejected - Quality Control indicates the data is not usabl

Table A-8. Sediment Elutriate Analytical Data

Location			DRET Elutriate	DRET Elutriate	DRET Elutriate	DRET Elutriate	Site Water	Site Water
Sample ID			TT-Comp1 DRET DISSOLVED	TT-Comp1 DRET TOTAL	TT-Comp2 DRET DISSOLVED	TT-Comp2 DRET TOTAL	TT-SW-02 Diss	TT-SW-02Tot
Parameter	**Method**	**Units**						
Arsenic	EPA 6020	µg/L	1.13 N	2.77 N	2.67 N	20.6 N	0.74 N	0.72 N
Cadmium	EPA 6020	µg/L	0.006 U	0.108	0.006 U	0.141 J	0.039	0.051
Chromium	EPA 6020	µg/L	0.07 B	7.13	0.04 B	32.5	0.16 B	0.21
Copper	EPA 6020	µg/L	0.578	52.3	0.346	261	0.935	0.699
Lead	EPA 6020	µg/L	0.089	18.8	0.078	63.3	0.089	0.15
Mercury	EPA 7470A	µg/L	0.03 U	0.36	0.03 B	0.59	0.03 U	0.03 U
Nickel	EPA 6020	µg/L	3.07	6.18	10.4	17.5 J	0.46	0.62
Selenium	EPA 7740	µg/L	7 U	7 U	7 U	7 U	7 U	7 U
Silver	EPA 6020	µg/L	0.004 U	0.068	0.004 U	0.08 J	0.004 U	0.017 B
Zinc	EPA 6020	µg/L	3.8	49.6	2.74	190	2.01	1.88
PCBs (total)	TT calculated	µg/L	0.037 U	0.176	0.04 U	0.72	0.0098 U	0.02 U
PCB-1016	EPA 8082	µg/L	0.0067 Ui UJ	0.001 U UJ	0.022 Ui UJ	0.001 U UJ	0.0037 Ui UJ	0.0082 Ui UJ
PCB-1221	EPA 8082	µg/L	0.037 Ui UJ	0.001 U UJ	0.04 Ui UJ	0.001 U UJ	0.0098 Ui UJ	0.0097 Ui UJ
PCB-1232	EPA 8082	µg/L	0.02 Ui UJ	0.001 U UJ	0.017 Ui UJ	0.001 U UJ	0.0093 Ui UJ	0.02 Ui UJ
PCB-1242	EPA 8082	µg/L	0.0099 Ui	0.001 U	0.013 Ui	0.001 U	0.0057 Ui	0.0092 Ui
PCB-1248	EPA 8082	µg/L	0.0057 Ui	0.001 U	0.018 Ui	0.001 U	0.007 Ui	0.0091 Ui
PCB-1254	EPA 8082	µg/L	0.014 Ui	0.13	0.011 Ui	0.56	0.0065 Ui	0.015 Ui
PCB-1260	EPA 8082	µg/L	0.0063 Ui	0.046	0.0049 Ui	0.16	0.0049 Ui	0.0049 Ui
PCB-1262	EPA 8082	µg/L	0.0056 Ui	0.001 U	0.0031 Ui	0.001 U	0.001 U	0.0049 Ui
PCB-1268	EPA 8082	µg/L	0.0069 Ui	0.001 U	0.001 U	0.001 U	0.001 U	0.0049 Ui
Aldrin	EPA 8081A	µg/L	0.48 P J	0.48 Ui UJ	0.48 Ui UJ	0.054 U UJ	0.49 Ui UJ	0.26 Ui UJ
alpha-Chlordane	EPA 8081A	µg/L	0.48 Ui	0.48 Ui	1.2 Ui	2 P J	1.2 Ui	1.2
Dieldrin	EPA 8081A	µg/L	0.4 U	4.1 Ui	0.4 U	20 Ui	0.4 U	0.4 U
Endosulfan I	EPA 8081A	µg/L	0.067 U	0.85 P J	0.067 U	7.1 P J	0.49 Ui	0.23 Ui
Endosulfan II	EPA 8081A	µg/L	1.1 Ui	3.4 Ui	0.087 U	0.73 Ui	0.67 P J	0.49 Ui
Endrin	EPA 8081A	µg/L	0.083 U	0.7 P J	0.51 Ui	3.2 P J	0.33 Ui	0.083 U
gamma-BHC	EPA 8081A	µg/L	0.49 Ui	0.48 Ui	0.51 Ui	2.7	0.49 Ui	0.76 Ui
gamma-Chlordane	EPA 8081A	µg/L	0.48 Ui	5.3	0.53 Ui	29 D	1.3 Ui	0.49 Ui
Heptachlor	EPA 8081A	µg/L	0.34 Ui	0.1 U	0.62 Ui	0.1 U	1.1 Ui	0.5 Ui
Heptachlor epoxide	EPA 8081A	µg/L	3.9 P J	0.48 Ui	2.7 P J	1.6 Ui	0.94 Ui	0.87 Ui
Toxaphene	EPA 8081A	µg/L	29 Ui UJ	61 Ui UJ	32 Ui UJ	560 Ui UJ	130 Ui UJ	45 Ui UJ
p,p-DDT	EPA 8081A	µg/L	0.33 U	10	1.3 Ui	67 D	1.6 Ui	0.45 Ui
Total DDT	TT Calculated	µg/L	0.33 U	10	1.3 U	67	1.6 U	0.45 U
Pentachlorophenol	EPA 8151M	µg/L	0.13 U	0.13 U	0.13 U	0.13 U	0.13 U	0.13 U

Notes:
0.14 U J – Result followed by laboratory data qualifier followed by data validator qualifier
Sample depth (MLLW) – the core increment elevation in mean lower low water
µg/L – micrograms per liter
ng/L – nanograms per liter

Laboratory Data Qualifiers
U – result was not detected at or above the method detection limit
J (for organics) – result is an estimated concentrations that is less than the reporting limit but greater than or equal to the detection limit
B (for metals) – result is an estimated concentrations that is less than the reporting limit but greater than or equal to the detection limit
* (for metals) – duplicate analysis not within control limits. See case narrative (in laboratory report)
D (for organics) – result reported is from a dilution
P (for organics) – The GC or HPLC confirmation criteria was exceeded. The relative percent difference is greater than 40% between the two analytical results.
i (for organics) – the MRL/MDL has been elevated due to a chromatographic interference.
N (for metals) – The Matrix Spike recovery is not within control limits. See case narrative in laboratory report.

Data Validation Qualifiers
U – Result should be considered not-detected at the quantitation limit shown
J – Result is an estimated concentration
R – Rejected - Quality Control indicates the data is not usable
UJ – The compound was not detected and the sample detection limit should be considered an estimated value

Table A-9. Column Settling Data

TT-Comp1

Sample Extraction Time (hrs)	Depth of Extraction (ft)	Suspended Solids (g/L)	Fraction of Initial SS (%)
1	0.2	0.35	0.9
1	0.7	0.39	1.0
1	1.2	0.22	0.6
1	1.7	0.27	0.7
1	2.2	0.27	0.7
1	2.7	0.35	0.9
1	3.2	2.12	5.3
1	3.7	20.05	50.7
1	4.2	23.34	59.0
1	4.7	24.25	61.3
1	5.7	29.64	74.9
1	6.2	32.36	81.8
2	0.7	0.06	0.2
2	1.2	0.10	0.2
2	1.7	0.13	0.3
2	2.2	0.14	0.4
2	2.7	0.15	0.4
2	3.2	0.17	0.4
2	3.7	0.18	0.4
2	4.2	0.18	0.4
2	4.7	0.18	0.5
2	5.7	NA	NA
2	6.2	NA	NA
4	0.7	0.02	0.1
4	1.2	0.02	0.0
4	1.7	0.03	0.1
4	2.2	0.04	0.1
4	2.7	0.05	0.1
4	3.2	0.06	0.2
4	3.7	0.07	0.2
4	4.2	0.09	0.2
4	4.7	0.07	0.2
4	5.7	0.07	0.2
4	6.2	0.08	0.2
6.5	0.7	0.00	0.0
6.5	1.2	0.01	0.0
6.5	1.7	0.01	0.0
6.5	2.2	0.02	0.0
6.5	2.7	0.02	0.1
6.5	3.2	0.03	0.1
6.5	3.7	0.03	0.1
6.5	4.2	0.02	0.1
6.5	4.7	0.03	0.1
6.5	5.7	0.05	0.1
6.5	6.2	0.05	0.1

TT-Comp1

Sample Extraction Time (hrs)	Depth of Extraction (ft)	Suspended Solids (g/L)	Fraction of Initial SS (%)
8.5	1.2	0.01	0.0
8.5	1.7	0.03	0.1
8.5	2.2	0.02	0.1
8.5	2.7	0.02	0.1
8.5	3.2	0.03	0.1
8.5	3.7	0.03	0.1
8.5	4.2	0.04	0.1
8.5	4.7	0.03	0.1
8.5	5.7	0.05	0.1
8.5	6.2	0.04	0.1
11	1.2	0.02	0.0
11	1.7	0.01	0.0
11	2.2	0.01	0.0
11	2.7	0.02	0.0
11	3.2	0.02	0.0
11	3.7	0.02	0.0
11	4.2	0.02	0.0
11	4.7	0.02	0.1
11	5.7	0.04	0.1
11	6.2	0.02	0.1
24	1.2	0.01	0.0
24	1.7	0.01	0.0
24	2.2	0.01	0.0
24	2.7	0.01	0.0
24	3.2	0.01	0.0
24	3.7	0.01	0.0
24	4.2	0.02	0.1
24	4.7	0.08	0.2
24	5.7	0.01	0.0
24	6.2	0.01	0.0
48	4.2	0.01	0.0
48	4.7	0.01	0.0
48	5.7	0.01	0.0
48	6.2	0.01	0.0

TT-Comp2

Sample Extraction Time (hrs)	Depth of Extraction (ft)	Suspended Solids (g/L)	Fraction of Initial SS (%)
1	0.6	0.22	0.9
1	1.1	0.46	1.9
1	1.6	0.22	0.9
1	2.1	0.57	2.4
1	2.6	0.25	1.0
1	3.1	0.21	0.9
1	3.6	0.32	1.3
1	4.1	1.95	8.2
1	4.6	2.42	10.2
1	5.6	15.92	66.8
2	0.6	0.11	0.5
2	1.1	0.10	0.4
2	1.6	0.14	0.6
2	2.1	0.13	0.5
2	2.6	0.06	0.3
2	3.1	0.07	0.3
2	3.6	0.10	0.4
2	4.1	0.13	0.5
2	4.6	0.15	0.6
2	5.6	0.10	0.4
2	6.1	0.15	0.6
4	0.6	0.02	0.1
4	1.1	0.04	0.2
4	1.6	0.04	0.2
4	2.1	0.05	0.2
4	2.6	0.04	0.2
4	3.1	0.04	0.2
4	3.6	0.04	0.2
4	4.1	0.05	0.2
4	4.6	0.05	0.2
4	5.6	0.06	0.3
4	6.1	0.18	0.8
6	0.6	0.10	0.4
6	1.1	0.02	0.1
6	1.6	0.02	0.1
6	2.1	0.02	0.1
6	2.6	0.03	0.1
6	3.1	0.06	0.3
6	3.6	0.03	0.1
6	4.1	0.05	0.2
6	4.6	0.04	0.2
6	5.6	0.04	0.2
6	6.1	0.04	0.2
8	0.6	0.01	0.1
8	1.1	0.01	0.0

TT-Comp2

Sample Extraction Time (hrs)	Depth of Extraction (ft)	Suspended Solids (g/L)	Fraction of Initial SS (%)
8	1.6	0.01	0.1
8	2.1	0.02	0.1
8	2.6	0.01	0.1
8	3.1	0.02	0.1
8	3.6	0.16	0.7
8	4.1	0.02	0.1
8	4.6	0.02	0.1
8	5.6	0.01	0.1
8	6.1	0.04	0.2
11	0.6	0.01	0.0
11	1.1	0.07	0.3
11	1.6	0.02	0.1
11	2.1	0.04	0.2
11	2.6	0.01	0.1
11	3.1	0.00	0.0
11	3.6	0.02	0.1
11	4.1	0.01	0.0
11	4.6	0.02	0.1
11	5.6	0.02	0.1
11	6.1	0.03	0.1
24	1.1	0.01	0.1
24	1.6	0.02	0.1
24	2.1	0.03	0.1
24	2.6	0.01	0.1
24	3.1	0.02	0.1
24	3.6	0.01	0.0
24	4.1	0.01	0.0
24	4.6	0.01	0.1
24	5.6	0.02	0.1
24	6.1	0.02	0.1
48	1.1	0.01	0.1
48	1.6	0.07	0.3
48	2.1	0.02	0.1
48	2.6	0.02	0.1
48	3.1	0.01	0.0
48	3.6	0.03	0.1
48	4.1	0.01	0.0
48	4.6	0.01	0.0
48	5.6	0.01	0.0
48	6.1	0.01	0.1

Table A-10a. Historical Sediment Core Analytical Data—Data Evaluation Summary Compared to SQS and CSL

Lockheed Shipyard No. 2 Subsurface Samples

				Sample Locations within Yard 2											
			Location	**C6**	**C6**	**C6**	**D5**	**SB1**	**SB1**	**D2**	**D3**	**SA8**	**SA9**	**SA9**	**SA5**
			Sample ID	**C6 (0-2)**	**C6 (2-5)**	**C6 (5-8)**	**D5-C**	**SB1-A**	**SB1-C**	**D2-C**	**D3-A**	**SA8-D**	**SA9-A**	**SA9-B**	**SA5-A**
			Sample Date	**12/1/1991**	**12/1/1991**	**12/1/1991**	**9/13/1989**	**9/12/1989**	**9/12/1989**	**9/7/1989**	**9/5/1989**	**9/1/1989**	**9/1/1989**	**9/1/1989**	**8/31/1989**
			Sample Depth	**0-2 ft**	**2-5 ft**	**5-8 ft**	**0-4 ft**	**0-2 ft**	**2-7.5 ft**	**0-4 ft**	**0-2 ft**	**3.5-5 ft**	**0-2 ft**	**2-5 ft**	**0-2 ft**
Parameter	**Units**	**SQS**	**CSL**												
Conventionals															
Total Organic Carbon	%	NA	NA	1.4762	1.3682	0.7154	0.67	1	0.81	1.1	0.56	0.61	0.63	0.69	1.1
Metals															
Arsenic	mg/kg	57	93	12.2	8.44	3.19	**64**	**110**	42	55	46	27	36	20	37
Cadmium	mg/kg	5.1	6.7	0.41	0.415	0.08	1.3 E	0.2 E	0.52 E	0.16 E	0.36 E	0.11 E	0.35 E	0.24 E	0.2 E
Chromium	mg/kg	260	270	29.8	29.2	16.6	190 E	**660** E	230 E	33 E	110 E	33 E	92 E	50 E	100 E
Copper	mg/kg	390	390	61.8 J	46.3 J	20.9 J	**1200** E	**1900** E	110 E	35 E	210 E	100 E	220 E	93 E	91 E
Lead	mg/kg	450	530	32	18	3	**610** E	**550** E	**550** E	6.1 E	100 E	30 E	120 E	20 E	18 E
Mercury	mg/kg	0.41	0.59	0.34	0.27	0.06 U	0.032	0.012	0.011	0.001	0.0008	0.001	0.0038	0.001	0.0005
Silver	mg/kg	6.1	6.1	0.27	0.17	0.03 U	1.2 E	0.64 E	0.76 E	0.1 U	0.23 E	0.1 U	0.24 E	0.1 U	0.14 E
Zinc	mg/kg	410	960	95.8	62.4	29.1	**2600** E	**960** E	**1100** E	48 E	**480** E	100 E	380 E	85 E	120 E
SVOCs															
Naphthalene	mg/kg-OCN	99	170	6.0	24	0.02	**1029.85**	**650**	**296.3**	3.27	17.86	NR	11.75	3.19 E	11.82
Acenaphthylene	mg/kg-OCN	66	66	1.0	7	0 J	29.85 E	**190**	28.4	0.82 E	10	NR	15.4	2.9 E	2.36
Acenaphthene	mg/kg-OCN	16	57	4.0	15	0.02	**537.31**	**540**	**160.49**	1.45 E	12.14	NR	13.49	6.09	6.55
Fluorene	mg/kg-OCN	23	79	3.0	13	0.02	**522.39**	**600**	**197.53**	1.55 E	16.96	NR	20.63	9.13	6.36
Phenanthrene	mg/kg-OCN	100	480	14.0	40	0.05	**1194.03**	**3500**	**839.51**	6	80.36	NR	**174.6**	63.77	20.91
Anthracene	mg/kg-OCN	220	1200	6.0	21	0.02	**298.51**	**870**	**246.91**	5.09	37.5	NR	23.81	20.29	10
2-Methylnaphthalene	mg/kg-OCN	38	64	1.0	5	0.01 J	**238.81**	**130**	33.33	2.27 U	4.82 E	NR	5.08	1.59 E	2.27
Total LPAH	mg/kg-OCN	370	780	34.0	120	0.13 J	**3611.94** E	**6350**	**1769.14**	18.18 E	174.82	NR	259.68	105.36 E	58
Fluoranthene	mg/kg-OCN	160	1200	14.0	31	0.05	**1447.76**	**3500**	**1086.42**	8.09	96.43	NR	**190.48**	63.77	34.55
Pyrene	mg/kg-OCN	1000	1400	35.0	95	0.15	**1194.03**	**3600**	938.27	18.18	285.71	NR	476.19	110.14	50 E
Benzo(a)anthracene	mg/kg-OCN	110	270	7.0	15	0.02	**477.61**	**1900**	**419.75**	3.82	**116.07**	NR	**134.92**	27.54	17.27
Chrysene	mg/kg-OCN	110	460	12.0	29	0.02	**522.39**	**1500**	**407.41**	5	100	NR	104.76	26.09	20.91
Benzofluoranthenes (total)	mg/kg-OCN	230	450	37.0	54	0.05	**761.19**	**2200**	**703.7**	17.27	146.43	NR	206.35	47.83	32.73
Benzo(a)pyrene	mg/kg-OCN	99	210	16.0	26	0.02	**373.13**	**1500**	**370.37**	6.82	75	NR	**109.52**	27.54	14.55
Indeno(1,2,3-cd)pyrene	mg/kg-OCN	34	88	10.0	12	0.01 J	**164.18**	**890**	**197.53**	3.45	**48.21**	NR	**66.67**	17.39	8
Dibenzo(a,h)anthracene	mg/kg-OCN	12	33	4.0	5	0.01 U	**82.09**	**420**	**98.77**	2.18 E	**21.43**	NR	**39.68**	10.87	3.73
Benzo(g,h,i)perylene	mg/kg-OCN	31	78	3.0	4	0.01	**179.1**	**880**	**185.19**	3.64	**44.64**	NR	**65.08**	21.74	8.45
Total HPAH	mg/kg-OCN	960	5300	138.0	271	0.33 J	**5201.49**	**16390**	**4407.41**	68.45 E	933.93	NR	**1393.65**	352.9	190.18 E
1,2-Dichlorobenzene	mg/kg-OCN	2.3	2.3	0.0 U	1 U	0.01 U	***17.91*** U	***14*** U	***14.81*** U	1.18 U	***2.32*** U	NR	2.06 U	1.88 U	1.09 U
1,4-Dichlorobenzene	mg/kg-OCN	3.1	9	0.0 U	1 U	0.01 U	***37.31*** U	***28*** U	***28.4*** U	2.27 U	***4.82*** U	NR	***4.29*** U	***3.77*** U	2.18 U
1,2,4-Trichlorobenzene	mg/kg-OCN	0.81	1.8	0.0 U	***1*** U	0.01 U	***17.91*** U	**28** E	***14.81*** U	***1.18*** U	***2.32*** U	NR	***2.06*** U	***1.88*** U	***1.09*** U
Hexachlorobenzene	mg/kg-OCN	0.38	2.3	0.0 U	***1*** U	0.01 U	***37.31*** U	***28*** U	***28.4*** U	***2.27*** U	***4.82*** U	NR	***4.29*** U	***3.77*** U	***2.18*** U
Dimethyl phthalate	mg/kg-OCN	53	53	0.0 U	1 U	0.01 U	37.31 U	28 U	28.4 U	2.27 U	4.82 U	NR	4.29 U	3.77 U	2.18 U
Diethylphthalate	mg/kg-OCN	61	110	0.0 U	1 U	0.01 U	37.31 U	28 U	28.4 U	2.27 U	4.82 U	NR	4.29 U	3.77 U	2.18 U
Di-n-butyl phthalate	mg/kg-OCN	220	1700	0.0 M	1 U	0.01 U	37.31 U	39	28.4 U	2.27 U	4.82 U	NR	14.13	3.77 U	2.18 U
Butyl benzyl phthalate	mg/kg-OCN	4.9	64	0.0 U	1 U	0.01 U	***37.31*** U	***28*** U	***28.4*** U	2.27 U	4.82 U	NR	4.29 U	3.77 U	2.18 U
bis(2-ethylhexyl)phthalate	mg/kg-OCN	47	78	3.0	1 M	0.01 U	**283.58**	**1100**	**395.06**	2.27 U	**114.29**	NR	**66.67**	30.43	15.45
Di-n-octyl phthalate	mg/kg-OCN	58	4500	0.0 U	1 U	0.01 U	37.31 U	28 U	28.4 U	2.27 U	9.29 E	NR	4.29 U	3.77 U	2.18 U
Dibenzofuran	mg/kg-OCN	15	58	2.0	10	0.01	**432.84**	**400**	**135.8**	1.18 E	10.36	NR	12.54	5.51	4.36
Hexachlorobutadiene	mg/kg-OCN	3.9	6.2	1.0 U	1 U	0.02 U	***37.31*** U	***28*** U	***28.4*** U	2.27 U	***4.82*** U	NR	***4.29*** U	3.77 U	2.18 U
N-Nitrosodiphenylamine	mg/kg-OCN	11	11	0.0 U	1 U	0.01 U	**40.3** E	***14*** U	***14.81*** U	1.18 U	2.32 U	NR	2.06 U	1.88 U	1.09 U
Phenol	µg/kg	420	1200	10	20 M	10 U	***500*** U	**1200**	***460*** U	51 U	63	NR	54 U	52 U	47 U
2-Methylphenol	µg/kg	63	63	10 U	10 U	10 U	***120*** U	**140** E	***120*** U	13 U	13 U	NR	13 U	13 U	12 U
4-Methylphenol	µg/kg	670	670	10 M	20 M	10 U	250 U	**730**	230 U	4 U	31	NR	27 U	26 U	24 U
2,4-Dimethylphenol	µg/kg	29	29	10 U	20 U	10 U	***120*** U	***140*** U	***120*** U	13 U	13 U	NR	13 U	13 U	12 U
Pentachlorophenol	µg/kg	360	690	30 U	30 U	30 U	***1200*** U	***1400*** U	***1200*** U	130 U	130 U	NR	130 U	130 U	120 U
Benzyl alcohol	µg/kg	57	73	10 U	20 U	10 U	***200*** U	***220*** U	***180*** U	20 U	22 U	NR	21 U	21 U	19 U
Benzoic acid	µg/kg	650	650	40	40	20 M	***1200*** U	***1400*** U	***1200*** U	130 U	130 U	NR	130 U	28 E	120 U
PCBs															
PCBs (total)	mg/kg-OCN	12	65	12	6 U	0.11 U	**417.91**	**590**	**283.95**	5.45 U	**43.93**	20.49	**96.83**	**20.72**	11

Notes:

J The analyte was analyzed for and positively identified, but the associated numerical value is an estimated quantity.

NA Not available

NR Not reported

U The analyte was undetected at reported detection limit.

Bold concentrations indicate an exceedance of the SQS.

Boxed concentrations indicate an exceedance of the CSL.

Italicized concentrations indicate a detection limit exceedance of either SQS or CSL.

Additional qualifier definitions for the various sampling events are unknown.

Table A-10a. Historical Sediment Core Analytical Data—Data Evaluation Summary Compared to SQS and CSL

Lockheed Shipyard No. 2 Subsurface Samples

				Sample Locations within Yard 2									
			Location	SA5	SA7	SA7	SA3	SA3	SA3	SA4	SA4	SA2	SA2
			Sample ID	SA5-C	SA7-A	SA7-D	SA3-A	SA3-B	SA3-D	SA4-C	SA4-D	SA2-C	SA2-D
			Sample Date	8/31/1989	8/31/1989	8/31/1989	8/30/1989	8/30/1989	8/30/1989	8/30/1989	8/30/1989	8/29/1989	8/29/1989
			Sample Depth	2-4.5 ft	0-2 ft	7.5-9 ft	0-2 ft	2-4.5 ft	8-10.5 ft	0-2 ft	2-4.5 ft	0-1 ft	2-5 ft
Parameter	**Units**	**SQS**	**CSL**										
Conventionals													
Total Organic Carbon	%	NA	NA	0.96	1	2.4	0.65	0.52	1	1.2	0.63	2.2	4.3
Metals													
Arsenic	mg/kg	57	93	36	55	**70**	**71**	31	1.6	3.6	7.5	11	40
Cadmium	mg/kg	5.1	6.7	0.092 E	0.15 E	0.31 E	0.2 E	0.15 E	0.18 E	0.27 E	0.098 E	1.5 E	0.49 E
Chromium	mg/kg	260	270	26 E	22 E	20 E	180 E	51 E	19 E	24 E	24 E	110 E	51 E
Copper	mg/kg	390	390	77 E	100 E	72 E	150 E	77 E	40 E	63 E	42 E	150 E	64 E
Lead	mg/kg	450	530	18 E	35 E	9 E	160 E	58 E	6.1 E	53 E	3.7 E	150 E	31 E
Mercury	mg/kg	0.41	0.59	0.0005 U	0.0005 U	0.0006	0.0006	0.0005	0.0005 U	0.0005	0.0005 U	0.0019	0.0011
Silver	mg/kg	6.1	6.1	0.13 E	0.15 E	0.13 E	0.34 E	0.1 U	0.12 E	0.1 U	0.1 U	1.1 E	0.17 E
Zinc	mg/kg	410	960	80 E	130 E	71 E	390 E	200 E	390 E	110 E	64 E	250 E	85 E
SVOCs													
Naphthalene	mg/kg-OCN	99	170	8.44	34	NR	10.77	11.15	2.4 U	27.5	2.86 E	24.09	23.26
Acenaphthylene	mg/kg-OCN	66	66	2.5 U	6 E	NR	6	6.15	2.4 U	6.25	3.97 U	15.45 U	7.44 U
Acenaphthene	mg/kg-OCN	16	57	4.06	13 E	NR	13.08	**18.27**	2.4 U	15	1.59 E	13.64 E	**141.86**
Fluorene	mg/kg-OCN	23	79	3.44	16 E	NR	15.23	**182.69**	2.4 U	19.17	1.75 E	17.27	**93.02**
Phenanthrene	mg/kg-OCN	100	480	11.46	97	NR	61.54	**826.92**	1.6 E	62.5	6.03	63.64	**181.4**
Anthracene	mg/kg-OCN	220	1200	3.54	35	NR	49.23	**346.15**	2.4 U	25.83	4.13	59.09	153.49
2-Methylnaphthalene	mg/kg-OCN	38	64	2.29 E	8 E	NR	3.54 E	6.15	2.4 U	7.92	0.63 E	5.91 E	7.21 E
Total LPAH	mg/kg-OCN	370	780	30.94	201 E	NR	155.85	**1391.35**	1.6 E	156.25	16.35 E	177.73 E	**593.02**
Fluoranthene	mg/kg-OCN	160	1200	16.67	**170**	NR	136.92	**653.85**	1.6 E	**307.5**	8.73	90.91	**395.35**
Pyrene	mg/kg-OCN	1000	1400	16.67 E	260	NR	135.38 E	538.46 E	1.6 E	116.67 E	14.92 E	545.45	395.35 E
Benzo(a)anthracene	mg/kg-OCN	110	270	4.48	56	NR	78.46	**250**	2.4 U	30.83	5.08	54.55	100
Chrysene	mg/kg-OCN	110	460	5.21	83	NR	78.46	**211.54**	0.9 E	50	7.3	77.27	102.33
Benzofluoranthenes (total)	mg/kg-OCN	230	450	7.81	120	NR	153.85	211.54	2.4 U	91.67	19.05	168.18	83.72
Benzo(a)pyrene	mg/kg-OCN	99	210	3.44	62	NR	61.54	80.77	2.4 U	40	8.1	68.18	34.88
Indeno(1,2,3-cd)pyrene	mg/kg-OCN	34	88	1.88 E	28	NR	33.85	NR	2.4 U	20	4.29	31.36	17.44
Dibenzo(a,h)anthracene	mg/kg-OCN	12	33	1.15 E	12 E	NR	**20**	**21.15**	2.4 U	**14.17**	3.02 E	**20.45** E	**13.72**
Benzo(g,h,i)perylene	mg/kg-OCN	31	78	2.19 E	30	NR	29.23	26.92	2.4 U	11.67	3.65 E	29.55	17.91
Total HPAH	mg/kg-OCN	960	5300	59.48 E	821 E	NR	727.69 E	**1994.23** E	4.1 E	682.5 E	74.13 E	**1085.91** E	**1160.7** E
1,2-Dichlorobenzene	mg/kg-OCN	2.3	2.3	1.25 U	***13*** U	NR	2 U	***2.5*** U	1.2 U	1.08 U	2.06 U	***7.73*** U	***3.02*** U
1,4-Dichlorobenzene	mg/kg-OCN	3.1	9	2.5 U	***25*** U	NR	***4.15*** U	***4.81*** U	2.4 U	2.25 U	***3.97*** U	***15.45*** U	***7.44*** U
1,2,4-Trichlorobenzene	mg/kg-OCN	0.81	1.8	***1.25*** U	***13*** U	NR	***1.23*** U	***1.54*** U	0.7 U	0.67 U	***1.27*** U	***7.73*** U	***2.33*** U
Hexachlorobenzene	mg/kg-OCN	0.38	2.3	***2.5*** U	***25*** U	NR	***4.15*** U	***4.81*** U	***2.4*** U	***2.25*** U	***3.97*** U	***15.45*** U	***7.44*** U
Dimethyl phthalate	mg/kg-OCN	53	53	2.5 U	25 U	NR	4.15 U	4.81 U	2.4 U	2.25 U	3.97 U	15.45 U	7.44 U
Diethylphthalate	mg/kg-OCN	61	110	2.5 U	25 U	NR	4.15 U	4.81 U	2.4 U	2.25 U	3.97 U	15.45 U	7.44 U
Di-n-butyl phthalate	mg/kg-OCN	220	1700	2.5 U	25 U	NR	4.15 U	4.81 U	2.4 U	2.25 U	3.97 U	15.45 U	7.44 U
Butyl benzyl phthalate	mg/kg-OCN	4.9	64	2.5 U	***25*** U	NR	4.15 U	4.81 U	2.4 U	2.25 U	3.97 U	***15.45*** U	***7.44*** U
bis(2-ethylhexyl)phthalate	mg/kg-OCN	47	78	6.88	**92**	NR	46.15	36.54	5.1	12.5	6.03	15.45 U	7.44 U
Di-n-octyl phthalate	mg/kg-OCN	58	4500	2.5 U	**66**	NR	4.15 U	11.35	2.4 U	10.83 U	3.97 U	15.45 U	7.44 U
Dibenzofuran	mg/kg-OCN	15	58	2.71	12 E	NR	9.08	36.54	2.4 U	12.5	1.11 E	10 E	44.19
Hexachlorobutadiene	mg/kg-OCN	3.9	6.2	2.5 U	***25*** U	NR	4.15 U	4.81 U	2.4 U	2.25 U	***3.97*** U	***15.45*** U	3.72 U
N-Nitrosodiphenylamine	mg/kg-OCN	11	11	1.25 U	***13*** U	NR	2 U	7.31 E	2.2 U	2 U	3.65 U	7.73 U	3.02 U
Phenol	µg/kg	420	1200	50	75 E	NR	53 U	51 U	48 U	58 E	51 U	***680*** U	***650*** U
2-Methylphenol	µg/kg	63	63	12 U	13 U	NR	10 U	9 U	9 U	10 U	9 U	***170*** U	***130*** U
4-Methylphenol	µg/kg	670	670	24 U	25 U	NR	27 U	25 U	24 U	27 U	25 U	340 U	320 U
2,4-Dimethylphenol	µg/kg	29	29	12 U	13 U	NR	8 U	8 U	7 U	8 U	8 U	***170*** U	**190**
Pentachlorophenol	µg/kg	360	690	120 U	120 U	NR	132 U	130 U	120 U	130 U	130 U	***1700*** U	***1600*** U
Benzyl alcohol	µg/kg	57	73	20 U	20 U	NR	16 U	15 U	14 U	16 U	15 U	***270*** U	***160*** U
Benzoic acid	µg/kg	650	650	120 U	120 U	NR	130 U	130 U	120 U	130 U	130 U	***1700*** U	230 U
PCBs													
PCBs (total)	mg/kg-OCN	12	65	**12.5**	**125**	5 U	**20.92**	NR	12 U	10.92	***19.1*** U	**15**	2.79

Notes:

J The analyte was analyzed for and positively identified, but the associated numerical value is an estimated quai

NA Not available

NR Not reported

U The analyte was undetected at reported detection limit.

Bold concentrations indicate an exceedance of the SQS.

Boxed concentrations indicate an exceedance of the CSL.

Italicized concentrations indicate a detection limit exceedance of either SQS or CSL.

Additional qualifier definitions for the various sampling events are unknown.

Table A-10a. Historical Sediment Core Analytical Data—Data Evaluation Summary Compared to SQS and CSL
Lockheed Shipyard No. 2 Subsurface Samples

				Sample Locations North of Yard 2							West Waterway	
			Location	**C5**	**C5**	**C5**	**C5**	**C5**	**C7**	**PC1**	**PC2**	**PC2**
			Sample ID	**C5 (0 - 2)**	**C5 (2-5)**	**C5 (5-8)**	**C8 (0 - 2)**	**C8 (2-5)**	**C7 (2-5)**	**PC-1A**	**PC-2A**	**PC-2B**
			Sample Date	**12/1/1991**	**12/1/1991**	**12/1/1991**	**12/1/1991**	**12/1/1991**	**12/1/1991**	**9/1/1992**	**9/1/1992**	**9/1/1992**
			Sample Depth	**0-2 ft**	**2-5 ft**	**5-8 ft**	**0-2 ft**	**2-5 ft**	**2-5 ft**	**0-4 ft**	**0-4 ft**	**4-8 ft**
Parameter	**Units**	**SQS**	**CSL**									
Conventionals												
Total Organic Carbon	%	NA	NA	0.654	0.5702	0.781	0.7418	0.648	0.7004	1.8	0.51	0.56
Metals												
Arsenic	mg/kg	57	93	2.5	2.03	2.1	2.83	2.25	1.68	17	10	8.9
Cadmium	mg/kg	5.1	6.7	0.08	0.06	0.04	0.09	0.07	0.03 U	NR	0.1 U	0.13
Chromium	mg/kg	260	270	16.9	15	13.6	18.3	15.9	9.1	0.22	NR	NR
Copper	mg/kg	390	390	17.9 J	14.4 J	12.9 J	19.9 J	16.1 J	9.2 J	82	29	25
Lead	mg/kg	450	530	4	3 U	3 U	3 U	3 U	3 U	130	39	27
Mercury	mg/kg	0.41	0.59	0.1 U	0.07 U	0.05 U	0.06 U	0.06 U	0.05 U	0.019	0.056	0.16
Silver	mg/kg	6.1	6.1	0.03 U	0.03 U	0.02 U	0.03 U	0.02 U	0.03 U	0.4	0.2 U	0.2 U
Zinc	mg/kg	410	960	29.5	26.1	24.6	39	27.1	19.4	240	93	75
SVOCs												
Naphthalene	mg/kg-OCN	99	170	1.0 J	1.0 U	1 U	1	1.0 U	0.0 J	7.78	3.73	8.75
Acenaphthylene	mg/kg-OCN	66	66	1.0 U	1.0 U	1 U	1 U	1.0 U	1.0 U	1.44	3.73 U	3.39 U
Acenaphthene	mg/kg-OCN	16	57	1.0 U	1.0 U	1 U	1 J	1.0 U	1.0 U	4.39	3.92	3.57
Fluorene	mg/kg-OCN	23	79	1.0 U	1.0 U	1 U	0 J	1.0 U	1.0 U	4.94	4.31	5.18
Phenanthrene	mg/kg-OCN	100	480	1.0	1.0 J	1 U	2	1.0 J	0.0 J	25	27.45	19.64
Anthracene	mg/kg-OCN	220	1200	1.0 J	1.0 U	1 U	1 J	1.0 U	1.0 U	7.22	7.84	8.21
2-Methylnaphthalene	mg/kg-OCN	38	64	1.0 U	1.0 U	1 U	0 M	1.0 U	1.0 U	3.11	3.73 U	3.39 U
Total LPAH	mg/kg-OCN	370	780	3.0 J	1.0 J	1 U	5 J	1.0 J	0.0 J	50.78	47.25	45.36
Fluoranthene	mg/kg-OCN	160	1200	1.0	0.0 J	1 U	2	1.0 U	1.0 U	33.89	50.98	35.71
Pyrene	mg/kg-OCN	1000	1400	2.0	0.0 J	1 U	4	0.0 J	1.0	105.56	145.1	73.21
Benzo(a)anthracene	mg/kg-OCN	110	270	1.0 J	1.0 U	1 U	1 J	1.0 U	1.0 U	19.44	33.33	19.64
Chrysene	mg/kg-OCN	110	460	1.0	1.0 U	1 U	1	1.0 U	1.0 U	29.44	45.1	26.79
Benzofluoranthenes (total)	mg/kg-OCN	230	450	3.0	2.0 U	1 U	4	1.0 U	1.0 U	55	121.57	42.14
Benzo(a)pyrene	mg/kg-OCN	99	210	1.0	1.0 U	1 U	1	1.0 U	1.0 U	25.56	52.94	21.43
Indeno(1,2,3-cd)pyrene	mg/kg-OCN	34	88	1.0	1.0 U	1 U	1	1.0 U	1.0 U	11.67	21.57	11.43
Dibenzo(a,h)anthracene	mg/kg-OCN	12	33	1.0 M	1.0 U	1 U	1 U	0.0 U	1.0 U	2.06	3.92	3.75
Benzo(g,h,i)perylene	mg/kg-OCN	31	78	1.0 M	1.0 U	1 U	0 M	1.0 U	1.0 U	10.56	19.61	11.61
Total HPAH	mg/kg-OCN	960	5300	12.0 JM	0.0 J	1 U	14 JM	0.0 J	1.0 U	293.17	494.12	245.71
1,2-Dichlorobenzene	mg/kg-OCN	2.3	2.3	1.0 U	1.0 U	1 U	1 U	1.0 U	1.0 U	0.17	0.2 U	0.36 U
1,4-Dichlorobenzene	mg/kg-OCN	3.1	9	1.0 U	1.0 U	1 U	1 U	1.0 U	1.0 U	0.17	0.39 U	0.36 U
1,2,4-Trichlorobenzene	mg/kg-OCN	0.81	1.8	***1.0*** U	***1.0*** U	***1*** U	***1*** U	***1.0*** U	***1.0*** U	0.38	***1.1*** U	***1*** U
Hexachlorobenzene	mg/kg-OCN	0.38	2.3	***1.0*** U	***1.0*** U	***1*** U	***1*** U	***1.0*** U	***1.0*** U	**0.78**	***2.16*** U	***1.96*** U
Dimethyl phthalate	mg/kg-OCN	53	53	1.0 U	1.0 U	1 U	1 U	1.0 U	1.0 U	1.28	3.73 U	3.39 U
Diethylphthalate	mg/kg-OCN	61	110	1.0 U	1.0 U	1 U	1 U	1.0 U	1.0 U	1.28	3.73 U	3.39 U
Di-n-butyl phthalate	mg/kg-OCN	220	1700	1.0 U	1.0 U	1 U	1 U	1.0 U	1.0 U	1.28	3.73 U	3.39 U
Butyl benzyl phthalate	mg/kg-OCN	4.9	64	1.0 U	1.0 U	1 U	1 U	1.0 U	1.0 U	1.28	3.73 U	3.39 U
bis(2-ethylhexyl)phthalate	mg/kg-OCN	47	78	2.0	3.0	1 J	1 J	1.0	1.0 U	4.67	15.88	3.39 U
Di-n-octyl phthalate	mg/kg-OCN	58	4500	1.0 U	1.0 U	1 U	1 U	1.0 U	1.0 U	1.28	3.73 U	3.39 U
Dibenzofuran	mg/kg-OCN	15	58	1.0 U	1.0 U	1 U	0 J	1.0 U	1.0 U	3.83	3.73 U	3.39 U
Hexachlorobutadiene	mg/kg-OCN	3.9	6.2	2.0 U	2.0 U	2 U	2 U	2.0 U	2.0 U	1.28	3.73 U	3.39 U
N-Nitrosodiphenylamine	mg/kg-OCN	11	11	1.0 U	1.0 U	1 U	1 U	1.0 U	1.0 U	0.78	2.16 U	1.96 U
Phenol	µg/kg	420	1200	10 M	10 U	10 U	20	10 U	10 U	23 U	19 U	19 U
2-Methylphenol	µg/kg	63	63	10 U	10 U	10 U	0 M	10 U	10 U	11 U	9.3 U	9.3 U
4-Methylphenol	µg/kg	670	670	10 U	10 U	10 U	10 U	10 U	10 U	23 U	19 U	19 U
2,4-Dimethylphenol	µg/kg	29	29	10 U	10 U	10 U	10 U	10 U	10 U	11 U	9.3 U	9.3 U
Pentachlorophenol	µg/kg	360	690	30 U	30 U	30 U	30 U	30 U	20 U	68 U	56 U	56 U
Benzyl alcohol	µg/kg	57	73	10 U	10 U	10 U	10 U	10 U	10 U	14 U	11 U	11 U
Benzoic acid	µg/kg	650	650	20 J	40	20 M	30	20 J	20 J	110 U	93 U	93 U
PCBs												
PCBs (total)	mg/kg-OCN	12	65	12 U	***14*** U	10 U	11 U	12 U	11 U	9.56	**43.14**	6.61 U

Notes:

J The analyte was analyzed for and positively identified, but the associated numerical value is an estimated qua

NA Not available

NR Not reported

U The analyte was undetected at reported detection limit.

Bold concentrations indicate an exceedance of the SQS.

Boxed concentrations indicate an exceedance of the CSL.

Italicized concentrations indicate a detection limit exceedance of either SQS or CSL.

Additional qualifier definitions for the various sampling events are unknown.

Table A-10a. Historical Sediment Core Analytical Data—Data Evaluation Summary Compared to SQS and CSL
Lockheed Shipyard No. 2 Subsurface Samples

				Sample Locations in the West Waterway					
			Location	PC2	SA10	SA10	SA10	SA10	M1
			Sample ID	PC-2C	SA10-A	SA10-B	SA10-C	SA10-D	M1-C
			Sample Date	9/1/1992	9/16/1989	9/16/1989	9/16/1989	9/16/1989	9/12/1989
			Sample Depth	8-12 ft	0-2 ft	2-5 ft	9-10.5 ft	10.5-12 ft	0-7.5 ft
Parameter	**Units**	**SQS**	**CSL**						
Conventionals									
Total Organic Carbon	%	NA	NA	1.1	1.2	1.1	1.5	0.68	0.61
Metals									
Arsenic	mg/kg	57	93	12	28	36	42	28	**110**
Cadmium	mg/kg	5.1	6.7	0.11	0.19 E	0.085 E	0.12 E	0.15 E	1.2 E
Chromium	mg/kg	260	270	NR	78	60 E	59 E	42 E	220 E
Copper	mg/kg	390	390	34	150 E	38 E	39 E	26 E	**1300** E
Lead	mg/kg	450	530	27	63 E	13 E	7 E	5.8 E	**2200** E
Mercury	mg/kg	0.41	0.59	0.085	0.0039	0.0009	0.0005	0.0005 U	0.011
Silver	mg/kg	6.1	6.1	0.2 U	0.87 E	0.64 E	0.12 E	0.27 E	0.75 E
Zinc	mg/kg	410	960	77	170 E	78 E	67 E	58 E	**1700** E
SVOCs									
Naphthalene	mg/kg-OCN	99	170	5.82	25 U	1.55 E	2 U	3.82 U	91.8
Acenaphthylene	mg/kg-OCN	66	66	2.27	5.08 E	1.36 E	2 U	3.82 U	42.62
Acenaphthene	mg/kg-OCN	16	57	2.09	4.92 E	2.73	0.27 E	3.82 U	**262.3**
Fluorene	mg/kg-OCN	23	79	3	5.42 E	3.73	0.4 E	3.82 U	**278.69**
Phenanthrene	mg/kg-OCN	100	480	11.82	65.83	21.82	2.13	3.82 U	**1049.18**
Anthracene	mg/kg-OCN	220	1200	5.73	27.5	7.09	1.4 E	3.82 U	**262.3**
2-Methylnaphthalene	mg/kg-OCN	38	64	1.91 U	24.17 U	0.91 E	2 U	3.82 U	**57.38**
Total LPAH	mg/kg-OCN	370	780	30.73	108.75 E	38.27 E	4.2 E	3.82 U	**1986.89**
Fluoranthene	mg/kg-OCN	160	1200	21.82	133.33	19.09	5.73	3.82 U	**1377.05**
Pyrene	mg/kg-OCN	1000	1400	30	250	44.55	8.67	3.82 U	**1262.3**
Benzo(a)anthracene	mg/kg-OCN	110	270	10	70 U	13.64	2.33	3.82 U	**524.59**
Chrysene	mg/kg-OCN	110	460	13.64	73.33	10	2.2	3.82 U	**475.41**
Benzofluoranthenes (total)	mg/kg-OCN	230	450	16.91	175	25.45	3.13	3.82 U	**737.7**
Benzo(a)pyrene	mg/kg-OCN	99	210	8.09	83.33	10.91	2 U	3.82 U	**360.66**
Indeno(1,2,3-cd)pyrene	mg/kg-OCN	34	88	4	**60.83**	7.55	2 U	3.82 U	**180.33**
Dibenzo(a,h)anthracene	mg/kg-OCN	12	33	1.91 U	**50**	3.36	2 U	3.82 U	**80.33**
Benzo(g,h,i)perylene	mg/kg-OCN	31	78	4	**75**	8.18	2 U	3.82 U	**196.72**
Total HPAH	mg/kg-OCN	960	5300	108.45	900.83	142.73	22.07	3.82 U	**5195.08**
1,2-Dichlorobenzene	mg/kg-OCN	2.3	2.3	0.27 U	***11.67*** U	1.09 U	1 U	1.91 U	***18.03*** U
1,4-Dichlorobenzene	mg/kg-OCN	3.1	9	0.27 U	***24.17*** U	2.18 U	2 U	***3.82*** U	***36.07*** U
1,2,4-Trichlorobenzene	mg/kg-OCN	0.81	1.8	0.56 U	***11.67*** U	***1.09*** U	***1*** U	0.74 U	***18.03*** U
Hexachlorobenzene	mg/kg-OCN	0.38	2.3	***1.09*** U	***24.17*** U	***2.18*** U	***2*** U	***3.82*** U	***36.07*** U
Dimethyl phthalate	mg/kg-OCN	53	53	1.91 U	24.17 U	2.18 U	2 U	3.82 U	36.07 U
Diethylphthalate	mg/kg-OCN	61	110	1.91 U	24.17 U	2.18 U	2 U	3.82 U	36.07 U
Di-n-butyl phthalate	mg/kg-OCN	220	1700	1.91 U	24.17 U	2.18 U	2 U	3.82 U	36.07 U
Butyl benzyl phthalate	mg/kg-OCN	4.9	64	1.91 U	***24.17*** U	2.18 U	2 U	3.82 U	***36.07*** U
bis(2-ethylhexyl)phthalate	mg/kg-OCN	47	78	1.91 U	32.5	7.45	3.4	3.82	**157.38**
Di-n-octyl phthalate	mg/kg-OCN	58	4500	1.91 U	24.17 U	2.45	2 U	3.82 U	36.07 U
Dibenzofuran	mg/kg-OCN	15	58	1.91 U	***25*** U	1.09 E	2 U	3.82 U	**180.33**
Hexachlorobutadiene	mg/kg-OCN	3.9	6.2	1.91 U	***24.17*** U	2.18 U	2 U	3.82 U	***36.07*** U
N-Nitrosodiphenylamine	mg/kg-OCN	11	11	1.09 U	***11.67*** U	1.09 U	1 U	1.91 U	***18.03*** U
Phenol	µg/kg	420	1200	21 U	***580*** U	48 U	60 U	51 U	***440*** U
2-Methylphenol	µg/kg	63	63	10 U	***140*** U	12 U	15 U	10 U	***110*** U
4-Methylphenol	µg/kg	670	670	21 U	290 U	24 U	30 U	26 U	220 U
2,4-Dimethylphenol	µg/kg	29	29	10 U	***140*** U	12 U	15 U	10 U	***110*** U
Pentachlorophenol	µg/kg	360	690	62 U	***1400*** U	119 U	150 U	130 U	***1100*** U
Benzyl alcohol	µg/kg	57	73	12 U	***230*** U	19 U	24 U	10 U	***180*** U
Benzoic acid	µg/kg	650	650	100 U	***1400*** U	119 U	150 U	130 U	***1100*** U
PCBs									
PCBs (total)	mg/kg-OCN	12	65	3.82 U	**21.67**	**20.91**	8 U	***17.65*** U	**426.23**

Notes:

J The analyte was analyzed for and positively identified, but the associated numerical value is an estimated quai

NA Not available

NR Not reported

U The analyte was undetected at reported detection limit.

Bold concentrations indicate an exceedance of the SQS.

Boxed concentrations indicate an exceedance of the CSL.

Italicized concentrations indicate a detection limit exceedance of either SQS or CSL.

Additional qualifier definitions for the various sampling events are unknown.

Table A-10b. Historical Sediment Core Analytical Data—Data Evaluation Summary Compared to LAET and 2LAET

Lockheed Shipyard No. 2 Subsurface Samples

				Sample Locations within Yard 2												
			Location	**D5**	**SB1**	**D4**	**D2**	**D3**	**D3**	**D3**	**SA8**	**SA8**	**SA9**	**SA9**	**SA5**	**SA6**
			Sample ID	**D5-D**	**SB1-D**	**D4-D**	**D2-D**	**D3-B**	**D3-C**	**D3-D**	**SA8-A**	**SA8-C**	**SA9-C**	**SA9-D**	**SA5-D**	**SA6-C**
			Sample Date	**9/13/1989**	**9/12/1989**	**9/8/1989**	**9/7/1989**	**9/5/1989**	**9/5/1989**	**9/5/1989**	**9/1/1989**	**9/1/1989**	**9/1/1989**	**9/1/1989**	**8/31/1989**	**8/31/1989**
			Sample Depth	**6-12 ft**	**7.5-13.5 ft**	**0-9.5 ft**	**4-10.5 ft**	**2-4.5 ft**	**10.5-12.5 ft**	**13-15 ft**	**0-2 ft**	**2-3.5 ft**	**9-10.5 ft**	**10.5-12 ft**	**4.5-7.5 ft**	**0-1.5 ft**
Parameter	**Units**	**LAET**	**2LAET**													
Conventionals																
Total Organic Carbon	%	NA	NA	0.36	0.37	0.41	0.4	0.28	0.08	0.23	0.34	0.16	0.34	0.25	0.25	0.35
Metals																
Arsenic	mg/kg	57	93	48	**82**	47	50	50	23	26	49	44	23	20	38	43
Cadmium	mg/kg	5.1	6.7	0.27 E	0.98 E	0.089 E	0.11 E	0.11 E	0.067 E	0.053 E	0.39 E	0.11 E	0.17 E	0.11 E	0.091 E	0.13 E
Chromium	mg/kg	260	270	2.2 E	110 E	14 E	32 E	62	34 E	36 E	62 E	53 E	38 E	44 E	34 E	22 E
Copper	mg/kg	390	390	170 E	**700** E	43 E	45 E	68 E	26 E	22 E	250 E	110 E	71 E	62 E	40 E	160 E
Lead	mg/kg	450	530	140 E	**680** E	14 E	5.9 E	28 E	11 E	6.7 E	140 E	32 E	61 E	15 E	13 E	46 E
Mercury	mg/kg	0.41	0.59	0.0008	0.005	0.0005 U	0.0005 U	0.0005 U	0.0005 U	0.0005 U	0.0033	0.0017	0.001	0.0005 U	0.0005 U	0.0005 U
Silver	mg/kg	6.1	6.1	0.1 U	0.67 E	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.16 E	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Zinc	mg/kg	410	960	380 E	**1600** E	56 E	55 E	140 E	56 E	57 E	250 E	110 E	98 E	72 E	110 E	160 E
SVOCs																
Naphthalene	µg/kg	2100	2400	611.11	1400	26	24 U	43	24 U	NR	270 U	33	24	47	62	25 U
Acenaphthylene	µg/kg	1300	1300	69.44 U	180 E	25 U	24 U	24 U	24 U	NR	290	36	24 E	61	25 U	25 E
Acenaphthene	µg/kg	500	730	388.89	**1300**	16 E	24 U	23 E	24 U	NR	300	34	17 E	45	23 E	15 E
Fluorene	µg/kg	540	1000	305.56	**1500**	22 E	24 U	24	24 U	NR	**720**	52	32	110	21 E	28
Phenanthrene	µg/kg	1500	5400	1055.56	**7200**	110	24 U	120	19 E	NR	**4000**	480	320	1000	75	200
Anthracene	µg/kg	960	4400	305.56	**2200**	57	24 U	34	24 U	NR	**1100**	86	63	89	24 E	61
2-Methylnaphthalene	µg/kg	670	1400	175	220 E	15 E	24 U	14 E	24 U	NR	270 U	10 E	7 E	20 E	15 E	8 E
Total LPAH	µg/kg	5200	13000	2666.67	**13780** E	231 E	24 U	244 E	19 E	NR	**6410**	721	480 E	1352	205 E	329 E
Fluoranthene	µg/kg	1700	2500	1222.22	**9500**	240	24 U	160	24 U	NR	**5100**	590	500	850	120	380
Pyrene	µg/kg	2600	3300	861.11	**8100**	220	12 E	240	24 U	NR	**8400**	1400	750	930	140 E	410 E
Benzo(a)anthracene	µg/kg	1300	1600	305.56	**3400**	60	40	58	24 U	NR	**2500**	330	220	270	37	150
Chrysene	µg/kg	1400	2800	333.33	**3200**	85	24 U	71	24 U	NR	**2200**	310	200	300	40	170
Benzofluoranthenes (total)	µg/kg	3200	3600	500	**4600**	170	24 U	120	24 U	NR	**4400**	650	300	410	53	250
Benzo(a)pyrene	µg/kg	1600	3000	272.22	**2400**	140	24 U	40	24 U	NR	**2200**	320	160	230	45	140
Indeno(1,2,3-cd)pyrene	µg/kg	600	690	122.22	**1300**	60	24 U	31	24 U	NR	**1400**	210	99	140	25 U	77
Dibenzo(a,h)anthracene	µg/kg	230	540	72.22	**530**	40	24 U	17 E	24 U	NR	**860**	93	43	55	25 U	32
Benzo(g,h,i)perylene	µg/kg	670	720	113.89	**1400**	67	24 U	33	24 U	NR	**1600**	230	120	160	25 U	89
Total HPAH	µg/kg	12000	17000	3802.78	**34430**	1082	52 E	770 E	24 U	NR	**28660**	4133	2392	3345	435 E	1698 E
1,2-Dichlorobenzene	µg/kg	35	50	***36.11*** U	***110*** U	13 U	12 U	12 U	12 U	NR	***140*** U	13 U	12 U	12 U	12 U	13 U
1,4-Dichlorobenzene	µg/kg	110	120	69.44 U	***230*** U	25 U	24 U	24 U	24 U	NR	***270*** U	26 U	24 U	24 U	25 U	25 U
1,2,4-Trichlorobenzene	µg/kg	31	51	***33.33*** U	***110*** U	1 U	12 U	12 U	12 U	NR	***140*** U	13 U	12 U	12 U	12 U	13 U
Hexachlorobenzene	µg/kg	22	70	***69.44*** U	***230*** U	***25*** U	***24*** U	***24*** U	***24*** U	NR	***270*** U	***26*** U	***24*** U	***24*** U	***25*** U	***25*** U
Dimethyl phthalate	µg/kg	71	160	69.44 U	***230*** U	25 U	24 U	24 U	24 U	NR	***270*** U	26 U	24 U	24 U	25 U	25 U
Diethylphthalate	µg/kg	200	200	69.44 U	***230*** U	25 U	24 U	24 U	24 U	NR	***270*** U	26 U	24 U	24 U	25 U	25 U
Di-n-butyl phthalate	µg/kg	1400	1400	69.44 U	230 U	25 U	24 U	24 U	24 U	NR	270 U	26 U	24 U	17	25 U	25 U
Butyl benzyl phthalate	µg/kg	63	900	***69.44*** U	***230*** U	25 U	24 U	24 U	24 U	NR	***270*** U	26 U	24 U	24 U	25 U	25 U
bis(2-ethylhexyl)phthalate	µg/kg	1300	1900	169.44	**3000**	25 U	24 U	150	69	NR	**1400**	150	77	200	43	75
Di-n-octyl phthalate	µg/kg	6200	6200	69.44 U	230 U	140	60	79	160	NR	270 U	36	26 E	30 E	52	47
Dibenzofuran	µg/kg	540	700	236.11	**1000**	15 E	24 U	19 E	24 U	NR	300	31	18 E	80	16 E	13 E
Hexachlorobutadiene	µg/kg	11	120	***69.44*** U	***230*** U	***18*** U	***24*** U	***24*** U	***24*** U	NR	***270*** U	***26*** U	***24*** U	***24*** U	***25*** U	***25*** U
N-Nitrosodiphenylamine	µg/kg	28	40	***36.11*** U	***110*** U	13 U	12 U	12 U	12 U	NR	***140*** U	13 U	12 U	12 U	12 U	13 U
Phenol	µg/kg	420	1200	***500*** U	***460*** U	50 U	49 U	47 U	48 U	NR	***550*** U	52 U	49 U	47 U	50 U	51 U
2-Methylphenol	µg/kg	63	72	***130*** U	***110*** U	10 U	12 U	12 U	12 U	NR	***140*** U	13 U	12 U	12 U	12 U	13 U
4-Methylphenol	µg/kg	670	1,800	250 U	230 U	25 U	24 U	24 U	24 U	NR	140 U	26 U	24 U	7 E	25 U	25 U
2,4-Dimethylphenol	µg/kg	29	72	***130*** U	***110*** U	10 U	12 U	12 U	12 U	NR	***140*** U	13 U	12 U	12 U	12 U	13 U
Pentachlorophenol	µg/kg	360	690	***1300*** U	***1100*** U	130 U	120 U	120 U	120 U	NR	***1400*** U	130 U	120 U	120 U	120 U	130 U
Benzyl alcohol	µg/kg	57	73	***200*** U	***180*** U	15 U	20 U	19 U	19 U	NR	***220*** U	21 U	20 U	19 U	20 U	20 U
Benzoic acid	µg/kg	650	650	***1300*** U	***1100*** U	8 E	120 U	120 U	120 U	NR	***1400*** U	130 U	120 U	120 U	120 U	130 U
PCBs																
PCBs (total)	µg/kg	130	1000	127.78	**2160**	93	60 U	**160**	120 U	120 U	**1090**	**235**	**210**	54	120 U	***135*** U

Notes:

J The analyte was analyzed for and positively identified, but the associated numerical value is an estimated quantity.

NA Not available

NR Not reported

U The analyte was undetected at reported detection limit.

Bold concentrations indicate an exceedance of the LAET.

Boxed concentrations indicate an exceedance of the 2LAET.

Italicized concentrations indicate a detection limit exceedance of either LAET or 2LAET.

Additional qualifier definitions for the various sampling events are unknown.

Table A-10b. Historical Sediment Core Analytical Data—Data Evaluation Summary Compared to LAET and 2LAET

Lockheed Shipyard No. 2 Subsurface Samples

							North of Yard 2		West Waterway		
			Location	**SA6**	**SA7**	**SA3**	**C7**	**C7**	**PC1**	**PC1**	**M1**
			Sample ID	**SA6-D**	**SA7-B/C**	**SA3-C**	**C7 (0 - 2)**	**C7 (5-8)**	**PC-1B**	**PC-1C**	**M1-D**
			Sample Date	**8/31/1989**	**8/31/1989**	**8/30/1989**	**12/1/1991**	**12/1/1991**	**9/1/1992**	**9/1/1992**	**9/12/1989**
			Sample Depth	**1.5-3 ft**	**2-6 ft**	**5-7.5 ft**	**0-2 ft**	**5-8 ft**	**4-8 ft**	**8-12 ft**	**7.5-12 ft**
Parameter	**Units**	**LAET**	**2LAET**								
Conventionals											
Total Organic Carbon	%	NA	NA	0.26	0.38	0.48	0.1931	0.4234	0.43	0.35	0.19
Metals											
Arsenic	mg/kg	57	93	28	**58**	3.9	1.36	1.64	6.3	5.8	**64**
Cadmium	mg/kg	5.1	6.7	0.079 E	0.008 E	0.14 E	0.02 U	0.02 U	NR	NR	0.11 E
Chromium	mg/kg	260	270	20 E	19 E	22 E	10	11.1	0.11	0.1 U	2.1 E
Copper	mg/kg	390	390	50 E	61 E	38 E	10.1 J	8.1 J	24	22	100 E
Lead	mg/kg	450	530	6 E	13 E	38 E	3 U	2 U	26	26	71 E
Mercury	mg/kg	0.41	0.59	0.0005	0.0005 U	0.0005 U	0.06 U	0.05 U	0.034	0.034	0.0007
Silver	mg/kg	6.1	6.1	0.1 U	0.1 U	0.1 U	0.02 U	0.02 U	0.2 U	0.2 U	0.1 U
Zinc	mg/kg	410	960	71 E	85 E	65 E	20.3	20	81	79	110 E
SVOCs											
Naphthalene	µg/kg	2100	2400	22 U	21 E	3.54 E	5.793 U	4.234 U	125.58	5.43 U	24
Acenaphthylene	µg/kg	1300	1300	22 U	24 U	5.21 U	5.793 U	4.234 U	4.65 U	5.43 U	13 E
Acenaphthene	µg/kg	500	730	22 U	8 E	2.5 E	5.793 U	4.234 U	10	5.43 U	130
Fluorene	µg/kg	540	1000	22 U	8 E	5.21 U	5.793 U	4.234 U	8.14	5.43 U	90
Phenanthrene	µg/kg	1500	5400	22 U	64	11.04	5.793 J	4.234 J	20.47	5.43 U	540
Anthracene	µg/kg	960	4400	22 U	20 E	3.33 E	1.931 J	4.234 U	6.05	5.43 U	140
2-Methylnaphthalene	µg/kg	670	1400	22 U	10 E	5.21 U	5.793 U	4.234 U	9.07	5.43 U	9 E
Total LPAH	µg/kg	5200	13000	22 U	121 E	20.42 E	7.724 J	4.234 J	170.23	5.43 U	937 E
Fluoranthene	µg/kg	1700	2500	46	96	18.75	11.586	4.234 J	13.49	10.86	750
Pyrene	µg/kg	2600	3300	48 E	150	20.62 E	11.586	16.936	16.05	12.57	810
Benzo(a)anthracene	µg/kg	1300	1600	22 U	54	6.25	5.793 J	4.234 U	4.65 U	5.43 U	310
Chrysene	µg/kg	1400	2800	20 E	41	7.5	9.655	4.234 U	4.65 U	5.43 U	350
Benzofluoranthenes (total)	µg/kg	3200	3600	22 U	80	10.62	13.517	4.234 J	4.65 U	5.43 U	430
Benzo(a)pyrene	µg/kg	1600	3000	22 U	40	4.38 E	5.793	4.234 U	4.65 U	5.43 U	230
Indeno(1,2,3-cd)pyrene	µg/kg	600	690	22 U	21 E	1.67 E	1.931 J	4.234 U	4.65 U	5.43 U	140
Dibenzo(a,h)anthracene	µg/kg	230	540	22 U	15 E	0.62 E	5.793 U	4.234 U	4.65 U	5.43 U	52
Benzo(g,h,i)perylene	µg/kg	670	720	22 U	22 E	1.67 E	1.931 J	4.234 U	4.65 U	5.43 U	160
Total HPAH	µg/kg	12000	17000	114 E	519 E	72.08 E	61.792 J	25.404 J	29.53	23.43	3232
1,2-Dichlorobenzene	µg/kg	35	50	11 U	12 U	2.5 U	5.793 U	4.234 U	0.7 U	0.86 U	12 U
1,4-Dichlorobenzene	µg/kg	110	120	22 U	24 U	5.21 U	5.793 U	4.234 U	0.7 U	0.86 U	24 U
1,2,4-Trichlorobenzene	µg/kg	31	51	11 U	12 U	1.46 U	5.793 U	4.234 U	1.37 U	1.66 U	12 U
Hexachlorobenzene	µg/kg	22	70	22 U	***24*** U	5.21 U	5.793 U	4.234 U	2.79 U	3.43 U	***24*** U
Dimethyl phthalate	µg/kg	71	160	22 U	24 U	5.21 U	5.793 U	4.234 U	4.65 U	5.43 U	24 U
Diethylphthalate	µg/kg	200	200	22 U	24 U	5.21 U	5.793 U	4.234 U	4.65 U	5.43 U	24 U
Di-n-butyl phthalate	µg/kg	1400	1400	22 U	24 U	5.21 U	5.793 U	4.234 U	4.65 U	5.43 U	20 E
Butyl benzyl phthalate	µg/kg	63	900	22 U	24 U	5.21 U	3.862 M	4.234 U	4.65 U	5.43 U	24 U
bis(2-ethylhexyl)phthalate	µg/kg	1300	1900	22 U	31	10.83	5.793 J	4.234 J	4.65 U	5.43 U	210
Di-n-octyl phthalate	µg/kg	6200	6200	22 U	24 U	5.21 U	5.793 U	4.234 U	4.65 U	5.43 U	130
Dibenzofuran	µg/kg	540	700	22 U	8 E	1.25 E	5.793 U	4.234 U	5.81	5.43 U	54
Hexachlorobutadiene	µg/kg	11	120	***22*** U	***24*** U	5.21 U	***11.586*** U	***12.702*** U	4.65 U	5.43 U	***24*** U
N-Nitrosodiphenylamine	µg/kg	28	40	11 U	12 U	4.58 U	5.793 U	4.234 U	2.79 U	3.43 U	12 U
Phenol	µg/kg	420	1200	44 U	73 E	49 U	0 M	10 U	20 U	19 U	47 U
2-Methylphenol	µg/kg	63	72	11 U	12 U	9 U	10 U	10 U	9.9 U	9.6 U	12 U
4-Methylphenol	µg/kg	670	1,800	22 U	24 U	25 U	10 U	10 U	20 U	19 U	24 U
2,4-Dimethylphenol	µg/kg	29	72	11 U	12 U	7 U	10 U	10 U	9.9 U	9.6 U	12 U
Pentachlorophenol	µg/kg	360	690	110 U	120 U	120 U	20 U	20 U	59 U	58 U	120 U
Benzyl alcohol	µg/kg	57	73	17 U	19 U	15 U	10 U	10 U	12 U	12 U	19 U
Benzoic acid	µg/kg	650	650	110 U	120 U	120 U	20 J	30	99 U	96 U	120 U
PCBs											
PCBs (total)	µg/kg	130	1000	120 U	125	25 U	79.171 U	80.446 U	9.3 U	11.14 U	***200*** U

Notes:

J The analyte was analyzed for and positively identified, but the associated numerical value is an estim

NA Not available

NR Not reported

U The analyte was undetected at reported detection limit.

Bold concentrations indicate an exceedance of the LAET.

Boxed concentrations indicate an exceedance of the 2LAET.

Italicized concentrations indicate a detection limit exceedance of either LAET or 2LAET.

Additional qualifier definitions for the various sampling events are unknown.

Table A-11a. Historical Surface Sediment Analytical Data—Data Evaluation Summary Compared to SQS and CSL

Lockheed Shipyard No. 2 Surface Samples

Parameter	Units	SQS	CSL	Sample Locations within Yard 2													
			Location	HC-03-16	HC-03-17	HC-03-18	HC-03-19	HC-03-01	HC-03-02	HC-03-03	HC-03-04	HC-03-05	HC-03-06	HC-03-07	HC-03-08	HC-03-09	HC-03-10
			Sample ID	HC-03-16	HC-03-17	HC-03-18	HC-03-19	HC-03-01	HC-03-02	HC-03-03	HC-03-04	HC-03-05	HC-03-06	HC-03-07	HC-03-08	HC-03-09	HC-03-10
			Sample Date	11/11/2003	11/11/2003	11/11/2003	11/11/2003	9/27/2003	9/27/2003	9/27/2003	9/27/2003	9/27/2003	9/27/2003	9/27/2003	9/27/2003	9/27/2003	9/27/2003
			Sample Depth	0-10 cm	0-10 cm	0-10 cm	0-10 cm	0-10 cm	0-10 cm	0-10 cm	0-10 cm	0-10 cm	0-10 cm	0-10 cm	0-10 cm	0-10 cm	0-10 cm
Conventionals																	
Total Organic Carbon	%	NA	NA	1.46	1.3	1.23	1.07	0.73	2.05	2.26	1.88	0.85	1.06	2.27	1.92	0.64	1.66
Metals																	
Arsenic	mg/kg	57	93	10.2	16.5	50.3	10.7	34.8	8.7	32	20.5	18.9	25.7	32.6	20.7	10.4	25.2
Cadmium	mg/kg	5.1	6.7	0.24	0.29	0.42	0.13	0.44	0.35	1.05	0.62	0.24	0.31	0.44	0.61	0.35	0.42
Chromium	mg/kg	260	270	30.2	31.4	89.9	20	166	23.7	196	59.4	35.8	67.6	51.3	46.5	**309**	39.8
Copper	mg/kg	390	390	61.8	169	**463**	71.2	**825**	46.7	204	151	159	111	374	164	123	177
Lead	mg/kg	450	530	45.2	49.1	226	47.3	93	52.6	144	85.8	55.2	76.8	157	118	57.8	109
Mercury	mg/kg	0.41	0.59	0.26	0.35	**0.83**	**0.48**	0.08	0.25	0.29	0.21	0.08	0.11	**0.7**	**0.57**	0.32	**0.63**
Silver	mg/kg	6.1	6.1	0.25	0.32	0.47	0.21	0.4	0.23	0.4	0.2	0.17	1.31	0.41	0.38	0.12	0.37
Zinc	mg/kg	410	960	78.8	120	**445**	84	356	73.7	**505**	238	202	140	306	175	202	173
SVOCs																	
Naphthalene	mg/kg-OCN	99	170	3.84	1.38	8.05	1.4	12.88	15.61	11.95	2.77	3.06	3.11	2.95	3.12	1.36 J	3.07 J
Acenaphthylene	mg/kg-OCN	66	66	1.58	2.69	10.57	1.5	6.16 J	3.46	7.52	2.82	3.65	2.26	5.29	6.77	3.12	5.3
Acenaphthene	mg/kg-OCN	16	57	3.15	1.69	**16.26**	1.4	9.04	8.29	10.62	2.5	3.06	2.45	4.32	4.79	2.97 J	4.58
Fluorene	mg/kg-OCN	23	79	3.22	2.62	**29.27**	1.87	16.44	9.76	13.72	4.52	4.71	3.4	6.17	6.77	3.59	6.63
Phenanthrene	mg/kg-OCN	100	480	13.01	28.46	**138.21**	11.21	75.34	35.61	44.25	19.15	31.76	17.92	39.21	38.02	25	42.17
Anthracene	mg/kg-OCN	220	1200	5.82	9.23	138.21	4.67	39.73	16.59	26.99	11.7	11.76	8.96	14.54	18.23	8.28	15.66
2-Methylnaphthalene	mg/kg-OCN	38	64	1.16	0.57 J	5.12	0.6 J	3.84 J	5.37	3.89	1.01 J	1.18 J	1.13 J	1.54 J	1.61 J	0.72 J	1.57 J
Total LPAH	mg/kg-OCN	370	780	30.62	46.08	340.57	22.06	159.59 J	89.32	115.04	43.46	58	38.11	72.47	77.71	44.33 J	77.41 J
Fluoranthene	mg/kg-OCN	160	1200	17.81	76.92	**455.28**	19.63	**178.08**	42.44	61.95	37.23	74.12	43.4	70.48	67.71	65.62	72.29
Pyrene	mg/kg-OCN	1000	1400	17.81	55.38	390.24	17.76	126.03	46.83	79.65	35.11	61.18	44.34	88.11	72.92	54.69	84.34
Benzo(a)anthracene	mg/kg-OCN	110	270	8.22	20	**211.38**	12.15	91.78	20.49	42.04	20.74	22.35	16.98	37.89	40.62	21.88	41.57
Chrysene	mg/kg-OCN	110	460	12.33	44.62	**276.42**	15.89	**150.68**	36.59	79.65	43.09	45.88	29.25	57.27	67.71	48.44	66.27
Benzofluoranthenes (total)	mg/kg-OCN	230	450	21.92	52.31	**373.98**	28.04	172.6	59.51	119.47	52.66	50.59	36.79	90.75	107.81	53.12	99.4
Benzo(a)pyrene	mg/kg-OCN	99	210	10.27	20.77	**186.99**	14.95	68.49	26.83	53.1	20.74	20	15.09	44.05	48.44	20.31	49.4
Indeno(1,2,3-cd)pyrene	mg/kg-OCN	34	88	6.85	13.08	**97.56**	10.28	**35.62**	15.12	28.76	12.77	12.94	9.43	27.75	29.17	12.19	30.12
Dibenzo(a,h)anthracene	mg/kg-OCN	12	33	1.85	3.38	**24.39**	2.52	10	4.44	7.96	3.62	3.29	2.36	7.05	7.81	3.91	7.83
Benzo(g,h,i)perylene	mg/kg-OCN	31	78	6.16	11.54	**81.3**	9.07	**31.51**	13.66	23.89	11.17	11.06	7.36	23.79	26.56	6.72	27.11
Total HPAH	mg/kg-OCN	960	5300	103.22	298	**2097.56**	130.28	864.79	265.9	496.46	237.13	301.41	205	447.14	468.75	286.88	478.31
1,2-Dichlorobenzene	mg/kg-OCN	2.3	2.3	0.53 U	0.62 U	0.98 U	0.67 U	1.22 U	0.98 U	0.58 U	1.06 U	0.42 U	1.89 U	0.62 U	0.99 U	0.55 U	0.78 U
1,4-Dichlorobenzene	mg/kg-OCN	3.1	9	0.53 U	0.62 U	1.38 U	0.67 U	1.78 U	0.98 U	2.39 U	1.06 U	2.35 U	1.89 U	2.64 U	2.97 U	0.8 U	1.14 U
1,2,4-Trichlorobenzene	mg/kg-OCN	0.81	1.8	0.53 U	0.62 U	***1.06*** U	0.67 U	***1.22*** U	0.24 U	0.66 U	0.26 U	0.48 U	0.42 U	0.7 U	0.78 U	0.62 U	***0.9*** U
Hexachlorobenzene	mg/kg-OCN	0.38	2.3	0.23 U	0.27 U	***1.46*** U	0.29 U	***2.05*** U	0.34 U	***0.88*** U	0.35 U	***0.68*** U	***0.58*** U	***0.97*** U	***1.09*** U	***0.88*** U	***1.27*** U
Dimethyl phthalate	mg/kg-OCN	53	53	0.53 U	0.62 U	3.5 U	0.67 U	6.85 U	0.98 U	2.39 U	1.06 U	2.35 U	1.89 U	2.64 U	2.97 U	3.12 U	3.43 U
Diethylphthalate	mg/kg-OCN	61	110	0.53 U	0.62 U	3.5 U	0.67 U	6.85 U	0.98 U	2.39 U	1.06 U	2.35 U	1.89 U	2.64 U	2.97 U	3.12 U	3.43 U
Di-n-butyl phthalate	mg/kg-OCN	220	1700	0.66 U	3.69	6.99 U	1.4 U	6.85 U	0.43 J	2.39 U	0.49 J	1.18 J	0.94 J	2.64 U	1.56 J	1.72 J	2.53 J
Butyl benzyl phthalate	mg/kg-OCN	4.9	64	0.55	0.85	3.33 J	2.34	1.51 U	0.98 U	0.84 J	0.96 J	0.91 J	1.89 U	1.98 J	1.51 J	1.88 J	1.63 J
bis(2-ethylhexyl)phthalate	mg/kg-OCN	47	78	4.32 J	10.77 J	**72.36** J	14.02 J	43.84 J	4.88 J	10.62 J	5.21 J	6.59 J	8.3 J	18.06 J	15.1 J	12.34 J	24.7 J
Di-n-octyl phthalate	mg/kg-OCN	58	4500	0.53 U	0.62 U	3.5 U	0.67 U	6.85 U	0.98 U	2.39 U	1.06 U	2.35 U	1.89 U	2.64 U	2.97 U	3.12 U	3.43 U
Dibenzofuran	mg/kg-OCN	15	58	2.33	1.38	12.2	1.03	8.49	7.32	8.41	2.07	2.71	1.98	2.51 J	2.81 J	1.72 J	2.65 J
Hexachlorobutadiene	mg/kg-OCN	3.9	6.2	0.53 U	0.62 U	3.5 U	0.67 U	1.32 U	0.98 U	2.39 U	1.06 U	2.35 U	1.89 U	2.64 U	2.97 U	3.12 U	3.43 U
N-Nitrosodiphenylamine	mg/kg-OCN	11	11	0.53 U	0.62 U	3.5 U	0.67 U	6.85 U	0.98 U	2.39 U	1.06 U	2.35 U	1.89 U	2.64 U	2.97 U	3.12 U	3.43 U
Phenol	µg/kg	420	1200	51	47	18 J	33	150 U	85	170 U	60 U	100	49 J	180 U	180	60 U	140 J
2-Methylphenol	µg/kg	63	63	7.7 U	8.1 U	43 U	7.2 U	50 U	20 U	54 U	20 U	20 U	20 U	60 U	57 U	20 U	57 U
4-Methylphenol	µg/kg	670	670	23	21	27 J	8.4	50 U	62	54 U	20 U	49	36	60 U	32 J	20 U	85
2,4-Dimethylphenol	µg/kg	29	29	8.5 U	9.1 U	***47*** U	8 U	***38*** U	19 U	***53*** U	18 U	15 U	17 U	***58*** U	***55*** U	15 U	***55*** U
Pentachlorophenol	µg/kg	360	690	77 U	81 U	**380** J	65 J	250 U	100 U	270 U	100 U	100 U	100 U	250 J	210 J	70 J	240 J
Benzyl alcohol	µg/kg	57	73	7.7 U	8.1 U	43 U	7.2 U	50 U	20 U	54 U	20 U	20 U	20 U	39 U	37 U	20 U	37 U
Benzoic acid	µg/kg	650	650	160 U	170 U	***820*** U	150 U	***660*** U	400 U	***920*** U	400 U	400 U	400 U	***1000*** U	***960*** U	400 U	**960** U
PCBs																	
PCBs (total)	mg/kg-OCN	12	65	**20.55**	**21.54**	**243.9**	**33.64**	**24.52**	6.63	**14.16**	9.79	8	**67.92**	**37.89**	**27.08**	**32.03**	**26.51**
Organometallics																	
TBT*	mg/kg-OCN	76	76	1.4	14.6	**122**	3.9	16.4	2.3	3.7	5.3	4.0	2.5	**79.3**	35.4	3.6	**84.3**

Notes:

* TBT concentrations are compared to the West Waterway Confirmational Number.

** The TBT concentration for sample EBB01C is reported in ug/kg-dry weight rather than mg/kg-OCN

J The analyte was analyzed for and positively identified, but the associated numerical value is an estimated quantity.

NA Not available

NR Not reported

U The analyte was undetected at reported detection limit.

Bold concentrations indicate an exceedance of the SQS.

Boxed concentrations indicate an exceedance of the CSL.

Italicized concentrations indicate a detection limit exceedance of either SQS or CSL.

Additional qualifier definitions for the various sampling events are unknown.

Table A-11a. Historical Surface Sediment Analytical Data—Data Evaluation Summary Compared to SQS and CSL

Lockheed Shipyard No. 2 Surface Samples

				Sample Locations within Yard 2													
			Location	**HC-03-11**	**HC-03-12**	**HC-03-07**	**HC-03-03**	**30-1-197**	**30-1-197**	**30-3-199**	**EB117**	**EB118**	**EB119**	**EB115**	**EB116**	**EB088**	**N-11**
			Sample ID	**HC-03-11**	**HC-03-12**	**HC-03-14**	**HC-03-15**	**197-1**	**197-2**	**199-1**	**SD3-EB117-0000**	**SD3-EB118-0000**	**SD3-EB119-0000**	**SD3-EB115-0000**	**SD3-EB116-0000**	**SD2-EB88-0000**	**N-11-10-9**
			Sample Date	**9/27/2003**	**9/27/2003**	**9/27/2003**	**9/27/2003**	**6/24/1998**	**6/24/1998**	**6/24/1998**	**7/29/1997**	**7/29/1997**	**7/29/1997**	**7/29/1997**	**7/29/1997**	**1996**	**10/9/1991**
			Sample Depth	**0-10 cm**	**0-10 cm**	**0-10 cm**	**0-10 cm**	**0-2 cm**	**0-2 cm**	**0-2 cm**	**0-10 cm**	**0-10 cm**	**0-10 cm**	**0-10 cm**	**0-10 cm**	**0-10 cm**	**0-2 cm**
Parameter	**Units**	**SQS**	**CSL**														
Conventionals																	
Total Organic Carbon	%	NA	NA	1.01	1.68	2.32	2.62	0.68	0.7	1.7	2	0.85	0.76	2.1	2.8	1.4	0.743
Metals																	
Arsenic	mg/kg	57	93	9.8	53.6	34.4	29.5	**102**	**713**	10.8	NR	NR	NR	NR	NR	NR	29.9
Cadmium	mg/kg	5.1	6.7	0.29	0.55	0.52	0.86	0.3	1.6	0.26	NR	NR	NR	NR	NR	NR	**6.5**
Chromium	mg/kg	260	270	33.7	35.8	61.2	155	49	203	30.7	NR	NR	NR	NR	NR	NR	NR
Copper	mg/kg	390	390	50.6	380	**455**	151	155	349	71.8	NR	NR	NR	NR	NR	NR	331
Lead	mg/kg	450	530	35.7	146	162	120	128	**453**	45.9	NR	NR	NR	NR	NR	NR	99.3
Mercury	mg/kg	0.41	0.59	0.1	**0.43**	**0.96**	0.27	0.1	0.11	0.28	NR	NR	NR	NR	NR	NR	**0.77**
Silver	mg/kg	6.1	6.1	0.18	0.43	0.42	0.45	0.31	1 U	0.33	NR	NR	NR	NR	NR	NR	NR
Zinc	mg/kg	410	960	73.7	403	372	270	322	**1760**	92.2	NR	NR	NR	NR	NR	NR	270
SVOCs																	
Naphthalene	mg/kg-OCN	99	170	3.07	6.55	2.03 J	20.61	20.15	18.86	67.06	10.50	4.45	15.92	**126.19**	**166.07**	**168.57**	9.15 E
Acenaphthylene	mg/kg-OCN	66	66	3.47	10.12	3.92	8.4	5.44	5.14	6.59	3.06	1.48	4.41	12.38	7.93	12.07	5.11 E
Acenaphthene	mg/kg-OCN	16	57	2.57	10.12	3.62	11.45	**17.21**	11.57	**21.12**	5.55	3.58	13.00	**63.81**	**45.00**	**65.36**	**20.19** E
Fluorene	mg/kg-OCN	23	79	3.76	13.1	4.74	15.27	22.06	13.86	19.71	7.40	6.05	12.38	**191.90**	**49.29**	**53.64**	**26.92** E
Phenanthrene	mg/kg-OCN	100	480	16.83	77.38	37.07	53.44	96.03	62.86	61.18	34.00	28.94	66.71	**647.62**	**252.86**	**147.14**	**201.88** E
Anthracene	mg/kg-OCN	220	1200	9.9	31.55	12.07	27.86	32.06	22.86	26.18	14.40	7.68	21.32	**576.19**	58.21	60.64	59.22 E
2-Methylnaphthalene	mg/kg-OCN	38	64	1.19 J	3.21 J	1.03 J	6.11	9.56	7	15	3.32	7.35	5.39	28.10	27.75	**42.21**	6.33 E
Total LPAH	mg/kg-OCN	370	780	39.6	148.81	63.45 J	137.02	192.94	135.14	201.82	74.91	52.18	133.74	**1618.10**	**579.36**	**507.43**	322.48 E
Fluoranthene	mg/kg-OCN	160	1200	33.66	**172.62**	68.97	68.7	110.88	84.57	52	**252.50**	47.41	100.79	**952.38**	**275.36**	151.43	**417.23** E
Pyrene	mg/kg-OCN	1000	1400	31.68	190.48	68.97	83.97	113.53	87.71	62.94	174.50	43.88	123.16	823.81	410.71	171.43	349.93 E
Benzo(a)anthracene	mg/kg-OCN	110	270	19.8	71.43	35.34	41.98	50	42	31.12	41.75	16.00	43.42	**315.71**	103.57	42.71	**228.8** E
Chrysene	mg/kg-OCN	110	460	37.62	**119.05**	56.03	68.7	80.88	64	46.24	96.00	30.82	63.29	**428.57**	**163.57**	60.93	**255.72** E
Benzofluoranthenes (total)	mg/kg-OCN	230	450	50.5	184.52	85.78	122.14	104.26	84.14	87.65	75.00	41.27	123.68	**472.38**	**281.14**	100.79	**417.23** E
Benzo(a)pyrene	mg/kg-OCN	99	210	21.78	89.29	40.09	53.44	45.74	37.57	40.76	32.50	18.47	70.53	**260.95**	**151.79**	43.79	**161.51** E
Indeno(1,2,3-cd)pyrene	mg/kg-OCN	34	88	13.86	**52.38**	25.86	27.1	24.85	20.71	21.41	14.30	10.68	**36.84**	**64.76**	**38.21**	19.86	**59.22** E
Dibenzo(a,h)anthracene	mg/kg-OCN	12	33	3.56	**14.29**	6.9	9.16	6.47	5.43	5.35	4.68	5.04	**12.01**	**15.48**	9.86	5.57	***115.75*** UE
Benzo(g,h,i)perylene	mg/kg-OCN	31	78	11.88	**48.81**	24.57	24.43	21.18	17.57	18.59	14.05	10.38	**38.55**	**64.76**	**36.43**	18.79	**51.14** E
Total HPAH	mg/kg-OCN	960	5300	224.36	942.86	412.5	499.62	557.79	443.71	366.06	705.28	223.95	612.28	**3398.81**	**1470.64**	615.29	**1940.78** E
1,2-Dichlorobenzene	mg/kg-OCN	2.3	2.3	1.98 U	0.77 U	0.6 U	2.06 U	0.81 U	0.73 U	0.38 U	NR	NR	NR	NR	NR	NR	***115.75*** UE
1,4-Dichlorobenzene	mg/kg-OCN	3.1	9	1.98 U	1.07 U	2.59 U	2.06 U	0.08 J	0.09 J	0.1 J	NR	NR	NR	NR	NR	NR	***115.75*** UE
1,2,4-Trichlorobenzene	mg/kg-OCN	0.81	1.8	0.46 U	***0.89*** U	0.69 U	0.57 U	***0.81*** U	0.73 U	0.38 U	NR	NR	NR	NR	NR	NR	***115.75*** UE
Hexachlorobenzene	mg/kg-OCN	0.38	2.3	***0.64*** U	***1.19*** U	***0.95*** U	***0.76*** U	0.02 J	0.08 U	0.01 NJ	NR	NR	NR	NR	NR	NR	***115.75*** UE
Dimethyl phthalate	mg/kg-OCN	53	53	1.98 U	3.21 U	2.59 U	2.06 U	0.81 U	0.73 U	0.19 J	NR	NR	NR	NR	NR	NR	***115.75*** UE
Diethylphthalate	mg/kg-OCN	61	110	1.98 U	3.21 U	2.59 U	2.06 U	0.81 UJ	0.73 UJ	0.38 UJ	NR	NR	NR	NR	NR	NR	***115.75*** UE
Di-n-butyl phthalate	mg/kg-OCN	220	1700	0.81 J	1.85 J	2.59 U	2.06 U	15.44	11	4.59 UJ	NR	NR	NR	NR	NR	NR	115.75 UE
Butyl benzyl phthalate	mg/kg-OCN	4.9	64	2.08	3.99	1.47 J	2.06 U	3.38 UJ	1.4 UJ	0.38 U	NR	NR	NR	NR	NR	NR	**7.81** E
bis(2-ethylhexyl)phthalate	mg/kg-OCN	47	78	8.22 J	30.95 J	13.36 J	7.25 J	26.62 UJ	8 UJ	13.47 UJ	NR	NR	NR	NR	NR	NR	***95.56*** UE
Di-n-octyl phthalate	mg/kg-OCN	58	4500	1.98 U	1.73 J	2.59 U	2.06 U	0.81 U	0.73 U	0.38 U	NR	NR	NR	NR	NR	NR	***115.75*** UE
Dibenzofuran	mg/kg-OCN	15	58	2.08	6.55	1.9 J	11.45	**17.35**	12.71	**22.18**	7.70	8.27	9.55	**66.19**	**46.07**	NR	13.46 E
Hexachlorobutadiene	mg/kg-OCN	3.9	6.2	1.98 U	3.21 U	2.59 U	2.06 U	0.81 U	0.73 U	0.38 U	NR	NR	NR	NR	NR	NR	***115.75*** UE
N-Nitrosodiphenylamine	mg/kg-OCN	11	11	1.98 U	3.21 U	2.59 U	2.06 U	0.81 U	0.73 U	0.38 U	NR	NR	NR	NR	NR	NR	***115.75*** UE
Phenol	µg/kg	420	1200	30 J	160 U	180 U	97 J	53	23 UJ	75	NR	NR	NR	NR	NR	NR	410 E
2-Methylphenol	µg/kg	63	63	20 U	54 U	60 U	54 U	3.9 NJ	4.7 J	13	NR	NR	NR	NR	NR	NR	***860*** UE
4-Methylphenol	µg/kg	670	670	20 U	33 J	60 U	390	**1280**	**1200**	**1110**	NR	NR	NR	NR	NR	NR	***860*** UE
2,4-Dimethylphenol	µg/kg	29	29	17 U	***52*** U	***58*** U	***53*** U	5.5 U	5.1 U	11	NR	NR	NR	NR	NR	NR	***860*** UE
Pentachlorophenol	µg/kg	360	690	97 U	280	200 J	81 U	116 J	104 NJ	150 J	NR	NR	NR	NR	NR	NR	***2200*** UE
Benzyl alcohol	µg/kg	57	73	20 U	54 U	39 U	54 U	16 UJ	11 UJ	13 UJ	NR	NR	NR	NR	NR	NR	NR
Benzoic acid	µg/kg	650	650	390 U	***910*** U	***1100*** U	***920*** U	**1220** J	**744** J	**1150** J	NR	NR	NR	NR	NR	NR	NR
PCBs																	
PCBs (total)	mg/kg-OCN	12	65	5.84	**29.17**	**26.72**	**14.12**	10.88	**22.71**	**12**	NR	NR	NR	NR	NR	NR	**58.01**
Organometallics																	
TBT*	mg/kg-OCN	76	76	5.0	**77.4**	51.7	1.6	NR	NR	NR	NR	NR	NR	NR	NR	NR	**228.8**

Notes:

* TBT concentrations are compared to the West Waterway Confirmational Number.

** The TBT concentration for sample EBB01C is reported in ug/kg-dry weight rather than mg/kg-OCN

J The analyte was analyzed for and positively identified, but the associated numerical value is an estimated quantity.

NA Not available

NR Not reported

U The analyte was undetected at reported detection limit.

Bold concentrations indicate an exceedance of the SQS.

Boxed concentrations indicate an exceedance of the CSL.

Italicized concentrations indicate a detection limit exceedance of either SQS or CSL.

Additional qualifier definitions for the various sampling events are unknown.

Table A-11a. Historical Surface Sediment Analytical Data—Data Evaluation Summary Compared to SQS and CSL

Lockheed Shipyard No. 2 Surface Samples

				Sample Locations within Yard 2													
			Location	N-12	N-20	N-21	D2-S	D4-S	G12	G2	G3	G4	G5	G6	G7	G8	G9
			Sample ID	N-12	N-20	N-21	D2-S	D4-S	G12	G2	G3	G4	G5	G6	G7	G8	G9
			Sample Date	10/9/1991	10/9/1991	10/9/1991	8/31/1989	8/31/1989	8/31/1989	8/31/1989	8/31/1989	8/31/1989	8/31/1989	8/31/1989	8/31/1989	8/31/1989	8/31/1989
			Sample Depth	0-2 cm	0-2 cm	0-2 cm	0-10 cm	0-10 cm	0-10 cm	0-10 cm	0-10 cm	0-10 cm	0-10 cm	0-10 cm	0-10 cm	0-10 cm	0-10 cm
Parameter	Units	SQS	CSL														
Conventionals																	
Total Organic Carbon	%	NA	NA	0.708	1.11	1.07	1.8	0.56	2.2	3.8	2.87	1.8	1.8	2.1	0.45	1.9	1.9
Metals																	
Arsenic	mg/kg	57	93	12.6	17.9	4.7	31	21	160	58	48	40	44	18	31	48	41
Cadmium	mg/kg	5.1	6.7	5.8	5.9	3.8	0.16 E	0.071 E	1.7 E	1.3 E	1.6 E	0.51 E	0.5 E	0.44 E	0.26 E	0.87 E	0.52 E
Chromium	mg/kg	260	270	106	NR	29.8	58 E	48 E	100 E	260 E	92 E	31 E	19 E	74 E	120 E	96 E	55 E
Copper	mg/kg	390	390	152	137	55.3	97 E	87 E	690 E	670 E	210 E	160 E	120 E	150 E	490 E	610 E	340 E
Lead	mg/kg	450	530	45.1 E	42.3	9.3 E	69 E	24 E	370 E	260 E	190 E	150 E	130 E	210 E	75 E	250 E	77 E
Mercury	mg/kg	0.41	0.59	0.14 E	0.33	0.13 E	0.0018	0.0008	0.0024	0.0024	0.0026	0.0012	0.0012	0.0012	0.0005 U	0.0012	0.001
Silver	mg/kg	6.1	6.1	NR	NR	0.34 E	0.32 E	0.21 E	0.88 E	1.3 E	1.1 E	0.44 E	0.37 E	0.5 E	0.41 E	0.57 E	0.8 E
Zinc	mg/kg	410	960	197	139	64.8	120 E	99 E	1500 E	1100 E	760 E	230 E	160 E	180 E	410 E	1200 E	190 E
SVOCs																	
Naphthalene	mg/kg-OCN	99	170	3.25 E	2.52 E	1.12 E	32.22	7.68	19.09 U	42.11	8.36 E	17.22 U	100	80.95	6	2.79	9.47 E
Acenaphthylene	mg/kg-OCN	66	66	1.69 E	0.99 E	0.56 E	4.72	3.75 E	7.73 E	12.89	5.92 E	13.33 E	17.22 E	10 E	10	5.26	9.47 E
Acenaphthene	mg/kg-OCN	16	57	3.95 E	3.15 E	1.21 E	13.33	5.71	15.91 E	34.21	8.71	7.22 E	355.56	166.67	10.44	6.32	21.05
Fluorene	mg/kg-OCN	23	79	6.36 E	4.5 E	1.68 E	13.89	7.5	38.64	47.37	11.15	14.44 E	416.67	209.52	16.89	9.47	34.21
Phenanthrene	mg/kg-OCN	100	480	31.07 E	35.14 E	10.28 E	44.44	55.36	345.45	157.89	52.26	94.44	1388.89	666.67	142.22	63.16	194.74
Anthracene	mg/kg-OCN	220	1200	24.01 E	11.71 E	5.42 E	18.33	15.54	150	168.42	48.78	100	416.67	228.57	48.89	18.42	110.53
2-Methylnaphthalene	mg/kg-OCN	38	64	1.27 E	1.17 E	0.47 E	5.56	2.68 E	19.09 U	7.89 E	8.36 U	17.22 U	77.78	47.62	2.89 E	2	4.84 E
Total LPAH	mg/kg-OCN	370	780	70.34 E	58.02 E	20.28 E	126.94	95.54 E	557.73 E	462.89	135.19 E	229.44 E	2695 E	1362.38 E	234.44	105.42	379.47 E
Fluoranthene	mg/kg-OCN	160	1200	77.68 E	78.38 E	24.3 E	51.67	85.71	500	247.37	73.17	466.67	150	666.67	355.56	136.84	526.32
Pyrene	mg/kg-OCN	1000	1400	62.15 E	58.56 E	16.82 E	77.78 E	92.86 E	545.45	342.11 E	306.62 E	405.56 E	1388.89 E	761.9	444.44	105.26	489.47
Benzo(a)anthracene	mg/kg-OCN	110	270	48.02 E	28.83 E	12.15 E	21.11	39.29	245.45	215.79	52.26	183.33	511.11	271.43	244.44	68.42	184.21
Chrysene	mg/kg-OCN	110	460	63.56 E	42.34 E	18.69 E	21.11	37.5	359.09	315.79	87.11	216.67	472.22	295.24	148.89	63.16	231.58
Benzofluoranthenes (total)	mg/kg-OCN	230	450	76.27 E	68.47 E	24.3 E	46.67	78.57	368.18	526.32	219.51	311.11	611.11	385.71	311.11	68.42	310.53
Benzo(a)pyrene	mg/kg-OCN	99	210	31.07 E	27.03 E	10.28 E	23.33	37.5	145.45	215.79	87.11	122.22	277.78	166.67	142.22	27.37	131.58
Indeno(1,2,3-cd)pyrene	mg/kg-OCN	34	88	15.54 E	9.91 E	5.7 E	13.89	26.79	81.82	102.63	34.84	61.11	116.67	76.19	95.56	17.37	68.42
Dibenzo(a,h)anthracene	mg/kg-OCN	12	33	22.6 UE	52.25 UE	14.95 UE	8.33	15.18	30.45	68.42	22.65	34.44	61.11	40	55.56	9.47	41.58
Benzo(g,h,i)perylene	mg/kg-OCN	31	78	14.12 E	52.25 UE	6.17 E	12.78	30.36	90.91	94.74	34.84	55.56	116.67	76.19	64.44	14.74	68.42
Total HPAH	mg/kg-OCN	960	5300	388.42 E	313.51 E	118.41 E	276.67 E	443.75 E	2366.82	2128.95 E	918.12 E	1856.67 E	3705.56 E	2740	1862.22	511.05	2052.11
1,2-Dichlorobenzene	mg/kg-OCN	2.3	2.3	22.6 UE	52.25 UE	14.95 UE	0.89 U	2.32 U	9.55 U	5 U	4.18 U	8.33 U	10.56 U	8.57 U	2.89 U	0.89 U	8.95 U
1,4-Dichlorobenzene	mg/kg-OCN	3.1	9	22.6 UE	52.25 UE	14.95 UE	1.78 U	4.46 U	19.09 U	10 U	8.36 U	17.22 U	21.11 U	17.14 U	5.78 U	1.79 U	17.89 U
1,2,4-Trichlorobenzene	mg/kg-OCN	0.81	1.8	22.6 UE	52.25 UE	14.95 UE	0.89 U	2.32 U	9.55 U	5 U	4.18 U	8.33 U	10.56 U	8.57 U	2.89 U	0.89 U	8.95 U
Hexachlorobenzene	mg/kg-OCN	0.38	2.3	22.6 UE	52.25 UE	14.95 UE	1.78 U	4.46 U	19.09 U	10 U	8.36 U	17.22 U	21.11 U	17.14 U	5.78 U	1.79 U	17.89 U
Dimethyl phthalate	mg/kg-OCN	53	53	22.6 UE	52.25 UE	14.95 UE	1.78 U	4.46 U	19.09 U	10 U	8.36 U	17.22 U	21.11 U	17.14 U	5.78 U	1.79 U	17.89 U
Diethylphthalate	mg/kg-OCN	61	110	22.6 UE	52.25 UE	14.95 UE	1.78 U	4.46 U	19.09 U	10 U	8.36 U	17.22 U	21.11 U	17.14 U	5.78 U	1.79 U	17.89 U
Di-n-butyl phthalate	mg/kg-OCN	220	1700	22.6 UE	2.34 E	14.95 UE	2.39	4.46 U	19.09 U	10 U	8.36 U	17.22 U	21.11 U	17.14 U	5.78 U	1.79 U	17.89 U
Butyl benzyl phthalate	mg/kg-OCN	4.9	64	2.4 E	52.25 UE	0.84 E	1.78 U	4.46 U	19.09 U	10 U	8.36 U	17.22 U	21.11 U	17.14 U	5.78 U	1.79 U	17.89 U
bis(2-ethylhexyl)phthalate	mg/kg-OCN	47	78	14.12 UE	13.51 UE	9.16 UE	6.67	23.21	72.73	39.47	11.5	26.11	22.22	52.38	33.33	11.58	68.42
Di-n-octyl phthalate	mg/kg-OCN	58	4500	22.6 UE	52.25 UE	14.95 UE	1.78 U	4.46 U	19.09 U	10 U	8.36 U	17.22 U	21.11 U	17.14 U	5.78 U	1.79 U	17.89 U
Dibenzofuran	mg/kg-OCN	15	58	3.11 E	2.43 E	0.84 E	11.11	4.46	12.73 E	28.95	6.27 E	6.11 E	283.33	147.62	5.78 U	5.79	17.89
Hexachlorobutadiene	mg/kg-OCN	3.9	6.2	22.6 UE	52.25	14.95 UE	1.78 U	4.46 U	19.09 U	10 U	8.36 U	17.22 U	21.11 U	17.14 U	5.78 U	1.79 U	17.89 U
N-Nitrosodiphenylamine	mg/kg-OCN	11	11	22.6 UE	52.25 UE	14.95 UE	0.89 U	2.32 U	9.55 U	5 U	4.18 U	8.33 U	10.56 U	8.57 U	2.89	0.89 U	8.95 U
Phenol	µg/kg	420	1200	430 E	580 UE	280 E	200	50 U	840 U	760 U	490 U	620 U	760 U	720 U	160	140	360 E
2-Methylphenol	µg/kg	63	63	160 UE	580 UE	160 UE	16 U	13 U	210 U	190 U	120 U	150 U	190 U	180 U	13 U	17 U	170 U
4-Methylphenol	µg/kg	670	670	160 UE	580 UE	160 UE	83	25 U	420 U	380 U	240 U	310 U	380 U	360 U	90	80	340 U
2,4-Dimethylphenol	µg/kg	29	29	160 UE	580 UE	160 UE	16 U	13 U	210 U	190 U	120 U	150 U	190 U	180 U	13 U	17 U	170 U
Pentachlorophenol	µg/kg	360	690	390 UE	1400 UE	390 UE	58 E	130 U	2100 U	1900 U	1200 U	1500 U	1900 U	1800 U	128 U	63 E	1700 U
Benzyl alcohol	µg/kg	57	73	NR	NR	NR	25 U	20 U	330 U	300 U	190 U	250 U	300 U	290 U	21 U	28 U	270 U
Benzoic acid	µg/kg	650	650	NR	NR	NR	158 U	130 U	2100 U	1900 U	1200 U	1500 U	1900 U	1800 U	128 U	172 U	1700 U
PCBs																	
PCBs (total)	mg/kg-OCN	12	65	5.23	2.63	9.16 E	10.56	34.82	48.64	21.05	9.13	12.78	10.33	8.19	28.67	7.79	15.84
Organometallics																	
TBT*	mg/kg-OCN	76	76	NR	216.2	86.0	NR	NR	272.7	NR	13.9	NR	NR	NR	NR	NR	NR

Notes:

* TBT concentrations are compared to the West Waterway Confirmational Number.

** The TBT concentration for sample EBB01C is reported in ug/kg-dry weight rather than mg/kg-OCN

J The analyte was analyzed for and positively identified, but the associated numerical value is an estimated quantity.

NA Not available

NR Not reported

U The analyte was undetected at reported detection limit.

Bold concentrations indicate an exceedance of the SQS.

Boxed concentrations indicate an exceedance of the CSL.

Italicized concentrations indicate a detection limit exceedance of either SQS or CSL.

Additional qualifier definitions for the various sampling events are unknown.

Table A-11a. Historical Surface Sediment Analytical Data—Data Evaluation Summary Compared to SQS and CSL

Lockheed Shipyard No. 2 Surface Samples

				Sample Locations within Yard 2								Sample Locations North of Yard 2					
			Location	**SA2-S**	**SA6-S**	**G13**	**G10**	**G11**	**G15**	**NH-04**	**NH-05**	**EBB01**	**EBB01**	**EBB01**	**EBB01**	**EB121**	**EB130**
			Sample ID	**SA2-S**	**SA6-S**	**G13**	**G10**	**G11**	**G15**	**NH-04**	**NH-05**	**EBB01-A**	**EBB01-B**	**EBB01-C**	**EBB01C**	**SD3-EB121-0000**	**SD3-EB130-0000**
			Sample Date	**8/31/1989**	**8/31/1989**	**8/31/1989**	**8/29/1989**	**8/29/1989**	**8/29/1989**	**10/15/1985**	**10/15/1985**	**7/3/2002**	**7/3/2002**	**7/3/2002**	**5/19/1988**	**7/29/1997**	**7/29/1997**
			Sample Depth	**0-10 cm**	**0-10 cm**	**0-10 cm**	**0-10 cm**	**0-10 cm**	**0-10 cm**	**0-10 cm**	**0-10 cm**	**0-10 cm**	**0-10 cm**	**0-10 cm**	**0-5 cm**	**0-10 cm**	**0-10 cm**
Parameter	**Units**	**SQS**	**CSL**														
Conventionals																	
Total Organic Carbon	%	NA	NA	2.5	0.54	2.1	1.8	1.2	2.5	2.04	2.55	NR	NR	NR	1	1.2	0.88
Metals																	
Arsenic	mg/kg	57	93	40	52	**77**	46	**57**	15	**174**	22.6	NR	NR	NR	12	NR	NR
Cadmium	mg/kg	5.1	6.7	0.53 E	0.16 E	0.65 E	0.42 E	0.2 E	0.45 E	0.71	0.93	NR	NR	NR	0.98 B	NR	NR
Chromium	mg/kg	260	270	95 E	82 E	34 E	85 E	150 E	170 E	127 E	212 E	NR	NR	NR	NR	NR	NR
Copper	mg/kg	390	390	140 E	160 E	170 E	**550** E	270 E	**390** E	**1770**	163	NR	NR	NR	56	NR	NR
Lead	mg/kg	450	530	160 E	80 E	190 E	190 E	210 E	240 E	349	137	NR	NR	NR	38	NR	NR
Mercury	mg/kg	0.41	0.59	0.0013	0.0005	0.0014	0.0013	0.0008	0.0057	**0.866** E	**0.426** E	0.284	0.383	0.225	0.2	NR	NR
Silver	mg/kg	6.1	6.1	0.34 E	0.19 E	0.43 E	0.57 E	0.68 E	0.65 E	0.93 E	0.48 E	NR	NR	NR	0.22	NR	NR
Zinc	mg/kg	410	960	170 E	160 E	240 E	**430** E	380 E	300 E	**994** E	304 E	NR	NR	NR	140	NR	NR
SVOCs																	
Naphthalene	mg/kg-OCN	99	170	14	6.67	12.86 E	9.44 E	42.5	14.4 U	24.51 E	**101.96**	NR	NR	NR	1.4 E	74.00	28.98
Acenaphthylene	mg/kg-OCN	66	66	6.4	5	20 U	7.78 E	29.17 U	14.4 U	27.45 E	11.76 E	NR	NR	NR	1.2 E	9.33	4.09
Acenaphthene	mg/kg-OCN	16	57	8.8	5.19	**20.95**	**94.44**	**466.67**	9.2 E	**32.84** E	**34.12** E	NR	NR	NR	1.3 E	**32.92**	8.38
Fluorene	mg/kg-OCN	23	79	10.8	8.89	**33.33**	**111.11**	**433.33**	13.2 E	**45.1** E	**38.04** E	NR	NR	NR	2.2 E	**32.08**	9.36
Phenanthrene	mg/kg-OCN	100	480	40	53.7	**166.67**	**438.89**	**1250**	88	**166.67**	78.43	NR	NR	NR	11	**295.83**	43.07
Anthracene	mg/kg-OCN	220	1200	29.6	20.37	80.95	161.11	**275**	76	73.53 E	70.59 E	NR	NR	NR	4.6	57.42	23.86
2-Methylnaphthalene	mg/kg-OCN	38	64	2.92	2.59 E	4.76 E	11.67 E	34.17	14.4 U	9.8 E	17.25 E	NR	NR	NR	0.5 E	19.83	8.31
Total LPAH	mg/kg-OCN	370	780	109.6	99.81	314.76 E	**822.78** E	**2467.5**	186.4 E	**370.1** E	334.9 E	NR	NR	NR	21.7 E	**501.58**	117.74
Fluoranthene	mg/kg-OCN	160	1200	60	90.74	**261.9**	**722.22**	**1583.33**	**252**	**328.43** E	90.2 E	NR	NR	NR	25	**262.50**	57.73
Pyrene	mg/kg-OCN	1000	1400	88 E	90.74	252.38 E	611.11	**1083.33** E	208 E	210.78	90.2	NR	NR	NR	26	397.50	86.82
Benzo(a)anthracene	mg/kg-OCN	110	270	44	42.59	90.48	**172.22**	**366.67**	**112**	88.24	43.14	NR	NR	NR	19	62.92	45.57
Chrysene	mg/kg-OCN	110	460	48	59.26	109.52	**222.22**	**366.67**	**164**	93.14	47.06	NR	NR	NR	21	85.00	83.18
Benzofluoranthenes (total)	mg/kg-OCN	230	450	88	81.48	133.33	**272.22**	**466.67**	220	205.88	109.8 E	NR	NR	NR	51	127.00	87.73
Benzo(a)pyrene	mg/kg-OCN	99	210	72	35.19	66.67	**105.56**	**133.33**	96	88.24 E	39.22 E	NR	NR	NR	16	76.00	39.09
Indeno(1,2,3-cd)pyrene	mg/kg-OCN	34	88	26.8	16.67	31.9	**50.56**	**53.33**	**48**	**88.24** E	23.92 E	NR	NR	NR	9.5	**34.08**	18.30
Dibenzo(a,h)anthracene	mg/kg-OCN	12	33	11.6	7.59	**18.57** E	**31.11**	**33.33**	**28.8**	**35.29** E	8.63 E	NR	NR	NR	3.8 E	10.42	6.48
Benzo(g,h,i)perylene	mg/kg-OCN	31	78	20.4	13.89	**31.9**	**47.22**	19.17 E	**48**	**73.53** E	19.61 E	NR	NR	NR	6.6	**39.33**	18.41
Total HPAH	mg/kg-OCN	960	5300	458.8 E	438.15	**996.67** E	**2234.44**	**4105.83** E	**1176.8** E	**1211.76** E	471.76 E	NR	NR	NR	177.9 E	**1094.75**	443.30
1,2-Dichlorobenzene	mg/kg-OCN	2.3	2.3	0.6 U	2.22 U	***10*** U	***6.67*** U	***11.67*** U	***6*** U	***8.33*** U	***5.88*** U	0.34 UJ	0.29 UJ	0.33 UJ	0.48 U	NR	NR
1,4-Dichlorobenzene	mg/kg-OCN	3.1	9	1.2 U	***4.63*** U	***20*** U	***17.22*** U	***29.17*** U	***14.4*** U	***8.33*** U	***5.88*** U	0.34 UJ	0.29 UJ	0.33 UJ	0.48 U	NR	NR
1,2,4-Trichlorobenzene	mg/kg-OCN	0.81	1.8	0.6 U	***2.22*** U	***10*** U	***5*** U	***8.33*** U	***4.4*** U	***6.86*** U	***3.45*** U	NR	NR	NR	0.48 U	NR	NR
Hexachlorobenzene	mg/kg-OCN	0.38	2.3	***1.2*** U	***4.63*** U	***20*** U	***17.22*** U	***29.17*** U	***14.4*** U	***6.37*** U	***2.86*** U	NR	NR	NR	***0.48*** U	NR	NR
Dimethyl phthalate	mg/kg-OCN	53	53	1.2 U	4.63 U	20 U	17.22 U	29.17 U	14.4 U	3.28 E	0.75 E	NR	NR	NR	0.48 U	NR	NR
Diethylphthalate	mg/kg-OCN	61	110	1.2 U	4.63 U	20 U	17.22 U	29.17 U	14.4 U	NR	NR	NR	NR	NR	0.48 U	NR	NR
Di-n-butyl phthalate	mg/kg-OCN	220	1700	1.2 U	4.63 U	20 U	17.22 U	29.17 U	14.4 U	NR	NR	NR	NR	NR	2.8 E	NR	NR
Butyl benzyl phthalate	mg/kg-OCN	4.9	64	1.2 U	4.63 U	**20** U	***17.22*** U	***29.17*** U	***14.4*** U	0.17 B	0.15 B	NR	NR	NR	1.6 E	NR	NR
bis(2-ethylhexyl)phthalate	mg/kg-OCN	47	78	9.2	18.52	**209.52**	15 E	29.17 U	20	NR	NR	NR	NR	NR	7.9 Z	NR	NR
Di-n-octyl phthalate	mg/kg-OCN	58	4500	1.2 U	4.63 U	20 U	17.22 U	29.17 U	14.4 U	4.22 E	0.06 U	NR	NR	NR	0.5 U	NR	NR
Dibenzofuran	mg/kg-OCN	15	58	7.2	5	**17.14** E	**66.67**	**325**	5.2 E	**17.65** E	**22.35** E	NR	NR	NR	1.3 E	**26.33**	8.58
Hexachlorobutadiene	mg/kg-OCN	3.9	6.2	1.2 U	***4.63*** U	***20*** U	***8.33*** U	***14.17*** U	***7.2*** U	***24.51*** U	***13.33*** U	NR	NR	NR	0.52 U	NR	NR
N-Nitrosodiphenylamine	mg/kg-OCN	11	11	0.6 U	2.22 U	10 U	6.67 U	***11.67*** U	6 U	NR	NR	NR	NR	NR	0.48 U	NR	NR
Phenol	µg/kg	420	1200	60 U	50 U	***840*** U	***610*** U	***700*** U	***730*** U	110 E	3.8 U	NR	NR	NR	54	NR	NR
2-Methylphenol	µg/kg	63	63	15 U	12 U	***210*** U	***120*** U	***140*** U	***150*** U	**240** E	8.8 U	NR	NR	NR	4.8 U	NR	NR
4-Methylphenol	µg/kg	670	670	30 U	25 U	420 U	310 U	350 U	360 U	**1000** E	8.9 U	NR	NR	NR	23 E	NR	NR
2,4-Dimethylphenol	µg/kg	29	29	15 U	12 U	***210*** U	***92*** U	***110*** U	***110*** U	**39** E	5.8 U	NR	NR	NR	NR	NR	NR
Pentachlorophenol	µg/kg	360	690	150 U	120 U	***2100*** U	***1500*** U	***1700*** U	***1800*** U	**6000** X	***440*** U	NR	NR	NR	7.6 U	NR	NR
Benzyl alcohol	µg/kg	57	73	24 U	20 U	***340*** U	***150*** U	***170*** U	***180*** U	***510*** U	***450*** U	NR	NR	NR	20 U	NR	NR
Benzoic acid	µg/kg	650	650	150 U	120 U	***2100*** U	210 U	240 U	260 U	92 U	56 U	NR	NR	NR	17 E	NR	NR
PCBs																	
PCBs (total)	mg/kg-OCN	12	65	8.08	**24.44**	9.38	**15.56**	**18.33**	**14.4**	7.84	**19.61**	NR	NR	NR	**20**	NR	NR
Organometallics																	
TBT*	mg/kg-OCN	76	76	NR	35.2	NR	NR	NR	NR	NR	NR	NR	NR	NR	180**	NR	NR

Notes:

* TBT concentrations are compared to the West Waterway Confirmational Number.

** The TBT concentration for sample EBB01C is reported in ug/kg-dry weight rather than mg/kg-OCN

J The analyte was analyzed for and positively identified, but the associated numerical value is an estimated quantity.

NA Not available

NR Not reported

U The analyte was undetected at reported detection limit.

Bold concentrations indicate an exceedance of the SQS.

Boxed concentrations indicate an exceedance of the CSL.

Italicized concentrations indicate a detection limit exceedance of either SQS or CSL.

Additional qualifier definitions for the various sampling events are unknown.

Table A-11a. Historical Surface Sediment Analytical Data—Data Evaluation Summary Compared to SQS and CSL

Lockheed Shipyard No. 2 Surface Samples

				Sample Locations North of Yard 2			Sample Locations in the West Waterway										
			Location	EB131	EB120	EB089	EB085	HC-03-13	N-28	N-09	N-10	N-19	W-52	W-53	W-40	W-42	W-44
			Sample ID	SD3-EB131-0000	SD3-EB120-0000	SD2-EB89-0000	SD2-EB85-0000	HC-03-13	N-28	N-09	N-10	N-19	W-52	W-53	W-40	W-42	W-44
			Sample Date	7/29/1997	7/29/1997	1996	1996	9/27/2003	10/9/1991	10/8/1991	10/8/1991	10/8/1991	10/8/1991	10/8/1991	10/7/1991	10/7/1991	10/7/1991
			Sample Depth	0-10 cm	0-10 cm	0-10 cm	0-10 cm	0-10 cm	0-2 cm	0-2 cm	0-2 cm	0-2 cm	0-2 cm	0-2 cm	0-2 cm	0-2 cm	0-2 cm
Parameter	Units	SQS	CSL														
Conventionals																	
Total Organic Carbon	%	NA	NA	1.4	2.1	1.5	1.8	0.78	0.551	0.494	1.54	1.98	1.83	2	1.02	1.32	1.25
Metals																	
Arsenic	mg/kg	57	93	NR	NR	NR	NR	**165**	8.1	10.9 E	**72.1**	10	16.7 E	37.4	15.5 E	24 E	23.4
Cadmium	mg/kg	5.1	6.7	NR	NR	NR	NR	0.47	3.9	2.3	**7.3**	4.3	**6**	**6.7**	**6.2**	**5.7** E	**6.5**
Chromium	mg/kg	260	270	NR	NR	NR	NR	127	NR	18.3 E	NR	NR	50.1 E	NR	58.3 E	NR	NR
Copper	mg/kg	390	390	NR	NR	NR	NR	**576**	90.3	54	**415**	107	132	358	175	176 E	264
Lead	mg/kg	450	530	NR	NR	NR	NR	**1160**	25.1	22.4	217	33.4	64.5	105	99.2	101	134
Mercury	mg/kg	0.41	0.59	NR	NR	NR	0.24	**0.86**	0.37	0.11 E	**1.7**	**2.2**	0.03 E	**1.2**	**0.78** E	**1.1**	**0.66**
Silver	mg/kg	6.1	6.1	NR	NR	NR	NR	0.49	NR	0.28 E	NR	NR	NR	NR	2 U	NR	NR
Zinc	mg/kg	410	960	NR	NR	NR	NR	**661**	95.6	65.5	**489**	108	174	271	370	235	277
SVOCs																	
Naphthalene	mg/kg-OCN	99	170	15.79	3.32	**107.33**	**403.33**	10.38	3.27 E	13.77 E	3.96 E	1.46 E	4.97 E	2 E	5.2 E	1.82 E	3.12 E
Acenaphthylene	mg/kg-OCN	66	66	1.86	0.68	6.22	8.06	12.18	1.09 E	2.02 E	1.56 E	0.51 E	1.91 E	1.85 E	1.86 E	1.21 E	1.84 E
Acenaphthene	mg/kg-OCN	16	57	6.22	1.45	**59.93**	**151.11**	14.1	3.27 E	**58.7** E	7.79 E	1.97 E	2.79 E	6 E	6.47 E	3.41 E	6 E
Fluorene	mg/kg-OCN	23	79	5.74	2.13	**49.60**	**148.89**	**23.08**	4.36 E	**66.8** E	9.09 E	2.42 E	3.39 E	8.5 E	9.02 E	4.09 E	7.2 E
Phenanthrene	mg/kg-OCN	100	480	23.57	9.86	**130.00**	**422.78**	**141.03**	36.3 E	**445.34** E	71.43 E	17.17 E	21.86 E	**115** E	59.8 E	37.12 E	60
Anthracene	mg/kg-OCN	220	1200	9.21	4.55	40.13	106.67	34.62	10.16 E	87.04 E	14.29 E	3.84 E	10.93 E	20.5 E	22.55 E	9.09 E	12.8
2-Methylnaphthalene	mg/kg-OCN	38	64	4.19	1.12	37.33	**124.44**	5.77 J	1.63 E	8.91 E	2.14 E	1.06 E	1.64 E	1.55 E	3.04 E	1.59 E	1.92 E
Total LPAH	mg/kg-OCN	370	780	62.39	21.99	**393.22**	**1240.83**	235.38	58.44 E	**673.68** E	108.12 E	27.37 E	45.85 E	153.85 E	104.9 E	56.74 E	90.96 E
Fluoranthene	mg/kg-OCN	160	1200	35.50	19.10	111.33	**323.33**	**371.79**	67.15 E	**465.59** E	110.39 E	25.25 E	47.54 E	**240** E	147.06 E	56.06 E	88 E
Pyrene	mg/kg-OCN	1000	1400	44.64	16.05	200.00	351.11	307.69	49 E	688.26 E	97.4 E	21.21 E	41.53 E	180 E	156.86 E	71.21 E	120 E
Benzo(a)anthracene	mg/kg-OCN	110	270	13.71	11.71	25.93	50.11	**119.23**	29.04 E	**404.86** E	56.49 E	12.63 E	21.86 E	80 E	71.57 E	31.06 E	46.4
Chrysene	mg/kg-OCN	110	460	20.57	16.24	35.13	58.89	**192.31**	39.93 E	**404.86** E	64.94 E	15.66 E	20.77 E	**125**	107.84 E	31.82 E	53.6
Benzofluoranthenes (total)	mg/kg-OCN	230	450	43.21	27.33	68.93	102.00	**258.97**	68.97 E	**615.38** E	123.38 E	27.78 E	52.46 E	145 E	120.59 E	59.09 E	96
Benzo(a)pyrene	mg/kg-OCN	99	210	21.14	12.86	29.27	39.39	**116.67**	27.22 E	**242.91** E	52.6 E	11.62 E	20.77 E	55 E	62.75 E	18.94 E	34.4
Indeno(1,2,3-cd)pyrene	mg/kg-OCN	34	88	13.57	6.19	13.87	16.28	**73.08**	11.43 E	**163.97** E	25.32 E	6.06 E	9.29 E	25.5 E	**49.02** E	6.29 E	10.4 E
Dibenzo(a,h)anthracene	mg/kg-OCN	12	33	4.74	2.54	1.35 J	4.71	**15.38**	***27.22*** UE	**87.04** E	1.36 E	0.25 E	9.29 UE	***50*** UE	**17.65** E	***12.88*** U	***12.8*** U
Benzo(g,h,i)perylene	mg/kg-OCN	31	78	12.14	5.24	14.87	15.67	**64.1**	11.8 E	**159.92** E	23.38 E	5.56 E	10.38 E	23 E	**52.94** E	5.38 E	8.8 E
Total HPAH	mg/kg-OCN	960	5300	209.24	117.26	500.68	**961.48**	**1519.23**	304.54 E	**3232.79** E	555.26 E	126.01 E	224.59 E	873.5 E	786.27 E	279.85 E	457.6 E
1,2-Dichlorobenzene	mg/kg-OCN	2.3	2.3	NR	NR	NR	NR	1.22 U	***27.22*** UE	***119.43*** UE	***40.91*** UE	***14.65*** UE	***9.29*** UE	***50*** UE	***65.69*** UE	***12.88*** U	***12.8*** U
1,4-Dichlorobenzene	mg/kg-OCN	3.1	9	NR	NR	NR	NR	1.79 U	***27.22*** UE	***119.43*** UE	***40.91*** UE	***14.65*** UE	***9.29*** UE	***50*** UE	***65.69*** UE	***12.88*** U	***12.8*** U
1,2,4-Trichlorobenzene	mg/kg-OCN	0.81	1.8	NR	NR	NR	NR	***1.41*** U	***27.22*** UE	***119.43*** UE	***40.91*** UE	***14.65*** UE	***9.29*** UE	***50*** UE	***65.69*** UE	***12.88*** U	***12.8*** U
Hexachlorobenzene	mg/kg-OCN	0.38	2.3	NR	NR	NR	NR	***2.05*** U	***27.22*** UE	***119.43*** UE	***40.91*** UE	***14.65*** UE	***9.29*** UE	***50*** UE	***65.69*** UE	***12.88*** U	***12.8*** U
Dimethyl phthalate	mg/kg-OCN	53	53	NR	NR	NR	NR	6.15 U	27.22 UE	***119.43*** UE	40.91 UE	14.65 UE	9.29 UE	50 UE	***65.69*** UE	12.88 U	0.8 E
Diethylphthalate	mg/kg-OCN	61	110	NR	NR	NR	NR	6.15 U	27.22 UE	***119.43*** UE	40.91 UE	0.05 E	9.29 UE	50 UE	***65.69*** UE	12.88 U	12.8 U
Di-n-butyl phthalate	mg/kg-OCN	220	1700	NR	NR	NR	NR	2.82 J	27.22 UE	119.43 UE	2.34 E	14.65 UE	9.29 UE	50 UE	1.76 E	12.88 U	12.8 U
Butyl benzyl phthalate	mg/kg-OCN	4.9	64	NR	NR	NR	NR	4.74 J	**5.08** E	**5.06** E	1.43 E	0.71 E	***9.29*** UE	1.75 E	***65.69*** UE	**7.58** E	2.56 E
bis(2-ethylhexyl)phthalate	mg/kg-OCN	47	78	NR	NR	NR	NR	**48.72** J	23.59 UE	32.39 UE	29.22 UE	9.09 UE	13.66 E	20.5 UE	27.45 UE	**106.06** E	**128** B
Di-n-octyl phthalate	mg/kg-OCN	58	4500	NR	NR	NR	NR	6.15 U	27.22 UE	***119.43*** UE	40.91 UE	14.65 UE	9.29 UE	50 UE	***65.69*** UE	12.88 U	12.8 U
Dibenzofuran	mg/kg-OCN	15	58	6.44	1.90	NR	NR	11.28	2.54 E	**24.29** E	4.94 E	1.21 E	2.13 E	3.5 E	4.02 E	2.2 E	3.68 E
Hexachlorobutadiene	mg/kg-OCN	3.9	6.2	NR	NR	NR	NR	1.41 U	***27.22*** UE	***119.43*** UE	***40.91*** UE	***14.65*** UE	***9.29*** UE	***50*** UE	***65.69*** UE	***12.88*** U	***12.8*** U
N-Nitrosodiphenylamine	mg/kg-OCN	11	11	NR	NR	NR	NR	6.15 U	***27.22*** UE	***119.43*** UE	***40.91*** UE	***14.65*** UE	9.29 UE	***50*** UE	***65.69*** UE	***12.88*** U	***12.8*** U
Phenol	µg/kg	420	1200	NR	NR	NR	NR	150 U	290 E	120 E	160 E	21 E	170 E	***1000*** UE	240 E	170 U	280
2-Methylphenol	µg/kg	63	63	NR	NR	NR	NR	48 U	***150*** UE	***590*** UE	***630*** UE	***290*** UE	***170*** UE	***1000*** UE	***670*** UE	***170*** U	***160*** U
4-Methylphenol	µg/kg	670	670	NR	NR	NR	NR	48 U	150 UE	590 UE	630 UE	290 UE	170 UE	***1000*** UE	670 UE	170 U	160 U
2,4-Dimethylphenol	µg/kg	29	29	NR	NR	NR	NR	***40*** U	***150*** UE	***590*** UE	***630*** UE	***290*** UE	***170*** UE	***1000*** UE	***670*** UE	***170*** U	***160*** U
Pentachlorophenol	µg/kg	360	690	NR	NR	NR	NR	180 J	***380*** UE	***1500*** UE	***1600*** UE	***740*** UE	NR	***2600*** UE	***1700*** UE	***420*** U	***400*** U
Benzyl alcohol	µg/kg	57	73	NR	NR	NR	NR	48 U	NR	NR	NR	NR	NR	NR	NR	NR	NR
Benzoic acid	µg/kg	650	650	NR	NR	NR	NR	***700*** U	NR	NR	NR	NR	NR	NR	NR	NR	NR
PCBs																	
PCBs (total)	mg/kg-OCN	12	65	NR	NR	NR	7.60	**206.41**	**254.08**	**19.64** E	**158.44**	6.06	0.06 E	0.25 E	1.14 E	2.07 E	**15.68** E
Organometallics																	
TBT*	mg/kg-OCN	76	76	NR	NR	NR	NR	**102.6**	69	56.7	47.4	16.7	12.6	**275**	42.4	22	36

Notes:

* TBT concentrations are compared to the West Waterway Confirmational Number.

** The TBT concentration for sample EBB01C is reported in ug/kg-dry weight rather than mg/kg-OCN

J The analyte was analyzed for and positively identified, but the associated numerical value is an estimated quantity.

NA Not available

NR Not reported

U The analyte was undetected at reported detection limit.

Bold concentrations indicate an exceedance of the SQS.

Boxed concentrations indicate an exceedance of the CSL.

Italicized concentrations indicate a detection limit exceedance of either SQS or CSL.

Additional qualifier definitions for the various sampling events are unknown.

Table A-11a. Historical Surface Sediment Analytical Data—Data Evaluation Summary Compared to SQS and CSL

Lockheed Shipyard No. 2 Surface Samples

				Sample Locations in the West Waterway					
			Location	W-48	W-49	G14	SA10-S	WW-17	WW-20
			Sample ID	W-48	W-49	G14	SA10-S	WW-17	WW-20
			Sample Date	10/7/1991	10/7/1991	8/31/1989	8/31/1989	10/3/1985	10/3/1985
			Sample Depth	0-2 cm	0-2 cm	0-10 cm	0-10 cm	0-10 cm	0-10 cm
Parameter	**Units**	**SQS**	**CSL**						
Conventionals									
Total Organic Carbon	%	NA	NA	0.811	2.56	0.79	0.91	2.04	1.07
Metals									
Arsenic	mg/kg	57	93	16.6 E	34.7	**88**	33	26.5	39.6
Cadmium	mg/kg	5.1	6.7	4.6	**6.2**	0.45 E	0.36 E	0.59	0.38
Chromium	mg/kg	260	270	44.7 E	NR	150 E	100 E	96 E	67 E
Copper	mg/kg	390	390	112	297	**900** E	160 E	265	167
Lead	mg/kg	450	530	220	116	180 E	130 E	223	101
Mercury	mg/kg	0.41	0.59	**0.6** E	**1.7**	0.0016	0.0018	**0.716** E	**0.776** E
Silver	mg/kg	6.1	6.1	NR	NR	0.75 E	0.25 E	0.56 E	0.36 E
Zinc	mg/kg	410	960	143	308	**580** E	190 E	297 E	259 E
SVOCs									
Naphthalene	mg/kg-OCN	99	170	6.91 E	5.08 E	72.15	9.23	15.2 XE	19.63 XE
Acenaphthylene	mg/kg-OCN	66	66	8.26 E	2.73 E	34.18 E	9.01	10.29 XE	7.01 E
Acenaphthene	mg/kg-OCN	16	57	11.96 E	9.38 E	**202.53**	12.09	11.27 E	4.95 E
Fluorene	mg/kg-OCN	23	79	**24.66** E	10.55	**240.51**	16.48	12.25 E	7.38 E
Phenanthrene	mg/kg-OCN	100	480	**123.3** E	85.94 E	**1518.99**	**131.87**	83.33	60.75 E
Anthracene	mg/kg-OCN	220	1200	10.97 E	16.02	**240.51**	31.87	36.76 E	22.43 E
2-Methylnaphthalene	mg/kg-OCN	38	64	4.93 E	3.01 E	26.58 E	3.74	2.7 E	3.55 E
Total LPAH	mg/kg-OCN	370	780	186.07 E	129.69 E	**2308.86** E	210.55	169.12 E	122.15 E
Fluoranthene	mg/kg-OCN	160	1200	123.3 E	140.62 E	**1898.73**	**208.79**	132.35 E	86.92 E
Pyrene	mg/kg-OCN	1000	1400	172.63 E	152.34 E	**2151.9** E	296.7	151.96	121.5
Benzo(a)anthracene	mg/kg-OCN	110	270	101.11 E	85.94 E	**696.2**	**142.86**	78.43	48.6 E
Chrysene	mg/kg-OCN	110	460	**123.3** E	78.12 E	**772.15**	106.59	**112.75**	68.22 E
Benzofluoranthenes (total)	mg/kg-OCN	230	450	161.53 E	167.97 E	**734.18**	186.81	196.08	119.63 E
Benzo(a)pyrene	mg/kg-OCN	99	210	93.71 E	58.59	**392.41**	**120.88**	73.53 E	45.79 E
Indeno(1,2,3-cd)pyrene	mg/kg-OCN	34	88	**69.05** E	32.42 E	**227.85**	**43.96**	**88.24** E	**61.68** E
Dibenzo(a,h)anthracene	mg/kg-OCN	12	33	**30.83** E	9.38 UE	**113.92**	**31.87**	**21.57** XE	11.5 UX
Benzo(g,h,i)perylene	mg/kg-OCN	31	78	**78.91** E	**34.38** E	**253.16**	**37.36**	**58.82** E	**38.32** E
Total HPAH	mg/kg-OCN	960	5300	954.38 E	750.39 E	**7240.51** E	**1175.82**	913.73 E	590.65 E
1,2-Dichlorobenzene	mg/kg-OCN	2.3	2.3	***75.22*** UE	***9.38*** U	***17.72*** U	1.43 U	***8.33*** U	***13.08*** U
1,4-Dichlorobenzene	mg/kg-OCN	3.1	9	***75.22*** UE	***9.38*** U	***36.71*** U	2.53 E	***8.33*** U	***13.08*** U
1,2,4-Trichlorobenzene	mg/kg-OCN	0.81	1.8	***75.22*** UE	***9.38*** U	***17.72*** U	***1.43*** U	***83.33*** U	***21.5*** U
Hexachlorobenzene	mg/kg-OCN	0.38	2.3	***75.22*** UE	***9.38*** U	***36.71*** U	***2.86*** U	***17.16*** U	***19.63*** U
Dimethyl phthalate	mg/kg-OCN	53	53	1.48 E	9.38 U	36.71 U	2.86 U	4.85 E	1.03 E
Diethylphthalate	mg/kg-OCN	61	110	***75.22*** UE	9.38 U	36.71 U	2.86 U	NR	NR
Di-n-butyl phthalate	mg/kg-OCN	220	1700	1.85 E	3.52 E	36.71 U	2.86 U	NR	NR
Butyl benzyl phthalate	mg/kg-OCN	4.9	64	3.58 E	**8.98** E	***36.71*** U	2.86 U	0.69 B	1.03 B
bis(2-ethylhexyl)phthalate	mg/kg-OCN	47	78	36.99 UE	**117.19** E	**177.22**	**95.6**	NR	NR
Di-n-octyl phthalate	mg/kg-OCN	58	4500	***75.22*** UE	8.98 U	36.71 U	2.86 U	4.22 E	7.1 E
Dibenzofuran	mg/kg-OCN	15	58	10.6 E	5.86 E	**164.56**	8.35	5.88 E	3.74 E
Hexachlorobutadiene	mg/kg-OCN	3.9	6.2	***75.22*** UE	***9.38*** U	***36.71*** U	2.86 U	***166.67*** U	***261.68*** U
N-Nitrosodiphenylamine	mg/kg-OCN	11	11	***75.22*** UE	9.38 U	***17.72*** U	1.43 U	NR	NR
Phenol	µg/kg	420	1200	280 E	400	***580*** U	220	66 U	11 U
2-Methylphenol	µg/kg	63	63	***610*** UE	17 E	***140*** U	13 U	***100*** U	29 U
4-Methylphenol	µg/kg	670	670	610 UE	21 E	290 U	350	110 U	29 U
2,4-Dimethylphenol	µg/kg	29	29	***610*** UE	13 E	***140*** U	13 U	***400*** U	***320*** U
Pentachlorophenol	µg/kg	360	690	***1500*** UE	230 E	***1400*** U	46 E	**360** XE	280 U
Benzyl alcohol	µg/kg	57	73	NR	NR	***230*** U	21 U	***490*** U	***400*** U
Benzoic acid	µg/kg	650	650	NR	NR	***1400*** U	130 U	***1000*** U	140 U
PCBs									
PCBs (total)	mg/kg-OCN	12	65	**14.67** E	0.73 E	**216.46**	**64.84**	**17.65**	**14.95** E
Organometallics									
TBT*	mg/kg-OCN	76	76	**135.6**	19.1	NR	NR	NR	NR

Notes:

* TBT concentrations are compared to the West Waterway Confirmational Number.

** The TBT concentration for sample EBB01C is reported in ug/kg-dry weight rather than mg/kg-OCN

J The analyte was analyzed for and positively identified, but the associated numerical value is an estimated quantity.

NA Not available

NR Not reported

U The analyte was undetected at reported detection limit.

Bold concentrations indicate an exceedance of the SQS.

Boxed concentrations indicate an exceedance of the CSL.

Italicized concentrations indicate a detection limit exceedance of either SQS or CSL.

Additional qualifier definitions for the various sampling events are unknown.

Table A-11b. Historical Surface Sediment Analytical Data—Data Evaluation Summary Compared to LAET and 2LAET

Lockheed Shipyard No. 2 Surface Samples

				Within Yard 2	Sample Locations North of Yard 2			West Waterway		
			Location	LTHB01	EBB01-1	EBB01-2	EBB01-3	WW-15	42	LTIC05
			Sample ID	8500342	E023	E024	E025	WW-15	42	8500364
			Sample Date	1/7/1985	7/6/2000	7/6/2000	7/6/2000	10/8/1985	7/26/1983	1/8/1985
			Sample Depth	0-10 cm	0-11 cm	0-9 cm	0-11.5 cm	0-10 cm	0-10 cm	0-10 cm
Parameter	**Units**	**LAET**	**2LAET**							
Conventionals										
Total Organic Carbon	%	NA	NA	NR	NR	NR	NR	0.12	NR	NR
Metals										
Arsenic	mg/kg	57	93	26.5	NR	NR	NR	31.2	**1420**	45.8
Cadmium	mg/kg	5.1	6.7	1.63	NR	NR	NR	0.21	2.2	0.813
Chromium	mg/kg	260	270	53.1	NR	NR	NR	178 E	165	47.9
Copper	mg/kg	390	390	98	NR	NR	NR	86.2	**1050**	229
Lead	mg/kg	450	530	100	NR	NR	NR	136	**2179**	177
Mercury	mg/kg	0.41	0.59	**0.469**	0.4	0.3	0.25	0.041 E	0.219	**0.729**
Silver	mg/kg	6.1	6.1	NR	NR	NR	NR	0.083 E	1.72	NR
Zinc	mg/kg	410	960	245	NR	NR	NR	253 E	**4810**	229
SVOCs										
Naphthalene	µg/kg	2100	2400	NR	NR	NR	NR	133.33 U	100 U	NR
Acenaphthylene	µg/kg	1300	1300	**3100**	NR	NR	NR	49.17 U	100 U	NR
Acenaphthene	µg/kg	500	730	NR	NR	NR	NR	74.17 U	100 U	NR
Fluorene	µg/kg	540	1000	**3700**	NR	NR	NR	83.33 U	100 U	NR
Phenanthrene	µg/kg	1500	5400	**14000**	NR	NR	NR	82.5 U	**2900**	**6500**
Anthracene	µg/kg	960	4400	**4900**	NR	NR	NR	77.5 U	640	**1700**
2-Methylnaphthalene	µg/kg	670	1400	NR	NR	NR	NR	166.67 U	100 U	NR
Total LPAH	µg/kg	5200	13000	**25700**	NR	NR	NR	133.33 U	3540	8200
Fluoranthene	µg/kg	1700	2500	**16000**	NR	NR	NR	9.17 E	**4800**	8100
Pyrene	µg/kg	2600	3300	**17000**	NR	NR	NR	10.83 E	**4400**	8500
Benzo(a)anthracene	µg/kg	1300	1600	**1900**	NR	NR	NR	26.67 U	**1800**	1000
Chrysene	µg/kg	1400	2800	**3300**	NR	NR	NR	30.83 U	**2400**	2000
Benzofluoranthenes (total)	µg/kg	3200	3600	**11000**	NR	NR	NR	41.67 U	**3600**	5600
Benzo(a)pyrene	µg/kg	1600	3000	**3900**	NR	NR	NR	33.33 U	**2100**	NR
Indeno(1,2,3-cd)pyrene	µg/kg	600	690	**980**	NR	NR	NR	30 U	100 U	NR
Dibenzo(a,h)anthracene	µg/kg	230	540	NR	NR	NR	NR	49.17 U	100 U	NR
Benzo(g,h,i)perylene	µg/kg	670	720	**800**	NR	NR	NR	29.17 U	**780**	NR
Total HPAH	µg/kg	12000	17000	**54880**	NR	NR	NR	20 E	**19880**	**25200**
1,2-Dichlorobenzene	µg/kg	35	50	NR	1.3 U	1.3 U	1.3 U	***175*** U	***100*** U	NR
1,4-Dichlorobenzene	µg/kg	110	120	NR	1.3 U	1.3 U	1.3 U	***383.33*** U	100 U	NR
1,2,4-Trichlorobenzene	µg/kg	31	51	NR	6.5 U	6.5 U	6.7 U	***733.33*** U	***100*** U	NR
Hexachlorobenzene	µg/kg	22	70	NR	NR	NR	NR	***683.33*** U	***100*** U	NR
Dimethyl phthalate	µg/kg	71	160	NR	NR	NR	NR	42.5 U	***100*** U	NR
Diethylphthalate	µg/kg	200	200	NR	NR	NR	NR	NR	100 U	NR
Di-n-butyl phthalate	µg/kg	1400	1400	530	NR	NR	NR	NR	100 U	NR
Butyl benzyl phthalate	µg/kg	63	900	NR	NR	NR	NR	29.17 U	***100*** U	NR
bis(2-ethylhexyl)phthalate	µg/kg	1300	1900	**1300**	NR	NR	NR	NR	100 U	NR
Di-n-octyl phthalate	µg/kg	6200	6200	NR	NR	NR	NR	19.17 U	100 U	2400
Dibenzofuran	µg/kg	540	700	NR	NR	NR	NR	166.67 E	100 U	NR
Hexachlorobutadiene	µg/kg	11	120	NR	NR	NR	NR	***1500*** U	***100*** U	NR
N-Nitrosodiphenylamine	µg/kg	28	40	NR	NR	NR	NR	NR	NR	NR
Phenol	µg/kg	420	1200	NR	NR	NR	NR	190 E	50 U	NR
2-Methylphenol	µg/kg	63	72	NR	NR	NR	NR	***75*** U	NR	NR
4-Methylphenol	µg/kg	670	1,800	NR	NR	NR	NR	180 E	50 U	NR
2,4-Dimethylphenol	µg/kg	29	72	NR	NR	NR	NR	***63*** U	***50*** U	NR
Pentachlorophenol	µg/kg	360	690	NR	NR	NR	NR	***900*** U	50 U	NR
Benzyl alcohol	µg/kg	57	73	NR	NR	NR	NR	***1700*** U	***100*** U	NR
Benzoic acid	µg/kg	650	650	NR	NR	NR	NR	520 U	50 U	NR
PCBs										NR
PCBs (total)	µg/kg	130	1000	**6560**	NR	NR	NR	NR	**3200**	**2270**

Notes:

J The analyte was analyzed for and positively identified, but the associated numerical value is an estimated quantity.

NA Not available

NR Not reported

U The analyte was undetected at reported detection limit.

Bold concentrations indicate an exceedance of the LAET.

Boxed concentrations indicate an exceedance of the 2LAET.

Italicized concentrations indicate a detection limit exceedance of either LAET or 2LAET.

Additional qualifier definitions for the various sampling events are unknown.

Table A-12a. US EPA/USACE "Bold Study" Analytical Data-SVOCs

Sample ID	AI_1		AI_11_C		AI_13_C		AI_20_C_GS		AI_5_C		CPS_0		CPS_1		CPS_3		CPS_4		CPS_5		HC_0		HC_1		HC_2		HC_3		HC_6		NCPS_0		NCPS_1		NCPS_2		NCPS_3		NCPS_4		PSPS_1		PSPS_2		PSPS_3	
Analyte (ug/kg)	**7/31/2008**	**Q**	**8/1/2008**	**Q**	**8/3/2008**	**Q**	**8/1/2008**	**Q**	**8/1/2008**	**Q**	**8/4/2008**	**Q**	**8/4/2008**	**Q**	**7/31/2008**	**Q**	**8/4/2008**	**Q**	**7/31/2008**	**Q**	**8/3/2008**	**Q**	**8/2/2008**	**Q**	**8/3/2008**	**Q**	**8/2/2008**	**Q**	**8/2/2008**	**Q**	**7/31/2008**	**Q**	**7/31/2008**	**Q**	**8/3/2008**	**Q**	**7/31/2008**	**Q**	**7/31/2008**	**Q**	**8/3/2008**	**Q**	**8/3/2008**	**Q**	**8/3/2008**	**Q**
Naphthalene	1.9	U	1.7	U	1.8	U	2	U	1.9	U	4.3		3		2	U	1.8	J	1.8	U	4.5	U	2.1	U	4	U	2.0	U	1.7	J	1.5	J	1.7	U	1.7	U	1.7	J	1.6	J	2.8	U	2.4	U	3.4	U
Acenaphthylene	1.9	U	1.7	U	1.8	U	2	U	1.9	U	4.1	U	2.3	U	2	U	2	U	1.8	U	4.5	U	2.1	U	4	U	2.0	U	2.5	U	1.7	U	1.7	U	1.7	U	2.3	U	1.9	U	2.8	U	2.4	U	3.4	U
Acenaphthene	1.9	U	1.7	U	1.8	U	2	U	1.9	U	4.1	U	2.3	U	2	U	2	U	1.8	U	4.5	U	2.1	U	4	U	2.0	U	2.5	U	1.7	U	1.7	U	1.7	U	2.3	U	1.9	U	2.8	U	2.4	U	3.4	U
Fluorene	1.9	U	1.7	U	1.8	U	2	U	1.9	U	4.1	U	2.3	U	2	U	2	U	1.8	U	4.5	U	2.1	U	4	U	2.0	U	2.5	U	1.7	U	1.7	U	1.7	U	2.3	U	1.9	U	2.8	U	2.4	U	3.4	U
Phenanthrene	3.1		1.7	U	2.4		3.4		1.8	J	12		7.8		8.8		2.4		3		4.6		2.9		4	U	5.7		5		9.2		1.7	U	3		11		3.6		2.8	U	2.4	U	3.4	U
Anthracene	1.9	U	1.7	U	1.8	U	2	U	1.9	U	2.8	J	2.3	U	2.7		2	U	1.8	U	4.5	U	2.1	U	4	U	2.0	U	1.5	J	2.5		1.7	U	1.7	U	3.6		1.9	U	2.8	U	2.4	U	3.4	U
2-Methylnaphthalene	1.7	J	1.7	U	1.8	U	2.3		1.9	U	3.1	J	2.3	J	2	U	1.5	J	1.8	U	4.5	U	2.1	U	4	U	2.4		1.7	J	1.1	J	1.7	U	1.7	U	2.1	J	2		2.8	U	2.4	U	3.4	U
Fluoranthene	3.3		1.7	U	2.7		3.2		2.1		20		19		16		4.3		7.6		6.5		2.8		4.8		7.1		9.0		11		1.7	U	5.3		22		4.4		2.8	U	3.6		6	
Pyrene	3.2		1.7	U	2.3		3		2.2		23		15		17		4.5		8.4		7.7		2.8		5.4		5.8		8.6		13		1.7	U	5.6		17		3.6		2.8	U	4.1		6.3	
Benzo(a)anthracene	1.9	U	1.7	U	1.8	U	1.4	J	1.9	U	12		8.6		8.1		2.1		4.2		4.5	UJ	2.1	U	4	U	2.6		5.4		5.2		1.7	U	3		10		1.7	J	2.8	U	2.4	U	13	
Chrysene	1.9	U	1.7	U	1.8	U	2.1		1.9	U	12		8.9		8.2		2.5		4.3		4.5	UJ	2.1	U	4	U	2.6		5.9		6.4		1.7	U	2.8		10		2		2.8	U	2.5		13	
Benzo(b)fluoranthene	3.1		1.7	U	2.3		3.1		2.4		27		12	D	14	D	5		8.8		6.9		3.1		5.2		7.7		11		8.7		1.7	U	8.9		24	D	5.5		2.8	U	5.7		39	D
Benzo(k)fluoranthene	1.3	J	1.7	U	1.6	J	2.2		1.6	J	9.7		8.3		7.4		2.1		3.3		4.8		1.1	J	4.2		3.3	J	6.1		5		1.7	U	3.9	J	14		2		2.8	U	3.8		22	
Benzo(a)pyrene	1.9	U	2.5		1.8	U	2	U	1.9	U	14		11		15		2.5		4.8		4.5	U	2.1	U	4	U	3.2		5.5		4.1		1.7	U	5		15		2.4		2.8	U	2.8		15	
Indeno(1,2,3-cd)pyrene	1.9	U	1.7	U	1.8	U	3.4		1.9	U	4.1	U	3.3		2	U	4.5		1.8	U	4.5	J	2.1	U	4	U	2.0	U	2.5	U	1.7	U	1.7	U	1.7	U	3.5		1.9	U	2.8	U	3.4		3.4	U
Dibenzo(a,h)anthracene	1.9	U	1.7	U	1.8	U	2	U	1.9	U	4.1	U	2.6		2	U	2	U	1.8	UJ	4.5	U	2.1	U	4	U	2.0	U	2.5	U	1.7	U	1.7	U	1.7	U	2.7		1.9	U	2.8	U	2.4	U	3.4	U
Benzo(g,h,I)perylene	1.9	U	1.7	U	1.8	U	2.4		1.9	U	4.1	U	2.3	U	2	U	2.1		1.8	U	4.5	U	2.1	U	4	U	3.6		5		1.7	U	1.7	U	1.7	U	2.3	U	2.7		2.8	U	2.4	U	3.4	U
1,3-Dichlorobenzene	19	U	17	U	18	U	20	U	19	U	42	U	23	U	21	U	20	U	18	U	46	U	21	U	40	U	20	U	26	U	18	U	17	U	17	U	24	U	20	U	28	U	24	U	34	U
1,4-Dichlorobenzene	19	U	17	U	18	U	20	U	19	U	42	U	23	U	21	U	20	U	18	U	46	U	21	U	40	U	20	U	26	U	18	U	17	U	17	U	24	U	20	U	28	U	24	U	34	U
1,2-Dichlorobenzene	19	U	17	U	18	U	20	U	19	U	42	U	23	U	21	U	20	U	18	U	46	U	21	U	40	U	20	U	26	U	18	U	17	U	17	U	24	U	20	U	28	U	24	U	34	U
Hexachlorobenzene	19	U	17	U	18	U	20	U	19	U	42	U	23	U	21	U	20	U	18	U	46	U	21	U	40	U	20	U	26	U	18	U	17	U	17	U	24	U	20	U	28	U	24	U	34	U
Dimethylphthalate	19	U	17	U	18	U	20	U	19	U	42	U	23	U	21	U	20	U	18	U	46	U	21	U	40	U	20	U	26	U	18	U	17	U	17	U	24	U	20	U	28	U	24	U	34	U
Diethylphthalate	19	U	17	U	18	U	20	U	19	U	42	U	23	U	21	U	20	U	18	U	46	U	21	U	40	U	20	U	26	U	18	U	17	U	17	U	24	U	20	U	28	U	24	U	34	U
Di-n-butylphthalate	19	U	17	U	18	U	20	U	19	U	42	U	23	U	21	U	20	U	18	U	46	U	21	U	40	U	20	U	26	U	18	U	17	U	17	U	24	U	20	U	28	U	24	U	34	U
Butylbenzylphthalate	19	U	17	U	18	U	20	U	19	U	42	U	23	U	21	U	20	U	18	U	46	U	21	U	40	U	20	U	26	U	18	U	17	U	17	U	24	U	20	U	28	U	24	U	34	U
Bis(2-ethylhexyl)phthalate	19	U	17	U	18	U	20	U	19	U	42	U	23	U	21	U	20	U	18	U	46	U	21	U	40	U	20	U	26	U	18	U	17	U	17	U	24	U	20	U	28	U	24	U	34	U
Di-n-octylphthalate	19	U	17	U	18	U	20	U	19	U	42	U	23	U	21	U	20	U	18	U	46	U	21	U	40	U	20	U	26	U	18	U	17	U	17	U	24	U	20	U	28	U	24	U	34	U
Phenol	190		17	U	340		220		290		150		69		210		20	U	110		240		280		1200		520		340		820		17	U	290		860		450		80		220		200	
2-Methylphenol	19	U	17	U	18	U	20	U	19	U	42	U	23	U	21	U	20	U	18	U	46	U	21	U	40	U	20	U	26	U	18	U	17	U	17	U	24	U	20	U	28	U	24	U	34	U
4-Methylphenol	27		17	U	99		120		86		130		55		140		20	U	18	U	46	U	160		300		180		55		330		17	U	75		190		150		28	U	24	U	34	U
2,4-Dimethylphenol	19	U	17	U	18	U	20	U	19	U	42	U	23	U	21	U	20	U	18	U	46	U	21	U	40	U	20	U	26	U	18	U	17	U	17	U	24	U	20	U	28	U	24	U	34	U
4,6-Dinitro-2-methylphenol	190	U	170	U	180	U	200	U	190	U	420	U	230	U	210	U	200	U	180	U	460	U	210	U	400	U	200	U	260	U	180	U	170	U	170	U	240	U	200	U	280	U	240	U	340	U
2-Nitrophenol	19	U	17	U	18	U	20	U	19	U	42	U	23	U	21	U	20	U	18	U	46	U	21	U	40	U	20	U	26	U	18	U	17	U	17	U	24	U	20	U	28	U	24	U	34	U
4-Nitrophenol	190	U	170	U	180	U	200	U	190	U	420	U	230	U	210	U	200	U	180	U	460	U	210	U	400	U	200	U	260	U	180	U	170	U	170	U	240	U	200	U	280	U	240	U	340	U
2,4-Dinitrophenol	190	UJ	170	UJ	180	UJ	200	UJ	190	UJ	420	UJ	230	UJ	210	UJ	200	UJ	180	UJ	460	UJ	210	UJ	400	UJ	200	U	260	UJ	180	UJ	170	UJ	170	UJ	240	UJ	200	UJ	280	UJ	240	UJ	340	UJ
2-Chlorophenol	19	U	17	U	18	U	20	U	19	U	42	U	23	U	21	U	20	U	18	U	46	U	21	U	40	U	20	U	26	U	18	U	17	U	17	U	24	U	20	U	28	U	24	U	34	U
4-Chloro-3-methylphenol	19	U	17	U	18	U	20	U	19	U	42	U	23	U	21	U	20	U	18	U	46	U	21	U	40	U	20	U	26	U	18	U	17	U	17	U	24	U	20	U	28	U	24	U	34	U
2,4-Dichlorophenol	19	U	17	U	18	U	20	U	19	U	42	U	23	U	21	U	20	U	18	U	46	U	21	U	40	U	20	U	26	U	18	U	17	U	17	U	24	U	20	U	28	U	24	U	34	U
2,4,6-Trichlorophenol	19	U	17	U	18	U	20	U	19	U	42	U	23	U	21	U	20	U	18	U	46	U	21	U	40	U	20	U	26	U	18	U	17	U	17	U	24	U	20	U	28	U	24	U	34	U
2,4,5-Trichlorophenol	19	U	17	U	18	U	20	U	19	U	42	U	23	U	21	U	20	U	18	U	46	U	21	U	40	U	20	U	26	U	18	U	17	U	17	U	24	U	20	U	28	U	24	U	34	U
2,3,4,6-Tetrachlorophenol	19	U	17	U	18	U	20	U	19	U	42	U	23	U	21	U	20	U	18	U	46	U	21	U	40	U	20	U	26	U	18	U	17	U	17	U	24	U	20	U	28	U	24	U	34	U
Pentachlorophenol	3.9	UJ	3.5	UJ	3.7	UJ	4	UJ	3.8	UJ	8.4	UJ	4.6	UJ	4.2	UJ	4.1	UJ	3.6	UJ	9.2	UJ	4.3	UJ	8.1	UJ	3.9	UJ	5.1	UJ	3.5	UJ	3.4	UJ	3.3	UJ	4.8	UJ	3.9	UJ	5.6	UJ	4.8	UJ	6.8	UJ
Benzyl alcohol	19	U	17	U	18	U	20	U	19	U	42	U	23	U	21	U	20	U	18	U	46	U	21	U	40	U	20	U	26	U	18	U	17	U	17	U	24	U	20	U	28	U	24	U	34	U
Benzoic Acid	19	U	17	U	18	U	20	U	19	U	42	U	23	U	21	U	20	U	18	U	46	U	21	U	40	U	20	U	26	U	18	U	17	U	17	U	24	U	20	U	28	U	24	U	34	U
Dibenzofuran	1.9	U	1.7	U	1.8	U	2	U	1.9	U	4.1	U	2.3	U	2	U	2	U	1.8	U	4.5	U	2.1	U	4	U	2.0	U	2.5	U	1.7	U	1.7	U	1.7	U	2.3	U	1.9	U	2.8	U	2.4	U	3.4	U
Hexachloroethane	19	U	17	U	18	U	20	U	19	U	42	U	23	U	21	U	20	U	18	U	46	U	21	U	40	U	20	U	26	U	18	U	17	U	17	U	24	U	20	U	28	U	24	U	34	U
Hexachlorobutadiene	19	U	17	U	18	U	20	U	19	U	42	U	23	U	21	U	20	U	18	U	46	U	21	U	40	U	20	U	26	U	18	U	17	U	17	U	24	U	20	U	28	U	24	U	34	U
N-Nitrosodiphenylamine	19	U	17	U	18	U	20	U	19	U	42	U	23	U	21	U	20	U	18	U	46	U	21	U	40	U	20	U	26	U	18	U	17	U	17	U	24	U	20	U	28	U	24	U	34	U
Benzaldehyde	19	U	17	U	18	U	20	U	19	U	42	U	23	U	21	U	20	U	18	U	46	U	21	U	40	U	20	U	26	U	18	U	17	U	17	U	24	U	20	U	28	U	24	U	34	U
Bis(2-Chloroethyl)ether	19	U	17	U	18	U	20	U	19	U	42	U	23	U	21	U	20	U	18	U	46	U	21	U	40	U	20	U	26	U	18	U	17	U	17	U	24	U	20	U	28	U	24	U	34	U
2,2'-Oxybis(1-chloropropane)	19	U	17	U	18	U	20	U	19	U	42	U	23	U	21	U	20	U	18	U	46	U	21	U	40	U	20	U	26	U	18	U	17	U	17	U	24	U	20	U	28	U	24	U	34	U
Acetophenone	19	U	17	U	18	U	20	U	19	U	42	U	23	U	21	U	20	U	18	U	46	U	21	U	40	U	20	U	26	U	18	U	17	U	17	U	24	U	20	U	28	U	24	U	34	U
N-Nitroso-di-n-propylamine	19	U	17	U	18	U	20	U	19	U	42	U	23	U	21	U	20	U	18	U	46	U	21	U	40	U	20	U	26	U	18	U	17	U	17	U	24	U	20	U	28	U	24	U	34	U
Isophorone	19	U	17	U	18	U	20	U	19	U	42	U	23	U	21	U	20	U	18	U	46	U	21	U	40	U	20	U	26	U	18	U	17	U	17	U	24	U	20	U	28	U	24	U	34	U
Bis(2-chloroethoxy)methane	19	U	17	U	18	U	20	U	19	U	42	U	23	U	21	U	20	U	18	U	46	U	21	U	40	U	20	U	26	U	18	U	17	U	17	U	24	U	20	U	28	U	24	U	34	U
4-Chloroaniline	19	U	17	U	18	U	20	U	19	U	42	U	23	U	21	U	20	U	18	U	46	U	21	U	40	U	20	U	26	U	18	U	17	U	17	U	24	U	20	U	28	U	24	U	34	U
Caprolactam	19	U	17	U	18	U	20	U	19	U	42	U	23	U	21	U	20	U	18	U	46	U	21	U	40	U	20	U	26	U	18	U	17	U	17	U	24	U	20	U	28	U	24	U	34	U
2,6-Dinitrotoluene	19	U	17	U	18	U	20	U	19	U	42	U	23	U	21	U	20	U	18	U	46	U	21	U	40	U	20	U	26	U	18	U	17	U	17	U	24	U	20	U	28	U	24	U	34	U
2,4-Dinitrotoluene	19	U	17	U	18	U	20	U	19	U	42	U	23	U	21	U	20	U	18	U	46	U	21	U	40	U	20	UJ	26	U	18	U	17	U	17	U	24	U	20	U	28	U	24	U	34	U
1,1'-Biphenyl	19	U	17	U	18	U	20	U	19	U	42	U	23	U	21	U	20	U	18	U	46	U	21	U	40	U	20	U	26	U	18	U	17	U	17	U	24	U	20	U	28	U	24	U	34	U
2-Chloronaphthalene	19	U	17	U	18	U	20	U	19	U	42	U	23	U	21	U	20	U	18	U	46	U	21	U	40	U	20	U	26	U	18	U	17	U	17	U	24	U	20	U	28	U	24	U	34	U
2-Nitroaniline	190	U	170	U	180	U	200	U	190	U	420	U	230	U	210	U	200	U	180	U	460	U	210	U	400	U	200	U	260	U	180	U	170	U	170	U	240	U	200	U	280	U	240	U	340	U
3-Nitroaniline	190	U	170	U	180	U	200	U	190	U	420	U	230	U	210	U	200	U	180	U	460	U	210	U	400	U	200	U	260	U	180	U	170	U	170	U	240	U	200	U	280	U	240	U	340	U
4-Nitroaniline	190	U	170	U	180	U	200	U	190	U	420	U	230	U	210	U	200	U	180	U	460	U	210	U	400	U	200	U	260	U	180	U	170	U	170	U	240	U	190	U	280	U	240	U	340	U
4-Chlorophenyl-phenylether	19	U	17	UJ	18	U	20	U	19	U	42	U	23	U	21	U	20	U	18	U	46	U	21	U	40	U	20	U	26	U	18	U	17	U	17	U	24	U	20	U	28	U	24	U	34	U
Nitrobenzene	19	U	17	U	18	U	20	U	19	U	42	U	23	U	21	U	20	U	18	U	46	U	21	U	40	U	20	U	26	U	18	U	17	U	17	U	24	U	20	U	28	U	24	U	34	U
1,2,4,5-Tetrachlorobenzene	19	U	17	U	18	U	20	U	19	U	42	U	23	U	21	U	20	U	18	U	46	U	21	U	40	U	20	U	26	U	18	U	17	U	17	U	24	U	20	U	28	U	24	U	34	U
4-Bromophenyl-phenylether	19	U	17	UJ	18	U	20	U	19	U	42	U	23	U	21	U	20	U	18	U	46	U	21	U	40	U	20	U	26	U	18	U	17	U	17	U	24	U	20	U	28	U	24	U	34	U
3,3'-Dichlorobenzidine	19	U	17	U	18	U	20	U	19	U	42	U	23	U	21	U	20	U	18	U	46	U	21	U	40	U	20	U	26	U	18	U	17	U	17	U	24	U	20	U	28	U	24	U	34	U
Hexachlorocyclopentadiene	19	U	17	U	18	U	20	U	19	U	42	U	23	U	21	U	20	U	18	U	46	U	21	U	40	U	20	U	26	U	18	U	17	U	17	U	24	U	20	U	28	U	24	U	34	U
Atrazine	19	U	17	U	18	U	20	U	19	U	42	U	23	U	21	U	20	U	18	U	46	U	21	U	40	U	20	U	26	U	18	U	17	U	17	U	24	U	20	U	28	U	24	U	34	U
Carbazole	19	U	17	UJ	18	U	20	U	19	U	42	U	23	U	21	U	20	U	18	U	46	U	21	U	40	U	20	U	26	U	18	U	17	U	17	U	24	U	20	U	28	U	24	U	34	U

Notes:
ug/kg = micrograms per kilogram
mg/kg = milligrams per kilogram
U = Result should be considered not-detected at the quantitation limit shown
J = Result is an estimated concentration
R = Rejected - Quality Control indicates the data is not usable
UJ = The compound was not detected and the sample detection limit should be considered an estimated value

Table A-12a. US EPA/USACE "Bold Study" Analytical Data-SVOCs

Sample ID	PSPS_8		PSPS_9		R_CAR_0		R_CAR_1		R_CAR_4		R_CAR_5		R_CAR_6_C		R_DAB_0		R_DAB_1		R_DAB_2		R_DAB_5		R_DAB_7_C		R_HOL_0		R_HOL_1		R_HOL_3		R_HOL_4		R_HOL_7		R_SAM_0		R_SAM_1		R_SAM_3	
Analyte (ug/kg)	**8/3/2008**	**Q**	**8/3/2008**	**Q**	**8/4/2008**	**Q**	**8/4/2008**	**Q**	**8/4/2008**	**Q**	**8/4/2008**	**Q**	**8/4/2008**	**Q**	**8/2/2008**	**Q**	**8/2/2008**	**Q**	**8/2/2008**	**Q**	**8/2/2008**	**Q**	**8/2/2008**	**Q**	**8/3/2008**	**Q**	**8/3/2008**	**Q**	**8/3/2008**	**Q**	**8/3/2008**	**Q**	**8/3/2008**	**Q**	**8/1/2008**	**Q**	**8/1/2008**	**Q**	**8/1/2008**	**Q**
Naphthalene	1.4	U	2.1	U	2.1	U	2	U	3	U	3.2	J	1.8	U	1.9	U	3.8	U	3	U	1.8	U	2	U	1.6	U	4.6	U	4.4	U	1.7	J	2.3	J	2.6	U	2.2	U	2.9	U
Acenaphthylene	1.4	U	2.1	U	2.1	U	2	U	3	U	3.9	U	1.8	U	1.9	U	3.8	U	3	U	1.8	U	2	U	1.6	U	4.6	U	4.4	U	1.9	U	2.9	U	2.6	U	2.2	U	2.9	U
Acenaphthene	1.4	U	2.1	U	2.1	U	2	U	3	U	3.9	U	1.8	U	1.9	U	3.8	U	3	U	1.8	U	2	U	6		4.6	U	4.4	U	1.9	U	2.9	U	2.6	U	2.2	U	2.9	U
Fluorene	1.4	U	2.1	U	2.1	U	2	U	3	U	3.9	U	1.8	U	1.9	U	3.8	U	3	U	1.8	U	2	U	1.6	U	4.6	U	4.4	U	1.9	U	2.9	U	2.6	U	2.2	U	2.9	U
Phenanthrene	1.4	U	2.1	U	2.1	U	2	U	3.3		4.5		1.8	U	1.5	J	3.9		4.7		1.8	U	2	U	1.6	U	4.9		4.4	J	3.6		7.4		6.5		4.4		2.9	
Anthracene	1.4	U	2.1	U	2.1	U	2	U	3	U	3.9	U	1.8	U	1.9	U	3.8	U	3	U	1.8	U	2	U	1.6	U	4.6	U	4.4	U	1.9	U	2.9	U	2.6	U	2.2	U	2.9	U
2-Methylnaphthalene	1.4	U	2.1	U	2.1	U	2	U	3	U	3.9	U	1.8	U	1.9	U	3.8	U	3	U	1.8	U	2	U	1.6	U	4.6	U	4.4	U	2		2.4	J	3.1		2.2	U	2.9	U
Fluoranthene	1.4	U	2	J	2	J	1.7	J	8.4		11		1.3	J	1.9		5.4		6.1		1.8	U	2.1		1.6	U	11		11		5.1		11		10		6.6		5.8	
Pyrene	1.4	U	2.1		2.8		2.3		7.1		10		1.5	J	1.8	J	5.5		6.8		1.8	U	2.3		5.8		12		11		3.9		11		8.2		6.3		5.4	
Benzo(a)anthracene	1.4	U	2.1	U	2.1	U	2	U	2.7	J	5.3		1.8	U	1.9	U	2.5	J	3	U	1.8	U	2	U	1.6	U	5.3		4.2	J	1.7	J	4.8		4.4		2.7		2.6	J
Chrysene	1.4	U	2.1	U	2.1	U	2	U	4.8		6.4		1.8	U	1.9	U	2.8	J	3.4		1.8	U	2	U	1.6	U	6.2		5.8		1.9		5.2		4.6		3.2		2.5	J
Benzo(b)fluoranthene	1.4	U	2.1	U	2.1	U	1.9	J	9.2		14		1.8	U	1.9	U	3.8	U	9.5		1.8	U	3.2		1.6	U	20		13		4		11		12		6.4		5.6	
Benzo(k)fluoranthene	1.4	U	2.1	U	2.1	U	0.96	J	3.9		5.5		1.8	U	1.9	U	3.8	U	3.3		1.8	U	1.2	J	1.6	U	8.8		5		1.5	J	4.5		4.3		2.3		2.1	J
Benzo(a)pyrene	3.5		2.1	U	2.1	U	2	U	4.2		6.1		1.8	U	1.9	U	3.8	U	4.4		3.7		2	U	3.2		9.9		6.6		1.9	U	4.6		2.6	U	2.6		2.5	J
Indeno(1,2,3-cd)pyrene	1.4	U	1.8	J	2.1	U	2	U	5.3		3.9	U	1.8	U	1.9	U	3.8	U	3	U	1.8	U	2	U	1.6	U	4.6	U	11		1.9	U	2.9	U	7.3		2.2	U	3.6	
Dibenzo(a,h)anthracene	1.4	U	2.1	U	2.1	U	2	U	3	U	3.9	U	1.8	U	1.9	U	3.8	U	3	U	1.8	U	2	U	1.6	U	4.6	U	4.4	U	1.9	U	2.9	U	2.6	U	2.2	U	2.9	U
Benzo(g,h,I)perylene	1.4	U	2.1	U	2.1	U	2	U	3.4		3.9	U	1.8	U	1.9	U	3.8	U	5.7		1.8	U	2	U	1.6	U	4.6	U	6.3		1.9	U	2.9	U	5.7		2.7		2.9	J
1,3-Dichlorobenzene	14	U	21	U	22	U	20	U	30	U	39	U	18	U	19	U	38	U	30	U	18	U	20	U	16	U	46	U	44	U	19	U	29	U	26	U	22	U	29	U
1,4-Dichlorobenzene	14	U	21	U	22	U	20	U	30	U	39	U	18	U	19	U	38	U	30	U	18	U	20	U	16	U	46	U	44	U	19	U	29	U	26	U	22	U	29	U
1,2-Dichlorobenzene	14	U	21	U	22	U	20	U	30	U	39	U	18	U	19	U	38	U	30	U	18	U	20	U	16	U	46	U	44	U	19	U	29	U	26	U	22	U	29	U
Hexachlorobenzene	14	U	21	U	22	U	20	U	30	U	39	U	18	U	19	U	38	U	30	U	18	U	20	U	16	U	46	U	44	U	19	U	29	U	26	U	22	U	29	U
Dimethylphthalate	14	U	21	U	22	U	20	U	30	U	39	U	18	U	19	UJ	38	U	30	U	18	U	20	U	16	U	46	U	44	U	19	U	29	U	26	U	22	U	29	U
Diethylphthalate	14	U	21	U	22	U	20	U	30	U	39	U	18	U	19	UJ	38	U	30	U	18	U	20	U	16	U	46	U	44	U	19	U	29	U	26	U	22	U	29	U
Di-n-butylphthalate	14	U	21	U	22	U	20	U	30	U	39	U	18	U	19	UJ	38	U	30	U	18	U	20	U	16	U	46	U	44	U	19	U	29	U	26	U	22	U	29	U
Butylbenzylphthalate	14	U	21	U	22	U	20	U	30	U	39	U	18	U	19	UJ	38	U	30	U	18	U	20	U	16	U	46	U	44	U	19	U	29	U	26	U	22	U	29	U
Bis(2-ethylhexyl)phthalate	14	U	21	U	22	U	20	U	30	U	39	U	18	U	19	UJ	38	U	30	U	18	U	71		45		46	U	44	U	19	U	29	U	26	U	22	U	29	U
Di-n-octylphthalate	14	U	21	U	22	U	20	U	30	U	39	U	18	U	19	UJ	38	U	30	U	18	U	20	U	16	U	46	U	44	U	19	U	29	U	26	U	22	U	29	U
Phenol	14	U	91		22	U	20	U	30	U	310		18	U	78		38	U	170		18	U	20	U	16	U	200		180		300		800		480		820		880	
2-Methylphenol	14	U	21	U	22	U	20	U	30	U	39	U	18	U	19	U	38	U	30	U	18	U	20	U	16	U	46	U	44	U	19	U	29	U	26	U	22	U	29	U
4-Methylphenol	14	U	21	U	56		20	U	72		120		18	U	70		38	U	30	U	18	U	69		16	U	63		530		86		530		370		260		790	
2,4-Dimethylphenol	14	U	21	U	22	U	20	U	30	U	39	U	18	U	19	U	38	U	30	U	18	U	20	U	16	U	46	U	44	U	19	U	29	U	26	U	22	U	29	U
4,6-Dinitro-2-methylphenol	140	U	210	U	220	U	200	U	300	U	390	U	180	U	190	U	380	U	300	U	180	U	200	U	160	U	460	U	440	U	190	U	290	U	260	U	220	U	290	U
2-Nitrophenol	14	U	21	U	22	U	20	U	30	U	39	U	18	U	19	U	38	U	30	U	18	U	20	U	16	U	46	U	44	U	19	U	29	U	26	U	22	U	29	U
4-Nitrophenol	140	U	210	U	220	U	200	U	300	U	390	U	180	U	190	U	380	U	300	U	180	U	200	U	160	U	460	U	440	U	190	U	290	U	260	U	220	U	290	U
2,4-Dinitrophenol	140	UJ	210	UJ	220	UJ	200	UJ	300	UJ	390	UJ	180	UJ	190	UJ	380	UJ	300	UJ	180	UJ	200	UJ	160	UJ	460	UJ	440	UJ	190	U	290	U	260	UJ	220	UJ	290	U
2-Chlorophenol	14	U	21	U	22	U	20	U	30	U	39	U	18	U	19	U	38	U	30	U	18	U	20	U	16	U	46	U	44	U	19	U	29	U	26	U	22	U	29	U
4-Chloro-3-methylphenol	14	U	21	U	22	U	20	U	30	U	39	U	18	U	19	U	38	U	30	U	18	U	20	U	16	U	46	U	44	U	19	U	29	U	26	U	22	U	29	U
2,4-Dichlorophenol	14	U	21	U	22	U	20	U	30	U	39	U	18	U	19	U	38	U	30	U	18	U	20	U	16	U	46	U	44	U	19	U	29	U	26	U	22	U	29	U
2,4,6-Trichlorophenol	14	U	21	U	22	U	20	U	30	U	39	U	18	U	19	U	38	U	30	U	18	U	20	U	16	U	46	U	44	U	19	U	29	U	26	U	22	U	29	U
2,4,5-Trichlorophenol	14	U	21	U	22	U	20	U	30	U	39	U	18	U	19	U	38	U	30	U	18	U	20	U	16	U	46	U	44	U	19	U	29	U	26	U	22	U	29	U
2,3,4,6-Tetrachlorophenol	14	U	21	U	22	U	20	U	30	U	39	U	18	U	19	U	38	U	30	U	18	U	20	U	16	U	46	U	44	U	19	U	29	U	26	U	22	U	29	U
Pentachlorophenol	2.7	U	4.3	UJ	4.4	UJ	4.1	UJ	6.1	UJ	7.9	UJ	3.6	UJ	3.8	UJ	7.6	UJ	6.1	UJ	3.6	UJ	4	UJ	1.6	J	9.3	UJ	8.9	UJ	3.8	UJ	5.9	UJ	5.3	UJ	4.5	UJ	5.8	UJ
Benzyl alcohol	14	U	21	U	22	U	20	U	30	U	39	U	18	U	19	U	38	U	30	U	18	U	20	U	16	U	46	U	44	U	19	U	29	U	26	U	22	U	29	U
Benzoic Acid	14	U	21	U	22	U	20	U	30	U	39	U	18	U	19	U	38	U	30	U	18	U	20	U	16	U	46	U	44	U	19	U	29	U	26	U	22	U	29	U
Dibenzofuran	1.4	U	2.1	U	2.1	U	2	U	3	U	3.9	U	1.8	U	1.9	U	3.8	U	3	U	1.8	U	2	U	1.6	U	4.6	U	4.4	U	1.9	U	2.9	U	2.6	U	2.2	U	2.9	U
Hexachloroethane	14	U	21	U	22	U	20	U	30	U	39	U	18	U	19	U	38	U	30	U	18	U	20	U	16	U	46	U	44	U	19	U	29	U	26	U	22	U	29	U
Hexachlorobutadiene	14	U	21	U	22	U	20	U	30	U	39	U	18	U	19	U	38	U	30	U	18	U	20	U	16	U	46	U	44	U	19	U	29	U	26	U	22	U	29	U
N-Nitrosodiphenylamine	14	U	21	U	22	U	20	U	30	U	39	U	18	U	19	U	38	U	30	U	18	U	20	U	16	U	46	U	44	U	19	U	29	U	26	U	22	U	29	U
Benzaldehyde	14	U	21	U	22	U	20	U	30	U	39	U	18	U	19	U	38	U	30	U	18	U	20	U	16	U	46	U	44	U	19	U	29	U	26	U	77		29	U
Bis(2-Chloroethyl)ether	14	U	21	U	22	U	20	U	30	U	39	U	18	U	19	U	38	U	30	U	18	U	20	U	16	U	46	U	44	U	19	U	29	U	26	U	22	U	29	U
2,2'-Oxybis(1-chloropropane)	14	U	21	U	22	U	20	U	30	U	39	U	18	U	19	U	38	U	30	U	18	U	20	U	16	U	46	U	44	U	19	U	29	U	26	U	22	U	29	U
Acetophenone	14	U	21	U	22	U	20	U	30	U	39	U	18	U	19	U	38	U	30	U	18	U	20	U	16	U	46	U	44	U	19	U	29	U	26	U	22	U	29	U
N-Nitroso-di-n-propylamine	14	U	21	U	22	U	20	U	30	U	39	U	18	U	19	U	38	U	30	U	18	U	20	U	16	U	46	U	44	U	19	U	29	U	26	U	22	U	29	U
Isophorone	14	U	21	U	22	U	20	U	30	U	39	U	18	U	19	U	38	U	30	U	18	U	20	U	16	U	46	U	44	U	19	U	29	U	26	U	22	U	29	U
Bis(2-chloroethoxy)methane	14	U	21	U	22	U	20	U	30	U	39	U	18	U	19	U	38	U	30	U	18	U	20	U	16	U	46	U	44	U	19	U	29	U	26	U	22	U	29	U
4-Chloroaniline	14	U	21	U	22	U	20	U	30	U	39	U	18	U	19	U	38	U	30	U	18	U	20	U	16	U	46	U	44	U	19	U	29	U	26	U	22	U	29	U
Caprolactam	14	U	21	U	22	U	20	U	30	U	39	U	18	U	19	UJ	38	U	30	U	18	U	20	U	16	U	46	U	44	U	19	U	29	U	26	U	22	U	29	U
2,6-Dinitrotoluene	14	U	21	U	22	U	20	U	30	U	39	U	18	U	19	U	38	U	30	U	18	U	20	U	16	U	46	U	44	U	19	U	29	U	26	U	22	U	29	U
2,4-Dinitrotoluene	14	U	21	U	22	U	20	U	30	U	39	U	18	U	19	U	38	U	30	U	18	U	20	U	16	U	46	U	44	U	19	UJ	29	UJ	26	U	22	U	29	UJ
1,1'-Biphenyl	14	U	21	U	22	U	20	U	30	U	39	U	18	U	19	UJ	38	U	30	U	18	U	20	U	16	U	46	U	44	U	19	U	29	U	26	U	22	U	29	U
2-Chloronaphthalene	14	U	21	U	22	U	20	U	30	U	39	U	18	U	19	U	38	U	30	U	18	U	20	U	16	U	46	U	44	U	19	U	29	U	26	U	22	U	29	U
2-Nitroaniline	140	U	210	U	220	U	200	U	300	U	390	U	180	U	190	U	380	U	300	U	180	U	200	U	160	U	460	U	440	U	190	U	290	U	260	U	220	U	290	U
3-Nitroaniline	140	U	210	U	220	U	200	U	300	U	390	U	180	U	190	U	380	U	300	U	180	U	200	U	160	U	460	U	440	U	190	U	290	U	260	U	220	U	290	U
4-Nitroaniline	140	U	210	U	220	U	200	U	300	U	390	U	180	U	190	U	380	U	300	U	180	U	200	U	160	U	460	U	440	U	190	U	290	U	260	U	220	U	290	U
4-Chlorophenyl-phenylether	14	U	21	U	22	U	20	U	30	U	39	U	18	U	19	UJ	38	U	30	U	18	U	20	U	16	U	46	U	44	U	19	U	29	U	26	U	22	U	29	U
Nitrobenzene	14	U	21	U	22	U	20	U	30	U	39	U	18	U	19	U	38	U	30	U	18	U	20	U	16	U	46	U	44	U	19	U	29	U	26	U	22	U	29	U
1,2,4,5-Tetrachlorobenzene	14	U	21	U	22	U	20	U	30	U	39	U	18	U	19	U	38	U	30	U	18	U	20	U	16	U	46	U	44	U	19	U	29	U	26	U	22	U	29	U
4-Bromophenyl-phenylether	14	U	21	U	22	U	20	U	30	U	39	U	18	U	19	UJ	38	U	30	U	18	U	20	U	16	U	46	U	44	U	19	U	29	U	26	U	22	U	29	U
3,3'-Dichlorobenzidine	14	U	21	U	22	U	20	U	30	U	39	U	18	U	19	U	38	U	30	U	18	U	20	U	16	U	46	U	44	U	19	U	29	U	26	U	22	U	29	U
Hexachlorocyclopentadiene	14	U	21	U	22	UJ	20	UJ	30	UJ	39	U	18	UJ	19	U	38	U	30	U	18	U	20	U	16	UJ	46	U	44	U	19	U	29	U	26	U	22	U	29	U
Atrazine	14	U	21	U	22	U	20	U	30	U	39	U	18	U	19	U	38	U	30	U	18	U	20	U	16	U	46	U	44	U	19	U	29	U	26	U	22	U	29	U
Carbazole	14	U	21	U	22	U	20	U	30	U	39	U	18	U	19	UJ	38	U	30	U	18	U	20	U	16	U	46	U	44	U	19	U	29	U	26	U	22	U	29	U

Notes:
ug/kg = micrograms per kilogram
mg/kg = milligrams per kilogram
U = Result should be considered not-detected at the quantitation limit shown
J = Result is an estimated concentration
R = Rejected - Quality Control indicates the data is not usable
UJ = The compound was not detected and the sample detection limit should be considered an estimated value

Table A-12a. US EPA/USACE “Bold Study” Analytical Data-SVOCs

Sample ID	R_SAM_4		R_SAM_5		SCPS_1		SCPS_10_C		SCPS_2		SCPS_3		SCPS_5		SJF_10_C		SJF_12_C_GS		SJF_2	
Analyte (ug/kg)	**8/1/2008**	**Q**	**8/1/2008**	**Q**	**8/4/2008**	**Q**	**8/5/2008**	**Q**	**8/4/2008**	**Q**	**8/4/2008**	**Q**	**8/4/2008**	**Q**	**8/1/2008**	**Q**	**8/2/2008**	**Q**	**8/1/2008**	**Q**
Naphthalene	3.6	U	3.2	U	3.5	U	1.8	U	1.6	U	4.2	U	1.9	U	1.7		3.1	U	2.4	
Acenaphthylene	3.6	U	3.2	U	3.5	U	1.8	U	1.6	U	4.2	U	1.9	U	1.6	U	3.1	U	1.8	U
Acenaphthene	3.6	U	3.2	U	3.5	U	1.8	U	1.6	U	4.2	U	1.9	U	1.6	U	3.1	U	1.8	U
Fluorene	3.6	U	3.2	U	3.5	U	1.8	U	1.6	U	4.2	U	1.9	U	1.6	U	3.1	U	1.8	U
Phenanthrene	4.9		3.1	J	12		1.4	J	1.6	U	20		2.2		3.4		4		5.3	
Anthracene	3.6	U	3.2	U	3.7		1.8	U	1.6	U	6		1.9	U	1.6	U	3.1	U	1.8	U
2-Methylnaphthalene	3.6	U	3.2	U	3.5		1.8	U	1.6	U	4.2	J	1.9	U	2.9		3.1	U	4.4	
Fluoranthene	7.4		4.8		26		2.3		1.7		38		4		2.5		6		2.6	
Pyrene	7.3		5.4		20		1.9		1.5	J	30		4.1		2.2		5.1	J	2.3	
Benzo(a)anthracene	3.7		3.2	U	20		1.8	U	1.6	U	24		1.8	J	1.2	J	3.1	U	1.3	J
Chrysene	4.4		2.9	J	16		1.8	U	1.6	U	18		2		1.3	J	2.8	J	1.4	J
Benzo(b)fluoranthene	13		7.6		40	E	2.9		1.6	U	56	D	5.2		3		7.6		3.3	
Benzo(k)fluoranthene	4.9		3.9		15		1.1	J	1.6	U	17		2.6		1.1	J	4		1.2	J
Benzo(a)pyrene	6.5		3.5		28		1.8	U	1.6	U	42		3.4		1.6	U	3.5		1.8	U
Indeno(1,2,3-cd)pyrene	3.6	U	3.2	U	4.8		1.8	U	1.6	U	50	E	3.7		1.6	U	3.1	U	1.6	J
Dibenzo(a,h)anthracene	3.6	U	3.2	U	5		1.8	U	1.6	U	4.2	U	1.9	U	1.6	U	3.1	U	1.8	U
Benzo(g,h,I)perylene	5.6		5		3.5	U	1.8	U	1.6	U	27		2.5		1.6	U	5.1		2.3	
1,3-Dichlorobenzene	37	U	32	U	35	U	18	U	16	U	42	U	19	U	16	U	31	U	18	U
1,4-Dichlorobenzene	37	U	32	U	35	U	18	U	16	U	42	U	19	U	16	U	31	U	18	U
1,2-Dichlorobenzene	37	U	32	U	35	U	18	U	16	U	42	U	19	U	16	U	31	U	18	U
Hexachlorobenzene	37	U	32	U	35	U	18	U	16	U	42	U	19	U	16	U	31	U	18	U
Dimethylphthalate	37	U	32	U	35	U	18	U	16	U	42	U	19	U	16	U	31	U	18	U
Diethylphthalate	37	U	32	U	35	U	18	U	16	U	42	U	19	U	16	U	31	U	18	U
Di-n-butylphthalate	37	U	32	U	35	U	18	U	16	U	42	U	19	U	16	U	31	U	18	U
Butylbenzylphthalate	37	U	32	U	35	U	18	U	16	U	42	U	19	U	16	U	31	U	18	U
Bis(2-ethylhexyl)phthalate	37	U	32	U	35	U	18	U	16	U	42	U	19	U	16	U	31	U	18	U
Di-n-octylphthalate	37	U	32	U	35	U	18	U	16	U	42	U	19	U	16	U	31	U	18	U
Phenol	230		210		83		18	U	16	U	210		110		16	U	120		18	U
2-Methylphenol	37	U	32	U	35	U	18	U	16	U	42	U	19	U	16	U	31	U	18	U
4-Methylphenol	37	U	32	U	59		18	U	16	U	42	U	46		16	U	64		39	
2,4-Dimethylphenol	37	U	32	U	35	U	18	U	16	U	42	U	19	U	16	U	31	U	18	U
4,6-Dinitro-2-methylphenol	370	U	320	U	350	U	180	U	160	U	420	U	190	U	160	U	310	U	180	U
2-Nitrophenol	37	U	32	U	35	U	18	U	16	U	42	U	19	U	16	U	31	U	18	U
4-Nitrophenol	370	U	320	U	350	U	180	U	160	U	420	U	190	U	160	U	310	U	180	U
2,4-Dinitrophenol	370	UJ	320	UJ	350	UJ	180	UJ	160	UJ	420	UJ	190	UJ	160	UJ	310	UJ	180	UJ
2-Chlorophenol	37	U	32	U	35	U	18	U	16	U	42	U	19	U	16	U	31	U	18	U
4-Chloro-3-methylphenol	37	U	32	U	35	U	18	U	16	U	42	U	19	U	16	U	31	U	18	U
2,4-Dichlorophenol	37	U	32	U	35	U	18	U	16	U	42	U	19	U	16	U	31	U	18	U
2,4,6-Trichlorophenol	37	U	32	U	35	U	18	U	16	U	42	U	19	U	16	U	31	U	18	U
2,4,5-Trichlorophenol	37	U	32	U	35	U	18	U	16	U	42	U	19	U	16	U	31	U	18	U
2,3,4,6-Tetrachlorophenol	37	U	32	U	35	U	18	U	16	U	42	U	19	U	16	U	31	U	18	U
Pentachlorophenol	7.4	UJ	6.4	UJ	7	UJ	3.6	UJ	3.3	UJ	8.4	UJ	3.9	UJ	3.3	UJ	6.3	UJ	3.5	UJ
Benzyl alcohol	37	U	32	U	35	U	18	U	16	U	42	U	19	U	16	U	31	U	18	U
Benzoic Acid	37	U	32	U	35	U	18	U	16	U	42	U	19	U	16	U	31	U	18	U
Dibenzofuran	3.6	U	3.2	U	3.5	U	1.8	U	1.6	U	4.2	U	1.9	U	1.6	U	3.1	U	1.8	U
Hexachloroethane	37	U	32	U	35	U	18	U	16	U	42	U	19	U	16	U	31	U	18	U
Hexachlorobutadiene	37	U	32	U	35	U	18	U	16	U	42	U	19	U	16	U	31	U	18	U
N-Nitrosodiphenylamine	37	U	32	U	35	U	18	U	16	U	42	U	19	U	16	U	31	U	18	U
Benzaldehyde	37	U	32	U	35	U	18	U	16	U	42	U	19	U	16	U	31	U	18	U
Bis(2-Chloroethyl)ether	37	U	32	U	35	U	18	U	16	U	42	U	19	U	16	U	31	U	18	U
2,2'-Oxybis(1-chloropropane)	37	U	32	U	35	U	18	U	16	U	42	U	19	U	16	U	31	U	18	U
Acetophenone	37	U	32	U	35	U	18	U	16	U	42	U	19	U	16	U	31	U	18	U
N-Nitroso-di-n-propylamine	37	U	32	U	35	U	18	U	16	U	42	U	19	U	16	U	31	U	18	U
Isophorone	37	U	32	U	35	U	18	U	16	U	42	U	19	U	16	U	31	U	18	U
Bis(2-chloroethoxy)methane	37	U	32	U	35	U	18	U	16	U	42	U	19	U	16	U	31	U	18	U
4-Chloroaniline	37	U	32	U	35	U	18	U	16	U	42	U	19	U	16	U	31	U	18	U
Caprolactam	37	U	32	U	35	U	18	U	16	U	42	U	19	U	16	U	31	U	18	U
2,6-Dinitrotoluene	37	U	32	U	35	U	18	U	16	U	42	U	19	U	16	U	31	U	18	U
2,4-Dinitrotoluene	37	U	32	U	35	U	18	U	16	U	42	U	19	U	16	U	31	U	18	U
1,1'-Biphenyl	37	U	32	U	35	U	18	U	16	U	42	U	19	U	16	U	31	U	18	U
2-Chloronaphthalene	37	U	32	U	35	U	18	U	16	U	42	U	19	U	16	U	31	U	18	U
2-Nitroaniline	370	U	320	U	350	U	180	U	160	U	420	U	190	U	160	U	310	U	180	U
3-Nitroaniline	370	U	320	U	350	U	180	U	160	U	420	U	190	U	160	U	310	U	180	U
4-Nitroaniline	370	U	320	U	350	U	180	U	160	U	420	U	190	U	160	U	310	U	180	U
4-Chlorophenyl-phenylether	37	U	32	U	35	U	18	U	16	U	42	U	19	U	16	U	31	U	18	U
Nitrobenzene	37	U	32	U	35	U	18	U	16	U	42	U	19	U	16	U	31	U	18	U
1,2,4,5-Tetrachlorobenzene	37	U	32	U	35	U	18	U	16	U	42	U	19	U	16	U	31	U	18	U
4-Bromophenyl-phenylether	37	U	32	U	35	U	18	U	16	U	42	U	19	U	16	U	31	U	18	U
3,3'-Dichlorobenzidine	37	U	32	U	35	U	18	U	16	U	42	U	19	U	16	U	31	U	18	U
Hexachlorocyclopentadiene	37	U	32	U	35	UJ	18	UJ	16	UJ	42	UJ	19	U	16	U	31	U	18	U
Atrazine	37	U	32	U	35	U	18	U	16	U	42	U	19	U	16	U	31	U	18	U
Carbazole	37	U	32	U	35	U	18	U	16	U	42	U	19	U	16	U	31	U	18	U

Sample ID	SJF_3		SJF_9_C		SJI_0		SJI_1		SJI_20_C_GS		SJI_3		SJI_8_C		SPSB_0		SPSB_1		SPSB_2		SPSB_3		SPSB_8_C	
Analyte (ug/kg)	**8/1/2008**	**Q**	**8/1/2008**	**Q**	**8/1/2008**	**Q**	**8/2/2008**	**Q**	**8/2/2008**	**Q**	**8/2/2008**	**Q**	**8/2/2008**	**Q**	**8/3/2008**	**Q**	**8/3/2008**	**Q**	**8/3/2008**	**Q**	**8/3/2008**	**Q**	**8/3/2008**	**Q**
Naphthalene	1.7	J	1.9	U	1.8	J	1.7		2.5	U	1.9	U	1.8	U	3.8	U	2.8	J	3.8	U	1.9	U	1.8	U
Acenaphthylene	1.7	U	1.9	U	1.9	U	1.6	U	2.5	U	1.9	U	1.8	U	3.8	U	3.6	U	3.8	U	1.9	U	1.8	U
Acenaphthene	1.7	U	1.9	U	1.9	U	1.6	U	2.5	U	1.9	U	1.8	U	3.8	U	3.6	U	3.8	U	1.9	U	1.8	U
Fluorene	1.7	U	1.9	U	1.9	U	1.6	U	2.5	U	1.9	U	1.8	U	3.8	U	3.6	U	3.8	U	1.9	U	1.8	U
Phenanthrene	3.8		3		9.9		5.7		7.8		4		1.8	U	5.7		4.8		2.9	J	1.5	J	1.8	U
Anthracene	1.7	U	1.9	U	1.7	J	1.5	J	1.8	J	1.9	U	1.8	U	3.8	U	3.6	U	3.8	U	1.9	U	1.8	U
2-Methylnaphthalene	3		2.9		3		2.7		4.1		3.1		1.8	U	3.8	U	3.6	U	3.8	U	1.9	U	1.8	U
Fluoranthene	1.7		1.8	J	9.8		5.7		12		2.4		1.8	U	13		9.6		6.6		1.7	J	1.8	U
Pyrene	2.1		2		8.1		4.4		9		2.4		1.8	U	11		8.9		6.2		1.5	J	1.8	U
Benzo(a)anthracene	0.82	J	1.9	U	3.8		2		4.5		1.9	U	1.8	U	6		4.6		2.7	J	1.9	U	1.8	U
Chrysene	1.4	J	1.9	U	3.8		1.6		6.3		1.6	J	1.8	U	6.8		4.7		3.1	J	1.9	U	1.8	U
Benzo(b)fluoranthene	2.4		2.5		8		2.9		14		1.9	U	1.8	U	16		14		7.3		1.9	U	3.5	
Benzo(k)fluoranthene	1.2	J	1.1	J	3.9		1.8		7.8		1.9	U	1.8	U	10		6.1		5.7		1.9	U	1.6	J
Benzo(a)pyrene	1.7	U	1.9	U	6.4		1.4	J	6.7		1.9	U	1.8	U	9.7		7		4.9		1.9	U	1.4	J
Indeno(1,2,3-cd)pyrene	1.7	U	1.9	U	5.3		1.6	U	2.5	U	1.9	U	1.8	U	3.8	U	3.6	U	3.8	U	1.9	U	2.4	
Dibenzo(a,h)anthracene	1.7	U	1.9	U	1.9	U	1.6	U	2.5	U	1.9	U	1.8	U	3.8	U	3.6	U	3.8	U	1.9	U	1.8	U
Benzo(g,h,I)perylene	1.6	J	1.9	U	3.5		1.6	J	2.5	U	1.9	U	1.8	U	3.8	U	3.6	U	6.9		1.9	U	1.8	J
1,3-Dichlorobenzene	17	U	19	U	19	U	16	U	25	U	18	U	18	U	38	U	36	U	38	U	19	U	18	U
1,4-Dichlorobenzene	17	U	19	U	19	U	16	U	25	U	18	U	18	U	38	U	36	U	38	U	19	U	18	U
1,2-Dichlorobenzene	17	U	19	U	19	U	16	U	25	U	18	U	18	U	38	U	36	U	38	U	19	U	18	U
Hexachlorobenzene	17	U	19	U	19	U	16	U	25	U	18	U	18	U	38	U	36	U	38	U	19	U	18	U
Dimethylphthalate	17	U	19	U	19	U	16	U	25	U	18	U	18	U	38	U	36	U	38	U	19	U	18	U
Diethylphthalate	17	U	19	U	19	U	16	U	25	U	18	U	18	U	38	U	36	U	38	U	19	U	18	U
Di-n-butylphthalate	17	U	19	U	19	U	16	U	25	U	18	U	18	U	38	U	36	U	38	U	19	U	18	U
Butylbenzylphthalate	17	U	19	U	19	U	16	U	25	U	18	U	18	U	38	U	36	U	38	U	19	U	18	U
Bis(2-ethylhexyl)phthalate	17	U	19	U	19	U	16	U	25	U	18	U	18	U	38	U	36	U	38	U	19	U	18	U
Di-n-octylphthalate	17	U	19	U	19	U	16	U	25	U	18	U	18	U	38	U	36	U	38	U	19	U	18	U
Phenol	17	U	65		450		350		60		18	U	18	U	38	U	36	U	38	U	30		18	U
2-Methylphenol	17	U	19	U	19	U	16	U	25	U	18	U	18	U	38	U	36	U	38	U	19	U	18	U
4-Methylphenol	17	U	190		470		99		25	U	18	U	18	U	38	U	36	U	38	U	19	U	18	U
2,4-Dimethylphenol	17	U	19	U	19	U	16	U	25	U	18	U	18	U	38	U	36	U	38	U	19	U	18	U
4,6-Dinitro-2-methylphenol	170	U	190	U	190	U	160	U	250	U	180	U	180	U	380	U	360	U	380	U	190	U	180	U
2-Nitrophenol	17	U	19	U	19	U	16	U	25	U	18	U	18	U	38	U	36	U	38	U	19	U	18	U
4-Nitrophenol	170	U	190	U	190	U	160	U	250	U	180	U	180	U	380	U	360	U	380	U	190	U	180	U
2,4-Dinitrophenol	170	UJ	190	UJ	190	U	160	U	250	UJ	180	U	180	UJ	380	UJ	360	UJ	380	UJ	190	UJ	180	UJ
2-Chlorophenol	17	U	19	U	19	U	16	U	25	U	18	U	18	U	38	U	36	U	38	U	19	U	18	U
4-Chloro-3-methylphenol	17	U	19	U	19	U	16	U	25	U	18	U	18	U	38	U	36	U	38	U	19	U	18	U
2,4-Dichlorophenol	17	U	19	U	19	U	16	U	25	U	18	U	18	U	38	U	36	U	38	U	19	U	18	U
2,4,6-Trichlorophenol	17	U	19	U	19	U	16	U	25	U	18	U	18	U	38	U	36	U	38	U	19	U	18	U
2,4,5-Trichlorophenol	17	U	19	U	19	U	16	U	25	U	18	U	18	U	38	U	36	U	38	U	19	U	18	U
2,3,4,6-Tetrachlorophenol	17	U	19	U	19	U	16	U	25	U	18	U	18	U	38	U	36	U	38	U	19	U	18	U
Pentachlorophenol	3.4	UJ	3.8	UJ	3.9	UJ	3.3	UJ	5.0	UJ	3.8	UJ	3.7	UJ	7.7	UJ	7.2	UJ	7.6	UJ	3.8	U	3.7	UJ
Benzyl alcohol	17	U	19	U	19	U	16	U	25	U	18	U	18	U	38	U	36	U	38	U	19	U	18	U
Benzoic Acid	17	U	19	U	19	U	16	U	25	U	18	U	18	U	38	U	36	U	38	U	19	U	18	U
Dibenzofuran	1.7	U	1.9	U	1.9	U	1.6	U	2.5	U	1.9	U	1.8	U	3.8	U	3.6	U	3.8	U	1.9	U	1.8	U
Hexachloroethane	17	U	19	U	19	U	16	U	25	U	18	U	18	U	38	U	36	U	38	U	19	U	18	U
Hexachlorobutadiene	17	U	19	U	19	U	16	U	25	U	18	U	18	U	38	U	36	U	38	U	19	U	18	U
N-Nitrosodiphenylamine	17	U	19	U	19	U	16	U	25	U	18	U	18	U	38	U	36	U	38	U	19	U	18	U
Benzaldehyde	17	U	19	U	67		16	U	25	U	18	U	18	U	38	U	36	U	38	U	19	U	18	U
Bis(2-Chloroethyl)ether	17	U	19	U	19	U	16	U	25	U	18	U	18	U	38	U	36	U	38	U	19	U	18	U
2,2'-Oxybis(1-chloropropane)	17	U	19	U	19	U	16	U	25	U	18	U	18	U	38	U	36	U	38	U	19	U	18	U
Acetophenone	17	U	19	U	19	U	16	U	25	U	18	U	18	U	38	U	36	U	38	U	19	U	18	U
N-Nitroso-di-n-propylamine	17	U	19	U	19	U	16	U	25	U	18	U	18	U	38	U	36	U	38	U	19	U	18	U
Isophorone	17	U	19	U	19	U	16	U	25	U	18	U	18	U	38	U	36	U	38	U	19	U	18	U
Bis(2-chloroethoxy)methane	17	U	19	U	19	U	16	U	25	U	18	U	18	U	38	U	36	U	38	U	19	U	18	U
4-Chloroaniline	17	U	19	U	19	U	16	U	25	U	18	U	18	U	38	U	36	U	38	U	19	U	18	U
Caprolactam	17	U	19	U	19	U	16	U	25	U	18	U	18	U	38	U	36	U	38	U	19	U	18	U
2,6-Dinitrotoluene	17	U	19	U	19	U	16	U	25	U	18	U	18	U	38	U	36	U	38	U	19	U	18	U
2,4-Dinitrotoluene	17	U	19	U	19	UJ	16	UJ	25	U	18	U	18	U	38	U	36	U	38	U	19	U	18	U
1,1'-Biphenyl	17	U	19	U	19	U	16	U	25	U	18	U	18	U	38	U	36	U	38	U	19	U	18	U
2-Chloronaphthalene	17	U	19	U	19	U	16	U	25	U	18	U	18	U	38	U	36	U	38	U	19	U	18	U
2-Nitroaniline	170	U	190	U	190	U	160	U	250	U	180	U	180	U	380	U	360	U	380	U	190	U	180	U
3-Nitroaniline	170	U	190	U	190	U	160	U	250	U	180	U	180	U	380	U	360	U	380	U	190	U	180	U
4-Nitroaniline	170	U	190	U	190	U	160	U	250	U	180	U	180	U	380	U	360	U	380	U	190	U	180	U
4-Chlorophenyl-phenylether	17	U	19	U	19	U	16	U	25	U	18	U	18	U	38	U	36	U	38	U	19	U	18	U
Nitrobenzene	17	U	19	U	19	U	16	U	25	U	18	U	18	U	38	U	36	U	38	U	19	U	18	U
1,2,4,5-Tetrachlorobenzene	17	U	19	U	19	U	16	U	25	U	18	U	18	U	38	U	36	U	38	U	19	U	18	U
4-Bromophenyl-phenylether	17	U	19	U	19	U	16	U	25	U	18	U	18	U	38	U	36	U	38	U	19	U	18	U
3,3'-Dichlorobenzidine	17	U	19	U	19	U	16	U	25	U	18	U	18	U	38	U	36	U	38	U	19	U	18	U
Hexachlorocyclopentadiene	17	U	19	U	19	U	16	U	25	U	18	U	18	U	38	U	36	UJ	38	U	19	UJ	18	UJ
Atrazine	17	U	19	U	19	U	16	U	25	U	18	U	18	U	38	U	36	U	38	U	19	U	18	U
Carbazole	17	U	19	U	19	U	16	U	25	U	18	U	18	U	38	U	36	U	38	U	19	U	18	U

Notes:

ug/kg = micrograms per kilogram

mg/kg = milligrams per kilogram

U = Result should be considered not-detected at the quantitation limit shown

J = Result is an estimated concentration

R = Rejected - Quality Control indicates the data is not usable

UJ = The compound was not detected and the sample detection limit should be considered an estimated value

Table A-12a. US EPA/USACE “Bold Study” Analytical Data-SVOCs

Sample ID	SS_0		SS_1		SS_2		SS_8_C		SS_9_C		CPS_3_Dup		HC_2_Dup		NCPS_2_Dup		PSPS_1_Dup		SPSB_0_Dup	
Analyte (ug/kg)	**8/4/2008**	**Q**	**8/4/2008**	**Q**	**8/4/2008**	**Q**	**8/4/2008**	**Q**	**8/4/2008**	**Q**	**7/31/2008**	**Q**	**8/3/2008**	**Q**	**8/3/2008**	**Q**	**8/3/2008**	**Q**	**8/3/2008**	**Q**
Naphthalene	3.3	J	1.4	U	3		2.1		4.5	U	1.4	J	4	U	1.3	J	3	U	3.9	U
Acenaphthylene	3.4	U	1.4	U	2.4	U	1.8	U	4.5	U	1.4	U	4	U	1.5	U	3	U	3.9	U
Acenaphthene	3.4	U	1.4	U	2.4	U	1.8	U	4.5	U	1.4	U	4	U	1.5	U	3	U	3.9	U
Fluorene	3.4	U	1.4	U	2.4	U	1.8	U	4.5	U	1.4	U	4	U	1.5	U	3	U	3.9	U
Phenanthrene	4.5		1.4	U	3.9		3.4		5.5		5		4	U	3		3	U	4.3	
Anthracene	3.4	U	1.4	U	2.4	U	1.8	U	4.5	U	1.4	U	4	U	1.5	U	3	U	3.9	U
2-Methylnaphthalene	2.5	J	1.4	U	3.5		2		4.5	U	1.2	J	4	U	1.1	J	3	U	3.9	U
Fluoranthene	11		1.4	U	6.1		5.6		12		9		4.4		8.4		3	U	9.8	
Pyrene	9.6		1.4	U	4.8		4.1		11		10		4.7		7.8		3	U	11	
Benzo(a)anthracene	4.3		1.4	U	3.2		3.1		5.4		4.3		4	U	3.3		3	U	6.8	
Chrysene	6.1		1.4	U	2.2	J	2.7		6.2		5.1		4	U	3.7		3	U	6.9	
Benzo(b)fluoranthene	13		1.4	U	7.5		8.3		20		8.5		7.2		8.6		3	U	16	
Benzo(k)fluoranthene	4.8		1.4	U	2.8		2.7		8.9		5.1		3.2	J	4.3		3	U	8.5	
Benzo(a)pyrene	3.4	U	1.4	U	3.6		3.8		10		5.1		3.7	J	4.1		7.7		7.9	
Indeno(1,2,3-cd)pyrene	3.4	U	1.4	U	5.1		6.2		4.5	U	1.4	U	4	U	1.5	U	3	U	3.9	U
Dibenzo(a,h)anthracene	3.4	U	1.4	U	2.4	U	1.8	U	4.5	U	1.4	U	4	U	1.5	U	3	U	3.9	U
Benzo(g,h,I)perylene	3.4	U	1.4	U	3.6		3.7		4.5	U	1.4	U	4		1.5	U	3	U	3.9	U
1,3-Dichlorobenzene	34	U	14	U	24	U	18	U	45	U	14	U	40	U	15	U	30	U	39	U
1,4-Dichlorobenzene	34	U	14	U	24	U	18	U	45	U	14	U	40	U	15	U	30	U	39	U
1,2-Dichlorobenzene	34	U	14	U	24	U	18	U	45	U	14	U	40	U	15	U	30	U	39	U
Hexachlorobenzene	34	U	14	U	24	U	18	U	45	U	14	U	40	U	15	U	30	U	39	U
Dimethylphthalate	34	U	14	U	24	U	18	U	45	U	14	U	40	U	15	U	30	U	39	U
Diethylphthalate	34	U	14	U	24	U	18	U	45	U	14	U	40	U	15	U	30	U	39	U
Di-n-butylphthalate	34	U	14	U	24	U	18	U	45	U	14	U	40	U	15	U	30	U	39	U
Butylbenzylphthalate	34	U	14	U	24	U	18	U	45	U	14	U	40	U	15	U	30	U	39	U
Bis(2-ethylhexyl)phthalate	3800	D	14	U	24	U	18	U	320		14	U	40	U	15	U	30	U	39	U
Di-n-octylphthalate	34	U	14	U	24	U	18	U	45	U	14	U	40	U	15	U	30	U	39	U
Phenol	34	U	14	U	24	U	35		190		100		900		150		100		180	
2-Methylphenol	34	U	14	U	24	U	18	U	45	U	14	U	40	U	15	U	30	U	39	U
4-Methylphenol	34	U	14	U	24	U	18	U	320		14	U	240		59		30	U	39	U
2,4-Dimethylphenol	34	U	14	U	24	U	18	U	45	U	14	U	40	U	15	U	30	U	39	U
4,6-Dinitro-2-methylphenol	340	U	140	U	240	U	180	U	450	U	140	U	400	U	150	U	300	U	390	U
2-Nitrophenol	34	U	14	U	24	U	18	U	45	U	14	U	40	U	15	U	30	U	39	U
4-Nitrophenol	340	U	140	U	240	U	180	U	450	U	140	U	400	U	150	U	300	U	390	U
2,4-Dinitrophenol	340	UJ	140	UJ	240	UJ	180	UJ	450	UJ	140	UJ	400	UJ	150	UJ	300	UJ	390	UJ
2-Chlorophenol	34	U	14	U	24	U	18	U	45	U	14	U	40	U	15	U	30	U	39	U
4-Chloro-3-methylphenol	34	U	14	U	24	U	18	U	45	U	14	U	40	U	15	U	30	U	39	U
2,4-Dichlorophenol	34	U	14	U	24	U	18	U	45	U	14	U	40	U	15	U	30	U	39	U
2,4,6-Trichlorophenol	34	U	14	U	24	U	18	U	45	U	14	U	40	U	15	U	30	U	39	U
2,4,5-Trichlorophenol	34	U	14	U	24	U	18	U	45	U	14	U	40	U	15	U	30	U	39	U
2,3,4,6-Tetrachlorophenol	34	U	14	U	24	U	18	U	45	U	14	U	40	U	15	U	30	U	39	U
Pentachlorophenol	6.9	UJ	2.9	UJ	2.7	J	3.7	UJ	9	UJ	2.9	UJ	8.1	UJ	3	UJ	6.1	UJ	7.9	UJ
Benzyl alcohol	34	U	14	U	24	U	18	U	45	U	14	U	40	U	15	U	30	U	39	U
Benzoic Acid	34	U	14	U	24	U	18	U	45	U	14	U	40	U	15	U	30	U	39	U
Dibenzofuran	3.4	U	1.4	U	2.4	U	1.8	U	4.5	U	1.4	U	4	U	1.5	U	3	U	3.9	U
Hexachloroethane	34	U	14	U	24	U	18	U	45	U	14	U	40	U	15	U	30	U	39	U
Hexachlorobutadiene	34	U	14	U	24	U	18	U	45	U	14	U	40	U	15	U	30	U	39	U
N-Nitrosodiphenylamine	34	U	14	U	24	U	18	U	45	U	14	U	40	U	15	U	30	U	39	U
Benzaldehyde	34	U	14	U	24	U	65		45	U	14	U	40	U	15	U	30	U	39	U
Bis(2-Chloroethyl)ether	34	U	14	U	24	U	18	U	45	U	14	U	40	U	15	U	30	U	39	U
2,2'-Oxybis(1-chloropropane)	34	U	14	U	24	U	18	U	45	U	14	U	40	U	15	U	30	U	39	U
Acetophenone	34	U	14	U	24	U	18	U	45	U	14	U	40	U	15	U	30	U	39	U
N-Nitroso-di-n-propylamine	34	U	14	U	24	U	18	U	45	U	14	U	40	U	15	U	30	U	39	U
Isophorone	34	U	14	U	24	U	18	U	45	U	14	U	40	U	15	U	30	U	39	U
Bis(2-chloroethoxy)methane	34	U	14	U	24	U	18	U	45	U	14	U	40	U	15	U	30	U	39	U
4-Chloroaniline	34	U	14	U	24	U	18	U	45	U	14	U	40	U	15	U	30	U	39	U
Caprolactam	34	U	14	U	24	U	18	U	45	U	14	U	40	U	15	U	30	U	39	U
2,6-Dinitrotoluene	34	U	14	U	24	U	18	U	45	U	14	U	40	U	15	U	30	U	39	U
2,4-Dinitrotoluene	34	U	14	U	24	U	18	U	45	U	14	U	40	U	15	U	30	U	39	U
1,1'-Biphenyl	34	U	14	U	24	U	18	U	45	U	14	U	40	U	15	U	30	U	39	U
2-Chloronaphthalene	34	U	14	U	24	U	18	U	45	U	14	U	40	U	15	U	30	U	39	U
2-Nitroaniline	340	U	140	U	240	U	180	U	450	U	140	U	400	U	150	U	300	U	390	U
3-Nitroaniline	340	U	140	U	240	U	180	U	450	U	140	U	400	U	150	U	300	U	390	U
4-Nitroaniline	340	U	140	U	240	U	180	U	450	U	140	U	400	U	150	U	300	U	390	U
4-Chlorophenyl-phenylether	34	U	14	U	24	U	18	U	45	U	14	U	40	U	15	U	30	U	39	U
Nitrobenzene	34	U	14	U	24	U	18	U	45	U	14	U	40	U	15	U	30	U	39	U
1,2,4,5-Tetrachlorobenzene	34	U	14	U	24	U	18	U	45	U	14	U	40	U	15	U	30	U	39	U
4-Bromophenyl-phenylether	34	U	14	U	24	U	18	U	45	U	14	U	40	U	15	U	30	U	39	U
3,3'-Dichlorobenzidine	34	U	14	U	24	U	18	U	45	U	14	U	40	U	15	U	30	U	39	U
Hexachlorocyclopentadiene	34	U	14	UJ	24	UJ	18	UJ	45	U	14	U	40	U	15	U	30	U	39	U
Atrazine	34	U	14	U	24	U	18	U	45	U	14	U	40	U	15	U	30	U	39	U
Carbazole	34	U	14	U	24	U	18	U	45	U	14	U	40	U	15	U	30	U	39	U

Notes:
ug/kg = micrograms per kilogram
mg/kg = milligrams per kilogram
U = Result should be considered not-detected at the quantitation limit shown
J = Result is an estimated concentration
R = Rejected - Quality Control indicates the data is not usable
UJ = The compound was not detected and the sample detection limit should be considered an estimated value

Table A-12b. US EPA/USACE "Bold Study" Analytical Data-Metals

Sample ID	AI_1	AI_11_C	AI_13_C	AI_20_C_GS	AI_5_C	CPS_0	CPS_1	CPS_3	CPS_4	CPS_5	HC_0	HC_1	HC_2	HC_3	HC_6	NCPS_0
Analyte (mg/kg)	7/31/2008 Q	8/1/2008 Q	8/3/2008 Q	8/1/2008 Q	8/1/2008 Q	8/4/2008 Q	8/4/2008 Q	7/31/2008 Q	8/4/2008 Q	7/31/2008 Q	8/3/2008 Q	8/2/2008 Q	8/3/2008 Q	8/2/2008 Q	8/2/2008 Q	7/31/2008 Q
Antimony	0.12 U	0.11 U	0.12 U	0.13 U	0.12 U	0.2 UJ	1.2 UJ	0.24 U	0.96 UJ	0.14 U	0.45 U	0.14 U	0.4 U	0.17 U	0.22 U	0.15 U
Arsenic	3.6 J	2.2 J	3 J	3.4 J	3.5 J	3.8 J	8.2	4.8 J	11.3	3.1 J	6.7	4.2 J	21	5.2	6.2	5.9
Cadmium	0.052 U	0.027 U	0.11 U	0.14 U	0.1 U	0.15 J	0.45 J	0.13 U	0.32 J	0.076 U	0.3 J	0.24 J	2.3 J	0.29 J	0.38 J	0.38 J
Chromium	22.1 J	15.3 J	13.3 J	22.9 J	19.1 J	15.1	25.2	25.3 J	17.4	18.4 J	49 J	24.2 J	70.4 J	28.1 J	36.4 J	27.6 J
Copper	6.8 J	4 J	7.5 J	9.3 J	7.8 J	15.7 J	20.4 J	11.9 J	13.6 J	7.4 J	56.7 J	9.9 J	91.2 J	16.3 J	25.8 J	14.2 J
Lead	4 J	1.6 J	4.2 J	4.7 J	4.3 J	9.1	13	7 J	17.6	5.7 J	17.2 J	5.1 J	10.4 J	7.8 J	11 J	8.1 J
Mercury	0.04 U	0.0054 U	0.05 U	0.0048 U	0.013 U	0.091 U	0.15	0.049 U	0.11	0.042 U	0.13	0.084	0.088 J	0.087	0.091	0.059
Nickel	28	23.2	18.1	23.9	23.3	13.3	26.9	30.6	28.5	19.5	42	25.2	46.7	25.5	29.2	26.1
Selenium	0.29 U	0.29 U	0.35 J	0.42 J	0.3 U	0.3 U	0.43 U	0.32 U	0.49 U	0.29 U	1.3 J	0.36 J	2.2 J	0.48 J	0.75 J	0.37 J
Silver	0.022 U	0.0074 U	0.035 U	0.059 U	0.04 U	0.12 J	0.12 J	0.08 J	0.065 J	0.037 U	0.17 J	0.046 U	0.24 J	0.084 J	0.14 J	0.091 J
Zinc	31.7	21.1	26.1	37.6	32.4	55.4 J	53.7 J	40.8	58 J	30.9	99.1	44.3	92.3	57.1	73	54.8

Sample ID	NCPS_1	NCPS_2	NCPS_3	NCPS_4	PSPS_1	PSPS_2	PSPS_3	PSPS_8	PSPS_9	R_CAR_0	R_CAR_1	R_CAR_4	R_CAR_5	R_CAR_6_C	R_DAB_0	R_DAB_1	R_DAB_2
Analyte (mg/kg)	7/31/2008 Q	8/3/2008 Q	7/31/2008 Q	7/31/2008 Q	8/3/2008 Q	8/3/2008 Q	8/3/2008 Q	8/3/2008 Q	8/3/2008 Q	8/4/2008 Q	8/4/2008 Q	8/4/2008 Q	8/4/2008 Q	8/4/2008 Q	8/2/2008 Q	8/2/2008 Q	8/2/2008 Q
Antimony	0.11 U	0.13 U	0.14 U	0.12 U	0.23 UJ	0.54 UJ	0.4 UJ	0.12 UJ	0.74 UJ	0.34 UJ	0.26 UJ	0.46 UJ	1 UJ	0.25 UJ	0.18 U	0.27 U	0.42 UJ
Arsenic	2.1 J	4.8 J	5.1	3.6 J	5.1	11	13.2	2.2 J	14	8.6	6.7	14.6	8.6	1.9 J	3.3 J	8.6	7
Cadmium	0.022 U	0.094 U	0.28 J	0.12 U	0.079 J	0.18 J	0.15 U	0.03 U	0.15 J	0.7 J	0.46 J	2.8	0.39 J	0.049 J	0.16 J	0.41 J	0.23 J
Chromium	12.4 J	32.1 J	26.1 J	19.1 J	32.2	53.8	105	22	97.1	50.1	29.7	53.4	23.9	12	27.4 J	49.3 J	42.6
Copper	3.2 J	13 J	13 J	9.8 J	20.5 J	48.1 J	42.9	3.3 J	41.1	28.8 J	14.4 J	39.6 J	36.7 J	4.6 J	25.3 J	51.3 J	31.7
Lead	2.9 J	8.4 J	6.6 J	4.8 J	7.5	14.7	13.4	3.3 J	14.5	12.3	9.6	16.5	20.9	2.9 J	6.5 J	12.1 J	14.1
Mercury	0.011 U	0.076	0.082	0.041 U	0.12	0.21	0.16	0.028 U	0.078	0.19	0.16	0.26	0.23	0.038 U	0.048 U	0.14	0.072
Nickel	13	27.5	28.7	20.5	31.1	49.5	94.7	19.3	84 J	50.9	25.1	43	22.7	12.9	20	39.8	31.4 J
Selenium	0.28 U	0.32 U	0.49 J	0.3 U	0.32 U	0.56 U	0.61 U	0.31 U	0.92 J	0.85 U	0.56 U	1.2 J	0.65 U	0.29 U	0.44 J	1 J	0.98 J
Silver	0.013 U	0.2 J	0.065 J	0.046 U	0.088 J	0.24 J	0.15 J	0.013 U	0.16 J	0.15 J	0.095 J	0.32 J	0.24 J	0.019 J	0.065 J	0.2 J	0.15 J
Zinc	17.9	47.4	49	33.7	42.4 J	80.8 J	95.5 J	18.6 J	92.9	79.2 J	47.2 J	93.5 J	69 J	18.2 J	55.6	84.4	79.6

Sample ID	R_DAB_5	R_DAB_7_C	R_HOL_0	R_HOL_1	R_HOL_3	R_HOL_4	R_HOL_7	R_SAM_0	R_SAM_1	R_SAM_3	R_SAM_4	R_SAM_5	SCPS_1	SCPS_10_C	SCPS_2	SCPS_3
Analyte (mg/kg)	8/2/2008 Q	8/2/2008 Q	8/3/2008 Q	8/3/2008 Q	8/3/2008 Q	8/3/2008 Q	8/3/2008 Q	8/1/2008 Q	8/1/2008 Q	8/1/2008 Q	8/1/2008 Q	8/1/2008 Q	8/4/2008 Q	8/5/2008 Q	8/4/2008 Q	8/4/2008 Q
Antimony	0.27 UJ	0.4 U	0.12 UJ	0.14 UJ	0.17 UJ	0.39 UJ	0.12 UJ	0.24 UJ	0.17 UJ	0.19 UJ	0.21 UJ	0.27 UJ	0.48 UJ	0.2 UJ	0.28 UJ	0.16 UJ
Arsenic	6.3	5.9	1.6 J	4.3 J	2.8 J	17.8	6.1	8.4	6.6	5.7	6.9	9.2	9.2	4 J	3.8 J	2.9 J
Cadmium	0.3 J	0.17 J	0.065 J	0.74 J	0.032 J	1.2 J	0.68 J	0.45 J	0.25 U	0.23 U	0.21 U	0.52 J	0.37 J	0.071 J	0.076 J	0.037 J
Chromium	37.4	38.8 J	10.8	18.2	15.2	76.3	26.2	41.2	26.5	31	34.8	46.2	34.8	19	17.1	14.1
Copper	24.1	32 J	3.6 J	10.6 J	3.3 J	57 J	19.7 J	26.4	15.6	19.3	21.7	30.2	34.6	8.9	6.6	3.6 J
Lead	11.6	10.6 J	1.9 J	2.6 J	2.6 J	17.6	4.7 J	12	7.1	10.3	11.4	13.6	22.8	7.5	7.6	5.7
Mercury	0.084	0.14	0.05 U	0.062 U	0.047 U	0.24	0.1	0.096	0.05 U	0.13	0.1	0.098	0.15	0.036	0.02 U	0.02 U
Nickel	28 J	30.7	10	17.3	13	62.5	22	33.7	24.1	25.4	28.5	38.6	28.8 J	19.5 J	18.6 J	12.4 J
Selenium	1.1 J	0.74 J	0.29 U	0.34 U	0.26 U	1.5 J	0.4 J	0.61 U	0.44 U	0.48 U	0.52 U	0.69 U	0.99 J	0.32 J	0.31 U	0.27 U
Silver	0.13 J	0.095 J	0.023 J	0.072 J	0.012 J	0.45 J	0.17 J	0.14 J	0.085 U	0.099 U	0.1 U	0.19 J	0.29 J	0.046 J	0.028 J	0.013 J
Zinc	70.5	69.4	13.9 J	26.4 J	15.5 J	109 J	37.3 J	73.9 J	46.9 J	63.4 J	68.1 J	83.7 J	81.3	30.3	27.7	20.7

*this sample was labled SS_10_C in the metals EDDs

Notes:

mg/kg = milligrams per kilogram

ug/kg = micrograms per kilogram

U = Result should be considered not-detected at the quantitation limit shown

J = Result is an estimated concentration

R = Rejected - Quality Control indicates the data is not usable

UJ = The compound was not detected and the sample detection limit should be considered an estimated value

Table A-12b. US EPA/USACE “Bold Study” Analytical Data-Metals

Sample ID	SCPS_5	SJF_10_C	SJF_12_C_GS	SJF_2	SJF_3	SJF_9_C	SJI_0	SJI_1	SJI_20_C_GS	SJI_3	SJI_8_C	SPSB_0	SPSB_1	SPSB_2	SPSB_3	SPSB_8_C	SS_0
Analyte (mg/kg)	**8/4/2008 Q**	**8/1/2008 Q**	**8/2/2008 Q**	**8/1/2008 Q**	**8/1/2008 Q**	**8/1/2008 Q**	**8/1/2008 Q**	**8/2/2008 Q**	**8/2/2008 Q**	**8/2/2008 Q**	**8/2/2008 Q**	**8/3/2008 Q**	**8/3/2008 Q**	**8/3/2008 Q**	**8/3/2008 Q**	**8/3/2008 Q**	**8/4/2008 Q**
Antimony	0.5 UJ	0.11 UJ	0.31 UJ	0.12 UJ	0.12 UJ	0.14 UJ	0.25 UJ	0.14 UJ	0.23 UJ	0.15 UJ	0.24 UJ	0.34 UJ	0.3 UJ	0.36 UJ	0.38 UJ	0.13 UJ	0.67 UJ
Arsenic	8.7	3.7 J	11.9	3.5 J	3.1 J	4.7 J	6	6.3	6.4	6	6.7	9.7	10.2	10.2	9.2	4.6 J	8.9
Cadmium	0.36 J	0.073 J	0.9 J	0.093 J	0.13 J	0.12 J	0.26 U	0.25 U	0.41 J	0.18 U	0.11 U	0.17 U	0.21 U	0.21 U	0.15 J	0.08 U	0.84 J
Chromium	35.7	16.9	41.3	16.9	18.9	21	26.2	23.9	33.1	23.4	20	61.6	61.7	64.2	39.1	24.1	34.4
Copper	37.3	7.1 J	29	9.2 J	10.4 J	12.3 J	15.6	10.6	20.2	11.8	9.2	37.2	37.9	40.2	26.8	16.4	31.5
Lead	27.5	3.6 J	13.7	4.7 J	5	6	8.4	6.1	11.1	6.5	5.2	21.9	16.4	21.3	6.6	3.5 J	16.8
Mercury	0.17	0.045 U	0.11	0.071 U	0.055 U	0.078 U	0.051 U	0.05 U	0.08	0.069 U	0.048 U	0.17	0.13	0.17	0.06	0.034 U	0.22
Nickel	30.1 J	18.4	29.7	14.8	20.1	19.1	21.2	23.4	23.7	18.2	15.7	54.5	51.5	55.8	33.6 J	24.7	26.6 J
Selenium	1.1 J	0.28 U	0.76 U	0.31 U	0.3 U	0.36 U	0.41 U	0.36 U	0.53 U	0.38 U	0.33 U	0.71 U	0.76 U	0.77 U	0.52 J	0.32 U	0.89 J
Silver	0.3 J	0.019 J	0.21 J	0.029 J	0.03 J	0.037 J	0.081 U	0.041 U	0.13 J	0.044 U	0.039 U	0.21 J	0.21 J	0.24 J	0.11 J	0.052 U	0.23 J
Zinc	86.5	28.4 J	81.6 J	32.8 J	39.3 J	43.2 J	57.1 J	44 J	69.4 J	46.8 J	40.3 J	93.1 J	87.1 J	97.3 J	53.9	35.4 J	75.1

Sample ID	SS_1	SS_2	SS_8_C	SS_9_C	CPS_3_Dup	HC_2_Dup	NCPS_2_Dup	PSPS_1_Dup	SPSB_0_Dup
Analyte (mg/kg)	**8/4/2008 Q**	**8/4/2008 Q**	**8/4/2008 Q**	**8/4/2008 Q**	**7/31/2008 Q**	**8/3/2008 Q**	**8/3/2008 Q**	**8/3/2008 Q**	**8/3/2008 Q**
Antimony	0.059 UJ	0.24 UJ	0.44 UJ	0.62 UJ	0.13 UJ	0.41 UJ	0.28 UJ	0.46 UJ	0.28 UJ
Arsenic	1.1 J	3.4 J	4.1 J	9.2	3.9 J	18.9	5.8	11.5	9.2
Cadmium	0.018 J	0.14 J	0.19 J	0.83 J	0.12 J	2.1 J	0.09 U	0.17 J	0.14 U
Chromium	7.1	10.6	11.6	31.8	22.1	61.4	31.8	78.4	58.6
Copper	5.8	13	14.7	39.4	10.8 J	81.4	11.7	44.5	36.3
Lead	1.2 J	6	7.6	22.2	6	9.3	7.6	17.3	21.4
Mercury	0.02 U	0.031	0.042	0.13	0.066 U	0.076	0.063 U	0.15	0.14
Nickel	4 J	8.4 J	9.7 J	24.7 J	26.2	42.7	26.7	67.9 J	53
Selenium	0.31 U	0.42 J	0.38 J	1.1 J	0.33 U	1 U	0.35 U	0.88 J	0.7 U
Silver	0.0094 J	0.055 J	0.072 J	0.32 J	0.067 J	0.2 J	0.067 U	0.22 J	0.2 J
Zinc	14 J	25.8	30.3	86.2	36.3 J	84.2 J	43.8 J	95.2	92 J

Notes:

mg/kg = milligrams per kilogram

ug/kg = micrograms per kilogram

U = Result should be considered not-detected at the quantitation limit shown

J = Result is an estimated concentration

R = Rejected - Quality Control indicates the data is not usable

UJ = The compound was not detected and the sample detection limit should be considered an estimated value

Table A-12c. US EPA/USACE “Bold Study” Analytical Data-Pesticides

Sample ID	AI_1		AI_11_C		AI_13_C		AI_20_C_GS		AI_5_C		CPS_0		CPS_1		CPS_3		CPS_4		CPS_5	
Analyte (ug/kg)	**7/31/2008**	**Q**	**8/1/2008**	**Q**	**8/3/2008**	**Q**	**8/1/2008**	**Q**	**8/1/2008**	**Q**	**8/4/2008**	**Q**	**8/4/2008**	**Q**	**7/31/2008**	**Q**	**8/4/2008**	**Q**	**7/31/2008**	**Q**
2,4'-DDD	0.5	U	0.44	UJ	0.47	U	0.51	UJ	0.49	UJ	1.1	UJ	0.59	UJ	0.53	U	0.52	UJ	0.46	U
2,4'-DDE	0.5	U	0.44	UJ	0.47	U	0.51	UJ	0.49	UJ	1.1	UJ	0.59	UJ	0.53	U	0.52	UJ	0.46	U
2,4'-DDT	0.5	U	0.44	UJ	0.47	U	0.51	UJ	0.49	UJ	1.1	UJ	0.59	UJ	0.53	U	0.52	UJ	0.46	U
4,4'-DDD	0.96	U	0.85	UJ	0.91	U	1	UJ	0.95	UJ	2.1	UJ	1.1	UJ	1	U	1	UJ	0.89	U
4,4'-DDE	0.96	U	0.85	UJ	0.91	U	1	UJ	0.95	UJ	2.1	UJ	1.1	UJ	1	U	1	UJ	0.89	U
4,4'-DDT	0.96	U	0.85	UJ	0.91	U	1	UJ	0.95	UJ	2.1	UJ	1.1	UJ	1	U	1	UJ	0.89	U
Methoxychlor	5	U	4.4	UJ	4.7	U	5.1	UJ	4.9	UJ	11	UJ	5.9	UJ	5.3	U	5.2	UJ	4.6	U
Aldrin	0.5	U	0.44	UJ	0.47	U	0.51	UJ	0.49	UJ	1.1	UJ	0.59	UJ	0.53	U	0.52	UJ	0.46	U
Dieldrin	0.96	U	0.85	UJ	0.91	U	1	UJ	0.95	UJ	2.1	UJ	1.1	UJ	1	U	1	UJ	0.89	U
Endrin	0.96	U	0.85	UJ	0.91	U	1	UJ	0.95	UJ	2.1	UJ	1.1	UJ	1	U	1	UJ	0.89	U
Endrin ketone	0.96	U	0.85	UJ	0.91	U	1	UJ	0.95	UJ	2.1	UJ	1.1	UJ	1	U	1	UJ	0.89	U
Endrin aldehyde	0.96	U	0.85	UJ	0.91	U	1	UJ	0.95	UJ	2.1	UJ	1.1	UJ	1	U	1	UJ	0.89	U
alpha-BHC	0.5	U	0.44	UJ	0.47	U	0.51	UJ	0.49	UJ	1.1	UJ	0.59	UJ	0.53	U	0.52	UJ	0.46	U
beta-BHC	0.5	U	0.44	UJ	0.47	U	0.51	UJ	0.49	UJ	1.1	UJ	0.59	UJ	0.53	U	0.52	UJ	0.46	U
delta-BHC	0.5	U	0.44	UJ	0.47	U	0.51	UJ	0.49	UJ	1.1	UJ	0.59	UJ	0.53	U	0.52	UJ	0.46	U
gamma-BHC (Lindane)	0.5	U	0.44	UJ	0.47	U	0.51	UJ	0.49	UJ	1.1	UJ	0.59	UJ	0.53	U	0.52	UJ	0.46	U
alpha-Chlordane	0.5	U	0.44	UJ	0.47	U	0.51	UJ	0.49	UJ	1.1	UJ	0.59	UJ	0.53	U	0.52	UJ	0.46	U
gamma-Chlordane	0.5	U	0.44	UJ	0.47	U	0.51	UJ	0.49	UJ	1.1	UJ	0.59	UJ	0.53	U	0.52	UJ	0.46	U
Cis-Nonachlor	0.5	U	0.44	UJ	0.47	U	0.51	UJ	0.49	UJ	1.1	UJ	0.59	UJ	0.53	U	0.52	UJ	0.46	U
Trans-Nonachlor	0.5	U	0.44	UJ	0.47	U	0.51	UJ	0.49	UJ	1.1	UJ	0.59	UJ	0.53	U	0.52	UJ	0.46	U
Oxychlordane	0.5	U	0.44	UJ	0.47	U	0.51	UJ	0.49	UJ	1.1	UJ	0.59	UJ	0.53	U	0.52	UJ	0.46	U
Heptachlor	0.5	U	0.44	UJ	0.47	U	0.51	UJ	0.49	UJ	1.1	UJ	0.59	UJ	0.53	U	0.52	UJ	0.46	U
Heptachlor epoxide	0.5	U	0.44	UJ	0.47	U	0.51	UJ	0.49	UJ	1.1	UJ	0.59	UJ	0.53	U	0.52	UJ	0.46	U
Mirex	0.5	U	0.44	UJ	0.47	U	0.51	UJ	0.49	UJ	1.1	UJ	0.59	UJ	0.53	U	0.52	UJ	0.46	U
Endosulfan I	0.5	U	0.44	UJ	0.47	U	0.51	UJ	0.49	UJ	1.1	UJ	0.59	UJ	0.53	U	0.52	UJ	0.46	U
Endosulfan II	0.96	U	0.85	UJ	0.91	U	1	UJ	0.95	UJ	2.1	UJ	1.1	UJ	1	U	1	UJ	0.89	U
Endosulfan sulfate	0.96	U	0.85	UJ	0.91	U	1	UJ	0.95	UJ	2.1	UJ	1.1	UJ	1	U	1	UJ	0.89	U
Toxaphene	50	U	44	UJ	47	U	51	UJ	49	UJ	110	UJ	59	UJ	53	U	52	UJ	46	U

Notes:

mg/kg = milligrams per kilogram

ug/kg = micrograms per kilogram

U = Result should be considered not-detected at the quantitation limit shown

J = Result is an estimated concentration

R = Rejected - Quality Control indicates the data is not usable

UJ = The compound was not detected and the sample detection limit should be considered an estimated value

Table A-12c. US EPA/USACE "Bold Study" Analytical Data-Pesticides

Sample ID	HC_0		HC_1		HC_2		HC_3		HC_6		NCPS_0		NCPS_1		NCPS_2		NCPS_3		NCPS_4	
Analyte (ug/kg)	**8/3/2008**	**Q**	**8/2/2008**	**Q**	**8/3/2008**	**Q**	**8/2/2008**	**Q**	**8/2/2008**	**Q**	**7/31/2008**	**Q**	**7/31/2008**	**Q**	**8/3/2008**	**Q**	**7/31/2008**	**Q**	**7/31/2008**	**Q**
2,4'-DDD	1.2	U	0.54	U	1.4	U	0.66	U	0.87	U	0.59	U	0.43	U	0.57	U	0.61	U	0.5	U
2,4'-DDE	1.2	U	0.54	U	1.4	U	0.66	U	0.87	U	0.59	U	0.43	U	0.57	U	0.61	U	0.5	U
2,4'-DDT	1.2	U	0.54	U	1.4	U	0.66	U	0.87	U	0.59	U	0.43	U	0.57	U	0.61	U	0.5	U
4,4'-DDD	2.2	U	1	U	2.6	U	1.3	U	1.7	U	1.2	U	0.84	U	1.1	U	1.2	U	0.97	U
4,4'-DDE	2.2	U	1	U	2.6	U	1.3	U	1.7	U	1.2	U	0.84	U	1.1	U	1.2	U	0.97	U
4,4'-DDT	2.2	U	1	U	2.6	U	1.3	U	1.7	U	1.2	U	0.84	U	1.1	U	1.2	U	0.97	U
Methoxychlor	12	U	5.4	U	14	U	6.6	U	8.7	U	5.9	U	4.3	U	5.7	U	6.1	U	5	U
Aldrin	1.2	U	0.54	U	1.4	U	0.66	U	0.87	U	0.59	U	0.43	U	0.57	U	0.61	U	0.5	U
Dieldrin	2.2	U	1	U	2.6	U	1.3	U	1.7	U	1.2	U	0.84	U	1.1	U	1.2	U	0.97	U
Endrin	2.2	U	1	U	2.6	U	1.3	U	1.7	U	1.2	U	0.84	U	1.1	U	1.2	U	0.97	U
Endrin ketone	2.2	U	1	U	2.6	U	1.3	U	1.7	U	1.2	U	0.84	U	1.1	U	1.2	U	0.97	U
Endrin aldehyde	2.2	U	1	U	2.6	U	1.3	U	1.7	U	1.2	U	0.84	U	1.1	U	1.2	U	0.97	U
alpha-BHC	1.2	U	0.54	U	1.4	U	0.66	U	0.87	U	0.59	U	0.43	U	0.57	U	0.61	U	0.5	U
beta-BHC	1.2	U	0.54	U	1.4	U	0.66	U	0.87	U	0.59	U	0.43	U	0.57	U	0.61	U	0.5	U
delta-BHC	1.2	U	0.54	U	1.4	U	0.66	U	0.87	U	0.59	U	0.43	U	0.57	U	0.61	U	0.5	U
gamma-BHC (Lindane)	1.2	U	0.54	U	1.4	U	0.66	U	0.87	U	0.59	U	0.43	U	0.57	U	0.61	U	0.5	U
alpha-Chlordane	1.2	U	0.54	U	1.4	U	0.66	U	0.87	U	0.59	U	0.43	U	0.57	U	0.61	U	0.5	U
gamma-Chlordane	1.2	U	0.54	U	1.4	U	0.66	U	0.87	U	0.59	U	0.43	U	0.57	U	0.61	U	0.5	U
Cis-Nonachlor	1.2	U	0.54	U	1.4	U	0.66	U	0.87	U	0.59	U	0.43	U	0.57	U	0.61	U	0.5	U
Trans-Nonachlor	1.2	U	0.54	U	1.4	U	0.66	U	0.87	U	0.59	U	0.43	U	0.57	U	0.61	U	0.5	U
Oxychlordane	1.2	U	0.54	U	1.4	U	0.66	U	0.87	U	0.59	U	0.43	U	0.57	U	0.61	U	0.5	U
Heptachlor	1.2	U	0.54	U	1.4	U	0.66	U	0.87	U	0.59	U	0.43	U	0.57	U	0.61	U	0.5	U
Heptachlor epoxide	1.2	U	0.54	U	1.4	U	0.66	U	0.87	U	0.59	U	0.43	U	0.57	U	0.61	U	0.5	U
Mirex	1.2	U	0.54	U	1.4	U	0.66	U	0.87	U	0.59	U	0.43	U	0.57	U	0.61	U	0.5	U
Endosulfan I	1.2	U	0.54	U	1.4	U	0.66	U	0.87	U	0.59	U	0.43	U	0.57	U	0.61	U	0.5	U
Endosulfan II	2.2	U	1	U	2.6	U	1.3	U	1.7	U	1.2	U	0.84	U	1.1	U	1.2	U	0.97	U
Endosulfan sulfate	2.2	U	1	U	2.6	U	1.3	U	1.7	U	1.2	U	0.84	U	1.1	U	1.2	U	0.97	U
Toxaphene	120	U	54	U	140	U	66	U	87	U	59	U	43	U	57	U	61	U	50	U

Notes:
mg/kg = milligrams per kilogram
ug/kg = micrograms per kilogram
U = Result should be considered not-detected at the quantitation limit shown
J = Result is an estimated concentration
R = Rejected - Quality Control indicates the data is not usable
UJ = The compound was not detected and the sample detection limit should be considered an estimated value

Table A-12c. US EPA/USACE "Bold Study" Analytical Data-Pesticides

Sample ID	**PSPS_1**		**PSPS_2**		**PSPS_3**		**PSPS_8**		**PSPS_9**		**R_CAR_0**		**R_CAR_1**		**R_CAR_4**		**R_CAR_5**		**R_CAR_6_C**	
Analyte (ug/kg)	**8/3/2008**	**Q**	**8/3/2008**	**Q**	**8/3/2008**	**Q**	**8/3/2008**	**Q**	**8/3/2008**	**Q**	**8/4/2008**	**Q**	**8/4/2008**	**Q**	**8/4/2008**	**Q**	**8/4/2008**	**Q**	**8/4/2008**	**Q**
2,4'-DDD	0.95	U	0.81	U	0.86	U	0.47	U	0.72	U	0.56	UJ	0.52	UJ	0.77	UJ	1	UJ	0.46	UJ
2,4'-DDE	0.95	U	0.81	U	0.86	U	0.47	U	0.72	U	0.56	UJ	0.52	UJ	0.77	UJ	1	UJ	0.46	UJ
2,4'-DDT	0.95	U	0.81	U	0.86	U	0.47	U	0.72	U	0.56	UJ	0.52	UJ	0.77	UJ	1	UJ	0.46	UJ
4,4'-DDD	1.8	U	1.6	U	1.7	U	0.91	U	1.4	U	1.1	UJ	1	UJ	1.5	UJ	1.9	UJ	0.89	UJ
4,4'-DDE	1.8	U	1.6	U	1.7	U	0.91	U	1.4	U	1.1	UJ	1	UJ	1.5	UJ	1.9	UJ	0.89	UJ
4,4'-DDT	1.8	U	1.6	U	1.7	U	0.91	U	1.4	U	1.1	UJ	1	UJ	1.5	UJ	1.9	UJ	0.89	UJ
Methoxychlor	9.5	U	8.1	U	8.6	U	4.7	U	7.2	U	5.6	UJ	5.2	UJ	7.7	UJ	10	UJ	4.6	UJ
Aldrin	0.95	U	0.81	U	0.86	U	0.47	U	0.72	U	0.56	UJ	0.52	UJ	0.77	UJ	1	UJ	0.46	UJ
Dieldrin	1.8	U	1.6	U	1.7	U	0.91	U	1.4	U	1.1	UJ	1	UJ	1.5	UJ	1.9	UJ	0.89	UJ
Endrin	1.8	U	1.6	U	1.7	U	0.91	U	1.4	U	1.1	UJ	1	UJ	1.5	UJ	1.9	UJ	0.89	UJ
Endrin ketone	1.8	U	1.6	U	1.7	U	0.91	U	1.4	U	1.1	UJ	1	UJ	1.5	UJ	1.9	UJ	0.89	UJ
Endrin aldehyde	1.8	U	1.6	U	1.7	U	0.91	U	1.4	U	1.1	UJ	1	UJ	1.5	UJ	1.9	UJ	0.89	UJ
alpha-BHC	0.95	U	0.81	U	0.86	UJ	0.47	U	0.72	U	0.56	UJ	0.52	UJ	0.77	UJ	1	UJ	0.46	UJ
beta-BHC	0.95	U	0.81	U	0.86	U	0.47	U	0.72	U	0.56	UJ	0.52	UJ	0.77	UJ	1	UJ	0.46	UJ
delta-BHC	0.95	U	0.81	U	0.86	U	0.47	U	0.72	U	0.56	UJ	0.52	UJ	0.77	UJ	1	UJ	0.46	UJ
gamma-BHC (Lindane)	0.95	U	0.81	U	0.86	U	0.47	U	0.72	U	0.56	UJ	0.52	UJ	0.77	UJ	1	UJ	0.46	UJ
alpha-Chlordane	0.95	U	0.81	U	0.86	U	0.47	U	0.72	U	0.56	UJ	0.52	UJ	0.77	UJ	1	UJ	0.46	UJ
gamma-Chlordane	0.95	U	0.81	U	0.86	U	0.47	U	0.72	U	0.56	UJ	0.52	UJ	0.77	UJ	1	UJ	0.46	UJ
Cis-Nonachlor	0.95	U	0.81	U	0.86	U	0.47	U	0.72	U	0.56	UJ	0.52	UJ	0.77	UJ	1	UJ	0.46	UJ
Trans-Nonachlor	0.95	U	0.81	U	0.86	U	0.47	U	0.72	U	0.56	UJ	0.52	UJ	0.77	UJ	1	UJ	0.46	UJ
Oxychlordane	0.95	U	0.81	U	0.86	U	0.47	U	0.72	U	0.56	UJ	0.52	UJ	0.77	UJ	1	UJ	0.46	UJ
Heptachlor	0.95	U	0.81	U	0.86	U	0.47	U	0.72	U	0.56	UJ	0.52	UJ	0.77	UJ	1	UJ	0.46	UJ
Heptachlor epoxide	0.95	U	0.81	U	0.86	U	0.47	U	0.72	U	0.56	UJ	0.52	UJ	0.77	UJ	1	UJ	0.46	UJ
Mirex	0.95	U	0.81	U	0.86	U	0.47	U	0.72	U	0.56	UJ	0.52	UJ	0.77	UJ	1	UJ	0.46	UJ
Endosulfan I	0.95	U	0.81	U	0.86	U	0.47	U	0.72	U	0.56	UJ	0.52	UJ	0.77	UJ	1	UJ	0.46	UJ
Endosulfan II	1.8	U	1.6	U	1.7	U	0.91	U	1.4	U	1.1	UJ	1	UJ	1.5	UJ	1.9	UJ	0.89	UJ
Endosulfan sulfate	1.8	U	1.6	U	1.7	U	0.91	U	1.4	U	1.1	UJ	1	UJ	1.5	UJ	1.9	UJ	0.89	UJ
Toxaphene	95	U	81	U	86	U	47	U	72	U	56	UJ	52	UJ	77	UJ	100	UJ	46	UJ

Notes:

mg/kg = milligrams per kilogram

ug/kg = micrograms per kilogram

U = Result should be considered not-detected at the quantitation limit shown

J = Result is an estimated concentration

R = Rejected - Quality Control indicates the data is not usable

UJ = The compound was not detected and the sample detection limit should be considered an estimated value

Table A-12c. US EPA/USACE "Bold Study" Analytical Data-Pesticides

Sample ID	**R_DAB_0**		**R_DAB_1**		**R_DAB_2**		**R_DAB_5**		**R_DAB_7_C**		**R_HOL_0**		**R_HOL_1**		**R_HOL_3**		**R_HOL_4**		**R_HOL_7**	
Analyte (ug/kg)	**8/2/2008**	**Q**	**8/2/2008**	**Q**	**8/2/2008**	**Q**	**8/2/2008**	**Q**	**8/2/2008**	**Q**	**8/3/2008**	**Q**	**8/3/2008**	**Q**	**8/3/2008**	**Q**	**8/3/2008**	**Q**	**8/3/2008**	**Q**
2,4'-DDD	0.49	U	0.96	U	0.83	U	0.94	U	0.77	U	0.45	UJ	0.51	UJ	0.42	UJ	1.2	UJ	1.1	UJ
2,4'-DDE	0.49	U	0.96	U	0.83	U	0.94	U	0.77	U	0.45	UJ	0.51	UJ	0.42	UJ	1.2	UJ	1.1	UJ
2,4'-DDT	0.49	U	0.96	U	0.83	U	0.94	U	0.77	U	0.45	UJ	0.51	UJ	0.42	UJ	1.2	UJ	1.1	UJ
4,4'-DDD	0.94	U	1.9	U	1.6	U	1.8	U	1.5	U	0.88	UJ	0.99	UJ	0.82	UJ	2.3	UJ	2.2	UJ
4,4'-DDE	0.94	U	1.9	U	1.6	U	1.8	U	1.5	U	0.88	UJ	0.99	UJ	0.82	UJ	2.3	UJ	2.2	UJ
4,4'-DDT	0.94	U	1.9	U	1.6	U	1.8	U	1.5	U	0.88	UJ	0.99	UJ	0.82	UJ	2.3	UJ	2.2	UJ
Methoxychlor	4.9	U	9.6	U	8.3	U	9.4	U	7.7	U	4.5	UJ	5.1	UJ	4.2	UJ	12	UJ	11	UJ
Aldrin	0.49	U	0.96	U	0.83	U	0.94	U	0.77	U	0.45	UJ	0.51	UJ	0.42	UJ	1.2	UJ	1.1	UJ
Dieldrin	0.94	U	1.9	U	1.6	U	1.8	U	1.5	U	0.88	UJ	0.99	UJ	0.82	UJ	2.3	UJ	2.2	UJ
Endrin	0.94	U	1.9	U	1.6	U	1.8	U	1.5	U	0.88	UJ	0.99	UJ	0.82	UJ	2.3	UJ	2.2	UJ
Endrin ketone	0.94	U	1.9	U	1.6	U	1.8	U	1.5	U	0.88	UJ	0.99	UJ	0.82	UJ	2.3	UJ	2.2	UJ
Endrin aldehyde	0.94	U	1.9	U	1.6	U	1.8	U	1.5	U	0.88	UJ	0.99	UJ	0.82	UJ	2.3	UJ	2.2	UJ
alpha-BHC	0.49	U	0.96	U	0.83	U	0.94	U	0.77	U	0.45	UJ	0.51	UJ	0.42	UJ	1.2	UJ	1.1	UJ
beta-BHC	0.49	U	0.96	U	0.83	U	0.94	U	0.77	U	0.45	UJ	0.51	UJ	0.42	UJ	1.2	UJ	1.1	UJ
delta-BHC	0.49	U	0.96	U	0.83	U	0.94	U	0.77	U	0.45	UJ	0.51	UJ	0.42	UJ	1.2	UJ	1.1	UJ
gamma-BHC (Lindane)	0.49	U	0.96	U	0.83	U	0.94	U	0.77	U	0.45	UJ	0.51	UJ	0.42	UJ	1.2	UJ	1.1	UJ
alpha-Chlordane	0.49	U	0.96	U	0.83	U	0.94	U	0.77	U	0.45	UJ	0.51	UJ	0.42	UJ	1.2	UJ	1.1	UJ
gamma-Chlordane	0.49	U	0.96	U	0.83	U	0.94	U	0.77	U	0.45	UJ	0.51	UJ	0.42	UJ	1.2	UJ	1.1	UJ
Cis-Nonachlor	0.49	U	0.96	U	0.83	U	0.94	U	0.77	U	0.45	UJ	0.51	UJ	0.42	UJ	1.2	UJ	1.1	UJ
Trans-Nonachlor	0.49	U	0.96	U	0.83	U	0.94	U	0.77	U	0.45	UJ	0.51	UJ	0.42	UJ	1.2	UJ	1.1	UJ
Oxychlordane	0.49	U	0.96	U	0.83	U	0.94	U	0.77	U	0.45	UJ	0.51	UJ	0.42	UJ	1.2	UJ	1.1	UJ
Heptachlor	0.49	U	0.96	U	0.83	U	0.94	U	0.77	U	0.45	UJ	0.51	UJ	0.42	UJ	1.2	UJ	1.1	UJ
Heptachlor epoxide	0.49	U	0.96	U	0.83	U	0.94	U	0.77	U	0.45	UJ	0.51	UJ	0.42	UJ	1.2	UJ	1.1	UJ
Mirex	0.49	U	0.96	U	0.83	U	0.94	U	0.77	U	0.45	UJ	0.51	UJ	0.42	UJ	1.2	UJ	1.1	UJ
Endosulfan I	0.49	U	0.96	U	0.83	U	0.94	U	0.77	U	0.45	UJ	0.51	UJ	0.42	UJ	1.2	UJ	1.1	UJ
Endosulfan II	0.94	U	1.9	U	1.6	U	1.8	U	1.5	U	0.88	UJ	0.99	UJ	0.82	UJ	2.3	UJ	2.2	UJ
Endosulfan sulfate	0.94	U	1.9	U	1.6	U	1.8	U	1.5	U	0.88	UJ	0.99	UJ	0.82	UJ	2.3	UJ	2.2	UJ
Toxaphene	49	U	96	U	83	U	94	U	77	U	45	UJ	51	UJ	42	UJ	120	UJ	110	UJ

Notes:

mg/kg = milligrams per kilogram

ug/kg = micrograms per kilogram

U = Result should be considered not-detected at the quantitation limit shown

J = Result is an estimated concentration

R = Rejected - Quality Control indicates the data is not usable

UJ = The compound was not detected and the sample detection limit should be considered an estimated value

Table A-12c. US EPA/USACE “Bold Study” Analytical Data-Pesticides

Sample ID	**R_SAM_0**		**R_SAM_1**		**R_SAM_3**		**R_SAM_4**		**R_SAM_5**		**SCPS_1**		**SCPS_10_C**		**SCPS_2**		**SCPS_3**		**SCPS_5**	
Analyte (ug/kg)	**8/1/2008**	**Q**	**8/1/2008**	**Q**	**8/1/2008**	**Q**	**8/1/2008**	**Q**	**8/1/2008**	**Q**	**8/4/2008**	**Q**	**8/5/2008**	**Q**	**8/4/2008**	**Q**	**8/4/2008**	**Q**	**8/4/2008**	**Q**
2,4'-DDD	0.64	U	1	U	0.9	U	0.76	U	0.97	U	0.89	UJ	0.49	U	0.46	UJ	0.41	UJ	1.1	UJ
2,4'-DDE	0.64	U	1	U	0.9	U	0.76	U	0.97	U	0.89	UJ	0.49	U	0.46	UJ	0.41	UJ	1.1	UJ
2,4'-DDT	0.64	U	1	U	0.9	U	0.76	U	0.97	U	0.89	UJ	0.49	U	0.46	UJ	0.41	UJ	1.1	UJ
4,4'-DDD	1.3	U	1.9	U	1.7	U	1.5	U	1.9	U	1.7	UJ	0.94	U	0.88	UJ	0.8	UJ	2.1	UJ
4,4'-DDE	1.3	U	1.9	U	1.7	U	1.5	U	1.9	U	1.7	UJ	0.94	U	0.88	UJ	0.8	UJ	2.1	UJ
4,4'-DDT	1.3	U	1.9	U	1.7	U	1.5	U	1.9	U	1.7	UJ	0.94	U	0.88	UJ	0.8	UJ	2.1	UJ
Methoxychlor	6.4	U	10	U	9	U	7.6	U	9.7	U	8.9	UJ	4.9	U	4.6	UJ	4.1	UJ	11	UJ
Aldrin	0.64	U	1	U	0.9	U	0.76	U	0.97	U	0.89	UJ	0.49	U	0.46	UJ	0.41	UJ	1.1	UJ
Dieldrin	1.3	U	1.9	U	1.7	U	1.5	U	1.9	U	1.7	UJ	0.94	U	0.88	UJ	0.8	UJ	2.1	UJ
Endrin	1.3	U	1.9	U	1.7	U	1.5	U	1.9	U	1.7	UJ	0.94	U	0.88	UJ	0.8	UJ	2.1	UJ
Endrin ketone	1.3	U	1.9	U	1.7	U	1.5	U	1.9	U	1.7	UJ	0.94	U	0.88	UJ	0.8	UJ	2.1	UJ
Endrin aldehyde	1.3	U	1.9	U	1.7	U	1.5	U	1.9	U	1.7	UJ	0.94	U	0.88	UJ	0.8	UJ	2.1	UJ
alpha-BHC	0.64	U	1	U	0.9	U	0.76	U	0.97	U	0.89	UJ	0.49	U	0.46	UJ	0.41	UJ	1.1	UJ
beta-BHC	0.64	U	1	U	0.9	U	0.76	U	0.97	U	0.89	UJ	0.49	U	0.46	UJ	0.41	UJ	1.1	UJ
delta-BHC	0.64	U	1	U	0.9	U	0.76	U	0.97	U	0.89	UJ	0.49	U	0.46	UJ	0.41	UJ	1.1	UJ
gamma-BHC (Lindane)	0.64	U	1	U	0.9	U	0.76	U	0.97	U	0.89	UJ	0.49	U	0.46	UJ	0.41	UJ	1.1	UJ
alpha-Chlordane	0.64	U	1	U	0.9	U	0.76	U	0.97	U	0.89	UJ	0.49	U	0.46	UJ	0.41	UJ	1.1	UJ
gamma-Chlordane	0.64	U	1	U	0.9	U	0.76	U	0.97	U	0.89	UJ	0.49	U	0.46	UJ	0.41	UJ	1.1	UJ
Cis-Nonachlor	0.64	U	1	U	0.9	U	0.76	U	0.97	U	0.89	UJ	0.49	U	0.46	UJ	0.41	UJ	1.1	UJ
Trans-Nonachlor	0.64	U	1	U	0.9	U	0.76	U	0.97	U	0.89	UJ	0.49	U	0.46	UJ	0.41	UJ	1.1	UJ
Oxychlordane	0.64	U	1	U	0.9	U	0.76	U	0.97	U	0.89	UJ	0.49	U	0.46	UJ	0.41	UJ	1.1	UJ
Heptachlor	0.64	U	1	U	0.9	U	0.76	U	0.97	U	0.89	UJ	0.49	U	0.46	UJ	0.41	UJ	1.1	UJ
Heptachlor epoxide	0.64	U	1	U	0.9	U	0.76	U	0.97	U	0.89	UJ	0.49	U	0.46	UJ	0.41	UJ	1.1	UJ
Mirex	0.64	U	1	U	0.9	U	0.76	U	0.97	U	0.89	UJ	0.49	U	0.46	UJ	0.41	UJ	1.1	UJ
Endosulfan I	0.64	U	1	U	0.9	U	0.76	U	0.97	U	0.89	UJ	0.49	U	0.46	UJ	0.41	UJ	1.1	UJ
Endosulfan II	1.3	U	1.9	U	1.7	U	1.5	U	1.9	U	1.7	UJ	0.94	U	0.88	UJ	0.8	UJ	2.1	UJ
Endosulfan sulfate	1.3	U	1.9	U	1.7	U	1.5	U	1.9	U	1.7	UJ	0.94	U	0.88	UJ	0.8	UJ	2.1	UJ
Toxaphene	64	U	100	U	90	U	76	U	97	U	89	UJ	49	U	46	UJ	41	UJ	110	UJ

Notes:
mg/kg = milligrams per kilogram
ug/kg = micrograms per kilogram
U = Result should be considered not-detected at the quantitation limit shown
J = Result is an estimated concentration
R = Rejected - Quality Control indicates the data is not usable
UJ = The compound was not detected and the sample detection limit should be considered an estimated value

Table A-12c. US EPA/USACE "Bold Study" Analytical Data-Pesticides

Sample ID	**SJF_10_C**		**SJF_12_C_GS**		**SJF_2**		**SJF_3**		**SJF_9_C**		**SJI_0**		**SJI_1**		**SJI_20_C_GS**		**SJI_3**		**SJI_8_C**	
Analyte (ug/kg)	**8/1/2008**	**Q**	**8/2/2008**	**Q**	**8/1/2008**	**Q**	**8/1/2008**	**Q**	**8/1/2008**	**Q**	**8/1/2008**	**Q**	**8/2/2008**	**Q**	**8/2/2008**	**Q**	**8/2/2008**	**Q**	**8/2/2008**	**Q**
2,4'-DDD	0.42	UJ	0.8	U	0.45	UJ	0.44	UJ	0.48	UJ	0.66	U	0.55	U	0.64	U	0.48	U	0.46	U
2,4'-DDE	0.42	UJ	0.8	U	0.45	UJ	0.44	UJ	0.48	UJ	0.66	U	0.55	U	0.64	U	0.48	U	0.46	U
2,4'-DDT	0.42	UJ	0.8	U	0.45	UJ	0.44	UJ	0.48	UJ	0.66	U	0.55	U	0.64	U	0.48	U	0.46	U
4,4'-DDD	0.81	UJ	1.6	U	0.87	UJ	0.85	UJ	0.94	UJ	1.3	U	1.1	U	1.2	U	0.94	U	0.9	U
4,4'-DDE	0.81	UJ	1.6	U	0.87	UJ	0.85	UJ	0.94	UJ	1.3	U	1.1	U	1.2	U	0.94	U	0.9	U
4,4'-DDT	0.81	UJ	1.6	U	0.87	UJ	0.85	UJ	0.94	UJ	1.3	U	1.1	U	1.2	U	0.94	U	0.9	U
Methoxychlor	4.2	UJ	8	U	4.5	UJ	4.4	UJ	4.8	UJ	6.6	U	5.5	U	6.4	U	4.8	U	4.6	U
Aldrin	0.42	UJ	0.8	U	0.45	UJ	0.44	UJ	0.48	UJ	0.66	U	0.55	U	0.64	U	0.48	U	0.46	U
Dieldrin	0.81	UJ	1.6	U	0.87	UJ	0.85	UJ	0.94	UJ	1.3	U	1.1	U	1.2	U	0.94	U	0.9	U
Endrin	0.81	UJ	1.6	U	0.87	UJ	0.85	UJ	0.94	UJ	1.3	U	1.1	U	1.2	U	0.94	U	0.9	U
Endrin ketone	0.81	UJ	1.6	U	0.87	UJ	0.85	UJ	0.94	UJ	1.3	U	1.1	U	1.2	U	0.94	U	0.9	U
Endrin aldehyde	0.81	UJ	1.6	U	0.87	UJ	0.85	UJ	0.94	UJ	1.3	U	1.1	U	1.2	U	0.94	U	0.9	U
alpha-BHC	0.42	UJ	0.8	U	0.45	UJ	0.44	UJ	0.48	UJ	0.66	U	0.55	U	0.64	U	0.48	U	0.46	U
beta-BHC	0.42	UJ	0.8	U	0.45	UJ	0.44	UJ	0.48	UJ	0.66	U	0.55	U	0.64	U	0.48	U	0.46	U
delta-BHC	0.42	UJ	0.8	U	0.45	UJ	0.44	UJ	0.48	UJ	0.66	U	0.55	U	0.64	U	0.48	U	0.46	U
gamma-BHC (Lindane)	0.42	UJ	0.8	U	0.45	UJ	0.44	UJ	0.48	UJ	0.66	U	0.55	U	0.64	U	0.48	U	0.46	U
alpha-Chlordane	0.42	UJ	0.8	U	0.45	UJ	0.44	UJ	0.48	UJ	0.66	U	0.55	U	0.64	U	0.48	U	0.46	U
gamma-Chlordane	0.42	UJ	0.8	U	0.45	UJ	0.44	UJ	0.48	UJ	0.66	U	0.55	U	0.64	U	0.48	U	0.46	U
Cis-Nonachlor	0.42	UJ	0.8	U	0.45	UJ	0.44	UJ	0.48	UJ	0.66	U	0.55	U	0.64	U	0.48	U	0.46	U
Trans-Nonachlor	0.42	UJ	0.8	U	0.45	UJ	0.44	UJ	0.48	UJ	0.66	U	0.55	U	0.64	U	0.48	U	0.46	U
Oxychlordane	0.42	UJ	0.8	U	0.45	UJ	0.44	UJ	0.48	UJ	0.66	U	0.55	U	0.64	U	0.48	U	0.46	U
Heptachlor	0.42	UJ	0.8	U	0.45	UJ	0.44	UJ	0.48	UJ	0.66	U	0.55	U	0.64	U	0.48	U	0.46	U
Heptachlor epoxide	0.42	UJ	0.8	U	0.45	UJ	0.44	UJ	0.48	UJ	0.66	U	0.55	U	0.64	U	0.48	U	0.46	U
Mirex	0.42	UJ	0.8	U	0.45	UJ	0.44	UJ	0.48	UJ	0.66	U	0.55	U	0.64	U	0.48	U	0.46	U
Endosulfan I	0.42	UJ	0.8	U	0.45	UJ	0.44	UJ	0.48	UJ	0.66	U	0.55	U	0.64	U	0.48	U	0.46	U
Endosulfan II	0.81	UJ	1.6	U	0.87	UJ	0.85	UJ	0.94	UJ	1.3	U	1.1	U	1.2	U	0.94	U	0.9	U
Endosulfan sulfate	0.81	UJ	1.6	U	0.87	UJ	0.85	UJ	0.94	UJ	1.3	U	1.1	U	1.2	U	0.94	U	0.9	U
Toxaphene	42	UJ	80	U	45	UJ	44	UJ	48	UJ	66	U	55	U	64	U	48	U	46	U

Notes:

mg/kg = milligrams per kilogram

ug/kg = micrograms per kilogram

U = Result should be considered not-detected at the quantitation limit shown

J = Result is an estimated concentration

R = Rejected - Quality Control indicates the data is not usable

UJ = The compound was not detected and the sample detection limit should be considered an estimated value

Table A-12c. US EPA/USACE “Bold Study” Analytical Data-Pesticides

Sample ID	**SPSB_0**		**SPSB_1**		**SPSB_2**		**SPSB_3**		**SPSB_8_C**		**SS_0**		**SS_1**		**SS_2**		**SS_8_C**		**SS_9_C**	
Analyte (ug/kg)	**8/3/2008**	**Q**	**8/3/2008**	**Q**	**8/3/2008**	**Q**	**8/3/2008**	**Q**	**8/3/2008**	**Q**	**8/4/2008**	**Q**	**8/4/2008**	**Q**	**8/4/2008**	**Q**	**8/4/2008**	**Q**	**8/4/2008**	**Q**
2,4'-DDD	0.98	UJ	0.92	UJ	0.96	UJ	0.49	UJ	0.47	UJ	0.88	UJ	0.37	UJ	0.61	UJ	0.47	UJ	1.2	UJ
2,4'-DDE	0.98	UJ	0.92	UJ	0.96	UJ	0.49	UJ	0.47	UJ	0.88	UJ	0.37	UJ	0.61	UJ	0.47	UJ	1.2	UJ
2,4'-DDT	0.98	UJ	0.92	UJ	0.96	UJ	0.49	UJ	0.47	UJ	0.88	UJ	0.37	UJ	0.61	UJ	0.47	UJ	1.2	UJ
4,4'-DDD	1.9	UJ	1.8	UJ	1.9	UJ	0.95	UJ	0.91	UJ	1.7	UJ	0.72	UJ	1.2	UJ	0.91	UJ	2.2	UJ
4,4'-DDE	1.9	UJ	1.8	UJ	1.9	UJ	0.95	UJ	0.91	UJ	1.7	UJ	0.72	UJ	1.2	UJ	0.91	UJ	2.2	UJ
4,4'-DDT	1.9	UJ	1.8	UJ	1.9	UJ	0.95	UJ	0.91	UJ	1.7	UJ	0.72	UJ	1.2	UJ	0.91	UJ	2.2	UJ
Methoxychlor	9.8	UJ	9.2	UJ	9.6	UJ	4.9	UJ	4.7	UJ	8.8	UJ	3.7	UJ	6.1	UJ	4.7	UJ	12	UJ
Aldrin	0.98	UJ	0.92	UJ	0.96	UJ	0.49	UJ	0.47	UJ	0.88	UJ	0.37	UJ	0.61	UJ	0.47	UJ	1.2	UJ
Dieldrin	1.9	UJ	1.8	UJ	1.9	UJ	0.95	UJ	0.91	UJ	1.7	UJ	0.72	UJ	1.2	UJ	0.91	UJ	2.2	UJ
Endrin	1.9	UJ	1.8	UJ	1.9	UJ	0.95	UJ	0.91	UJ	1.7	UJ	0.72	UJ	1.2	UJ	0.91	UJ	2.2	UJ
Endrin ketone	1.9	UJ	1.8	UJ	1.9	UJ	0.95	UJ	0.91	UJ	1.7	UJ	0.72	UJ	1.2	UJ	0.91	UJ	2.2	UJ
Endrin aldehyde	1.9	UJ	1.8	UJ	1.9	UJ	0.95	UJ	0.91	UJ	1.7	UJ	0.72	UJ	1.2	UJ	0.91	UJ	2.2	UJ
alpha-BHC	0.98	UJ	0.92	UJ	0.96	UJ	0.49	UJ	0.47	UJ	0.88	UJ	0.37	UJ	0.61	UJ	0.47	UJ	1.2	UJ
beta-BHC	0.98	UJ	0.92	UJ	0.96	UJ	0.49	UJ	0.47	UJ	0.88	UJ	0.37	UJ	0.61	UJ	0.47	UJ	1.2	UJ
delta-BHC	0.98	UJ	0.92	UJ	0.96	UJ	0.49	UJ	0.47	UJ	0.88	UJ	0.37	UJ	0.61	UJ	0.47	UJ	1.2	UJ
gamma-BHC (Lindane)	0.98	UJ	0.92	UJ	0.96	UJ	0.49	UJ	0.47	UJ	0.88	UJ	0.37	UJ	0.61	UJ	0.47	UJ	1.2	UJ
alpha-Chlordane	0.98	UJ	0.92	UJ	0.96	UJ	0.49	UJ	0.47	UJ	0.88	UJ	0.37	UJ	0.61	UJ	0.47	UJ	1.2	UJ
gamma-Chlordane	0.98	UJ	0.92	UJ	0.96	UJ	0.49	UJ	0.47	UJ	0.88	UJ	0.37	UJ	0.61	UJ	0.47	UJ	1.2	UJ
Cis-Nonachlor	0.98	UJ	0.92	UJ	0.96	UJ	0.49	UJ	0.47	UJ	0.88	UJ	0.37	UJ	0.61	UJ	0.47	UJ	1.2	UJ
Trans-Nonachlor	0.98	UJ	0.92	UJ	0.96	UJ	0.49	UJ	0.47	UJ	0.88	UJ	0.37	UJ	0.61	UJ	0.47	UJ	1.2	UJ
Oxychlordane	0.98	UJ	0.92	UJ	0.96	UJ	0.49	UJ	0.47	UJ	0.88	UJ	0.37	UJ	0.61	UJ	0.47	UJ	1.2	UJ
Heptachlor	0.98	UJ	0.92	UJ	0.96	UJ	0.49	UJ	0.47	UJ	0.88	UJ	0.37	UJ	0.61	UJ	0.47	UJ	1.2	UJ
Heptachlor epoxide	0.98	UJ	0.92	UJ	0.96	UJ	0.49	UJ	0.47	UJ	0.88	UJ	0.37	UJ	0.61	UJ	0.47	UJ	1.2	UJ
Mirex	0.98	UJ	0.92	UJ	0.96	UJ	0.49	UJ	0.47	UJ	0.88	UJ	0.37	UJ	0.61	UJ	0.47	UJ	1.2	UJ
Endosulfan I	0.98	UJ	0.92	UJ	0.96	UJ	0.49	UJ	0.47	UJ	0.88	UJ	0.37	UJ	0.61	UJ	0.47	UJ	1.2	UJ
Endosulfan II	1.9	UJ	1.8	UJ	1.9	UJ	0.95	UJ	0.91	UJ	1.7	UJ	0.72	UJ	1.2	UJ	0.91	UJ	2.2	UJ
Endosulfan sulfate	1.9	UJ	1.8	UJ	1.9	UJ	0.95	UJ	0.91	UJ	1.7	UJ	0.72	UJ	1.2	UJ	0.91	UJ	2.2	UJ
Toxaphene	98	UJ	92	UJ	96	UJ	49	UJ	47	UJ	88	UJ	37	UJ	61	UJ	47	UJ	120	UJ

Notes:

mg/kg = milligrams per kilogram

ug/kg = micrograms per kilogram

U = Result should be considered not-detected at the quantitation limit shown

J = Result is an estimated concentration

R = Rejected - Quality Control indicates the data is not usable

UJ = The compound was not detected and the sample detection limit should be considered an estimated value

Table A-12c. US EPA/USACE “Bold Study” Analytical Data-Pesticides

Sample ID	CPS_3_Dup		HC_2_Dup		NCPS_2_Dup		PSPS_1_Dup		SPSB_0_Dup	
Analyte (ug/kg)	7/31/2008	Q	8/3/2008	Q	8/3/2008	Q	8/3/2008	Q	8/3/2008	Q
2,4'-DDD	0.49	U	1.4	U	0.5	U	1	U	0.99	U
2,4'-DDE	0.49	U	1.4	U	0.5	U	1	U	0.99	U
2,4'-DDT	0.49	U	1.4	U	0.5	U	1	U	0.99	U
4,4'-DDD	0.95	U	2.6	U	0.98	U	2	U	1.9	U
4,4'-DDE	0.95	U	2.6	U	0.98	U	2	U	1.9	U
4,4'-DDT	0.95	U	2.6	U	0.98	U	2	U	1.9	U
Methoxychlor	4.9	U	14	U	5	U	10	U	9.9	U
Aldrin	0.49	U	1.4	U	0.5	U	1	U	0.99	U
Dieldrin	0.95	U	2.6	U	0.98	U	2	U	1.9	U
Endrin	0.95	U	2.6	U	0.98	U	2	U	1.9	U
Endrin ketone	0.95	U	2.6	U	0.98	U	2	U	1.9	U
Endrin aldehyde	0.95	U	2.6	U	0.98	U	2	U	1.9	U
alpha-BHC	0.49	U	1.4	U	0.5	U	1	U	0.99	U
beta-BHC	0.49	U	1.4	U	0.5	U	1	U	0.99	U
delta-BHC	0.49	U	1.4	U	0.5	U	1	U	0.99	U
gamma-BHC (Lindane)	0.49	U	1.4	U	0.5	U	1	U	0.99	U
alpha-Chlordane	0.49	U	1.4	U	0.5	U	1	U	0.99	U
gamma-Chlordane	0.49	U	1.4	U	0.5	U	1	U	0.99	U
Cis-Nonachlor	0.49	U	1.4	U	0.5	U	1	U	0.99	U
Trans-Nonachlor	0.49	U	1.4	U	0.5	U	1	U	0.99	U
Oxychlordane	0.49	U	1.4	U	0.5	U	1	U	0.99	U
Heptachlor	0.49	U	1.4	U	0.5	U	1	U	0.99	U
Heptachlor epoxide	0.49	U	1.4	U	0.5	U	1	U	0.99	U
Mirex	0.49	U	1.4	U	0.5	U	1	U	0.99	U
Endosulfan I	0.49	U	1.4	U	0.5	U	1	U	0.99	U
Endosulfan II	0.95	U	2.6	U	0.98	U	2	U	1.9	U
Endosulfan sulfate	0.95	U	2.6	U	0.98	U	2	U	1.9	U
Toxaphene	49	U	140	U	50	U	100	U	99	U

Notes:

mg/kg = milligrams per kilogram

ug/kg = micrograms per kilogram

U = Result should be considered not-detected at the quantitation limit shown

J = Result is an estimated concentration

R = Rejected - Quality Control indicates the data is not usable

UJ = The compound was not detected and the sample detection limit should be considered an estimated value

Table A-12d. US EPA/USACE "Bold Study" Analytical Data-PCB Aroclors

Sample ID	AI_1		AI_11_C		AI_13_C		AI_20_C_GS		AI_5_C		CPS_0		CPS_1		CPS_3		CPS_4		CPS_5		HC_0		HC_1		HC_2		HC_3	
Analyte (ug/kg)	7/31/2008	Q	8/1/2008	Q	8/3/2008	Q	8/1/2008	Q	8/1/2008	Q	8/4/2008	Q	8/4/2008	Q	7/31/2008	Q	8/4/2008	Q	7/31/2008	Q	8/3/2008	Q	8/2/2008	Q	8/3/2008	Q	8/2/2008	Q
Aroclor-1016	7.3	U	6.5	U	6.9	U	7.6	U	7.2	U	16	U	8.7	U	7.8	U	7.7	U	6.8	U	17	UJ	7.9	U	20	U	9.8	U
Aroclor-1221	7.3	U	6.5	U	6.9	U	7.6	U	7.2	U	16	U	8.7	U	7.8	U	7.7	U	6.8	U	17	UJ	7.9	U	20	U	9.8	U
Aroclor-1232	7.3	U	6.5	U	6.9	U	7.6	U	7.2	U	16	U	8.7	U	7.8	U	7.7	U	6.8	U	17	UJ	7.9	U	20	U	9.8	U
Aroclor-1242	7.3	U	6.5	U	6.9	U	7.6	U	7.2	U	16	U	8.7	U	7.8	U	7.7	U	6.8	U	17	UJ	7.9	U	20	U	9.8	U
Aroclor-1248	7.3	U	6.5	U	6.9	U	7.6	U	7.2	U	16	U	8.7	U	7.8	U	7.7	U	6.8	U	17	UJ	7.9	U	20	U	9.8	U
Aroclor-1254	7.3	U	6.5	U	6.9	U	7.6	U	7.2	U	16	U	8.7	U	7.8	U	7.7	U	6.8	U	17	UJ	7.9	U	20	U	9.8	U
Aroclor-1260	7.3	U	6.5	U	6.9	U	7.6	U	7.2	U	16	U	8.7	U	7.8	U	7.7	U	6.8	U	17	UJ	7.9	U	20	U	9.8	U
Aroclor-1262	7.3	U	6.5	U	6.9	U	7.6	U	7.2	U	16	U	8.7	U	7.8	U	7.7	U	6.8	U	17	UJ	7.9	U	20	U	9.8	U
Aroclor-1268	7.3	U	6.5	U	6.9	U	7.6	U	7.2	U	16	U	8.7	U	7.8	U	7.7	U	6.8	U	17	UJ	7.9	U	20	U	9.8	U

Sample ID	HC_6		NCPS_0		NCPS_1		NCPS_2		NCPS_3		NCPS_4		PSPS_1		PSPS_2		PSPS_3		PSPS_8		PSPS_9		R_CAR_0		R_CAR_1		R_CAR_4		R_CAR_5	
Analyte (ug/kg)	8/2/2008	Q	7/31/2008	Q	7/31/2008	Q	8/3/2008	Q	7/31/2008	Q	7/31/2008	Q	8/3/2008	Q	8/3/2008	Q	8/3/2008	Q	8/3/2008	Q	8/3/2008	Q	8/4/2008	Q	8/4/2008	Q	8/4/2008	Q	8/4/2008	Q
Aroclor-1016	13	U	8.7	U	6.3	U	8.3	U	8.9	U	7.3	U	14	U	12	U	13	U	6.9	U	11	U	8.2	U	7.7	U	11	U	15	U
Aroclor-1221	13	U	8.7	U	6.3	U	8.3	U	8.9	U	7.3	U	14	U	12	U	13	U	6.9	U	11	U	8.2	U	7.7	U	11	U	15	U
Aroclor-1232	13	U	8.7	U	6.3	U	8.3	U	8.9	U	7.3	U	14	U	12	U	13	U	6.9	U	11	U	8.2	U	7.7	U	11	U	15	U
Aroclor-1242	13	U	8.7	U	6.3	U	8.3	U	8.9	U	7.3	U	14	U	12	U	13	U	6.9	U	11	U	8.2	U	7.7	U	11	U	15	U
Aroclor-1248	13	U	8.7	U	6.3	U	8.3	U	8.9	U	7.3	U	14	U	12	U	13	U	6.9	U	11	U	8.2	U	7.7	U	11	U	15	U
Aroclor-1254	13	U	8.7	U	6.3	U	8.3	U	8.9	U	7.3	U	14	U	12	U	13	U	6.9	U	11	U	8.2	U	7.7	U	11	U	15	U
Aroclor-1260	13	U	8.7	U	6.3	U	8.3	U	8.9	U	7.3	U	14	U	12	U	13	U	6.9	U	11	U	8.2	U	7.7	U	11	U	15	U
Aroclor-1262	13	U	8.7	U	6.3	U	8.3	U	8.9	U	7.3	U	14	U	12	U	13	U	6.9	U	11	U	8.2	U	7.7	U	11	U	15	U
Aroclor-1268	13	U	8.7	U	6.3	U	8.3	U	8.9	U	7.3	U	14	U	12	U	13	U	6.9	U	11	U	2.1	J	7.7	U	31		15	U

Sample ID	R_CAR_6_C		R_DAB_0		R_DAB_1		R_DAB_2		R_DAB_5		R_DAB_7_C		R_HOL_0		R_HOL_1		R_HOL_3		R_HOL_4		R_HOL_7		R_SAM_0		R_SAM_1		R_SAM_3		R_SAM_4	
Analyte (ug/kg)	8/4/2008	Q	8/2/2008	Q	8/2/2008	Q	8/2/2008	Q	8/2/2008	Q	8/2/2008	Q	8/3/2008	Q	8/3/2008	Q	8/3/2008	Q	8/3/2008	Q	8/3/2008	Q	8/1/2008	Q	8/1/2008	Q	8/1/2008	Q	8/1/2008	Q
Aroclor-1016	6.7	U	7.2	U	14	U	12	U	14	U	11	U	6.7	U	7.5	U	6.2	U	17	U	17	U	9.5	U	15	U	13	U	11	U
Aroclor-1221	6.7	U	7.2	U	14	U	12	U	14	U	11	U	6.7	U	7.5	U	6.2	U	17	U	17	U	9.5	U	15	U	13	U	11	U
Aroclor-1232	6.7	U	7.2	U	14	U	12	U	14	U	11	U	6.7	U	7.5	U	6.2	U	17	U	17	U	9.5	U	15	U	13	U	11	U
Aroclor-1242	6.7	U	7.2	U	14	U	12	U	14	U	11	U	6.7	U	7.5	U	6.2	U	17	U	17	U	9.5	U	15	U	13	U	11	U
Aroclor-1248	6.7	U	7.2	U	14	U	12	U	14	U	11	U	6.7	U	7.5	U	6.2	U	17	U	17	U	9.5	U	15	U	13	U	11	U
Aroclor-1254	6.7	U	7.2	U	14	U	12	U	14	U	11	U	6.7	U	7.5	U	6.2	U	17	U	17	U	9.5	U	15	U	13	U	11	U
Aroclor-1260	6.7	U	7.2	U	14	U	12	U	14	U	11	U	6.7	U	7.5	U	6.2	U	17	U	17	U	9.5	U	15	U	13	U	11	U
Aroclor-1262	6.7	U	7.2	U	14	U	12	U	14	U	11	U	6.7	U	7.5	U	6.2	U	17	U	17	U	9.5	U	15	U	13	U	11	U
Aroclor-1268	7.3		7.2	U	14	U	12	U	14	U	11	U	6.7	U	2.9	J	6.2	U	15		17	U	9.5	U	15	U	13	U	11	U

Sample ID	R_SAM_5		SCPS_1		SCPS_10_C		SCPS_2		SCPS_3		SCPS_5		SJF_10_C		SJF_12_C_GS		SJF_2		SJF_3		SJF_9_C		SJI_0		SJI_1		SJI_20_C_GS		SJI_3	
Analyte (ug/kg)	8/1/2008	Q	8/4/2008	Q	8/5/2008	Q	8/4/2008	Q	8/4/2008	Q	8/4/2008	Q	8/1/2008	Q	8/2/2008	Q	8/1/2008	Q	8/1/2008	Q	8/1/2008	Q	8/1/2008	Q	8/2/2008	Q	8/2/2008	Q	8/2/2008	Q
Aroclor-1016	14	U	13	U	7.1	U	6.7	U	6	U	16	U	6.2	UJ	12	U	6.6	UJ	6.4	UJ	7.1	UJ	9.7	U	8.1	U	9.4	U	7.1	U
Aroclor-1221	14	U	13	U	7.1	U	6.7	U	6	U	16	U	6.2	UJ	12	U	6.6	UJ	6.4	UJ	7.1	UJ	9.7	U	8.1	U	9.4	U	7.1	U
Aroclor-1232	14	U	13	U	7.1	U	6.7	U	6	U	16	U	6.2	UJ	12	U	6.6	UJ	6.4	UJ	7.1	UJ	9.7	U	8.1	U	9.4	U	7.1	U
Aroclor-1242	14	U	13	U	7.1	U	6.7	U	6	U	16	U	6.2	UJ	12	U	6.6	UJ	6.4	UJ	7.1	UJ	9.7	U	8.1	U	9.4	U	7.1	U
Aroclor-1248	14	U	13	U	7.1	U	6.7	U	6	U	16	U	6.2	UJ	12	U	6.6	UJ	6.4	UJ	7.1	UJ	9.7	U	8.1	U	9.4	U	7.1	U
Aroclor-1254	14	U	13	U	7.1	U	6.7	U	6	U	16	U	6.2	UJ	12	U	6.6	UJ	6.4	UJ	7.1	UJ	9.7	U	8.1	U	9.4	U	7.1	U
Aroclor-1260	14	U	13	U	7.1	U	6.7	U	6	U	16	U	6.2	UJ	12	U	6.6	UJ	6.4	UJ	7.1	UJ	9.7	U	8.1	U	9.4	U	7.1	U
Aroclor-1262	14	U	13	U	7.1	U	6.7	U	6	U	16	U	6.2	UJ	12	U	6.6	UJ	6.4	UJ	7.1	UJ	9.7	U	8.1	U	9.4	U	7.1	U
Aroclor-1268	14	U	13	U	7.1	U	6.7	U	6	U	16	U	6.2	UJ	12	U	6.6	UJ	6.4	UJ	7.1	UJ	9.7	U	8.1	U	9.4	U	7.1	U

Sample ID	SJI_8_C		SPSB_0		SPSB_1		SPSB_2		SPSB_3		SPSB_8_C		SS_0		SS_1		SS_2		SS_8_C		SS_9_C		CPS_3_Dup		HC_2_Dup		NCPS_2_Dup		PSPS_1_Dup		SPSB_0_Dup	
Analyte (ug/kg)	8/2/2008	Q	8/3/2008	Q	8/3/2008	Q	8/3/2008	Q	8/3/2008	Q	8/3/2008	Q	8/4/2008	Q	8/4/2008	Q	8/4/2008	Q	8/4/2008	Q	8/4/2008	Q	7/31/2008	Q	8/3/2008	Q	8/3/2008	Q	8/3/2008	Q	8/3/2008	Q
Aroclor-1016	6.8	U	14	U	14	U	14	U	7.2	U	6.9	U	13	U	5.4	U	9	U	6.9	U	17	U	7.2	U	20	U	7.4	U	15	U	15	U
Aroclor-1221	6.8	U	14	U	14	U	14	U	7.2	U	6.9	U	13	U	5.4	U	9	U	6.9	U	17	U	7.2	U	20	U	7.4	U	15	U	15	U
Aroclor-1232	6.8	U	14	U	14	U	14	U	7.2	U	6.9	U	13	U	5.4	U	9	U	6.9	U	17	U	7.2	U	20	U	7.4	U	15	U	15	U
Aroclor-1242	6.8	U	14	U	14	U	14	U	7.2	U	6.9	U	13	U	5.4	U	9	U	6.9	U	17	U	7.2	U	20	U	7.4	U	15	U	15	U
Aroclor-1248	6.8	U	14	U	14	U	14	U	7.2	U	6.9	U	13	U	5.4	U	9	U	6.9	U	17	U	7.2	U	20	U	7.4	U	15	U	15	U
Aroclor-1254	6.8	U	14	U	14	U	14	U	7.2	U	6.9	U	13	U	5.4	U	9	U	6.9	U	17	U	7.2	U	20	U	7.4	U	15	U	15	U
Aroclor-1260	6.8	U	14	U	14	U	14	U	7.2	U	6.9	U	13	U	5.4	U	9	U	6.9	U	17	U	7.2	U	20	U	7.4	U	15	U	15	U
Aroclor-1262	6.8	U	14	U	14	U	14	U	7.2	U	6.9	U	13	U	5.4	U	9	U	6.9	U	17	U	7.2	U	20	U	7.4	U	15	U	15	U
Aroclor-1268	6.8	U	14	U	14	U	14	U	7.2	U	6.9	U	5.3	J	5.4	U	9	U	6.9	U	17	U	7.2	U	20	U	7.4	U	15	U	15	U

Notes:

mg/kg = milligrams per kilogram

ug/kg = micrograms per kilogram

U = Result should be considered not-detected at the quantitation limit shown

J = Result is an estimated concentration

R = Rejected - Quality Control indicates the data is not usable

UJ = The compound was not detected and the sample detection limit should be considered an estimated value

Table A-12e. US EPA/USACE "Bold Study" Analytical Data-PCB Congeners

Sample ID / Analyte (pg/g)	TEF	AI_1 7/31/2008	Q	AI_11_C 8/1/2008	Q	AI_13_C 8/3/2008	Q	AI_20_C_GS 8/1/2008	Q	AI_5_C 8/1/2008	Q	CPS_0 8/4/2008	Q	CPS_1 8/4/2008	Q	CPS_3 7/31/2008	Q	CPS_4 8/4/2008	Q	CPS_5 7/31/2008	Q	HC_0 8/3/2008	Q
1-MoCB		0.107	U	0.0833	U	0.221	U	0.0747	U	0.0956	U	17.3		0.144	U	5.06		0.0999	U	0.0782	U	15.3	
2-MoCB		0.109	U	0.0854	U	0.193	U	0.072	U	0.101	U	12		0.143	U	0.113	U	0.109	U	0.0785	U	8.93	
3-MoCB		0.107	U	0.0844	U	0.157	U	0.0673	U	0.0973	U	9.49		0.133	U	0.114	U	0.11	U	0.0742	U	7.29	
4-DiCB		1.76		0.533	U	2	J	2.76	J	2.42		27		9.59		7.58		3.82		4.6		38.5	
5-DiCB		0.403	U	0.583	U	0.666	U	0.358	U	10.2		1.94	U	0.339	U	1.14		0.452	U	0.374	U	1.85	U
6-DiCB		0.393	U	0.569	U	0.648	U	0.35	U	0.532	U	16.2		0.333	U	0.455	U	0.445	U	0.368	U	10.8	
7-DiCB		0.386	U	0.558	U	0.623	U	0.343	U	0.534	U	6.34		1.9		1.43		0.727	J	0.358	U	1.77	U
8-DiCB		0.369	U	0.534	U	0.607	U	10.6		0.514	U	93.6		0.317	U	24.7		0.423	U	0.35	U	74.6	
9-DiCB		0.384	U	0.555	U	0.626	U	0.341	U	0.536	U	4.15		1.01	J	0.829	J	0.434	U	0.359	U	1.78	U
10-DiCB		0.634	U	0.473	U	0.337	U	0.578	U	0.348	U	1.46	J	0.598	U	0.391	U	0.648	U	0.441	U	2.12	J
11-DiCB		0.387	U	0.56	U	0.639	U	0.344	U	0.543	U	96.2		0.339	U	0.464	U	0.453	U	0.375	U	1.85	U
12+13-DiCB		0.388	U	0.561	U	1.24	J	1.81	J	0.542	U	12.5		3.03		2.84		0.45	U	1.43	J	13.1	
14-DiCB		0.382	U	0.552	U	0.647	U	0.34	U	0.531	U	1.83	U	0.33	U	0.451	U	0.44	U	0.364	U	1.8	U
15-DiCB		0.463	U	0.645	U	0.704	U	0.388	U	0.653	U	89.5		23.6		21.7		17.6		0.455	U	66.4	
16-TrCB		0.548	U	1.16		3.45		4.21		3.31		30.5		9.62		7.41		5.52		3.91		28.1	
17-TrCB		3.51		0.227	U	3.21		4.54		4.09		42		15.4		11.5		6.46		6.99		48.3	
18+30-TrCB		5.25		1.71	J	5.16		7.31		5.94		61.1		21.7		15.7		9.99		8.97		52.1	
19-TrCB		0.42	U	0.238	U	0.248	U	0.909	J	0.343	U	7.45		3.51		2.23		1.12		1.82		8.75	
20+28-TrCB		0.301	U	0.158	U	0.195	U	32.5		25.9		289		74.7		66.1		50.9		0.233	U	210	
21+33-TrCB		0.294	U	0.154	U	0.193	U	0.223	U	0.27	U	82.1		21.1		19.3		0.285	U	0.231	U	66.2	
22-TrCB		0.324	U	0.17	U	0.212	U	0.246	U	0.303	U	64.1		0.287	U	0.31	U	0.321	U	0.26	U	46.3	
23-TrCB		0.358	U	0.188	U	0.227	U	0.272	U	0.309	U	1.12	U	0.293	U	0.317	U	0.328	U	0.266	U	1.26	U
24-TrCB		0.314	U	0.165	U	0.203	U	0.238	U	0.286	U	1.41	J	0.478	J	0.312	U	0.468	J	0.273	J	1.24	U
25-TrCB		1.18		0.127	U	1.45		0.183	U	1.64		21		5.2		4.33		2.97		2.3		12.2	
26+29-TrCB		2.75		0.165	U	2.67		4.01		3.19		38.4		9.19		8.2		5.7		3.85		19.9	
27-TrCB		0.305	U	0.16	U	0.197	U	0.232	U	0.785	J	7.84		3.17		1.98		1.22		1.15		7.63	
31-TrCB		14.1		0.158	U	14		20.8		16.3		166		43.4		37.9		31.5		0.236	U	119	
32-TrCB		0.288	U	0.802	J	0.194	U	0.219	U	0.267	U	47.2		19		14.5		6.92		9.17		65.7	
34-TrCB		0.319	U	0.168	U	0.205	U	0.242	U	0.287	U	1.04	U	0.266	U	0.288	U	0.298	U	0.242	U	1.45	J
35-TrCB		0.533	U	0.666	J	0.579	U	1.69		1.09		2.17	U	2.22		2.27		1.79		1.46		9.52	
36-TrCB		0.496	U	0.236	U	0.512	U	0.596	U	0.567	U	3.44		0.748	U	0.606	J	0.592	J	0.467	U	2.51	U
37-TrCB		9.26		3.02		7.9		11.5		8.87		84.7		23.4		20.1		20.5		11.6		77.8	
38-TrCB		0.51	U	0.242	U	0.552	U	0.613	U	0.563	U	2	U	0.778	U	0.621	U	0.597	U	0.485	U	2.61	U
39-TrCB		0.48	U	0.228	U	0.509	U	0.577	U	0.534	U	1.89	U	0.745	U	0.594	U	0.572	U	0.465	U	2.5	U
40+71-TeCB		6.9		1.38	J	7.34		11.4		7.93		98.8		33		27.1		17		13.9		111	
41-TeCB		0.295	U	0.16	U	0.782	J	1.1		0.935		9.06		0.357	U	2.41		0.478	U	0.399	U	6.92	
42-TeCB		4.1		0.199	U	3.96		5.7		0.188	U	54.5		19.6		15		8.87		0.405	U	56.7	
43-TeCB		0.464	U	0.251	U	0.481	U	0.658	J	0.241	U	1.45	U	2.67		1.7		1.24		0.534	U	4.53	
44+47+65-TeCB		12.6		3.28		14.3		19.6		14.7		179		65		50.6		29.3		25.2		181	
45+51-TeCB		1.87	J	0.572	J	1.68	J	2.43		0.28	U	24.2		11.5		8.48		4.3		5.12		33.4	
46-TeCB		0.675	J	0.18	J	0.208	U	1.06		1.14		8.55		5.37		0.208	U	1.58		2.58		9.51	
48-TeCB		2.11		0.448	J	0.372	U	3.44		2.43		30.7		9.47		7.64		4.5		4.18		25.7	
49+69-TeCB		9		1.84		8.92		13.8		10.6		138		49.6		38		21.8		18		153	
50+53-TeCB		1.79	J	0.515	J	0.182	U	2.25		2.12		21.9		13.1		8.32		3.93		5.86		26.7	
52-TeCB		13.6		0.151	U	15.4		20.7		16.1		199		75.5		57.1		36.2		26.8		195	
54-TeCB		0.126	U	0.0569	U	0.0848	U	0.137	U	0.127	U	0.348	U	0.788	J	0.387	J	0.17	J	0.549	J	0.426	U
55-TeCB		0.515	U	0.246	U	0.867	U	0.813	U	0.467	U	3.36	U	1.75		0.827	U	0.893	U	1.3	U	2.07	U
56-TeCB		9.09		1.68		8.18		14.2		8.4		114		31.9		26.3		19.5		15.5		86	
57-TeCB		0.419	U	0.2	U	0.729	U	0.662	U	0.404	U	2.91	U	1.16	U	0.745	U	0.804	U	1.17	U	1.86	U
58-TeCB		0.403	U	0.193	U	0.714	U	0.636	U	0.385	U	2.78	U	1.14	U	0.73	U	0.788	U	1.15	U	1.83	U
59+62+75-TeCB		1.28	J	0.131	U	0.279	U	1.92	J	1.54	J	17.6		6.59		4.65		2.54	J	2.59	J	18	
60-TeCB		4.42		1.04		3.91		0.709	U	5.05		59.4		17.7		15		0.8	U	8.05		44.4	
61+70+74+76-TeCB		30.8		0.194	U	28.6		47.4		33		442		131		106		77.8		55.1		296	
63-TeCB		0.422	U	0.202	U	0.759	U	1.16		0.954		10.7		3.74		3.31		0.841	U	1.71		10.7	
64-TeCB		5.07		1.27		5.2		7.78		5.57		66.6		21.7		17.6		12.2		8.41		54.2	
66-TeCB		19.7		3.5		18.6		30.8		19.5		278		80		67.7		50.7		34.3		214	
67-TeCB		0.495	J	0.193	U	0.682	U	0.637	U	0.708	J	9.92		2.98		2.32		1.55		1.04	U	5.86	
68-TeCB		0.378	U	0.181	U	0.698	U	0.597	U	0.371	U	3.82		1.35		1.06		0.751	U	1.09	U	1.74	U
72-TeCB		0.392	U	0.188	U	0.692	U	0.619	U	0.389	U	4.89		1.63		1.31		0.762	U	1.11	U	4.94	
73-TeCB		0.238	U	0.129	U	0.289	U	0.223	U	0.131	U	0.782	U	0.242	U	0.656	J	0.386	J	0.271	U	2.08	J
77-TeCB	0.0001	2.83		0.538	J	3.25		4.36		2.83		44		12.7		11.4		8.3		7.14		42.7	
78-TeCB		0.45	U	0.215	U	0.774	U	0.71	U	0.433	U	3.12	U	1.16	U	0.742	U	0.801	U	1.17	U	1.85	U
79-TeCB		0.38	U	0.182	U	0.621	U	0.6	U	0.451	J	2.47	U	2.4		1.58		0.655	U	1.77		4.66	
80-TeCB		0.393	U	0.188	U	0.675	U	0.621	U	0.354	U	2.55	U	0.982	U	0.628	U	0.678	U	0.989	U	2.16	J
81-TeCB	0.0003	0.459	U	0.214	U	0.725	U	0.692	U	0.4	U	2.97	U	1.18	U	0.73	U	0.813	U	1.18	U	1.93	U
82-PeCB		2.73		0.389	U	3.99		4.01		3.32		53.6		17		13.7		8.32		8.4		33.7	
83-PeCB		0.466	U	0.429	J	0.345	U	1.25		0.541	U	1.15	U	8.28		4.04		5.42		3.24		16.6	
84-PeCB		5.28		0.377	U	5.86		7.52		6.98		85.6		33.3		27.1		14.5		12.5		70.7	
85+116+117-PeCB		4.46		0.833	J	6.57		7.42		5.98		73.4		26.6		23.6		14.2		11.2		72.2	
86+87+97+108+119+125-PeCB		16.1		0.293	U	17.8		23.6		18.4		267		88.3		74.9		44.6		38.9		183	
88+91-PeCB		0.445	U	0.312	U	0.334	U	4.21		3.4		49.2		22.3		15.9		9.15		8.43		51.2	
89-PeCB		0.512	U	0.359	U	0.362	U	0.43	U	0.568	U	4.74		1.39		0.456	U	0.697	U	0.32	U	1.74	U
90+101+113-PeCB		25.3		5.71		26.3		36.9		27.7		409		141		114		66.9		55.6		328	
92-PeCB		0.506	U	1.33		5.33		7.13		5.39		75		26.3		21.7		12.4		10.2		67.3	
93+100-PeCB		0.407	U	0.285	U	0.304	U	0.531	J	0.47	U	5.83		2.4		1.46	J	1.08	J	0.269	U	1.47	U
94-PeCB		0.493	U	0.345	U	0.382	U	0.413	U	0.576	U	1.23	U	0.736	U	0.821	J	0.73	U	0.335	U	1.88	J
95-PeCB		14.5		0.3	U	17.9		20.4		18.4		237		94.4		75.8		44.6		36.8		223	
96-PeCB		0.211	U	0.159	U	0.245	U	0.307	J	0.181	U	0.597	U	1.71		0.26	U	0.488	J	0.235	U	2.54	
98+102-PeCB		0.46	U	0.322	U	0.596	J	1.14	J	0.545	U	14.8		8.18		5.91		2.07		4.11		1.71	U
99-PeCB		13.1		2.45		14.9		19.2		15.4		225		88		76		40.2		35.3		246	
103-PeCB		0.404	U	0.283	U	0.305	U	0.339	U	0.476	U	5.37		2.81		2.03		0.58	U	1.45		1.45	U
104-PeCB		0.122	U	0.0927	U	0.163	U	0.108	U	0.105	U	0.327	U	0.209	U	0.148	U	0.144	U	0.128	U	0.514	U
105-PeCB	0.00003	9.84		0.28	U	11.8		15.2		11.9		187		59.1		49.2		33.6		25.4		128	
106-PeCB		0.424	U	0.297	U	1.03	U	0.319	U	0.379	U	3.31	U	0.965	U	0.531	U	0.743	U	1.28	U	1.63	U
107+124-PeCB		0.403	U	0.283	U	1.08	J	1.44	J	0.957	J	17.8		5.91		4.93		2.99		3.42		1.56	U
109-PeCB		2.13		0.216	U	2.47		3.26		2.47		42.3		13		10.1		6.82		6.31		32	
110+115-PeCB		25.3		0.25	U	25.5		35.7		27.3		447		148		117		70.1		58		289	
111-PeCB		0.365	U	0.255	U	0.253	U	0.306	U	0.403	U	0.86	U	0.482	U	0.313	U	0.478	U	1.11		1.2	U
112-PeCB		0.469	U	0.328	U	0.292	U	23.4		0.471	U	1.01	U	0.522	U	0.339	U	0.518	U	0.238	U	1.3	U
114-PeCB	0.00003	0.413	U	0.269	U	0.957	U	0.303	U	0.517	J	6.25		2.32		0.537	U	0.756	U	1.31	U	4.21	
118-PeCB	0.00003	25.4		0.279	U	30.5		37.7		28.8		509		159		130		88.8		64.9		320	
120-PeCB		0.349	U	0.244	U	0.238	U	0.292	U	0.382	U	3.72		1.54		1.27		0.66	J	1.96		3.75	
121-PeCB		0.372	U	0.261	U	0.264	U	0.312	U	0.415	U	0.887	U	0.498	U	0.323	U	0.494	U	0.227	U	1.24	U
122-PeCB		0.386	U	0.271	U	0.954	U	0.448	J	0.344	U	3.86		0.941	U	1.36		0.724	U	1.25	U	1.59	U
123-PeCB	0.00003	0.354	U	0.262	U	0.885	U	0.268	U	0.413	J	2.8	U	1.8		1.62		0.707	U	1.29		1.45	U

Sample ID / Analyte (pg/g)	HC_1 8/2/2008	Q	HC_2 8/3/2008	Q	HC_3 8/2/2008	Q	HC_6 8/2/2008	Q	NCPS_0 7/31/2008	Q	NCPS_1 7/31/2008	Q	NCPS_2 8/3/2008	Q	NCPS_3 7/31/2008	Q	NCPS_4 7/31/2008	Q	PSPS_1 8/3/2008	Q	PSPS_2 8/3/2008	Q	PSPS_3 8/3/2008	Q
1-MoCB	0.12	U	0.257	U	0.152	U	7.75		6.3		0.0525	U	5.93		0.224	U	0.111	U	3.18		0.0767	U	0.208	U
2-MoCB	0.128	U	0.283	U	0.158	U	9.94		0.148	U	0.0524	U	0.0801	U	0.253	U	0.113	U	2.71		0.106	U	0.218	U
3-MoCB	0.126	U	0.29	U	0.164	U	0.116	U	0.139	U	0.0531	U	0.084	U	0.25	U	0.103	U	0.0847	U	0.0811	U	0.194	U
4-DiCB	5.06		11.8		7.13		13		9.14		0.893		9.94		5.37		2.7		8.04		3.14		1.09	U
5-DiCB	0.46	U	2.4	U	0.423	U	2.71		2.23		0.714	U	1.1		1.3	U	0.601	U	0.641	U	0.562	U	0.537	U
6-DiCB	0.452	U	2.36	U	0.378	U	5.41		4.87		0.638	U	0.43	U	1.26	U	0.585	U	3.28		1.46	J	0.489	U
7-DiCB	0.439	U	2.29	U	0.374	U	2.04		1.69		0.632	U	1.75		1.21	U	0.563	U	1.29	J	0.505	U	0.477	U
8-DiCB	0.43	U	25.4		0.344	U	30.7		27.6		0.581	U	0.392	U	1.18	U	0.548	U	21.2		9.69		0.438	U
9-DiCB	0.441	U	2.3	U	0.382	U	0.827	U	1.26		0.645	U	0.801	J	1.22	U	0.565	U	0.988	J	0.518	U	0.489	U
10-DiCB	0.415	U	1.6	U	0.691	U	1.22	U	1.02	U	0.355	U	0.533	J	1.56	U	0.439	U	0.625	U	0.364	U	0.86	U
11-DiCB	0.46	U	2.4	U	0.394	U	64.4		0.743	U	0.666	U	0.449	U	1.24	U	0.577	U	0.58	U	0.508	U	0.492	U
12+13-DiCB	2.69		2.39	U	3.61		5.73		0.74	U	0.663	U	2.89		1.24	U	0.574	U	3.37	J	1.52	J	0.496	U
14-DiCB	0.448	U	2.34	U	0.388	U	0.84	U	0.752	U	0.655	U	0.442	U	1.26	U	0.584	U	0.604	U	0.529	U	0.484	U
15-DiCB	0.576	U	26.2		27.3		42.5		32		0.828	U	26.6		22.9		12.3		21.5		10.7		0.556	U
16-TrCB	6.8		10.1		10.4		17.1		13.3		1.45		7.7		9.09		4.64		9.61		4.61		0.511	U
17-TrCB	9.68		1.79	U	13.1		22.1		15.5		0.324	U	13.9		10.3		5.28		14.1		0.432	U	0.438	U
18+30-TrCB	14.3		20.9		18		32.8		23.5		2.64		16.2		16.7		7.89		18.3		8.55		0.381	U
19-TrCB	1.51		3.42		0.34	U	3.06		2.59		0.296	U	0.319	U	1.45		0.897	J	2.29		0.379	U	0.433	U
20+28-TrCB	52.5		84.1		83.6		141		95.7		0.222	U	75.6		64.2		34.9		80.3		35.9		0.322	U
21+33-TrCB	0.455	U	22.7		27		47.6		30.8		0.214	U	20.7		21		0.246	U	24.6		13.8		0.309	U
22-TrCB	0.513	U	1.37	U	20.9		37		22		4.1		16.2		0.763	U	0.271	U	20.5		11.8		0.355	U
23-TrCB	0.524	U	1.4	U	0.304	U	0.718	U	0.606	U	0.253	U	0.295	U	0.818	U	0.29	U	0.345	U	0.331	U	0.323	U
24-TrCB	0.546	J	1.38	U	0.273	U	0.664	J	0.541	U	0.228	U	0.265	U	4.84		0.259	U	0.317	U	0.304	U	0.318	U
25-TrCB	3.32		5.86		5.03		8.03		6.43		0.699	J	4.5		3.66		1.99		5.1		2.15		0.256	U
26+29-TrCB	6.24		7.05		9.28		15.9		11.5		1.27	J	8.35		7.86		3.94		8.75		4.06		0.317	U
27-TrCB	0.448	U	2.36	J	2.24		4.03		0.524	U	0.231	U	2.9		0.707	U	0.897	J	2.45		0.296	U	0.322	U
31-TrCB	33.2		42.1		49.9		87		55.2		0.22	U	41.8		39.2		20.5		51.9		23.6		0.324	U
32-TrCB	8.49		15.8		12.2		22.7		15.8		0.217	U	20.9		9.06		5.08		14.9		5.49		0.301	U
34-TrCB	0.476	U	1.27	U	0.274	U	0.646	U	0.545	U	0.228	U	0.383	J	0.737	U	0.261	U	0.329	U	0.315	U	0.336	U
35-TrCB	2.06		3.51		2.54		4.68		3.38		0.387	J	2.38		2.97		1.25		2.05		1.04	U	0.726	U
36-TrCB	1.07	J	1.56	U	0.921	U	1.68	J	1.06	U	0.343	U	0.6	J	1.32	U	0.512	J	1.64	U	1.01	U	0.649	U
37-TrCB	19.8		22.9		28.3		52.8		30.6		4.64		28.2		21		12.8		26.1		13.8		0.69	U
38-TrCB	0.742	U	1.62	U	0.996	U	1.19	U	1.14	U	0.371	U	0.643	U	1.42	U	0.55	U	1.66	U	1.03	U	0.696	U
39-TrCB	0.711	U	1.55	U	0.929	U	1.11	J	1.05	U	0.346	U	0.599	U	1.31	U	0.506	U	1.66	U	1.03	U	0.642	U
40+71-TeCB	17.7		30.3		27.2		56.5		36		0.79	U	34.6		22.3		13.5		25.2		11.7		0.416	U
41-TeCB	2.11		2.34	J	1.93	U	8.76		1.01	U	0.801	U	2.58		1.28	U	1.27		0.411	U	0.18	U	0.486	U
42-TeCB	9.76		21.4		14.3		32.2		20.4		0.831	U	19		11.8		6.84		15.2		6.56		0.428	U
43-TeCB	1.42		1.81	U	2.29	U	3.51		1.3	U	0.948	U	1.72	U	1.66	U	0.335	U	2.35		0.247	U	0.505	U
44+47+65-TeCB	34.8		75.2		51.5		104		63.3		4.5		65.1		41.3		22.6		57.2		25.4		10.8	
45+51-TeCB	4.81		10.7		0.856	U	16.9		0.487	U	0.892	U	13		0.725	U	3		0.409	U	3.57		1.94	J
46-TeCB	1.8		4.04		2.69		6.24		0.537	U	0.988	U	1.44	U	0.8	U	0.265	U	3		0.338	U	0.51	U
48-TeCB	5.62		9.53		9.5		20.1		10.3		0.82	U	10.2		6.12		3.99		8.88		4.1		1.57	J
49+69-TeCB	23.8		58.2		35.7		70.4		45.4		0.642	U	47.9		28		15.8		44.5		17.3		5.89	
50+53-TeCB	0.642	U	12.1		0.847	U	1.47	U	8.79		0.882	U	11.1		5.56		3.52		8.31		3.08	J	0.442	U
52-TeCB	37.7		108		58.8		103		67.4		0.695	U	63.5		45.7		23.7		62.7		28.8		13.1	
54-TeCB	0.253	U	0.246	U	0.342	U	0.569	U	0.405	J	0.346	U	0.468	U	0.284	U	0.227	J	0.188	U	0.147	U	0.23	U
55-TeCB	0.644	U	1.28	U	1.02	U	2.53		1.88	U	1.05	U	1	U	1.16	U	0.591	U	0.652	U	0.4	U	0.613	U
56-TeCB	19.4		21.8		28.6		59.6		1.57	U	0.922	U	34.1		23.7		11.5		28.1		13.2		6.33	
57-TeCB	0.579	U	1.15	U	0.925	U	2.09	U	1.58	U	0.95	U	0.909	U	0.975	U	0.497	U	0.594	U	0.365	U	0.562	U
58-TeCB	0.568	U	1.13	U	0.905	U	2.04	U	1.55	U	0.929	U	0.889	U	0.955	U	0.486	U	3.3		0.351	U	0.563	U
59+62+75-TeCB	3.2	J	7.17	J	4.99		10.2		6.15		0.593	U	6.41		3.63		2.16	J	5.51	J	2.61	J	0.327	U
60-TeCB	11.7		11.8		17.7		2.05	U	19.9		0.931	U	17.5		13.2		6.82		16.8		7.51		0.564	U
61+70+74+76-TeCB	73.9		96.8		111		205		131		0.875	U	125		89.9		44.5		94.6		46.5		22.4	
63-TeCB	0.606	U	3.72		3.63		6.7		3.58		0.989	U	3.66		1.02	U	0.518	U	2.82		1.29	J	0.543	U
64-TeCB	13.3		28.5		19.4		40.4		23.9		1.7		23		14.8		8.44		21.7		9.19		4.08	
66-TeCB	44.1		52.2		65.2		126		83.4		0.828	U	79.9		54.4		27.3		66.1		29.7		13.3	
67-TeCB	1.58		1.02	U	0.881	U	5.84		2.87		0.905	U	0.865	U	1.96		1.01		0.536	U	0.329	U	0.483	U
68-TeCB	0.541	U	1.85	J	0.897	U	2.08		1.51	U	0.921	U	1.09		0.934	U	0.476	U	1.03	J	0.354	U	0.532	U
72-TeCB	0.955	J	1.85	J	0.874	U	1.97	U	1.64		0.897	U	0.858	U	0.926	U	0.472	U	0.572	U	0.351	U	0.522	U
73-TeCB	0.262	U	1.44	J	1.48	U	1.47	U	0.781	U	0.615	U	1.12	U	0.994	U	0.201	U	0.31	U	0.136	U	0.32	U
77-TeCB	7.1		1.29	U	10.5		20		15.6		1.12	U	15		9.32		4.93		12.2		4.31		0.645	U
78-TeCB	0.577	U	1.15	U	0.941	U	2.13	U	1.68	U	0.967	U	0.925	U	1.04	U	0.527	U	0.618	U	0.379	U	0.606	U
79-TeCB	0.697	J	0.939	U	0.75	U	1.69	U	1.35	U	0.77	U	1.64		0.831	U	0.424	U	0.5	U	0.306	U	0.487	U
80-TeCB	0.489	U	0.973	U	0.749	U	1.69	U	1.46	U	0.769	U	0.735	U	0.903	U	0.46	U	0.565	U	0.346	U	0.507	U
81-TeCB	0.614	U	1.17	U	0.955	U	2.21	U	1.85	U	1	U	0.985	U	1.07	U	0.585	U	0.67	U	0.405	U	0.656	U
82-PeCB	6.76		10.8		10.8		18.9		13.9		1.05		19.9		9.73		5.51		17.3		7.02		2.29	
83-PeCB	2.54		6.9		5.06		0.728	U	5.65		0.435	J	8.97		1.19	U	1.93		0.261	U	0.315	U	0.472	U
84-PeCB	12.4		27.5		20.9		35.7		24.8		2.66		38.5		16.8		9.53		24.8		13.1		4.67	
85+116+117-PeCB	11.6		24		17.1		30.3		20.8		1.39	J	30.9		16.9		7.5		27.4		11.7		3.71	
86+87+97+108+119+125-PeCB	36.7		63		56.7		90.2		72.1		0.241	U	99.4		50.9		29		83.9		37.5		14.1	
88+91-PeCB	8.03		19.3		11.7		21.2		15.3		1.23	J	24.6		10		5.93		15.3		6.48		2.69	J
89-PeCB	1.1	U	1.56	U	0.933	J	1.98		0.873	U	0.308	U	0.547	U	1.25	U	0.433	U	0.284	U	0.343	U	0.582	U
90+101+113-PeCB	56.4		139		89.7		146		114		8.08		153		78.5		42.2		138		58.5		21.7	
92-PeCB	10.4		28.3		16.3		27.3		21.8		0.291	U	29.5		14.5		8.21		27.1		10.8		3.33	
93+100-PeCB	0.93	U	1.9	J	0.592	U	0.676	U	0.734	U	0.265	U	2.24		1.05	U	0.364	U	0.242	U	0.292	U	0.493	U
94-PeCB	1.16	U	1.63	U	0.712	U	1.28	J	0.921	U	0.319	U	0.567	U	1.32	U	0.457	U	0.292	U	0.352	U	0.564	U
95-PeCB	35.1		110		59.3		91.2		66.6		0.275	U	103		49.3		26.9		67.5		33.3		12.8	
96-PeCB	0.307	U	1.38	J	0.264	U	0.331	U	0.75	J	0.151	U	0.183	U	0.683	U	0.208	U	0.954	J	0.213	U	0.376	U
98+102-PeCB	2.06	J	1.52	U	2.98		5.41		0.857	U	0.376	J	7.87		1.22	U	1.99		0.269	U	0.324	U	0.539	U
99-PeCB	35.2		92.4		46.7		83.8		64.3		3.93		85.9		43.9		23		76.8		29.8		10.8	
103-PeCB	0.919	U	1.3	U	0.569	U	2.46		1.89		0.255	U	3.44		1.05	U	0.64	J	0.234	U	0.283	U	0.476	U
104-PeCB	0.166	U	0.507	U	0.141	U	0.172	U	0.227	U	0.0779	U	0.0912	U	0.384	U	0.115	U	0.161	U	0.163	U	0.258	U
105-PeCB	25.3		29		40.8		68.7		53.1		0.802	U	66.3		33		18.2		52.7		18.5		7.8	
106-PeCB	0.572	U	1.15	U	1.46	U	1.45	U	1.2	U	0.685	U	1.43	U	0.93	U	0.297	U	0.669	U	0.509	U	0.383	U
107+124-PeCB	2.47		1.1	U	3.33		5.28		4.5		0.685	U	6.13		0.809	U	1.65	J	5.46		2.42	J	0.371	U
109-PeCB	4.96		10		7.89		13		10.3		0.552	U	14.2		7.17		0.212	U	11.1		0.375	U	1.58	J
110+115-PeCB	57.3		112		87.4		145		116		0.203	U	162		78.5		42.5		142		61.8		21.2	
111-PeCB	0.758	U	1.07	U	0.497	U	0.568	U	0.61	U	0.223	U	0.395	U	0.872	U	0.302	U	0.2	U	0.241	U	0.43	U
112-PeCB	0.821	U	1.16	U	0.553	U	0.632	U	0.703	U	0.248	U	0.44	U	1	U	0.349	U	0.227	U	0.274	U	0.468	U
114-PeCB	0.596	U	1.19	U	1.86		2.3		1.99		0.775	U	2.52		0.865	U	0.291	U	0.638	U	0.493	U	0.458	U
118-PeCB	61.9		92.1		98.9		165		132		7.85		174		87.5		46.8		128		48.1		20.2	
120-PeCB	0.741	J	1.03	U	0.452	U	1.45	J	0.574	U	0.203	U	1.78		0.82	U	0.285	U	1.4	J	0.235	U	0.404	U
121-PeCB	0.783	U	1.1	U	0.481	U	0.55	U	0.637	U	0.216	U	0.383	U	0.91	U	0.316	U	0.201	U	0.243	U	0.412	U
122-PeCB	0.628	J	1.12	U	1.42	U	1.41	U	1.11	U	0.665	U	1.39	U	0.858	U	0.274	U	1.3	J	0.469	U	0.384	U
123-PeCB	0.516	U	1.09	U	1.54	U	1.7	J	1.04	U	0.717	U	1.83		0.777	U	0.251	U	2.25		0.428	U	0.404	U

Table A-12e. US EPA/USACE "Bold Study" Analytical Data-PCB Congeners

Sample ID		AI_1		AI_11_C		AI_13_C		AI_20_C_GS		AI_5_C		CPS_0		CPS_1		CPS_3	
Analyte (pg/g)	TEF	7/31/2008	Q	8/1/2008	Q	8/3/2008	Q	8/1/2008	Q	8/1/2008	Q	8/4/2008	Q	8/4/2008	Q	7/31/2008	Q
126-PeCB	0.1	0.492	U	0.312	U	1.13	U	0.353	U	0.417	U	3.8	U	1.13	U	0.664	U
127-PeCB		0.401	U	0.281	U	0.918	U	0.302	U	0.335	U	2.93	U	0.905	U	0.498	U
128+166-HxCB		5.31		0.224	U	6.81		7.2		6.09		114		37.8		30.2	
129+138+163-HxCB		29.2		5.34		39.9		44.4		35		652		209		169	
130-HxCB		2.45		0.368	J	2.71		3.51		0.62	U	48.8		15.9		12.6	
131-HxCB		0.461	U	0.231	U	1.12	U	0.373	U	0.509	U	4.95	U	1.73		1.83	
132-HxCB		8.37		2.01		11.2		11.5		0.587	U	184		57.5		49.7	
133-HxCB		0.505	U	0.253	U	1.32	U	0.409	U	0.576	U	11.4		4.65		3.05	
134-HxCB		1.05		0.259	J	1.37		1.57		1.08		21.4		7.06		6.58	
135+151-HxCB		8.51		1.99		0.582	U	12.2		11		179		60.7		50.2	
136-HxCB		3.15		0.828	J	3.92		4.03		3.68		58.9		20.2		17.7	
137-HxCB		1.38		0.221	U	1.56		1.98		0.488	U	28.3		7.51		7.07	
139+140-HxCB		0.452	U	0.226	U	1.13	U	0.687	J	0.516	U	11.3		3.71		2.74	
141-HxCB		2.82		0.294	U	4.12		4.8		3.49		45.7		17.5		13.9	
142-HxCB		0.57	U	0.286	U	1.4	U	0.462	U	0.68	U	6.62	U	1.71	U	1.61	U
143-HxCB		0.575	U	0.288	U	1.41	U	0.466	U	0.694	U	29.4		1.82	U	1.71	U
144-HxCB		0.433	U	0.226	U	1.49		1.7		1.36		22.1		6.75		5.96	
145-HxCB		0.338	U	0.176	U	0.467	U	0.251	U	0.435	U	0.526	U	0.468	U	0.521	U
146-HxCB		4.79		0.809	J	6.13		6.86		5.32		93.3		33.1		26.4	
147+149-HxCB		22.7		4.54		26.9		31.8		24.3		437		152		124	
148-HxCB		0.451	U	0.235	U	0.615	U	0.335	U	0.561	U	0.679	U	0.599	U	0.781	J
150-HxCB		0.348	U	0.181	U	0.477	U	0.259	U	0.445	U	0.582	J	0.464	U	0.517	U
152-HxCB		0.315	U	0.164	U	0.42	U	0.234	U	0.391	U	0.473	U	0.419	U	0.467	U
153+168-HxCB		27.3		4.46		38		41.2		34		618		204		161	
154-HxCB		0.669	J	0.198	U	0.524	U	0.887	J	0.771	J	13.2		5.62		0.584	U
155-HxCB		0.24	U	0.0952	U	0.407	U	0.219	U	0.321	U	0.323	U	0.251	U	0.421	U
156+157-HxCB	0.00003	3.14		0.285	U	3.78		4.42		3.46		70.6		21.4		18.4	
158-HxCB		2.39		0.181	U	3.28		3.6		2.81		56.5		17.5		14.1	
159-HxCB		0.484	U	0.229	U	0.692	U	0.313	U	0.348	U	1.66	U	1.52		1.24	U
160-HxCB		0.458	U	0.23	U	1.08	U	0.371	U	0.512	U	4.98	U	1.29	U	1.22	U
161-HxCB		0.422	U	0.211	U	1.06	U	0.342	U	0.48	U	4.68	U	1.24	U	1.16	U
162-HxCB		0.514	U	0.243	U	0.731	U	0.333	U	0.36	U	1.71	U	1.75		1.7	
164-HxCB		1.59		0.211	U	1.02	U	1.96		2.11		31.3		12.2		8.91	
165-HxCB		0.4	U	0.2	U	0.998	U	0.324	U	0.453	U	4.41	U	1.18	U	1.11	U
167-HxCB	0.00003	0.521	U	0.252	U	0.673	U	1.57		1.36		27.6		9.64		7.38	
169-HxCB	0.03	0.528	U	0.248	U	0.648	U	0.302	U	0.353	U	1.74	U	1.02	U	1.19	U
170-HpCB		6.86		0.749	U	8.35		9.64		7.14		136		42.3		35.5	
171+173-HpCB		1.29	U	0.676	U	3.21		3.35		0.709	U	56.8		17.6		13.7	
172-HpCB		1.38	U	0.725	U	1.37		1.88		1.36		21.8		8.18		6.74	
174-HpCB		6.86		0.966		8.51		8.73		7.18		152		46		36.7	
175-HpCB		0.479	U	0.35	U	0.494	U	0.58	J	0.412	U	1.24	U	2.64		2.23	
176-HpCB		0.893	J	0.278	U	0.393	U	1.58		1.12		22.7		7.5		0.449	U
177-HpCB		1.33	U	0.7	U	7.08		8.04		6.44		122		38.1		31	
178-HpCB		2.42		0.382	U	0.528	U	3.09		2.38		50.6		18.7		13.1	
179-HpCB		3.37		0.266	U	4.21		4.54		3.52		70.5		24.4		20	
180+193-HpCB		11.9		0.507	U	14.2		16.6		12.5		221		78.3		60.1	
181-HpCB		1.12	U	0.587	U	0.478	U	0.436	U	0.606	U	2.35	U	1.32	U	1.13	U
182-HpCB		0.497	U	0.363	U	0.501	U	0.396	U	0.424	U	1.28	U	0.644	U	0.572	U
183+185-HpCB		4.11		0.83	J	5.88		6.93		5.55		107		36		27.4	
184-HpCB		0.352	U	0.257	U	0.382	U	0.28	U	0.312	U	0.944	U	0.489	U	0.434	U
186-HpCB		0.393	U	0.287	U	0.407	U	0.313	U	0.34	U	1.03	U	0.527	U	0.468	U
187-HpCB		11.4		1.35		15		16.1		13.2		248		85.5		66.8	
188-HpCB		0.33	U	0.244	U	0.348	U	0.25	U	0.297	U	0.921	U	0.463	J	0.363	U
189-HpCB	0.00003	1.12	U	0.247	U	0.743	U	0.39	U	0.438	U	3.75	U	2.39	U	1.06	U
190-HpCB		1.05	U	0.554	U	1.62		1.86		1.3		28.5		8.46		6.52	
191-HpCB		1.02	U	0.538	U	0.391	U	0.4	U	0.532	U	2.06	U	1.94		1.39	
192-HpCB		1.12	U	0.587	U	0.445	U	0.437	U	0.572	U	2.22	U	1.25	U	1.07	U
194-OcCB		3.5		0.876	U	1.3	U	4.48		3.56		74.2		29		21.3	
195-OcCB		1.47		0.909	U	1.39	U	2.05		0.632	U	36.6		11.6		8.71	
196-OcCB		1.7		0.51	U	0.714	U	3.01		2.21		56.5		19		0.808	U
197+200-OcCB		0.664	J	0.378	U	0.575	U	0.829	J	0.795	J	18.2		6.65		4.11	
198+199-OcCB		4.99		0.526	U	7.11		8.17		5.62		147		50.2		34.3	
201-OcCB		0.493	U	0.392	U	1.13		1.1		0.354	U	19.1		7.11		4.81	
202-OcCB		1.24		0.362	U	1.84		2.03		1.54		33.1		12.8		8.23	
203-OcCB		3.04		0.514	U	3.64		0.511	U	2.8		62.9		21.3		16	
204-OcCB		0.481	U	0.383	U	0.558	U	0.381	U	0.351	U	3.03	U	1.91	U	0.614	U
205-OcCB		0.428	U	0.818	U	1.15	U	0.551	U	0.531	U	2.57	U	2.77		1.28	
206-NoCB		2.92		0.546	U	3.83		4.04		2.91		95		38.8		20.6	
207-NoCB		0.674	U	0.432	U	0.545	U	0.471	U	0.5	U	11.8		5.2		3.05	
208-NoCB		1.19		0.415	U	1.53		1.62		0.486	U	35.4		14.4		7.86	
209-DeCB		3.71		0.393	U	4.33		4.31		3.56		119		59.4		26	
Total PCBs (0 DL)		505.3		58.1		575.8		843.6		615.5		10569.2		3447.9		2736.1	
TEQ WHO-05 (1 DL)		0.067		0.039		0.134		0.047		0.054		0.462		0.153		0.110	
TEQ WHO-05 (1/2 DL)		0.034		0.019		0.068		0.025		0.028		0.245		0.081		0.059	
TEQ WHO-05 (0 DL)		0.001		0.000		0.002		0.002		0.002		0.028		0.009		0.007	

Sample ID	CPS_4		CPS_5		HC_0		HC_1		HC_2		HC_3		HC_6		NCPS_0	
Analyte (pg/g)	8/4/2008	Q	7/31/2008	Q	8/3/2008	Q	8/2/2008	Q	8/3/2008	Q	8/2/2008	Q	8/2/2008	Q	7/31/2008	Q
126-PeCB	0.943	U	1.63		2.07	U	0.702	U	1.38	U	2.13	U	2.04	U	1.44	U
127-PeCB	0.697	U	1.2	U	1.53	U	0.536	U	1.08	U	1.33	U	1.32	U	1.06	U
128+166-HxCB	19.8		16		67.8		12.4		18.2		17.2		31.2		29.7	
129+138+163-HxCB	114		86.4		404		68.9		122		105		179		160	
130-HxCB	8.34		8.4		31.3		5.13		8.87		7.95		13.4		11.6	
131-HxCB	1.43	U	1.74	U	3.53	U	0.861	U	1.66	U	1.6	U	1.96		2.29	U
132-HxCB	29		25		102		17.9		28.4		35.5	U	47.4		44.5	
133-HxCB	2.03		2.57		3.89	U	0.949	U	2.65		2.6		4.18		3.72	
134-HxCB	3.23		3.33		15.3		2.38		4.64		3.99		6.7		2.37	U
135+151-HxCB	31.1		25.3		131		20.4		41.5		31.6		56.5		44.3	
136-HxCB	10.5		9.65		46.6		0.418	U	1.76	U	11		19.4		14.8	
137-HxCB	6.38		4.79		10.2		3.14		1.57	U	4.5		0.966	U	8.65	
139+140-HxCB	1.41	U	4.2		3.47	U	0.847	U	1.63	U	1.9	J	2.96	J	2.3	U
141-HxCB	11.1		9.16		22.7		5.27		1.99	U	11.9		15.1		12.6	
142-HxCB	1.78	U	2.16	U	4.38	U	1.07	U	2.06	U	1.96	U	1.28	U	2.86	U
143-HxCB	4.48		2.3	U	4.65	U	1.14	U	2.19	U	1.88	U	1.22	U	2.87	U
144-HxCB	4.23		4.73		12.6		2.54		3.4		3.29		6.51		6.37	
145-HxCB	0.424	U	0.412	U	1.53	U	0.44	U	1.86	U	0.772	U	0.481	U	0.662	U
146-HxCB	16.9		15.4		70.8		11.3		23.6		16.2		31.9		25.2	
147+149-HxCB	76		58.4		303		47.5		94.4		72.9		129		112	
148-HxCB	0.542	U	1.62		1.95	U	0.562	U	2.37	U	1.02	U	0.633	U	0.872	U
150-HxCB	0.42	U	1.62		1.52	U	0.436	U	1.84	U	0.795	U	0.495	U	0.676	U
152-HxCB	0.379	U	0.369	U	1.37	U	0.394	U	1.66	U	0.718	U	0.447	U	0.595	U
153+168-HxCB	108		80.4		415		65.7		136		96.4		170		154	
154-HxCB	2.15		3.31		11.6		0.493	U	3.59		2.03		3.96		0.743	U
155-HxCB	0.202	U	0.21	U	1.19	U	0.284	U	1.17	U	0.457	U	0.267	U	0.379	U
156+157-HxCB	11.8		12.9		33.5		7.22		11.2		13		18.4		16.4	
158-HxCB	9.17		8.85		27.7		5.38		8.43		9.15		13.8		13.8	
159-HxCB	0.721	U	1.4		2.84	U	0.629	U	1.46	U	1.33	U	1.17	U	1.01	U
160-HxCB	1.34	U	1.64	U	3.31	U	0.809	U	1.56	U	1.42	U	0.923	U	2.21	U
161-HxCB	1.29	U	1.57	U	3.17	U	0.774	U	1.49	U	1.37	U	0.895	U	2.16	U
162-HxCB	0.761	U	0.928	U	3	U	0.664	U	1.54	U	1.41	U	1.24	U	2.1	
164-HxCB	5.17		4.82		22.4		3.26		6.1		5.96		9.94		8.35	
165-HxCB	1.22	U	1.49	U	3.01	U	0.736	U	1.42	U	1.33	U	0.868	U	2.04	U
167-HxCB	5.4		5.5		15.5		2.76		4.62		4.62		7.92		6.96	
169-HxCB	0.793	U	0.92	U	2.74	U	0.637	U	1.43	U	1.34	U	1.24	U	1.11	U
170-HpCB	22.5		19.1		55.9		13		19.5		18.6		30.9		30.5	
171+173-HpCB	8.67		9.39		27		5.05		6.72		6.63		13.2		13.2	
172-HpCB	3.21		5.55		3.75	U	2.64		6.15		3.6		6.61		5.15	
174-HpCB	22.4		18.9		59.5		11.8		20.3		18.6		34.7		34.3	
175-HpCB	0.65	U	3.66		2.17	U	0.602	J	1.68	U	1.3	J	2.24		0.995	U
176-HpCB	3.62		0.423	U	11.6		1.86		3.37		2.72		5.08		5.12	
177-HpCB	21.2		15.2		70.3		11.3		18.9		15.4		29.3		26.9	
178-HpCB	10.6		6.48		34.2		4.96		9.9		6.66		14.3		11.7	
179-HpCB	13		9.77		45.3		6.4		12		9.36		19.1		18.2	
180+193-HpCB	40.6		34.6		98.8		21.9		43.5		32.4		53.9		52.7	
181-HpCB	1.13	U	1.09	U	3.04	U	0.631	U	2.01	U	2.06	U	3.33	U	2.38	U
182-HpCB	0.657	U	1.19		2.19	U	0.598	U	1.7	U	0.599	U	0.786	U	1.01	U
183+185-HpCB	19.5		17.1		52.2		9.92		13.2		12.2		23.7		23.2	
184-HpCB	0.499	U	2.37		1.67	U	0.454	U	1.29	U	0.451	U	0.593	U	0.771	U
186-HpCB	0.538	U	0.44	U	1.79	U	0.49	U	1.39	U	0.481	U	0.632	U	0.819	U
187-HpCB	46.3		32		165		23.1		50.2		33.7		65		59.9	
188-HpCB	0.435	U	0.359	U	1.41	U	0.408	U	1.13	U	0.417	U	0.542	U	0.67	U
189-HpCB	1.66	U	2.15		6.26	U	0.867	U	1.68	U	1.89	U	1.89	U	3.44	U
190-HpCB	4.82		3.76		10.7		2.43		3.9		3.63		5.96		2.11	U
191-HpCB	0.945	U	0.914	U	2.54	U	0.528	U	1.69	U	1.65	U	2.66	U	1.95	U
192-HpCB	1.07	U	1.03	U	2.88	U	0.597	U	1.91	U	1.83	U	2.95	U	2.22	U
194-OcCB	15.1		11.2		32		6.86		15.7		2.57	U	18		15.8	
195-OcCB	5.9		4.72		16.2		2.88		4.63		4.47		8.19		6.68	
196-OcCB	8.32		9.58		25		4.04		1.96	U	5.47		11.7		2.2	U
197+200-OcCB	2.83		5.01		8.22		1.55	J	2.89	J	2.27	J	0.671	U	1.78	U
198+199-OcCB	26.8		17.8		70.9		10.9		26.6		15.5		31.1		28.7	
201-OcCB	3.41		5.23		9.78		1.57		3.99		2.24		3.85		4.63	
202-OcCB	6.99		4.28		19.7		2.89		7.17		4.16		0.657	U	6.86	
203-OcCB	12		8.02		33.5		5.16		1.97	U	7.72		0.818	U	2.27	U
204-OcCB	1.3	U	0.522	U	1.67	U	0.558	U	1.49	U	0.492	U	0.659	U	1.72	U
205-OcCB	1.52		1.34	U	6.16	U	0.701	U	3.33	U	2.52	U	1.51	U	3.86	U
206-NoCB	19.2		10.4		42.5		6.51		25.6		8.47		21.8		16.8	
207-NoCB	2.37		2.35		7.53		0.704	J	3.98		0.474	U	2.98		2.35	
208-NoCB	6.62		0.549	U	17.7		2.35		9.18		3.46		8.02		5.63	
209-DeCB	26.8		11.6		47.9		6.73		26.3		9.47		31.7		22.8	
Total PCBs (0 DL)	1769.6		1349.6		7376.7		1301.5		2482.0		2008.8		3752.1		2757.4	
TEQ WHO-05 (1 DL)	0.123		0.195		0.309		0.093		0.186		0.259		0.252		0.186	
TEQ WHO-05 (1/2 DL)	0.064		0.181		0.164		0.048		0.095		0.133		0.131		0.097	
TEQ WHO-05 (0 DL)	0.005		0.167		0.019		0.004		0.004		0.006		0.010		0.008	

Sample ID	NCPS_1		NCPS_2		NCPS_3		NCPS_4		PSPS_1		PSPS_2		PSPS_3	
Analyte (pg/g)	7/31/2008	Q	8/3/2008	Q	7/31/2008	Q	7/31/2008	Q	8/3/2008	Q	8/3/2008	Q	8/3/2008	Q
126-PeCB	0.957	U	2	U	1.06	U	0.359	U	0.724	U	0.557	U	0.503	U
127-PeCB	0.624	U	1.3	U	0.826	U	0.263	U	0.597	U	0.454	U	0.373	U
128+166-HxCB	1.45	J	41		18.8		10.5		33.5		13		4.05	
129+138+163-HxCB	9.3		242		111		61.3		196		74.5		27.7	
130-HxCB	0.638	J	16.9		8.61		0.462	U	14.5		5.83		2.16	U
131-HxCB	0.543	U	2.2		1.91	U	0.389	U	1.11	U	0.685	U	1.81	U
132-HxCB	2.87		73.8		30.2		17.5		60.8		24.5		8.43	
133-HxCB	0.589	U	4.93		2.24	U	1.28		4.03		0.761	U	2	U
134-HxCB	0.522	U	8.94		3.77		2.33		6.39		2.96		1.79	U
135+151-HxCB	3.4		79		31.8		16.8		60.7		23.7		10.3	
136-HxCB	1.07		27.7		0.774	U	6.08		20		8.25		0.392	U
137-HxCB	0.662	J	10.2		1.79	U	0.365	U	8.26		0.647	U	1.83	U
139+140-HxCB	0.518	U	4.63		2	J	0.39	U	4.02		1.25	J	1.82	U
141-HxCB	0.919		16.8		8.7		6.96		17.4		8.47		2.05	U
142-HxCB	0.664	U	1.25	U	2.38	U	0.486	U	1.42	U	0.876	U	2.15	U
143-HxCB	0.635	U	1.19	U	2.39	U	0.487	U	1.52	U	0.938	U	2.13	U
144-HxCB	0.446	J	10		1	U	2.26		7.75		3.17		1.48	J
145-HxCB	0.281	U	0.525	U	0.805	U	0.495	U	0.258	U	0.243	U	0.419	U
146-HxCB	1.4		39.5		19.1		9.33		32		11.7		4.39	
147+149-HxCB	7.22		184		79.7		41.9		148		55.5		17.7	
148-HxCB	0.37	U	0.69	U	1.06	U	0.652	U	0.331	U	0.312	U	0.555	U
150-HxCB	0.29	U	0.54	U	0.822	U	0.506	U	0.26	U	0.245	U	0.403	U
152-HxCB	0.262	U	0.488	U	0.723	U	0.445	U	0.246	U	0.233	U	0.381	U
153+168-HxCB	8.84		235		105		56		199		71		26.6	
154-HxCB	0.306	U	6.86		2.45		0.556	U	0.297	U	0.28	U	0.464	U
155-HxCB	0.131	U	0.264	U	0.456	U	0.292	U	0.18	U	0.177	U	0.252	U
156+157-HxCB	0.947	J	24.5		10.8		6.85		18		6.98		2.67	J
158-HxCB	0.39	U	21.4		9.46		5.46		16.7		6.62		2.53	
159-HxCB	0.543	U	0.481	U	2.97	U	0.62	J	1.49	J	0.944	U	0.364	U
160-HxCB	0.48	U	0.901	U	1.84	U	0.375	U	1.1	U	0.677	U	1.76	U
161-HxCB	0.465	U	0.873	U	1.8	U	0.367	U	1.01	U	0.625	U	1.57	U
162-HxCB	0.577	U	0.511	U	3.14	U	0.574	U	0.787	U	0.937	U	0.373	U
164-HxCB	0.477	J	0.883	U	4.46		3.61		11.7		0.666	U	1.53	U
165-HxCB	0.451	U	0.847	U	1.7	U	0.346	U	1	U	0.617	U	1.6	U
167-HxCB	0.602	U	10.3		4.33		2.57		7.25		3.04		0.441	UJ
169-HxCB	0.606	U	0.525	U	3.12	U	0.59	U	0.769	U	0.906	U	0.395	U
170-HpCB	1.88	U	47.2		20.2		12		32.6		14.7		0.585	U
171+173-HpCB	1.97	U	19.3		8.88		4.54		14.5		6.44		0.629	U
172-HpCB	2.05	U	8.09		3.75		0.615	U	0.767	U	0.539	U	0.62	U
174-HpCB	2.07	U	54.5		19.6		12.3		38.7		17.8		0.642	U
175-HpCB	0.309	U	3.3		1.15	U	0.384	U	0.483	U	0.378	U	0.67	U
176-HpCB	0.297	J	8.97		3.94		0.305	U	5.88		2.65		0.693	J
177-HpCB	2	U	44.3		20.8		10.1		32.7		12.9		0.63	U
178-HpCB	0.744	J	20		8.47		4.31		14.5		5.53		1.66	J
179-HpCB	0.249	U	30.5		12.6		6.45		23.7		8.43		3.21	
180+193-HpCB	3.24		85		35.2		20.4		52.6		24.4		6.59	
181-HpCB	1.78	U	1.12	U	1.31	U	0.544	U	0.694	U	0.488	U	0.587	U
182-HpCB	0.317	U	0.549	J	1.17	U	0.39	U	0.495	U	0.388	U	0.66	U
183+185-HpCB	1.71	U	43.4		18.6		9.03		31.8		14.9		0.561	U
184-HpCB	0.239	U	0.328	U	0.889	U	0.298	U	0.363	U	0.284	U	0.497	U
186-HpCB	0.255	U	0.351	U	0.945	U	0.316	U	0.4	U	0.313	U	0.527	U
187-HpCB	3.2		96.8		42.8		21.4		77.3		29.1		10.4	
188-HpCB	0.207	U	0.284	U	0.765	U	0.257	U	0.363	U	0.283	U	0.44	U
189-HpCB	1.19	U	1.66		1.47	U	0.843	U	1.07	U	0.276	U	0.632	U
190-HpCB	1.44	U	8.56		4.08		0.481	U	7.31		0.407	U	1.05	J
191-HpCB	1.43	U	2.17		1.07	U	0.445	U	0.552	U	0.388	U	0.452	U
192-HpCB	1.58	U	0.993	U	1.22	U	0.506	U	0.612	U	0.43	U	0.505	U
194-OcCB	1.07	U	26.2		10.4		6.8		15.6		1.41	U	0.784	U
195-OcCB	1.17	U	11.9		3.55	U	2.81		8.37		4.16		1	J
196-OcCB	0.642	J	18.6		6.92		3.25		12.7		5.21		0.655	U
197+200-OcCB	0.265	U	6.54		1.35	U	0.439	U	4.64		1.83	J	0.74	J
198+199-OcCB	1.34	J	45.1		21.6		10.3		35.5		14.9		0.693	U
201-OcCB	0.265	U	6.87		3.42		1.53		5.23		1.85		0.56	U
202-OcCB	0.307	J	11.5		1.33	U	2.63		9.48		3.62		0.522	U
203-OcCB	0.624	J	21.7		1.72	U	5.1		17.3		8.54		2.06	
204-OcCB	0.261	U	0.401	U	1.31	U	0.426	U	0.398	U	0.443	U	0.574	U
205-OcCB	1.12	U	2.36	U	2.89	U	0.684	U	4.15	U	1.14	U	0.679	U
206-NoCB	1.09		27.7		11.8		5.5		21.4		8.85		2.11	
207-NoCB	0.594	U	3.86		1.82	U	0.895	J	0.597	U	0.43	U	0.694	U
208-NoCB	0.566	U	10.3		4.16		1.97		7.57		2.9		1.13	J
209-DeCB	1.01		31		10.8		6.1		23.7		8.55		2.53	
Total PCBs (0 DL)	101.4		3675.3		1826.2		986.9		3009.8		1221.8		345.3	
TEQ WHO-05 (1 DL)	0.115		0.226		0.205		0.057		0.103		0.086		0.063	
TEQ WHO-05 (1/2 DL)	0.057		0.118		0.105		0.030		0.055		0.044		0.032	
TEQ WHO-05 (0 DL)	0.000		0.010		0.005		0.003		0.007		0.003		0.001	

Notes:

mg/kg = milligrams per kilogram

ug/kg = micrograms per kilogram

pg/g = picogram per gram

U = Result should be considered not-detected at the quantitation limit shown

J = Result is an estimated concentration

R = Rejected - Quality Control indicates the data is not usable

UJ = The compound was not detected and the sample detection limit should be considered an estimated value

TEF = Toxicity Equivancy Factor

Table A-12e. US EPA/USACE "Bold Study" Analytical Data-PCB Congeners

Sample ID	PSPS_8		PSPS_9		R_CAR_0		R_CAR_1		R_CAR_4		R_CAR_5		R_CAR_6_C		R_DAB_0		R_DAB_1		R_DAB_2	
Analyte (pg/g)	8/3/2008	Q	8/3/2008	Q	8/4/2008	Q	8/4/2008	Q	8/4/2008	Q	8/4/2008	Q	8/4/2008	Q	8/2/2008	Q	8/2/2008	Q	8/2/2008	Q
1-MoCB	0.0602	U	0.154	U	0.46	J	0.0592	U	0.521	J	0.534	U	0.11	U	0.128	U	1.94		0.165	U
2-MoCB	0.0708	U	0.19	U	0.112	U	0.0808	U	0.0994	U	0.593	U	0.14	U	0.169	U	1.24	J	0.209	U
3-MoCB	0.0693	U	0.193	U	0.0677	U	0.0612	U	0.794	J	0.464	U	0.123	U	0.153	U	1.37	J	0.183	U
4-DiCB	0.352	U	1.18	U	1.5		0.374	U	1.83		0.764	U	1.04		0.396	U	9.68		3.04	
5-DiCB	0.319	U	0.458	U	0.327	U	0.417	U	0.589	U	1.02	U	0.276	U	0.457	U	0.514	U	0.583	U
6-DiCB	0.291	U	0.418	U	0.303	U	0.385	U	0.985	J	1.56	J	0.245	U	0.406	U	0.457	U	0.519	U
7-DiCB	0.283	U	0.407	U	0.294	U	0.375	U	0.529	U	0.905	U	0.246	U	0.407	U	0.458	U	0.52	U
8-DiCB	0.26	U	0.374	U	4.25		4.23		6.69		10.8		3.39		3.3		14.7		9.33	
9-DiCB	0.29	U	0.417	U	0.302	U	0.384	U	0.543	U	0.914	U	0.249	U	0.411	U	0.463	U	0.525	U
10-DiCB	0.296	U	0.893	U	0.391	U	0.271	U	0.477	U	0.608	U	0.282	U	0.379	U	0.906	U	0.439	U
11-DiCB	0.292	U	0.42	U	0.296	U	0.377	U	0.533	U	0.967	U	0.263	U	0.436	U	0.49	U	0.556	U
12+13-DiCB	0.839	J	0.423	U	0.736	J	0.378	U	1.12	J	1.53	J	0.491	J	0.417	U	2.1	J	0.533	U
14-DiCB	0.287	U	0.413	U	0.308	U	0.393	U	0.555	U	0.931	U	0.253	U	0.419	U	0.472	U	0.535	U
15-DiCB	0.344	U	0.465	U	4.44		4.21		9.41		9.8		4.09		3.57		16		9.73	
16-TrCB	0.212	U	2.89		1.85		0.337	U	3.7		1.04	U	0.496	U	0.379	U	0.759	U	0.615	U
17-TrCB	0.182	U	3.87		2.08		1.82		0.468	U	0.957	U	1.63		1.78		10.4		4.99	
18+30-TrCB	0.159	U	0.488	U	2.96		2.61		6.19		7.86		2.44		2.62		12.3		6.44	
19-TrCB	0.181	U	0.58	U	0.262	U	0.257	U	0.384	U	0.693	U	0.416	J	0.273	U	0.566	U	0.468	U
20+28-TrCB	0.134	U	0.412	U	14.5		0.188	U	34.3		34.3		0.315	U	8.9		44		27.3	
21+33-TrCB	0.128	U	0.395	U	5.1		0.192	U	10.1		10.6		0.306	U	3.72		16		9.37	
22-TrCB	0.147	U	0.454	U	4.56		0.222	U	8.59		8.81		0.341	U	3.29		12.9		7.86	
23-TrCB	0.134	U	0.412	U	0.203	U	0.203	U	0.358	U	0.71	U	0.339	U	0.259	U	0.519	U	0.42	U
24-TrCB	0.132	U	0.406	U	0.187	U	0.186	U	0.329	U	2.81		0.357	U	1.2		4.32		2.21	
25-TrCB	0.107	U	0.328	U	0.838	J	0.158	U	2.24		2.32		0.256	U	0.583	J	2.43		1.82	J
26+29-TrCB	0.132	U	2.89	J	0.189	U	1.52	J	0.333	U	4.44		0.319	U	1.18	J	4.24		3.08	J
27-TrCB	0.134	U	0.412	U	0.182	UJ	0.182	U	0.321	U	0.697	U	0.333	U	0.304	J	2.01		0.81	J
31-TrCB	0.135	U	0.415	U	9.21		7.55		20.4		19.7		6.5		5.74		25.1		15.7	
32-TrCB	0.125	U	0.385	U	2.86		2.65		4.95		6.07		0.308	U	1.69		12.3		5.38	
34-TrCB	0.14	U	0.429	U	0.194	U	0.193	U	0.341	U	0.692	U	0.331	U	0.253	U	0.505	U	0.41	U
35-TrCB	0.208	U	0.618	U	0.607	J	0.485	U	1.37	U	1.36	U	0.631	U	0.599	U	1.91	J	1.11	U
36-TrCB	0.186	U	0.551	U	0.508	U	0.472	U	1.33	U	1.25	U	0.576	U	0.547	U	1.28	U	1.01	U
37-TrCB	8.13		0.568	U	5.25		4.65		10.8		9.79		0.617	U	3.46		19.8		10.1	
38-TrCB	0.199	U	0.592	U	0.516	U	0.479	U	1.35	U	1.25	U	0.579	U	0.55	U	1.28	U	1.01	U
39-TrCB	0.184	U	0.546	U	0.514	U	0.477	U	1.34	U	1.19	U	0.55	U	0.521	U	1.22	U	0.963	U
40+71-TeCB	0.235	U	4.86		3.92		3.63		10.1		9.89		0.229	U	0.256	U	16.8		8.55	
41-TeCB	0.426	J	0.562	U	0.445	J	0.158	U	1.03	J	0.689	U	0.453	J	0.268	U	1.92	J	1.31	J
42-TeCB	0.242	U	0.495	U	2.26		1.91		5.83		5.22		1.63		0.246	U	9.44		5.02	
43-TeCB	0.285	U	0.584	U	0.16	U	0.294	J	0.565	U	1.49	J	0.266	U	0.297	U	1	U	0.534	U
44+47+65-TeCB	0.217	U	10.7		8.4		7.73		21.4		23.9		6.49		5.49		35.4		18	
45+51-TeCB	0.3	U	1.65	U	0.186	U	0.325	U	0.269	U	3.57	J	1.12	J	0.808	U	8		2.95	J
46-TeCB	0.332	U	1.83	U	0.471	J	0.36	U	0.297	U	0.787	U	0.414	J	0.885	U	2.44		0.395	U
48-TeCB	0.247	U	0.505	U	1.2		1.05		3.38		3.33		0.227	U	0.253	U	4.9		2.5	
49+69-TeCB	0.196	U	6.31		6.45		5.07		17.3		16.7		4.66		3.38		25.3		12.6	
50+53-TeCB	0.287	U	1.58	U	1.36	J	1.01	J	2.99		2.96	J	1.05	J	0.773	U	6.66		2.62	J
52-TeCB	0.234	U	12.8		9.4		8.03		25.6		31.9		7.6		6.56		36.9		20.3	
54-TeCB	0.144	U	0.832	U	0.0936	U	0.161	U	0.121	U	0.281	U	0.0967	U	0.32	U	0.188	U	0.138	U
55-TeCB	0.373	U	0.374	U	0.158	U	0.146	U	0.294	U	0.662	U	8.1		0.244	U	39.7		25	
56-TeCB	0.347	U	6.42		3.78		3.34		9.23		0.697	U	0.264	U	1.94		14.7		9.79	
57-TeCB	0.342	U	0.343	U	0.144	U	0.133	U	0.268	U	0.694	U	0.263	U	0.255	U	0.506	U	0.404	U
58-TeCB	0.343	U	0.344	U	0.496	J	0.128	U	0.258	U	0.73	U	0.277	U	0.269	U	0.533	U	0.425	U
59+62+75-TeCB	0.489	J	0.378	U	0.815	J	0.119	U	2.09	J	2.16	J	0.174	U	0.611	J	3.87	J	0.348	U
60-TeCB	0.343	U	4.35		2.32		2.2		4.91		5.21		1.68		1.34		8.87		5.67	
61+70+74+76-TeCB	0.33	U	21.6		14.3		13.3		31.6		43.4		12.5		7.56		51.5		35.1	
63-TeCB	0.33	U	0.331	U	0.144	U	0.134	U	0.269	U	0.629	U	0.42	J	0.232	U	0.459	U	0.366	U
64-TeCB	1.79		4.35		2.79		2.48		8.24		7.48		2.66		2.15		12.9		6.68	
66-TeCB	0.328	U	13.6		9.52		8.3		20.5		25.4		7.64		0.23	U	37.5		23.6	
67-TeCB	0.294	U	0.295	U	0.356	J	0.12	U	0.242	U	0.607	U	0.23	U	0.224	U	0.995	J	0.353	U
68-TeCB	0.323	U	0.324	U	0.14	U	0.314	J	0.64	J	0.65	U	0.246	U	0.239	U	0.772	J	0.378	U
72-TeCB	0.318	U	0.319	U	0.138	U	0.128	U	0.258	U	0.619	U	0.234	U	0.228	U	0.729	J	0.36	U
73-TeCB	0.181	U	0.37	U	0.088	U	0.119	U	0.312	U	0.501	U	0.175	U	0.195	U	0.659	U	0.351	U
77-TeCB	0.406	U	0.403	U	1.71		1.23		4		3.55		1.17		0.56	J	0.559	U	3.6	
78-TeCB	0.369	U	0.37	U	0.15	U	0.138	U	0.278	U	0.681	U	0.258	U	0.251	U	0.497	U	0.396	U
79-TeCB	0.296	U	0.297	U	0.121	U	0.112	U	0.225	U	0.57	U	0.216	U	0.21	U	0.416	U	0.332	U
80-TeCB	0.308	U	0.309	U	0.137	U	0.126	U	0.501	J	0.569	U	0.215	U	0.209	U	0.415	U	0.331	U
81-TeCB	0.391	U	0.385	U	0.156	U	0.157	U	0.313	U	0.71	U	0.262	U	0.278	U	0.503	U	0.427	U
82-PeCB	0.335	U	2.31		0.197	U	0.276	U	4.79		0.839	U	1.34		0.459	U	6		3.37	
83-PeCB	0.256	U	0.545	U	0.781	J	0.232	U	0.491	U	0.825	U	0.42	U	0.452	U	4.85		1.67	J
84-PeCB	2.42		0.694	U	0.187	U	2.73		9.19		12.6		2.74		0.444	U	13.7		0.639	U
85+116+117-PeCB	1.97		3.99		3.11		2.46		8.25		9.4		2.34		0.349	U	11		6.11	
86+87+97+108+119+125-PeCB	0.26	U	14.3		9.62		7.4		28.5		30.6		7.57		5.19	J	33.1		17.9	
88+91-PeCB	1.46	J	2.47	J	0.166	U	2.04		6.06		7.36		2.13		0.414	U	11.1		4.75	
89-PeCB	0.317	U	0.674	U	0.179	U	0.252	U	0.533	U	0.799	U	0.407	U	0.437	U	0.877	U	0.629	U
90+101+113-PeCB	10.3		20.3		16.3		13.3		58.3		48.9		12.2		8.57		59.3		29	
92-PeCB	1.84		3.67		3.36		2.46		11.1		9.06		2.49		0.428	U	0.858	U	5.82	
93+100-PeCB	0.268	U	0.57	U	0.153	U	0.215	U	0.455	U	0.721	U	0.368	U	0.395	U	0.792	U	0.568	U
94-PeCB	0.307	U	0.653	U	0.184	U	0.258	U	0.547	U	0.799	U	0.407	U	0.437	U	0.877	U	0.629	U
95-PeCB	7.58		13.1		9.74		8.81		28.1		34.9		8.96		0.393	U	44.2		20.3	
96-PeCB	0.207	U	0.436	U	0.124	U	0.17	U	0.298	U	0.598	U	0.27	U	0.253	U	0.413	U	0.376	U
98+102-PeCB	0.306	J	0.623	U	0.17	U	0.568	J	0.505	U	1.67	J	0.362	U	0.389	U	0.78	U	0.559	U
99-PeCB	5.06		10.7		9.32		7.03		30.1		27.9		8.1		4.43		36.6		18.1	
103-PeCB	0.259	U	0.55	U	0.252	J	0.208	U	0.441	U	0.683	U	0.348	U	0.374	U	1.12	J	0.538	U
104-PeCB	0.135	U	0.294	U	0.0916	U	0.127	U	0.215	U	0.324	U	0.161	U	0.145	U	0.238	U	0.208	U
105-PeCB	3.6		7.51		5.16		0.178	U	14.7		17.1		4.44		2.17		18		11.7	
106-PeCB	0.249	U	0.613	U	0.279	U	0.2	U	0.551	U	0.547	U	0.409	U	0.343	U	0.615	U	0.575	U
107+124-PeCB	0.361	J	0.679	J	0.547	J	0.178	U	0.49	U	1.83	J	0.444	U	0.372	U	2.03	J	0.624	U
109-PeCB	0.7	J	1.24	J	1.26		0.147	U	3.99		3.51		0.369	U	0.556	J	4.92		2.66	
110+115-PeCB	9.75		20.6		14.9		12.1		48.2		47.3		11.2		6.77		52.9		26	
111-PeCB	0.234	U	0.497	U	0.126	U	0.177	U	0.376	U	0.585	U	0.298	U	0.32	U	0.642	U	0.46	U
112-PeCB	0.255	U	0.541	U	0.144	U	0.201	U	0.427	U	0.564	U	0.288	U	0.309	U	0.619	U	0.444	U
114-PeCB	0.298	U	0.734	U	0.26	U	0.192	U	0.529	U	0.978	J	0.486	U	0.415	U	0.717	U	0.692	U
118-PeCB	9.46		17.3		14.3		11.9		42.1		44.3		11.5		5.38		49.6		27.3	
120-PeCB	0.22	U	0.468	U	0.123	U	0.173	U	0.366	U	0.558	U	0.285	U	0.306	U	0.613	U	0.44	U
121-PeCB	0.224	U	0.476	U	0.127	U	0.179	U	0.378	U	0.585	U	0.298	U	0.32	U	0.642	U	0.461	U
122-PeCB	0.25	U	0.615	U	0.257	U	0.184	U	0.582	J	0.635	U	0.475	U	0.398	U	0.713	U	0.668	U
123-PeCB	0.255	U	0.638	U	0.246	U	0.164	U	0.478	U	0.902	J	0.425	U	0.343	U	0.648	U	0.615	U

Sample ID	R_DAB_5		R_DAB_7_C		R_HOL_0		R_HOL_1		R_HOL_3		R_HOL_4		R_HOL_7		R_SAM_0		R_SAM_1		R_SAM_3		R_SAM_4	
Analyte (pg/g)	8/2/2008	Q	8/2/2008	Q	8/3/2008	Q	8/3/2008	Q	8/3/2008	Q	8/3/2008	Q	8/3/2008	Q	8/1/2008	Q	8/1/2008	Q	8/1/2008	Q	8/1/2008	Q
1-MoCB	2		0.184	U	0.0594	U	0.104	U	0.504	J	1.44	J	2.1		0.183	U	0.131	U	0.152	U	0.204	U
2-MoCB	0.245	U	0.221	U	0.0619	U	0.107	U	0.267	J	0.24	U	2.03	J	0.203	U	2.09		1.74		0.217	U
3-MoCB	0.198	U	0.185	U	0.0587	U	0.105	U	0.434	J	1.79	J	1.85	J	0.202	U	0.134	U	0.169	U	0.209	U
4-DiCB	4.62		15		0.584	U	0.645	U	0.946		3.44		2.84		0.868	U	1.1	U	1.22	U	2.44	
5-DiCB	0.921	U	0.492	U	0.39	U	0.465	U	0.513	U	0.981	U	1.15	U	1.15	U	0.494	U	1.38	U	0.768	U
6-DiCB	0.818	U	0.437	U	0.369	U	0.454	U	0.486	U	0.93	U	1.47	J	1.08	U	1.83		1.92		0.723	U
7-DiCB	0.82	U	0.438	U	0.371	U	0.446	U	0.488	U	0.934	U	1.1	U	1.1	U	0.473	U	1.32	U	0.735	U
8-DiCB	13.9		18.8		3.97		4.41		3.42		10.7		9.7		13.4		0.426	U	1.19	U	0.661	U
9-DiCB	0.828	U	0.443	U	0.373	U	0.443	U	0.49	U	0.938	U	1.1	U	1.1	U	0.475	U	1.32	U	0.737	U
10-DiCB	0.749	U	0.963	J	0.506	U	0.558	U	0.394	U	0.801	U	0.846	U	0.757	U	0.915	U	1	U	0.736	U
11-DiCB	0.877	U	0.469	U	0.377	U	0.447	U	0.496	U	0.95	U	1.11	U	1.08	U	0.468	U	1.3	U	0.726	U
12+13-DiCB	2.02	J	2.85	J	0.762	J	0.862	J	0.496	U	1.91	J	1.11	U	1.09	U	1.66	J	1.31	U	0.731	U
14-DiCB	0.844	U	0.451	U	0.369	U	0.441	U	0.486	U	0.93	U	1.09	U	1.06	U	0.456	U	1.27	U	0.707	U
15-DiCB	14.2		18.2		5.32		6.59		4.82		14.6		17.5		1.24	U	0.518	U	1.44	U	0.81	U
16-TrCB	0.773	U	0.73	U	1.84		0.317	U	0.209	U	5.22		0.866	U	0.678	U	0.445	U	3.01		0.513	U
17-TrCB	8.3		15.2		2.37		2.16		1.31		5.18		4.81		0.623	U	0.409	U	0.748	U	0.472	U
18+30-TrCB	12.4		17.3		3.31		3.25		1.98		7.55		7.98		0.556	U	0.366	U	0.668	U	0.422	U
19-TrCB	1.39	J	3.38		0.668	J	0.544	J	0.162	U	1.39	J	1.06	J	0.649	U	0.42	U	0.766	U	0.484	U
20+28-TrCB	41.6		61.9		14		15.4		9.57		36.3		44.1		0.443	U	0.291	U	0.532	U	0.336	U
21+33-TrCB	14		20.6		4.31		5.09		3.73		11.2		11		0.422	U	0.278	U	0.507	U	0.32	U
22-TrCB	11.3		15.1		0.142	U	4.45		3.16		9.87		9.74		0.481	U	0.316	U	0.578	U	0.365	U
23-TrCB	0.528	U	0.499	U	0.145	U	0.207	U	0.126	U	0.522	U	0.567	U	0.475	U	0.312	U	0.57	U	0.36	U
24-TrCB	4.25		5.43		0.135	U	0.182	U	0.121	J	0.484	U	0.497	U	0.477	U	0.314	U	0.573	U	0.362	U
25-TrCB	2.28		3.64		0.791	J	0.14	U	0.528	J	2.07	J	0.381	U	0.359	U	0.236	U	0.431	U	0.272	U
26+29-TrCB	4.9		5.99		1.37	J	1.74	J	0.984	J	3.45	J	3.74	J	3.11	J	0.29	U	0.53	U	0.334	U
27-TrCB	1.31	J	2.91		0.404	J	0.177	U	0.259	J	0.45	U	1.28	J	0.612	J	0.293	U	0.797	J	0.338	U
31-TrCB	25.2		34.5		8.12		9.02		6.04		19.9		23.2		0.444	U	0.292	U	0.533	U	0.336	U
32-TrCB	7.63		24.9		2.41		2.16		0.109	U	5.86		5.44		0.423	U	0.278	U	0.508	U	0.321	U
34-TrCB	0.515	U	0.486	U	0.135	U	0.185	U	0.117	U	0.484	U	0.505	U	0.463	U	0.304	U	0.555	U	0.351	U
35-TrCB	1.09	U	1.12	U	0.457	J	0.599	J	0.478	J	0.887	U	0.932	U	1.56	U	0.814	U	1.23	U	0.608	U
36-TrCB	0.995	U	1.03	U	0.304	U	0.343	U	0.198	U	0.825	U	0.867	U	1.38	U	0.724	U	1.09	U	0.54	U
37-TrCB	15.8		25.3		4.46		5.54		4.69		14.2		16.7		1.49	U	0.791	U	1.19	U	11.6	
38-TrCB	1	U	1.03	U	0.301	U	0.352	U	0.196	U	0.818	U	0.891	U	1.44	U	0.751	U	1.13	U	0.561	U
39-TrCB	0.949	U	0.978	U	0.286	U	0.332	U	0.186	U	0.776	U	0.839	U	1.4	U	0.734	U	1.11	U	0.548	U
40+71-TeCB	15.7		25.8		3.72		4.53		2.74		12.4		15.1		0.391	U	0.315	U	5		4.17	
41-TeCB	0.427	U	1.01	U	0.298	U	0.554	J	0.345	J	1.44	J	1.69	J	0.415	U	0.335	U	0.94	J	0.425	U
42-TeCB	8.26		14.7		2.5		0.261	U	1.52		7.02		10.3		2.19		0.321	U	3.13		1.89	
43-TeCB	0.472	U	1.11	U	0.415	U	0.328	U	0.26	U	0.857	U	0.862	J	0.671	J	0.426	U	0.726	U	0.541	U
44+47+65-TeCB	31.5		55.5		8.06		9.54		5.33		23.6		31		6.95		9.45		10.9		0.352	U
45+51-TeCB	5.21		15.9		1.54	J	1.55	J	0.866	J	3.74	J	0.658	U	0.397	U	0.471	JU	0.7	U	0.475	U
46-TeCB	0.411	U	3.78		0.254	U	0.449	J	0.175	U	1.21	J	1.42	J	0.443	U	0.526	U	0.781	U	0.53	U
48-TeCB	5.69		8		1.33		0.231	U	0.897		3.2		4.18		0.391	U	0.316	U	0.538	U	0.401	U
49+69-TeCB	22.4		44.2		6.23		7.12		3.61		17.6		23.3		3.79		5.51		6.39		4.98	
50+53-TeCB	0.359	U	11.1		1.38	J	1.37	J	0.761	J	3.03	J	3.79	J	0.382	U	1.15	J	0.675	U	0.458	U
52-TeCB	32.6		55.9		10		11.7		6.19		30.9		35.9		0.356	U	9.75		11.4		0.364	U
54-TeCB	0.145	U	0.133	U	0.0873	U	0.179	U	0.0609	U	0.264	U	0.282	U	0.212	U	0.256	U	0.392	U	0.244	U
55-TeCB	42.4		63		0.473	U	0.567	U	0.287	U	0.839	U	0.971	U	0.718	U	0.474	J	0.52	U	0.436	U
56-TeCB	17.2		24.4		3.78		4.58		2.71		12.1		15.7		0.649	U	7.79		0.47	U	6.54	
57-TeCB	1.24	J	0.379	U	0.41	U	0.461	U	0.248	U	0.726	U	0.79	U	0.637	U	0.369	U	0.462	U	0.387	U
58-TeCB	0.318	U	0.399	U	0.391	U	0.444	U	0.237	U	0.692	U	0.759	U	0.632	U	0.366	U	0.458	U	0.384	U
59+62+75-TeCB	3.44	J	5.67		0.814	J	0.97	J	0.499	J	0.465	U	0.308	U	0.3	JU	0.805	J	0.412	U	0.307	U
60-TeCB	8.86		12.9		2.39		2.51		1.94		6.61		0.846	U	0.647	U	0.375	U	0.469	U	4.72	
61+70+74+76-TeCB	58.5		80.6		15.7		16.8		10.4		44.7		58		0.613	U	25.1		28.5		20.4	
63-TeCB	1.59	J	2.69		0.404	U	0.465	U	0.245	U	0.716	U	1.94	J	0.641	U	0.371	U	0.757	J	0.39	U
64-TeCB	11.7		17.9		3.49		4.12		2.04		10.2		13.9		3.12		0.213	U	3.98		3.14	
66-TeCB	40		59.4		9.38		10.3		6.38		28.1		40.1		12.3		15.3		18.3		12.9	
67-TeCB	0.265	U	0.332	U	0.381	U	0.444	U	0.231	U	0.674	U	1.48	J	0.57	U	0.33	U	0.414	U	0.347	U
68-TeCB	0.283	U	0.355	U	0.376	U	0.416	U	0.228	U	0.666	U	0.712	U	0.605	U	0.35	U	0.439	U	0.368	U
72-TeCB	0.269	U	1.35	J	0.394	U	0.432	U	0.239	U	0.698	U	0.74	U	0.61	U	0.354	U	0.443	U	0.371	U
73-TeCB	0.31	U	0.731	U	0.224	U	0.169	U	0.141	U	0.464	U	0.305	U	0.284	U	0.229	U	0.39	U	0.291	U
77-TeCB	6.19		10.6		1.37		1.51		1.2		3.64		6.01		0.713	U	0.409	U	0.504	U	0.427	U
78-TeCB	0.296	U	0.372	U	0.439	U	0.495	U	0.266	U	0.778	U	0.848	U	0.656	U	0.38	U	0.476	U	0.399	U
79-TeCB	0.248	U	0.312	U	0.348	U	0.418	U	0.211	U	0.617	U	0.716	U	0.55	U	0.319	U	0.399	U	0.334	U
80-TeCB	0.248	U	0.311	U	0.359	U	0.433	U	0.217	U	0.636	U	0.741	U	0.586	U	0.339	U	0.425	U	0.357	U
81-TeCB	0.315	U	0.392	U	0.437	U	0.47	U	0.263	U	0.772	U	0.84	U	0.657	U	0.372	U	0.468	U	0.408	U
82-PeCB	6.19		10.1		0.335	U	2.12		1.04		5.92		7.2		1.03	U	1.81		0.74	U	1.29	J
83-PeCB	0.633	U	0.435	U	0.289	U	0.34	U	0.563	J	0.771	U	43.7		1.03	U	0.92	J	10.1		0.642	U
84-PeCB	12.4		23.8		3.79		4.38		0.375	U	12.9		16.5		2.98		0.476	U	2.52		2.39	
85+116+117-PeCB	11.7		18.8		2.83		0.286	U	0.269	U	9.75		13.6		0.764	U	3.01		3.28		1.76	J
86+87+97+108+119+125-PeCB	33.7		54		9.12		11.2		6.4		33.7		44.4		9.65	J	9.4		11		7.62	J
88+91-PeCB	7.58		17.2		2.45		2.74		1.63	J	8.77		10.1		0.922	U	1.29	J	0.664	U	1.39	J
89-PeCB	0.614	U	1.94		0.304	U	0.374	U	0.349	U	0.81	U	0.73	U	0.966	U	0.437	U	0.696	U	0.601	U
90+101+113-PeCB	54.1		102		16.5		20.9		11		56.8		75.9		24.2		13.1		13.5		9.31	
92-PeCB	9.93		20.2		3.4		4.36		2.15		11.4		16.7		3.45		2.51		2.52		0.605	UJ
93+100-PeCB	0.554	U	6.03		0.251	U	0.297	U	0.289	U	0.67	U	0.58	U	0.89	U	0.402	U	0.641	U	0.554	U
94-PeCB	0.614	U	0.422	U	0.308	U	0.359	U	0.354	U	0.822	U	0.702	U	0.988	U	0.447	U	0.712	U	0.614	U
95-PeCB	35.4		76		12.2		12.5		8.3		40.8		48.4		15.2		0.406	U	7.59		7.17	
96-PeCB	0.537	J	0.339	U	0.172	U	0.168	U	0.167	U	0.487	U	0.397	U	0.506	U	0.264	U	0.502	U	0.396	U
98+102-PeCB	0.545	U	5.93		0.292	U	0.71	J	0.335	U	0.777	U	0.655	U	0.901	U	0.407	U	0.649	U	0.56	U
99-PeCB	30.8		71.4		9.31		10.9		5.31		27.4		36.1		4.92		0.346	U	7.52		0.476	U
103-PeCB	0.618	J	2.17		0.255	U	0.295	U	0.293	U	0.678	U	0.576	U	0.83	U	0.375	U	0.598	U	0.516	U
104-PeCB	0.211	U	0.187	U	0.092	U	0.102	U	0.0856	U	0.256	U	0.22	U	0.387	U	0.223	U	0.425	U	0.28	U
105-PeCB	20.6		36.3		4.71		4.58		3.12		16.3		20.4		0.834	U	6.48		7.32		4.45	
106-PeCB	0.619	U	0.468	U	0.181	U	0.277	U	0.22	U	0.808	U	0.625	U	0.825	U	0.379	U	0.577	U	0.723	U
107+124-PeCB	0.671	U	3.24		0.559	J	0.832	J	0.352	J	2.14	J	2.52	J	0.798	U	0.367	JU	0.559	U	0.699	U
109-PeCB	4.74		8.92		1.17		1.34		0.803	J	0.565	U	4.91		0.956	J	1.19	J	0.458	U	0.573	U
110+115-PeCB	49.2		88.4		15.2		18.4		10.2		56.5		77		16.3		13.2		14		10.2	
111-PeCB	0.449	U	0.309	U	0.216	U	0.266	U	0.248	U	0.575	U	0.52	U	0.728	U	0.329	U	0.524	U	0.453	U
112-PeCB	0.433	U	0.298	U	0.252	U	0.342	U	0.29	U	0.672	U	0.668	U	0.79	U	0.357	U	0.569	U	0.491	U
114-PeCB	1.11	J	1.33	J	0.176	U	0.258	U	0.209	U	0.8	U	0.638	U	0.905	U	0.41	U	0.609	U	0.781	U
118-PeCB	52.1		85.9		13.3		14.1		8.81		43.1		55.5		11.3		14.8		16		10.1	
120-PeCB	0.445	J	0.294	U	0.205	U	0.254	U	0.235	U	0.545	U	0.497	U	0.698	U	0.316	U	0.503	U	0.434	U
121-PeCB	0.449	U	0.309	U	0.222	U	0.271	U	0.255	U	0.592	U	0.53	U	0.718	U	0.324	U	0.517	U	0.446	U
122-PeCB	0.718	U	1.06	J	0.164	U	0.252	U	0.2	U	0.734	U	0.569	U	0.794	U	0.365	U	0.556	U	0.695	U
123-PeCB	0.928	J	1.36	J	0.157	U	0.237	U	0.195	U	0.699	U	0.53	U	0.775	U	0.354	U	0.543	U	0.695	U

Table A-12e. US EPA/USACE "Bold Study" Analytical Data-PCB Congeners

Sample ID	PSPS_8		PSPS_9		R_CAR_0		R_CAR_1		R_CAR_4		R_CAR_5		R_CAR_6_C	
Analyte (pg/g)	8/3/2008	Q	8/3/2008	Q	8/4/2008	Q	8/4/2008	Q	8/4/2008	Q	8/4/2008	Q	8/4/2008	Q
126-PeCB	0.324	U	0.824	U	0.326	U	0.217	U	0.627	U	0.789	U	0.541	U
127-PeCB	0.242	U	0.598	U	0.249	U	0.178	U	0.492	U	0.536	U	0.401	U
128+166-HxCB	2.12		4.55		3.38		2.68		11.9		8.99		0.315	U
129+138+163-HxCB	14.8		28.7		18.5		16.3		79.3		61.1		15.3	
130-HxCB	0.423	U	0.98	U	0.51	U	0.904	J	5.32		4.56		1.19	
131-HxCB	0.356	U	0.825	U	0.44	U	0.395	U	0.519	U	1.01	U	0.319	U
132-HxCB	4.68		8.28		4.61		4.48		22		17.2		0.379	U
133-HxCB	0.392	U	0.907	U	0.489	U	0.439	U	0.578	U	1.15	U	0.362	U
134-HxCB	0.608	J	0.812	U	0.581	J	0.37	U	2.92		2.32		0.339	U
135+151-HxCB	5.73		10.4		5.6		5.08		27.7		20.8		0.397	U
136-HxCB	1.94		3.22		1.84		1.88		8.28		7.27		1.68	
137-HxCB	0.359	UJ	0.832	U	0.416	U	0.373	U	2.42		1.1	U	0.347	U
139+140-HxCB	0.358	U	0.828	U	0.438	U	0.393	U	0.517	U	1.06	U	0.332	U
141-HxCB	0.402	U	0.931	U	1.95		1.8		9.68		5.37		0.355	U
142-HxCB	0.423	U	0.979	U	0.563	U	0.506	U	0.665	U	1.2	U	0.378	U
143-HxCB	0.418	U	0.969	U	0.603	U	0.541	U	0.711	U	1.15	U	0.363	U
144-HxCB	0.728	J	1.1	J	0.766	J	0.64	J	3		2.42		0.624	J
145-HxCB	0.188	U	0.405	U	0.278	U	0.12	U	0.489	U	0.645	U	0.315	U
146-HxCB	2.32		4.55		0.38	U	2.5		14.8		9.86		2.69	
147+149-HxCB	9.42		17.3		13.2		10.9		63.2		43.3		10.2	
148-HxCB	0.249	U	0.536	U	0.357	U	0.153	U	0.627	U	0.832	U	0.407	U
150-HxCB	0.181	U	0.389	U	0.28	U	0.121	U	0.492	U	0.619	U	0.303	U
152-HxCB	0.171	U	0.368	U	0.266	U	0.114	U	0.467	U	0.583	U	0.285	U
153+168-HxCB	15.7		28.2		18.2		15		88.4		61.1		15.3	
154-HxCB	0.209	U	0.449	U	0.32	U	0.138	U	0.562	U	0.708	U	0.42	J
155-HxCB	0.0902	U	0.209	U	0.174	U	0.0674	U	0.302	U	0.315	U	0.155	U
156+157-HxCB	0.579	U	2.74	J	1.73	J	1.6	J	6.76		6.13		1.38	J
158-HxCB	0.265	U	2.67		0.334	U	1.35		6.8		5.83		1.21	
159-HxCB	0.423	U	0.558	U	0.337	U	0.46	U	0.854	U	0.994	U	0.321	U
160-HxCB	0.345	U	0.798	U	0.435	U	0.391	U	0.514	U	0.935	U	0.294	U
161-HxCB	0.308	U	0.713	U	0.402	U	0.361	U	0.474	U	0.853	U	0.268	U
162-HxCB	0.433	U	0.571	U	0.334	U	0.456	U	0.848	U	1	U	0.324	U
164-HxCB	0.301	U	0.697	U	1.06	J	0.92	J	5.52		2.81		0.281	U
165-HxCB	0.314	U	0.727	U	0.397	U	0.356	U	0.468	U	0.953	U	0.3	U
167-HxCB	0.647	J	1.17	J	0.328	U	0.62	J	2.98		1.08	U	0.738	J
169-HxCB	0.484	U	0.651	U	0.336	U	0.465	U	0.847	U	1.29	U	0.387	U
170-HpCB	0.268	U	5.56		3.73		2.75		21.9		13.5		2.59	
171+173-HpCB	0.288	U	0.733	U	1.22	J	1.29	J	8.08		4.54		1.15	U
172-HpCB	0.284	U	0.722	UJ	0.512	U	0.728	J	4.29		2.3		1.22	U
174-HpCB	0.294	U	0.749	U	3.81		3.18		20.5		13.3		1.08	U
175-HpCB	0.349	U	1.42	U	0.216	U	0.303	U	0.615	U	1.07	U	0.51	U
176-HpCB	0.272	U	1.11	J	0.174	U	0.394	J	0.497	U	2.58		0.513	J
177-HpCB	0.289	U	4.45		0.509	U	2.07		16.1		9.2		1.17	U
178-HpCB	1.08		2.4		1.44		1.46		6.86		5.79		1	
179-HpCB	0.269	U	3.58		1.91		0.233	U	10.5		6.66		1.65	
180+193-HpCB	0.21	U	10.7		6.8		0.378	U	36.9		26.1		5.58	
181-HpCB	0.269	U	0.684	U	0.463	U	0.483	U	1.17	U	1.06	U	1.06	U
182-HpCB	0.344	U	1.4	U	0.221	U	0.31	U	0.631	U	1.08	U	0.511	U
183+185-HpCB	1.96		4.45		2.79		2.57		14.8		1.05	U	1.05	U
184-HpCB	0.259	U	1.06	U	0.162	U	0.227	U	0.462	U	0.819	U	0.388	U
186-HpCB	0.274	U	1.12	U	0.179	U	0.251	U	0.51	U	0.896	U	0.425	U
187-HpCB	0.326	U	12.4		6.79		6.12		36.2		25.1		6.27	
188-HpCB	0.233	U	0.925	U	0.153	U	0.221	U	0.444	U	0.704	U	0.359	U
189-HpCB	0.293	U	0.642	U	0.467	U	0.551	U	0.755	U	1.41	U	0.534	U
190-HpCB	0.206	U	0.525	U	0.738	J	0.476	J	0.98	U	2.02		0.967	U
191-HpCB	0.207	U	0.527	U	0.368	U	0.384	U	0.934	U	0.946	U	0.946	U
192-HpCB	0.231	U	0.589	U	0.408	U	0.426	U	1.04	U	0.98	U	0.981	U
194-OcCB	0.312	U	0.975	U	1.87		1.87		11.7		8.25		0.685	U
195-OcCB	0.345	U	1.08	U	0.597	U	0.942	U	4.6		1.75	U	0.742	U
196-OcCB	0.385	U	0.834	U	0.309	U	0.314	U	5.73		5.46		0.622	U
197+200-OcCB	0.326	U	0.708	U	0.241	U	0.245	U	0.461	U	2.08	J	0.48	U
198+199-OcCB	2.07		4		3.01		3.23		14.7		15.2		2.66	
201-OcCB	0.329	U	0.729	J	0.249	U	0.252	U	2.04		2.03		0.473	U
202-OcCB	0.295	U	1.07	J	0.252	U	0.253	U	3.92		0.889	U	0.407	U
203-OcCB	0.371	U	2.77		1.65		1.52		7.2		1.26	U	0.585	U
204-OcCB	0.338	U	0.732	U	0.239	U	0.243	U	0.457	U	1.05	U	0.485	U
205-OcCB	0.282	U	0.883	U	0.456	U	0.729	U	1.04	U	1.64	U	0.696	U
206-NoCB	0.36	U	0.926	U	1.91		0.354	U	0.546	U	10.6		1.99	
207-NoCB	0.305	U	0.8	U	0.239	U	0.428	J	0.442	U	1.91	U	0.67	U
208-NoCB	0.303	U	0.81	U	0.241	U	0.306	U	2.62		3.49		0.621	U
209-DeCB	1.42		3.18		2.23		0.264	U	6.67		1.93	U	0.732	U
Total PCBs (0 DL)	131.7		382.1		331.2		254.7		1182.2		1032.1		225.6	
TEQ WHO-05 (1 DL)	0.048		0.103		0.044		0.036		0.091		0.120		0.066	
TEQ WHO-05 (1/2 DL)	0.024		0.052		0.022		0.018		0.047		0.061		0.034	
TEQ WHO-05 (0 DL)	0.000		0.001		0.001		0.001		0.002		0.002		0.001	

Sample ID	R_DAB_0		R_DAB_1		R_DAB_2		R_DAB_5		R_DAB_7_C		R_HOL_0		R_HOL_1	
Analyte (pg/g)	8/2/2008	Q	8/2/2008	Q	8/2/2008	Q	8/2/2008	Q	8/2/2008	Q	8/3/2008	Q	8/3/2008	Q
126-PeCB	0.476	U	0.875	U	0.868	U	0.891	U	0.692	U	0.226	U	0.335	U
127-PeCB	0.336	U	0.602	U	0.563	U	0.606	U	0.459	U	0.16	U	0.262	U
128+166-HxCB	1.12	J	12.1		6.17		11.5		22.2		2.88		3.31	
129+138+163-HxCB	8.47		70.7		35.9		69.1		133		16.7		19	
130-HxCB	0.503	U	5.24		2.8		5.3		9.46		1.26		1.47	
131-HxCB	0.409	U	0.685	U	0.454	U	0.441	U	0.74	U	0.421	U	0.409	U
132-HxCB	2.54		17		9.96		19.4		33.5		4.86		5.24	
133-HxCB	0.464	U	0.777	U	0.515	U	0.5	U	2.93		0.476	U	0.448	U
134-HxCB	0.435	U	0.729	U	1.39	J	2.89		6.08		0.686	J	0.597	J
135+151-HxCB	3.24		24.4		12.7		23.6		49.9		6.09		6.91	
136-HxCB	1.17		8.48		0.959	U	7.31		17.5		2.22		2.31	
137-HxCB	0.445	U	0.745	U	2.09		0.479	U	6.56		0.403	U	0.392	U
139+140-HxCB	0.426	U	0.714	U	0.472	U	0.459	U	0.771	U	0.427	U	0.401	U
141-HxCB	0.455	U	0.762	U	2.75		5.14		8.46		0.535	U	0.521	U
142-HxCB	0.485	U	0.813	U	0.538	U	0.523	U	0.878	U	0.562	U	0.506	U
143-HxCB	0.466	U	0.78	U	0.517	U	0.502	U	0.843	U	0.574	U	0.511	U
144-HxCB	0.597	U	2.51		1.21	U	2.57		0.77	U	0.338	U	0.625	U
145-HxCB	0.493	U	0.378	U	1	U	0.441	U	0.636	U	0.271	U	0.488	U
146-HxCB	1.58		12.7		6.09		11.2		26.9		2.73		3.46	
147+149-HxCB	6.36		48.1		26.2		48.2		101		14.2		17	
148-HxCB	0.636	U	0.487	U	1.29	U	0.569	U	0.82	U	0.35	U	0.65	U
150-HxCB	0.473	U	0.363	U	0.961	U	0.424	U	0.789	J	0.277	U	0.502	U
152-HxCB	0.446	U	0.341	U	0.905	U	0.399	U	0.575	U	0.244	U	0.455	U
153+168-HxCB	8.72		70.3		36		67.6		143		17.9		19.5	
154-HxCB	0.541	U	0.414	U	1.1	U	0.484	U	4.45		0.398	J	0.55	U
155-HxCB	0.236	U	0.181	U	0.46	U	0.206	U	0.3	U	0.125	U	0.376	U
156+157-HxCB	0.622	J	5.69		0.728	U	5.7		10.1		1.32	J	0.33	U
158-HxCB	0.805	J	5.27		2.93		5.14		9.71		1.52		1.65	
159-HxCB	0.379	U	0.519	U	0.537	U	0.766	U	0.644	U	0.323	U	0.297	U
160-HxCB	0.377	U	0.632	U	0.418	U	0.406	U	0.682	U	0.423	U	0.407	U
161-HxCB	0.344	U	0.576	U	0.381	U	0.371	U	0.622	U	0.397	U	0.375	U
162-HxCB	0.383	U	0.525	U	0.543	U	0.774	U	1.72		0.334	U	0.315	U
164-HxCB	0.361	U	2.75		1.7	J	0.389	U	5.33		0.648	J	0.854	J
165-HxCB	0.384	U	0.644	U	0.426	U	0.414	U	0.695	U	0.374	U	0.355	U
167-HxCB	0.408	U	2.55		0.57	U	3.15		4.4		0.349	U	0.295	U
169-HxCB	0.449	U	0.652	U	0.712	U	0.985	U	0.781	U	0.392	U	0.326	U
170-HpCB	1.76		11.4		5.41		12.1		19.2		0.576	U	4.02	
171+173-HpCB	0.674	J	4.04		0.689	U	5.11		7.85		1.25	J	0.416	U
172-HpCB	0.49	U	2.43		0.732	U	1.1	U	4.3		0.566	U	0.446	U
174-HpCB	1.41		10.7		5.51		10.4		18.8		2.95		3.89	
175-HpCB	0.437	U	0.814	U	0.758	U	0.772	U	1.82		0.342	U	0.382	U
176-HpCB	0.354	U	0.659	U	0.613	U	2.35		4.09		0.436	J	0.571	J
177-HpCB	0.472	U	10.3		5.45		11.3		20.6		2.59		2.94	
178-HpCB	0.456	U	4.52		2.99		4.53		10.7		0.369	U	1.49	
179-HpCB	0.346	U	6.8		4.55		7.96		16.2		1.68		2.13	
180+193-HpCB	3.17		20.7		9.4		20.3		37.5		4.63		7.24	
181-HpCB	0.425	U	0.753	U	0.634	U	0.957	U	0.939	U	0.471	U	0.361	U
182-HpCB	0.439	U	0.818	U	0.761	U	0.775	U	0.693	U	0.353	U	0.396	U
183+185-HpCB	1.41	J	10		4.88		10.8		18.8		2.45		0.36	U
184-HpCB	0.333	U	0.62	U	0.577	U	0.588	U	0.526	U	0.26	U	0.28	U
186-HpCB	0.365	U	0.679	U	0.632	U	0.644	U	0.575	U	0.283	U	0.313	U
187-HpCB	2.41		27.2		13.5		26.9		56.8		0.32	U	7.16	
188-HpCB	0.301	U	0.544	U	0.493	U	0.529	U	0.456	U	0.222	U	0.248	U
189-HpCB	0.424	U	1.53	U	0.853	U	1	U	1.07	U	0.416	U	0.503	U
190-HpCB	0.389	U	0.689	U	0.58	U	2.86		3.8		0.439	U	0.341	U
191-HpCB	0.38	U	0.674	U	0.568	U	0.856	U	0.84	U	0.414	U	0.331	U
192-HpCB	0.394	U	0.699	U	0.589	U	0.888	U	0.872	U	0.445	U	0.361	U
194-OcCB	0.484	U	4.65		0.59	U	5.1		11.9		1.21		1.78	
195-OcCB	0.524	U	2.06		0.64	U	2.98		4.94		0.413	U	0.674	J
196-OcCB	0.706	U	4.22		2.05	U	1.13	U	10.2		0.505	U	0.534	U
197+200-OcCB	0.544	U	0.762	U	1.58	U	1.69	J	0.72	U	0.395	U	0.395	U
198+199-OcCB	1.49	J	10.9		5.7		12.9		25		2.22		0.551	U
201-OcCB	0.536	U	1.59	J	1.56	U	0.859	U	4.05		0.488	J	0.41	U
202-OcCB	0.477	U	0.679	U	1.69	J	2.74		0.628	U	0.344	U	0.363	U
203-OcCB	0.663	U	5.02		1.92	U	1.06	U	10.5		0.5	U	1.47	
204-OcCB	0.55	U	0.771	U	1.6	U	0.881	U	0.728	U	0.39	U	0.4	U
205-OcCB	0.473	U	0.97	U	0.556	U	0.941	U	1.29	U	0.385	U	0.441	U
206-NoCB	0.983	U	8.1		1.59	U	1.44	U	17.3		0.613	U	4.53	
207-NoCB	0.779	U	1.33	U	1.31	U	1.14	U	3.14		0.495	U	0.647	U
208-NoCB	0.694	U	2.77		1.68	J	2.99		6.74		0.485	U	2.03	
209-DeCB	0.823	J	7.18		3.92		1.18	U	20.7		0.533	U	20.6	
Total PCBs (0 DL)	151.8		1324.8		686.5		1262.5		2373.4		314.1		390.3	
TEQ WHO-05 (1 DL)	0.062		0.110		0.110		0.122		0.098		0.035		0.044	
TEQ WHO-05 (1/2 DL)	0.031		0.056		0.056		0.063		0.052		0.018		0.022	
TEQ WHO-05 (0 DL)	0.000		0.002		0.002		0.003		0.005		0.001		0.001	

Sample ID	R_HOL_3		R_HOL_4		R_HOL_7		R_SAM_0		R_SAM_1		R_SAM_3		R_SAM_4	
Analyte (pg/g)	8/3/2008	Q	8/3/2008	Q	8/3/2008	Q	8/1/2008	Q	8/1/2008	Q	8/1/2008	Q	8/1/2008	Q
126-PeCB	0.277	U	1.03	U	0.757	U	1.04	U	0.456	U	0.653	U	0.822	U
127-PeCB	0.195	U	0.715	U	0.592	U	0.821	U	0.377	U	0.575	U	0.72	U
128+166-HxCB	1.96		9.79		11.9		2.27	J	2.78		0.556	U	0.495	U
129+138+163-HxCB	11.8		59.1		72.5		22.3		15.4		17.4		11.3	
130-HxCB	0.24	U	4.99		5.74		1.1	U	1.24	J	1.12	J	0.614	U
131-HxCB	0.197	U	0.811	U	1.17	U	0.89	U	0.695	U	0.557	U	0.495	U
132-HxCB	3.64		19.4		22.7		1.04	U	3.96		4.36		0.58	U
133-HxCB	0.257	J	0.918	U	1.79	J	1.02	U	0.799	U	0.64	U	0.569	U
134-HxCB	0.196	U	2.4		1.15	U	1.58	J	0.695	U	0.556	U	0.495	U
135+151-HxCB	4.53		19.6		24.8		16		0.544	U	0.627	U	0.6	U
136-HxCB	1.43		7.89		8.72		7.66		0.401	U	1.5		1.13	J
137-HxCB	0.189	U	3.06		1.12	U	0.901	U	0.704	U	0.7	J	0.502	U
139+140-HxCB	0.2	U	0.823	U	1.15	U	0.923	U	0.721	U	0.578	U	0.514	U
141-HxCB	1.31		1.03	U	7.21		5.24		0.862	U	2.7		1.87	
142-HxCB	0.264	U	1.08	U	1.44	U	1.1	U	0.859	U	0.687	U	0.612	U
143-HxCB	0.269	U	1.11	U	1.46	U	1.1	U	0.862	U	0.69	U	0.614	U
144-HxCB	0.429	J	0.938	U	2.65		2.59		0.53	UJ	0.612	U	0.586	U
145-HxCB	0.262	U	0.752	U	0.463	U	0.961	U	0.414	U	0.477	U	0.457	U
146-HxCB	1.79		9.14		12		0.791	U	0.618	U	2.45		1.43	J
147+149-HxCB	9.57		46		67.1		31.6		7.97		9.01		0.584	U
148-HxCB	0.338	U	0.971	U	0.617	U	1.23	U	0.531	U	0.613	U	0.587	U
150-HxCB	0.268	U	0.769	U	0.477	U	0.925	U	0.398	U	0.459	U	0.439	U
152-HxCB	0.236	U	0.677	U	0.432	U	0.897	U	0.386	U	0.446	U	0.426	U
153+168-HxCB	11.8		56.6		68		27.7		13.9		15.6		10.7	
154-HxCB	0.295	U	1.51	J	1.65	J	1.09	U	0.47	U	0.543	U	0.52	U
155-HxCB	0.108	U	0.358	U	0.325	U	0.713	U	0.334	U	0.336	U	0.282	U
156+157-HxCB	1.22	J	5.57		6.51		0.819	U	2.08	J	0.702	U	1.5	J
158-HxCB	0.155	U	4.91		5.61		0.7	U	0.548	UJ	1.7		0.39	U
159-HxCB	0.319	U	1.33	U	0.65	U	0.642	U	0.575	U	0.531	U	0.642	U
160-HxCB	0.199	U	0.816	U	1.16	U	0.905	U	0.707	U	0.566	U	0.504	U
161-HxCB	0.186	U	0.766	U	1.07	U	0.855	U	0.668	U	0.535	U	0.476	U
162-HxCB	0.329	U	1.38	U	0.69	U	0.674	U	0.604	U	0.557	U	0.674	U
164-HxCB	0.182	U	0.749	U	3.76		0.816	U	0.795	J	0.511	U	0.454	U
165-HxCB	0.176	U	0.722	U	1.01	U	0.828	U	0.647	U	0.518	U	0.461	U
167-HxCB	0.548	J	2.27		2.75		0.747	U	0.771	J	1	J	0.773	J
169-HxCB	0.394	U	1.54	U	0.717	U	0.716	U	0.633	U	0.567	U	0.733	U
170-HpCB	2.23		9.77		14.9		4.77		0.481	U	4.33		0.813	U
171+173-HpCB	0.87	J	1.61	U	4.95		0.716	U	0.479	U	1.46	J	0.809	U
172-HpCB	0.348	U	2.4		1.02	U	0.693	U	0.839	J	0.917	U	0.783	U
174-HpCB	2.51		10.9		14.7		0.682	U	0.456	U	3.41		0.77	U
175-HpCB	0.394	U	1.15	U	0.853	U	1.11	U	0.662	U	0.842	U	0.928	U
176-HpCB	0.314	U	1.97	J	0.676	U	1.34	J	0.507	U	0.646	U	0.712	U
177-HpCB	1.82		8.74		11.6		0.689	U	0.46	U	3.14		0.778	U
178-HpCB	0.424	U	3.34		0.93	U	1.7	J	1.08	J	0.92	J	0.981	U
179-HpCB	0.305	U	6.21		8.17		4.24		0.491	U	0.624	U	0.688	U
180+193-HpCB	3.55		18.2		27.4		0.51	U	0.34	U	7.84		0.575	U
181-HpCB	0.289	U	1.38	U	0.828	U	0.64	U	0.427	U	0.846	U	0.723	U
182-HpCB	0.405	U	1.18	U	0.883	U	1.09	U	0.651	U	0.828	U	0.913	U
183+185-HpCB	1.65	J	7.76		10.7		0.622	U	0.416	U	2.4	J	0.703	U
184-HpCB	0.299	U	0.87	U	0.625	U	0.828	U	0.495	U	0.63	U	0.694	U
186-HpCB	0.325	U	0.947	U	0.699	U	0.888	U	0.53	U	0.675	U	0.744	U
187-HpCB	4.14		17.8		29.5		1.06	U	0.63	U	0.802	U	0.885	U
188-HpCB	0.258	U	0.733	U	0.548	U	0.758	U	0.459	U	0.608	U	0.663	U
189-HpCB	0.424	U	1.41	U	1.08	U	0.663	U	0.66	U	0.648	U	0.555	U
190-HpCB	0.27	U	1.56	J	0.782	U	0.6	J	0.375	U	0.743	U	0.634	U
191-HpCB	0.254	U	1.21	U	0.759	U	0.525	U	0.351	U	0.694	U	0.593	U
192-HpCB	0.273	U	1.3	U	0.828	U	0.564	U	0.377	U	0.746	U	0.637	U
194-OcCB	0.352	U	5.3		7.42		1.47	U	2.1		0.957	U	0.735	U
195-OcCB	0.524	J	1.98	J	2.74		1.57	U	1.12	J	1.02	U	0.787	U
196-OcCB	0.455	U	3.35		4.69		1.2	U	0.568	U	0.929	U	0.83	U
197+200-OcCB	0.356	U	1.03	U	1.58	J	0.943	U	0.639	J	0.728	U	0.651	U
198+199-OcCB	1.51	J	8.31		11.1		1.29	U	4.04		0.995	U	0.889	U
201-OcCB	0.355	U	1.02	U	1.68	J	0.937	U	0.717	J	0.723	U	0.647	U
202-OcCB	0.305	U	2.44		2.89		0.864	U	0.436	U	0.718	U	0.622	U
203-OcCB	0.451	U	3.31		5.9		1.19	U	2.42		0.916	U	0.819	U
204-OcCB	0.352	U	1.01	U	0.886	U	0.956	U	0.452	U	0.738	U	0.66	U
205-OcCB	0.353	U	1.05	U	1.03	U	1.35	U	0.709	U	0.805	U	0.641	U
206-NoCB	1.4		1.78	U	7.28		1.34	U	0.75	U	1	U	0.91	U
207-NoCB	0.486	U	1.41	U	1.15	J	1.07	U	0.62	U	0.82	U	0.743	U
208-NoCB	0.465	U	1.35	U	2.91		1.06	U	0.779	J	0.833	U	0.756	U
209-DeCB	1.14		4.51		9.43		6.15	U	1.68		2.13		0.739	U
Total PCBs (0 DL)	222.0		1061.1		1410.2		265.0		213.8		275.3		157.2	
TEQ WHO-05 (1 DL)	0.040		0.152		0.101		0.126		0.066		0.083		0.105	
TEQ WHO-05 (1/2 DL)	0.020		0.077		0.052		0.063		0.033		0.042		0.053	
TEQ WHO-05 (0 DL)	0.001		0.002		0.003		0.000		0.001		0.001		0.001	

Notes:

mg/kg = milligrams per kilogram

ug/kg = micrograms per kilogram

pg/g = picogram per gram

U = Result should be considered not-detected at the quantitation limit shown

J = Result is an estimated concentration

R = Rejected - Quality Control indicates the data is not usable

UJ = The compound was not detected and the sample detection limit should be considered an estimated value

TEF = Toxicity Equivancy Factor

Table A-12e. US EPA/USACE "Bold Study" Analytical Data-PCB Congeners

Sample ID	R_SAM_5		SCPS_1		SCPS_10_C		SCPS_2		SCPS_3		SCPS_5		SJF_10_C		SJF_12_C_GS	
Analyte (pg/g)	8/1/2008	Q	8/4/2008	Q	8/5/2008	Q	8/4/2008	Q	8/4/2008	Q	8/4/2008	Q	8/1/2008	Q	8/2/2008	Q
1-MoCB	0.241	U	2.8		0.0943	U	0.0999	U	0.091	U	5.13		0.0897	U	0.278	U
2-MoCB	0.256	U	2.31		0.0967	U	0.106	U	0.0988	U	0.331	U	0.0927	U	0.298	U
3-MoCB	0.253	U	2.75		0.0923	U	0.105	U	0.0994	U	3.9		0.0892	U	0.303	U
4-DiCB	1.22	U	4.74		0.479	U	0.254	U	0.547	U	6.11		0.463	U	0.945	U
5-DiCB	1.08	U	1.41	U	0.499	U	0.484	U	0.413	U	1.47	U	0.276	U	1.01	U
6-DiCB	2.45		3.06		0.442	U	0.428	U	0.366	U	1.3	U	0.244	U	0.841	U
7-DiCB	0.928	U	1.22	U	0.43	U	0.417	U	0.356	U	1.26	U	0.238	U	0.863	U
8-DiCB	0.841	U	19.2		0.39	U	0.378	U	0.323	U	25.7		0.216	U	0.759	U
9-DiCB	0.95	U	1.24	U	0.44	U	0.427	U	0.364	U	1.29	U	0.244	U	0.867	U
10-DiCB	1.03	U	0.865	U	0.386	U	0.217	U	0.479	U	1.31	U	0.403	U	0.81	U
11-DiCB	0.958	U	1.26	U	0.444	U	0.43	U	0.368	U	1.31	U	0.246	U	0.867	U
12+13-DiCB	0.949	U	2.44	J	1.39	J	0.71	J	0.67	J	1.29	JU	0.916	J	2.16	J
14-DiCB	0.926	U	1.21	U	0.429	U	0.416	U	0.355	U	1.26	U	0.237	U	0.869	U
15-DiCB	1.2	U	21.1		0.54	U	0.543	U	0.469	U	28.2		0.311	U	1.08	U
16-TrCB	1.06	U	6.33		0.281	U	0.332	U	0.326	U	7.43		0.328	U	5.98	
17-TrCB	0.89	U	7.12		0.237	U	0.28	U	0.275	U	7.91		0.277	U	0.759	U
18+30-TrCB	0.783	U	10.8		0.208	U	0.246	U	0.242	U	13.5		0.244	U	9	
19-TrCB	0.755	U	1.24	J	0.238	U	0.291	U	0.291	U	0.944	U	0.295	U	0.742	U
20+28-TrCB	0.666	U	59.4		0.177	U	0.21	U	0.206	U	69.8		0.208	U	0.563	U
21+33-TrCB	0.653	U	20.3		0.174	U	0.206	U	0.202	U	23.9		0.203	U	0.533	U
22-TrCB	0.764	U	18.3		0.203	U	0.24	U	0.236	U	23.3		0.238	U	0.622	U
23-TrCB	0.702	U	0.714	U	0.187	U	0.221	U	0.217	U	0.739	U	0.219	U	0.587	U
24-TrCB	0.691	U	0.702	U	0.184	U	0.218	U	0.214	U	0.769	J	0.215	U	0.595	U
25-TrCB	0.547	U	3.55		0.146	U	0.172	U	0.169	U	3.99		0.17	U	0.464	U
26+29-TrCB	4.81		7.1		0.179	U	0.211	U	0.208	U	8.63		0.209	U	4.77	
27-TrCB	0.638	U	1.21	J	0.17	U	0.201	U	0.198	U	0.671	U	0.199	U	1.12	J
31-TrCB	0.686	U	0.698	U	0.183	U	0.216	U	0.212	U	0.722	U	0.214	U	0.561	U
32-TrCB	0.616	U	7.74		7.27		2.63		0.191	U	0.648	U	0.192	U	4.09	
34-TrCB	0.699	U	0.71	U	0.186	U	0.22	U	0.216	U	0.735	U	0.217	U	0.565	U
35-TrCB	1.91	U	1.47	U	0.367	U	0.728	J	0.312	U	1.96	J	0.556	U	1.51	U
36-TrCB	1.76	U	1.35	U	0.337	U	0.325	U	0.287	U	1.43	U	0.512	U	1.37	U
37-TrCB	2.29	U	23.6		15.5		7.06		0.32	U	31		0.565	U	1.52	U
38-TrCB	1.84	U	1.41	U	0.352	U	0.339	U	0.299	U	1.5	U	0.534	U	1.39	U
39-TrCB	1.77	U	1.36	U	0.338	U	0.326	U	0.288	U	1.44	U	0.513	U	1.36	U
40+71-TeCB	0.724	U	12.5		11.1		4.02		2.6		15.4		0.332	U	7.11	
41-TeCB	1.88	J	1.02	U	1.3		0.443	U	0.377	U	1.19	U	0.372	U	1.3	J
42-TeCB	3.04		6.61		6.31		2.24		0.35	U	8.85		0.346	U	0.905	U
43-TeCB	0.919	U	1.15	U	0.428	U	0.502	U	0.426	U	1.34	U	0.421	U	1.22	U
44+47+65-TeCB	13.7		25.4		21.4		0.365	U	5.53		32.4		0.307	U	14.1	
45+51-TeCB	2	J	0.608	U	0.443	U	0.316	U	0.913	J	4.62	J	0.204	U	1.51	U
46-TeCB	1.03	U	1.52	J	1.16		0.546	J	0.456	J	0.845	U	0.369	J	1.67	U
48-TeCB	0.741	U	0.929	U	0.345	U	0.404	U	0.344	U	5.15		0.339	U	2.51	
49+69-TeCB	8.34		18.7		16.4		6.07		0.294	U	0.925	U	0.29	U	0.763	U
50+53-TeCB	1.54	J	3.56	J	0.425	U	1.24	J	0.251	U	3.3	J	0.196	U	1.47	U
52-TeCB	19		30		23.5		0.381	U	0.324	U	36.8		0.32	U	14.9	
54-TeCB	0.45	U	0.29	U	0.2	U	0.153	U	0.125	U	0.368	U	0.103	U	0.682	U
55-TeCB	0.767	U	0.819	U	0.265	U	0.33	U	0.473	U	1.02	U	0.23	U	0.866	U
56-TeCB	8.58		17.4		14		0.305	U	0.437	U	20.8		5.12		9.69	
57-TeCB	0.705	U	0.753	U	0.243	U	0.303	U	0.434	U	0.934	U	0.211	U	0.771	U
58-TeCB	0.67	U	0.715	U	0.231	U	0.288	U	0.412	U	0.886	U	0.201	U	0.763	U
59+62+75-TeCB	0.577	U	0.724	U	2.34	J	0.801	J	0.268	U	0.843	U	0.264	U	0.672	U
60-TeCB	6		10.1		8.26		0.304	U	0.435	U	11.9		3.19		7.4	
61+70+74+76-TeCB	30.1		60.6		55.1		20.1		0.414	U	74.3		0.201	U	33.5	
63-TeCB	0.702	U	0.749	U	1.37		0.522	J	0.432	U	2.04	J	0.351	J	0.776	U
64-TeCB	5.19		9.76		7.98		3.12		0.229	U	11.3		2.35		6.3	
66-TeCB	18.3		40.9		36.6		13.1		0.432	U	50.8		0.21	U	20.2	
67-TeCB	0.646	U	1.26	J	1.27		0.278	U	0.398	U	1.39	J	0.193	U	0.723	U
68-TeCB	0.653	U	0.697	U	0.433	J	0.281	U	0.402	U	0.864	U	0.196	U	0.744	U
72-TeCB	0.649	U	0.693	U	0.418	J	0.279	U	0.4	U	0.859	U	0.194	U	0.746	U
73-TeCB	0.544	U	0.682	U	0.253	U	0.297	U	0.252	U	0.794	U	0.249	U	0.665	U
77-TeCB	3.01		0.916	U	6.57		0.347	U	0.509	U	8.65		0.244	U	1	U
78-TeCB	0.724	U	0.773	U	0.25	U	0.311	U	0.446	U	0.958	U	0.217	U	0.832	U
79-TeCB	0.616	U	0.793	J	1.43		0.265	U	0.379	U	0.814	U	0.184	U	0.7	U
80-TeCB	0.633	U	0.676	U	0.219	U	0.273	U	0.39	U	0.838	U	0.19	U	0.72	U
81-TeCB	0.788	U	0.842	U	0.277	U	0.348	U	0.491	U	1.06	U	0.241	U	0.941	U
82-PeCB	1.35	U	1.37	U	6.45		2.17		0.704	U	8.52		1.24		1.16	U
83-PeCB	1.28	U	2.77		2.92		1.11		0.668	U	1.16	U	0.376	U	1.03	U
84-PeCB	6.54		1.37	U	10.8		0.403	U	0.707	U	14.7		0.398	U	4.98	
85+116+117-PeCB	5.62		1.01	U	10.5		3.07		2.27		14.8		1.93		4.89	
86+87+97+108+119+125-PeCB	23.7		35.8		35.4		0.309	U	7.63		47.8		0.305	U	17.6	
88+91-PeCB	1.28	U	7.77		7.11		2.55		1.91		9.09		0.375	U	1.02	U
89-PeCB	1.33	U	1.35	U	0.477	U	0.396	U	0.695	U	1.2	U	0.391	U	1.12	U
90+101+113-PeCB	33.9		58.2		52.5		18.6		13.1		73.5		0.324	U	32.7	
92-PeCB	5.1		9.65		8.94		0.376	U	2.23		14		1.57		5.19	
93+100-PeCB	1.23	U	1.25	U	0.441	U	0.367	U	0.643	U	1.11	U	0.362	U	0.952	U
94-PeCB	1.38	U	1.4	U	0.493	U	0.41	U	0.719	U	1.25	U	0.405	U	1.13	U
95-PeCB	20.6		32.5		31.9		12.8		8.78		41.7		0.369	U	18.3	
96-PeCB	0.672	U	0.71	U	0.221	U	0.231	U	0.278	U	0.782	U	0.23	U	0.835	U
98+102-PeCB	1.27	U	1.78	J	0.455	U	0.715	J	0.664	U	2.22	J	0.374	U	1.08	U
99-PeCB	15.7		33.9		30.1		10.2		6.48		41.3		4.81		12.2	
103-PeCB	1.16	U	1.18	U	0.415	U	0.345	U	0.605	U	1.05	U	0.341	U	0.963	U
104-PeCB	0.529	U	0.552	U	0.16	U	0.173	U	0.206	U	0.592	U	0.171	U	0.581	U
105-PeCB	9.65		28.3		28.2		8.66		5.05		34.7		0.34	U	9.87	
106-PeCB	0.801	U	0.865	U	0.327	U	0.368	U	0.349	U	1	U	0.319	U	0.791	U
107+124-PeCB	1.6	J	0.833	U	2.81		0.846	J	0.336	U	0.967	U	0.307	U	0.702	U
109-PeCB	1.97	J	5.06		5.5		0.291	U	0.275	U	0.793	U	0.252	U	2.54	
110+115-PeCB	33		57.1		55.3		18.5		11		69.8		8.97		30.1	
111-PeCB	0.939	U	0.951	U	0.336	U	0.279	U	0.49	U	0.848	U	0.276	U	0.777	U
112-PeCB	1.01	U	1.02	U	0.359	U	0.299	U	0.524	U	0.907	U	0.295	U	0.84	U
114-PeCB	0.915	U	0.941	UJ	1.11		0.405	U	0.401	U	1.14	U	0.359	U	0.839	U
118-PeCB	28.7		73.6		70.5		22.5		13.2		91		10.8		28.7	
120-PeCB	0.881	U	0.892	U	0.315	U	0.262	U	0.459	U	0.795	U	0.258	U	0.726	U
121-PeCB	0.944	U	0.956	U	0.338	U	0.281	U	0.492	U	0.852	U	0.277	U	0.79	U
122-PeCB	0.779	U	0.84	U	0.687	J	0.358	U	0.339	U	0.975	U	0.31	U	0.713	U
123-PeCB	0.803	U	0.852	U	1.03		0.538	J	0.342	U	0.995	U	0.309	U	0.721	U

Sample ID	SJF_2		SJF_3		SJF_9_C		SJI_0		SJI_1		SJI_20_C_GS		SJI_3		SJI_8_C		SPSB_0		SPSB_1		SPSB_2	
Analyte (pg/g)	8/1/2008	Q	8/1/2008	Q	8/1/2008	Q	8/1/2008	Q	8/2/2008	Q	8/2/2008	Q	8/2/2008	Q	8/2/2008	Q	8/3/2008	Q	8/3/2008	Q	8/3/2008	Q
1-MoCB	0.0776	U	0.075	U	0.125	U	0.125	U	0.0903	U	0.133	U	0.102	U	0.105	U	2.61		0.247	U	3.57	
2-MoCB	0.082	U	0.0785	U	0.124	U	0.132	U	0.1	U	0.136	U	0.109	U	0.0979	U	0.178	U	0.257	U	0.22	U
3-MoCB	0.0711	U	0.0675	U	0.102	U	0.115	U	0.0907	U	0.133	U	0.111	U	0.0885	U	2.71		3.11		3	
4-DiCB	1.57		1.66		2.38		0.634	U	3.02		3.87		2.06		1.91		5.37		8.12		7.8	
5-DiCB	0.247	U	0.247	U	0.203	U	0.358	U	0.211	U	0.628	U	0.309	U	0.287	U	0.414	U	24.2		1.09	U
6-DiCB	0.229	U	0.229	U	0.188	U	0.331	U	1.85		2.49		0.257	U	0.238	U	2.28		1.06	U	2.66	
7-DiCB	0.23	U	0.28	J	0.189	U	0.332	U	0.196	U	0.578	J	0.264	U	0.245	U	0.734	J	1.09	U	0.933	U
8-DiCB	0.214	U	0.214	U	0.176	U	0.309	U	0.182	U	0.472	U	0.232	U	0.215	U	0.311	U	18.1		18.2	
9-DiCB	0.315	J	0.235	U	0.193	U	0.339	U	0.6	J	0.807	J	0.468	J	0.408	J	0.355	U	1.09	U	0.938	U
10-DiCB	0.222	U	0.229	U	0.246	U	0.494	U	0.345	U	0.507	U	0.324	U	0.315	U	0.771	U	1.01	U	0.66	U
11-DiCB	0.233	U	0.233	U	0.192	U	0.337	U	0.199	U	0.538	U	0.265	U	0.246	U	0.355	U	1.09	U	0.937	U
12+13-DiCB	0.232	U	1.02	J	1.35	J	1.55	J	1.26	J	0.545	U	0.268	U	0.249	U	0.359	U	1.1	U	2.53	J
14-DiCB	0.233	U	0.233	U	0.191	U	0.337	U	0.199	U	0.539	U	0.266	U	0.246	U	0.356	U	1.09	U	0.939	U
15-DiCB	0.281	U	0.285	U	0.231	U	0.403	U	0.242	U	0.662	U	0.325	U	0.289	U	20		1.37	U	1.17	U
16-TrCB	1.86		2.1		3.3		0.343	U	3.56		8.67		2.41		2.46		5.34		0.933	U	5.39	
17-TrCB	2.19		2.24		3.38		3.62		3.85		8.1		2.48		2.38		6.67		7.09		7.65	
18+30-TrCB	0.16	U	0.148	U	0.134	U	0.294	U	0.3	U	15.9		0.272	U	0.192	U	9.1		9.68		10.3	
19-TrCB	0.427	J	0.522	J	0.671	J	0.772	J	0.308	U	1.65	J	0.326	U	0.21	U	1.62	J	2.17	J	1.71	J
20+28-TrCB	0.126	U	0.117	U	0.106	U	0.232	U	0.236	U	51.8		0.228	U	0.161	U	45.7		42.9		45.5	
21+33-TrCB	0.12	U	0.111	U	0.1	U	0.22	U	0.224	U	20.1		0.216	U	0.152	U	0.293	U	0.563	U	0.603	U
22-TrCB	0.135	U	0.125	U	0.113	U	0.249	U	0.253	U	18.3		0.252	U	0.178	U	0.341	U	14.2		0.704	U
23-TrCB	0.132	U	0.123	U	0.111	U	0.243	U	0.248	U	0.364	U	0.238	U	0.168	U	0.323	U	0.621	U	0.665	U
24-TrCB	0.142	U	0.131	U	0.119	U	0.26	U	0.265	U	0.369	U	0.241	U	0.17	U	0.327	U	1.33	J	3.63	
25-TrCB	0.105	U	0.0971	U	0.0879	U	0.193	U	0.196	U	2.79		0.188	U	0.133	U	2.23		0.491	U	0.525	U
26+29-TrCB	0.126	U	0.117	U	0.106	U	0.232	U	0.236	U	6.09		0.221	U	0.156	U	4.12	J	3.93	J	0.618	U
27-TrCB	0.13	U	0.407	J	0.628	J	0.748	J	0.244	U	0.341	U	0.451	J	0.157	U	0.302	U	1.23	J	1.42	J
31-TrCB	0.127	U	0.117	U	0.106	U	0.232	U	0.237	U	35.2		0.227	U	0.16	U	27.6		25.6		27.4	
32-TrCB	0.123	U	0.115	U	0.104	U	0.227	U	0.231	U	6.11		0.21	U	0.148	U	7.84		9.86		9.52	
34-TrCB	0.133	U	0.124	U	0.112	U	0.245	U	0.25	U	0.35	U	0.229	U	0.162	U	0.311	U	0.598	U	0.64	U
35-TrCB	0.727	J	0.203	U	0.255	U	1.07	J	0.746	U	1.12	U	0.462	U	0.393	U	0.738	U	1.67	J	1.59	J
36-TrCB	0.185	U	0.186	U	0.234	U	0.476	U	0.683	U	1.01	U	0.42	U	0.357	U	0.67	U	1.18	U	1.02	U
37-TrCB	0.214	U	0.209	U	0.262	U	0.563	U	0.856	U	1.16	U	0.444	U	0.4	U	0.715	U	15.7		1.16	U
38-TrCB	0.196	U	0.198	U	0.248	U	0.505	U	0.725	U	1.03	U	0.428	U	0.364	U	0.683	U	1.2	U	1.04	U
39-TrCB	0.186	U	0.187	U	0.236	U	0.48	U	0.688	U	1.01	U	0.419	U	0.356	U	0.669	U	1.18	U	1.02	U
40+71-TeCB	0.207	U	0.231	U	5.44		5.06		0.191	U	10.3		0.304	U	0.214	U	10.6		8.95		0.779	U
41-TeCB	0.625	J	0.265	U	1.07	J	0.951	J	0.696	J	0.395	U	0.282	U	0.199	U	0.467	U	0.815	U	0.725	U
42-TeCB	0.21	U	0.235	U	0.249	U	0.322	U	0.194	U	5.41		0.304	U	0.214	U	0.503	U	5.91		6.04	
43-TeCB	0.275	U	0.307	U	0.326	U	0.421	U	0.254	U	0.572	U	0.409	U	0.288	U	0.676	U	1.18	U	1.05	U
44+47+65-TeCB	0.197	U	0.219	U	11.4		10.7		0.181	U	21.1		0.269	U	0.189	U	21		19.5		23.1	
45+51-TeCB	0.913	J	1.01	J	1.48	J	1.48	J	1.49	J	3.64		0.401	U	0.995	J	0.765	U	4.23	J	0.479	U
46-TeCB	0.253	U	0.238	J	0.186	U	0.204	U	0.505	J	0.331	U	0.442	U	0.222	U	0.844	U	1.15	U	1.43	J
48-TeCB	0.217	U	1.35		2.04		2.13		1.86		0.422	U	0.99	J	1.12		3.27		0.871	U	0.774	U
49+69-TeCB	3.95		4.68		7		6.22		5.34		11.8		0.256	U	4.28		14.5		14.3		16.8	
50+53-TeCB	0.226	U	0.694	J	0.167	U	1.08	J	0.363	U	2.76	J	0.39	U	0.196	U	0.744	U	3.5	J	3.61	J
52-TeCB	0.206	U	0.23	U	12.6		12.3		9.03		22.9		0.266	U	0.187	U	22		20.1		23.2	
54-TeCB	0.119	U	0.0869	U	0.0963	U	0.109	U	0.21	U	0.147	U	0.198	U	0.0951	U	0.378	U	0.495	U	0.236	U
55-TeCB	0.235	U	0.186	U	0.198	U	0.27	U	0.24	U	0.383	U	0.263	U	0.171	U	0.483	U	1.12	U	0.983	U
56-TeCB	0.225	U	0.179	U	8.72		7.88		0.231	U	14.1		4.32		0.155	U	12.3		9.29		11.7	
57-TeCB	0.212	U	0.168	U	0.179	U	0.245	U	0.217	U	0.341	U	0.234	U	0.153	U	0.43	U	0.993	U	0.875	U
58-TeCB	0.207	U	0.164	U	0.174	U	0.238	U	0.256	J	0.338	U	0.232	U	0.151	U	0.426	U	0.983	U	0.866	U
59+62+75-TeCB	0.603	J	0.848	J	1.04	J	0.256	U	0.838	J	0.316	U	0.226	U	0.159	U	2.13	J	2.18	J	2.3	J
60-TeCB	0.22	U	0.174	U	0.185	U	0.254	U	0.225	U	9.78		0.241	U	0.157	U	8.26		1.02	U	7.03	
61+70+74+76-TeCB	0.207	U	19.6		31.3		26.3		0.212	U	42.7		0.232	U	0.152	U	44		32.5		42	
63-TeCB	0.21	U	0.167	U	0.177	U	0.786	J	0.215	U	1.07	J	0.331	J	0.342	J	0.433	U	0.999	U	0.881	U
64-TeCB	2.51		0.16	U	4.64		4.05		3.17		7.71		2.79		2.34		8.06		6.47		0.506	U
66-TeCB	0.213	U	12.5		19.6		16.2		0.218	U	25.8		0.231	U	0.15	U	28.8		21.3		29.5	
67-TeCB	0.271	J	0.384	J	0.613	J	0.224	U	0.199	U	0.32	U	0.219	U	0.143	U	1.04	J	0.931	U	0.82	U
68-TeCB	0.203	U	0.161	U	0.217	J	0.234	U	0.208	U	0.425	J	0.226	U	0.147	U	0.415	U	0.959	U	0.845	U
72-TeCB	0.206	U	0.163	U	0.173	U	0.237	U	0.211	U	0.33	U	0.226	U	0.148	U	0.416	U	0.96	U	0.846	U
73-TeCB	0.164	U	0.184	U	0.195	U	0.252	U	0.152	U	0.313	U	0.224	U	0.157	U	0.37	U	0.645	U	0.573	U
77-TeCB	0.243	U	1.96		2.64		2.3		1.78		0.439	U	1.37		1.47		5.69		1.22	U	1.12	U
78-TeCB	0.226	U	0.18	U	0.191	U	0.261	U	0.232	U	0.368	U	0.252	U	0.165	U	0.464	U	1.07	U	0.944	U
79-TeCB	0.187	U	0.148	U	0.157	U	0.215	U	0.191	U	0.31	U	0.212	U	0.139	U	0.391	U	0.903	U	0.795	U
80-TeCB	0.202	U	0.16	U	0.17	U	0.233	U	0.207	U	0.319	U	0.219	U	0.143	U	0.402	U	0.929	U	0.818	U
81-TeCB	0.241	U	0.192	U	0.19	U	0.262	U	0.231	U	0.391	U	0.275	U	0.182	U	0.492	U	1.21	U	1	U
82-PeCB	1.3		1.4		2.26		1.53		0.37	U	3.59		0.397	U	1.16		5.21		4.74		1.16	U
83-PeCB	0.324	U	0.683	J	0.886	J	0.78	J	0.337	U	0.586	U	0.351	U	0.456	J	0.606	U	2.41		1.02	U
84-PeCB	1.85		2.37		3.2		2.58		0.359	U	5.69		2.53		1.57		9.04		7.66		9.13	
85+116+117-PeCB	0.265	U	0.218	U	4.02		0.351	U	2.12	J	4.52		0.283	U	0.281	U	8.74		0.869	U	8.25	
86+87+97+108+119+125-PeCB	0.269	U	0.22	U	10.9		9.49		7.26		17.1		7.67		0.291	U	26.6		22.2		27.2	
88+91-PeCB	1.13	J	0.254	U	2.05	J	1.58	J	0.322	U	2.74	J	0.35	U	0.347	U	0.603	U	5.51		1.02	U
89-PeCB	0.332	U	0.272	U	0.251	U	0.439	U	0.345	U	0.639	U	0.383	U	0.38	U	0.661	U	1.18	U	1.12	U
90+101+113-PeCB	9.06		10.5		16.9		13.2		9.1		23.1		11.2		0.308	U	41.5		38.5		43.6	
92-PeCB	0.317	U	0.259	U	2.83		2.38		1.46		4.14		2.23		1.47		0.617	U	6.95		1.04	U
93+100-PeCB	0.295	U	0.242	U	0.223	U	0.389	U	0.306	U	0.543	U	0.326	U	0.323	U	0.561	U	0.999	U	0.948	U
94-PeCB	0.333	U	0.273	U	0.252	U	0.44	U	0.346	U	0.645	U	0.386	U	0.383	U	0.666	U	1.19	U	1.13	U
95-PeCB	0.298	U	6.27		9.39		7.98		0.31	U	15.8		0.355	U	0.352	U	27.1		1.09	U	28.3	
96-PeCB	0.172	U	0.182	U	0.149	U	0.239	U	0.206	U	0.378	U	0.248	U	0.194	U	0.494	U	0.716	U	0.766	U
98+102-PeCB	0.309	U	0.253	U	0.452	J	0.408	U	0.321	U	0.618	U	0.371	U	0.368	U	0.639	U	1.14	U	1.08	U
99-PeCB	4.82		5.84		9.62		0.378	U	5.52		11.7		5.41		0.306	U	22.9		21.5		25.2	
103-PeCB	0.281	U	0.23	U	0.212	U	0.371	U	0.292	U	0.549	U	0.329	U	0.327	U	0.567	U	1.01	U	0.959	U
104-PeCB	0.117	U	0.126	U	0.111	U	0.173	U	0.162	U	0.281	U	0.171	U	0.138	U	0.335	U	0.57	U	0.532	U
105-PeCB	0.247	U	5.12		9.11		6.66		0.209	U	10.8		0.326	U	4.32		19.5		14.7		18.1	
106-PeCB	0.235	U	0.219	U	0.295	U	0.483	U	0.209	U	0.444	U	0.325	U	0.386	U	0.594	U	1.07	U	1.28	U
107+124-PeCB	0.432	J	0.216	U	0.834	J	0.477	U	0.418	J	1.11	J	0.626	J	0.343	U	1.74	J	0.952	U	1.13	U
109-PeCB	0.189	U	0.94	J	0.237	U	0.389	U	0.168	U	0.319	U	0.917	J	0.749	J	3.74		0.771	U	3.64	
110+115-PeCB	0.228	U	10.7		16.7		13.7		9.32		23.5		11.2		8.54		42.8		37.9		42.7	
111-PeCB	0.244	U	0.2	U	0.184	U	0.322	U	0.253	U	0.443	U	0.266	U	0.264	U	0.458	U	0.815	U	0.774	U
112-PeCB	0.259	U	0.212	U	0.196	U	0.342	U	0.269	U	0.479	U	0.287	U	0.285	U	0.495	U	0.881	U	0.837	U
114-PeCB	0.269	U	0.397	J	0.335	U	0.573	U	0.227	U	0.474	U	0.351	U	0.406	U	0.945	J	1.05	U	1.32	U
118-PeCB	9.76		11.1		19.2		14.9		10		22		12.4		9.52		0.573	U	35.4		43.2	
120-PeCB	0.233	U	0.191	U	0.176	U	0.308	U	0.242	U	0.414	U	0.248	U	0.246	U	0.428	U	0.762	U	0.723	U
121-PeCB	0.235	U	0.193	U	0.178	U	0.311	U	0.244	U	0.451	U	0.27	U	0.268	U	0.466	U	0.828	U	0.787	U
122-PeCB	0.241	U	0.224	U	0.302	U	0.495	U	0.214	U	0.4	U	0.293	U	0.348	U	0.535	U	0.967	U	1.15	U
123-PeCB	0.245	U	0.219	U	0.301	U	0.468	U	0.205	U	0.382	U	0.294	U	0.346	U	0.56	U	1	U	1.16	U

Table A-12e. US EPA/USACE "Bold Study" Analytical Data-PCB Congeners

Sample ID	R_SAM_5		SCPS_1		SCPS_10_C		SCPS_2		SCPS_3		SCPS_5		SJF_10_C		SJF_12_C_GS	
Analyte (pg/g)	8/1/2008	Q	8/4/2008	Q	8/5/2008	Q	8/4/2008	Q	8/4/2008	Q	8/4/2008	Q	8/1/2008	Q	8/2/2008	Q
126-PeCB	1.03	U	1.18	U	0.39	U	0.465	U	0.414	U	1.28	U	0.424	U	1.09	U
127-PeCB	0.787	U	0.849	U	0.321	U	0.361	U	0.342	U	0.984	U	0.313	U	0.683	U
128+166-HxCB	1.84	U	15.5		14.3		4.8		0.34	U	17		1.84	J	8.79	
129+138+163-HxCB	44.1		101		81.4		27.3		15.7		101		0.338	U	80	
130-HxCB	2.53		6.49		5.86		1.9		0.418	U	7.02		0.698	J	1.97	U
131-HxCB	1.93	U	1.26	U	0.954	U	0.577	U	0.357	U	1.57	U	0.387	U	1.61	U
132-HxCB	15.7		28.3		22.2		7.79		4.53		30.1		0.451	U	23.2	
133-HxCB	2.14	U	1.65	J	1.3		0.639	U	0.396	U	1.74	U	0.429	U	1.81	U
134-HxCB	2.01	U	1.31	U	2.79		0.6	U	0.371	U	3.8		0.402	U	1.66	U
135+151-HxCB	13.1		30.7		21		7.1		4.75		28.3		0.3	U	22.6	
136-HxCB	1.38	U	9.27		7.13		2.62		0.353	U	10.6		0.235	U	1.05	U
137-HxCB	1.89	U	1.23	U	3.3		0.565	U	0.35	U	3.96		0.379	U	1.51	U
139+140-HxCB	1.99	U	1.3	U	0.983	U	0.594	U	0.368	U	1.62	U	0.398	U	1.63	U
141-HxCB	7.72		1.4	U	1.06	U	2.87		1.71		8.96		0.431	U	17.4	
142-HxCB	2.33	U	1.52	U	1.15	U	0.695	U	0.431	U	1.89	U	0.466	U	2.16	U
143-HxCB	2.39	U	1.55	U	1.18	U	0.713	U	0.442	U	1.94	U	0.478	U	2.04	U
144-HxCB	2.15		4.72		2.66		0.891	J	0.441	U	2.87	U	0.294	U	1.36	U
145-HxCB	1.4	U	0.477	U	0.208	U	0.303	U	0.359	U	2.34	U	0.24	U	1.07	U
146-HxCB	1.67	U	14.4		11.8		4.07		2.41		15.1		1.76		9.64	
147+149-HxCB	34		63.6		52.5		15.6		9.26		62.1		0.497	U	50.2	
148-HxCB	1.81	U	0.613	U	0.267	U	0.389	U	0.462	U	3.01	U	0.308	U	1.39	U
150-HxCB	1.36	U	0.461	U	0.201	U	0.293	U	0.348	U	2.26	U	0.232	U	1.07	U
152-HxCB	1.33	U	0.452	U	0.197	U	0.287	U	0.341	U	2.22	U	0.227	U	1.06	U
153+168-HxCB	42.8		97.2		76.6		26.7		16.7		94.5		0.329	U	83.2	
154-HxCB	1.52	U	0.516	U	0.225	U	0.328	U	0.389	U	2.53	U	0.259	U	1.19	U
155-HxCB	0.992	U	0.333	U	0.138	U	0.188	U	0.212	U	1.55	U	0.186	U	0.69	U
156+157-HxCB	5.26		13.1		10.3		3.44		1.86		12.2		0.908	U	8.51	
158-HxCB	4.08		0.952	U	6.97		2.62		1.29		8.51		0.293	U	8.26	
159-HxCB	0.884	U	1.68	U	0.881	U	0.459	U	0.376	U	1.4	U	0.748	U	1.28	U
160-HxCB	1.98	U	1.29	U	0.976	U	0.591	U	0.366	U	1.6	U	0.396	U	1.66	U
161-HxCB	1.73	U	1.13	U	0.856	U	0.518	U	0.321	U	1.41	U	0.347	U	1.45	U
162-HxCB	0.889	U	1.69	U	0.886	U	0.462	U	0.378	U	1.4	U	0.752	U	1.28	U
164-HxCB	3.23		7.43		5.36		1.49		0.314	U	5.2		0.34	U	6.49	
165-HxCB	1.72	U	1.12	U	0.85	U	0.514	U	0.318	U	1.4	U	0.345	U	1.47	U
167-HxCB	0.943	U	1.94	U	3.97		1.54		0.84	J	1.66	U	0.808	U	1.37	U
169-HxCB	0.982	U	1.8	U	0.95	U	0.503	U	0.425	U	1.52	U	0.8	U	1.46	U
170-HpCB	12.8		35.9		17.6		6.93		2.85		18.5		0.399	U	35.8	
171+173-HpCB	4.44		9.78		8.35		2.56		0.456	U	8.39		0.406	U	1.04	U
172-HpCB	1.75	U	5.69		3.03		1.18		0.445	UJ	2.17	U	0.524	J	1.03	U
174-HpCB	1.72	U	25.9		18.1		6.82		2.93		18.7		0.388	U	30.6	
175-HpCB	1.4	U	1.16	U	0.476	U	0.388	U	0.556	U	1.51	U	0.441	U	1.72	U
176-HpCB	1.14	U	0.948	U	2.68		0.799	J	0.536	J	3.49		0.359	U	4.07	
177-HpCB	7.33		19.9		14.8		4.88		2.39		17.4		0.402	U	17.3	
178-HpCB	2.45		8.14		8.08		2.39		0.605	U	8.19		0.847	J	6.39	
179-HpCB	4.72		12.9		9.12		3.35		1.56		12.7		0.347	U	10.8	
180+193-HpCB	23.4		59.5		32.4		13.1		5.73		29.6		4.2		65.1	
181-HpCB	1.66	U	1.38	U	0.975	U	0.639	U	0.421	U	2.05	U	0.375	U	0.9	U
182-HpCB	1.43	U	1.19	U	0.485	U	0.396	U	0.567	U	1.54	U	0.45	U	1.72	U
183+185-HpCB	1.6	U	17.5		12.9		4.54		0.407	U	12		0.362	U	15	
184-HpCB	1.08	U	0.895	U	0.366	U	0.299	U	0.428	U	1.16	U	0.339	U	1.28	U
186-HpCB	1.18	U	0.979	U	0.4	U	0.327	U	0.468	U	1.27	U	0.371	U	1.4	U
187-HpCB	14.4		40.5		32.4		10.8		6.19		38.5		0.416	U	33.4	
188-HpCB	1.06	U	0.866	U	0.364	U	0.307	U	0.441	U	1.15	U	0.342	U	1.16	U
189-HpCB	1.21	U	0.829	U	1.29	U	0.634	U	0.514	U	1.32	U	0.289	U	2.78	U
190-HpCB	1.38	U	7.81		3.45		1.34		0.351	U	4.79		0.312	U	7.97	
191-HpCB	1.32	U	1.09	U	0.773	U	0.506	U	0.334	U	1.63	U	0.297	U	1.52	J
192-HpCB	1.4	U	1.16	U	0.824	U	0.54	U	0.356	U	1.74	U	0.317	U	0.823	U
194-OcCB	5.96		23.2		10.2		4.91		1.81		10.9		0.55	U	13.8	
195-OcCB	2.21		9.97		2.81	U	0.743	U	0.777	U	6.53		0.579	U	1.74	U
196-OcCB	1.31	U	10.1		6.68		0.724	U	1.38		1.76	U	0.54	U	8.52	
197+200-OcCB	0.997	U	2.31	J	1.17	U	0.553	U	0.423	U	1.35	U	0.412	U	1.29	U
198+199-OcCB	5.91		26.6		19.5		6.79		0.567	U	23.1		0.553	U	15.2	
201-OcCB	1.08	U	3.6		2.9		0.857	J	0.459	U	3.33		0.449	J	1.31	U
202-OcCB	1.02	U	5.77		1.31	U	0.574	U	0.44	U	6.17		0.535	J	1.27	U
203-OcCB	1.27	U	15.3		8.97		0.703	U	0.538	U	11.4		0.525	U	1.63	U
204-OcCB	1.02	U	1.56	U	1.2	U	0.566	U	0.433	U	1.38	U	0.422	U	1.31	U
205-OcCB	1.48	U	2.57	U	2.01	U	0.572	U	0.596	U	3.91	U	0.456	U	1.44	U
206-NoCB	1.68	U	19.3		14.9		4.77		0.612	U	19.6		0.606	U	5.3	
207-NoCB	1.34	U	2.25		0.428	U	0.52	U	0.489	U	2.69		0.486	U	1.69	U
208-NoCB	1.39	U	5.94		0.454	U	0.532	U	0.913		6.43		0.505	U	1.64	U
209-DeCB	1.56	J	24.4		18.8		0.38	U	2.45		49.6		0.556	U	4.58	
Total PCBs (0 DL)	573.9		1596.2		1177.2		351.9		169.6		1733.7		52.5		904.8	
TEQ WHO-05 (1 DL)	0.134		0.176		0.072		0.063		0.055		0.179		0.067		0.155	
TEQ WHO-05 (1/2 DL)	0.068		0.090		0.038		0.032		0.028		0.092		0.034		0.078	
TEQ WHO-05 (0 DL)	0.002		0.003		0.004		0.001		0.001		0.005		0.000		0.001	

Sample ID	SJF_2		SJF_3		SJF_9_C		SJI_0		SJI_1		SJI_20_C_GS		SJI_3		SJI_8_C		SPSB_0		SPSB_1		SPSB_2	
Analyte (pg/g)	8/1/2008	Q	8/1/2008	Q	8/1/2008	Q	8/1/2008	Q	8/2/2008	Q	8/2/2008	Q	8/2/2008	Q	8/2/2008	Q	8/3/2008	Q	8/3/2008	Q	8/3/2008	Q
126-PeCB	0.302	U	0.262	U	0.396	U	0.645	U	0.256	U	0.566	U	0.398	U	0.485	U	0.698	U	1.17	U	1.52	U
127-PeCB	0.234	U	0.218	U	0.293	U	0.48	U	0.208	U	0.383	U	0.281	U	0.333	U	0.513	U	0.926	U	1.1	U
128+166-HxCB	1.65	J	2		4.12		2.79		1.85	J	2.89	J	2.15	J	1.98	J	0.734	U	7.06		9.71	
129+138+163-HxCB	11.5		14		24.2		17.9		11.5		16.4		12.8		9.8		61.8		42.7		50.7	
130-HxCB	0.798	J	0.865	J	1.66		1.26	J	0.358	U	1.22	J	0.738	U	0.933	J	4.4		2.71		1.28	U
131-HxCB	0.35	U	0.291	U	0.776	U	0.766	U	0.294	U	0.559	U	0.602	U	0.687	U	0.744	U	0.876	U	1.04	U
132-HxCB	2.68		3.49		6.11		4.33		3.09		5.69		3.91		2.89		0.908	U	13.7		15.9	
133-HxCB	0.398	U	0.331	U	0.883	U	0.872	U	0.334	U	0.632	U	0.68	U	0.776	U	0.841	U	1.1	J	1.18	U
134-HxCB	0.451	J	0.295	U	0.787	U	0.777	U	0.38	J	0.579	U	0.622	U	0.71	U	2.33		1.61	J	1.08	U
135+151-HxCB	3.93		4.39		6.7		5.19		0.503	U	4.94		0.28	U	0.232	U	17.2		13.6		16.7	
136-HxCB	1.05		0.271	U	2.16		0.835	U	0.358	U	2.08		0.215	U	0.178	U	6.02		5		5.83	
137-HxCB	0.363	U	0.301	U	0.804	U	0.794	U	0.304	U	0.526	U	0.617	J	0.646	U	0.7	U	0.823	U	0.981	U
139+140-HxCB	0.356	U	0.296	U	0.789	U	0.779	U	0.298	U	0.568	U	0.611	U	0.697	U	0.756	U	0.889	U	1.06	U
141-HxCB	1.37		0.34	U	0.906	U	0.894	U	0.343	U	2.67		1.98		1.29		6.44		1.1	U	4.08	
142-HxCB	0.433	U	0.36	U	0.96	U	0.948	U	0.363	U	0.754	U	0.811	U	0.926	U	1	U	1.18	U	1.41	U
143-HxCB	0.399	U	0.331	U	0.883	U	0.872	U	0.334	U	0.711	U	0.765	U	0.873	U	0.947	U	1.11	U	1.33	U
144-HxCB	0.312	U	0.363	U	0.238	U	1.12	U	0.479	U	0.819	U	0.28	U	0.41	J	0.614	U	0.717	U	2	J
145-HxCB	0.238	U	0.276	U	0.181	U	0.851	U	0.365	U	0.647	U	0.221	U	0.183	U	0.485	U	0.566	U	0.65	U
146-HxCB	1.77		0.271	U	3.51		2.61		1.73		2.08		1.69		1.47		9.2		7.2		8.3	
147+149-HxCB	0.391	U	4.88		13.3		7.69		6.35		11.1		5.36		0.832	U	23.4		27.8		33.5	
148-HxCB	0.313	U	0.364	U	0.238	U	1.12	U	0.48	U	0.836	U	0.285	U	0.237	U	0.627	U	0.731	U	0.839	U
150-HxCB	0.237	U	0.275	U	0.18	U	0.847	U	0.363	U	0.643	U	0.22	U	0.182	U	0.482	U	0.562	U	0.646	U
152-HxCB	0.232	U	0.27	U	0.177	U	0.83	U	0.356	U	0.635	U	0.217	U	0.18	U	0.476	U	0.555	U	0.638	U
153+168-HxCB	11.1		12.9		21.8		15.4		10.3		14.5		10.3		9		0.639	U	41.9		50.5	
154-HxCB	0.265	U	0.308	U	0.473	J	0.949	U	0.407	U	0.713	U	0.244	U	0.24	J	0.535	U	1.11	J	1.58	J
155-HxCB	0.131	U	0.161	U	0.104	U	0.627	U	0.305	U	0.512	U	0.148	U	0.141	U	0.305	U	0.429	U	0.432	U
156+157-HxCB	1.51	J	1.69	J	2.82		1.93	J	1.21	J	0.534	U	0.25	U	1.3	J	7.26		3.87	J	1.03	U
158-HxCB	0.274	U	1.21		2.16		1.52		1.04	J	1.41	J	1.38		0.537	U	5.82		3.9		0.817	U
159-HxCB	0.212	U	0.227	U	0.364	U	0.505	U	0.295	U	0.479	U	0.206	U	0.268	U	0.622	U	1.17	U	0.85	U
160-HxCB	0.326	U	0.271	U	0.722	U	0.713	U	0.273	U	0.58	U	0.624	U	0.712	U	0.772	U	0.908	U	1.08	U
161-HxCB	0.307	U	0.255	U	0.68	U	0.671	U	0.257	U	0.505	U	0.544	U	0.621	U	0.673	U	0.791	U	0.943	U
162-HxCB	0.215	U	0.231	U	0.369	U	0.512	U	0.299	U	0.479	U	0.206	U	0.268	U	0.621	U	1.17	U	0.849	U
164-HxCB	0.599	J	0.254	U	1.37		1.04	J	0.615	J	0.549	U	0.591	U	0.675	U	3.98		2.77		1.03	U
165-HxCB	0.321	U	0.267	U	0.711	U	0.702	U	0.269	U	0.513	U	0.552	U	0.63	U	0.683	U	0.804	U	0.958	U
167-HxCB	0.256	U	0.61	J	0.993	J	0.807	J	0.31	U	0.512	U	0.223	U	0.41	J	0.725	U	1.5	J	2.54	
169-HxCB	0.232	U	0.23	U	0.402	U	0.544	U	0.293	U	0.512	U	0.218	U	0.269	U	0.671	U	1.17	U	0.89	U
170-HpCB	2.89		0.275	U	5.95		0.474	U	0.281	U	3.18		2.54		0.392	U	16.9		7.28		8.81	
171+173-HpCB	0.291	U	0.996	J	1.71	J	1.01	J	0.272	U	1.09	J	0.884	J	0.851	J	1.2	U	3.01	J	4.33	J
172-HpCB	0.495	J	0.647	J	0.974	J	0.572	J	0.281	U	0.578	U	0.4	U	0.388	U	2.49		1.14	U	1.11	U
174-HpCB	0.296	U	0.271	U	0.361	U	3.06		0.277	U	0.579	U	0.4	U	0.389	U	15.7		8.59		10.1	
175-HpCB	0.461	U	0.52	U	0.37	U	0.5	U	0.423	U	0.668	U	0.488	U	0.357	U	0.942	U	1.38	U	1.4	U
176-HpCB	0.356	U	0.485	J	0.285	U	0.385	U	0.326	U	0.561	J	0.375	U	0.275	U	2.16		1.06	U	1.99	J
177-HpCB	2.11		2.43		3.8		2.66		1.9		2.38		0.396	U	0.385	U	12		1.13	U	9.68	
178-HpCB	0.484	U	0.884	J	1.67		0.524	U	0.444	U	1.24	J	0.591	J	0.665	J	5.02		1.47	U	3.67	
179-HpCB	1.32		1.4		2.53		1.45		1.17		1.56	J	0.844	J	0.961	J	7.33		5.48		7.28	
180+193-HpCB	0.217	U	6.79		9.77		6.15		4.41		5.74		0.289	U	0.281	U	28.2		11.1		12.4	
181-HpCB	0.276	U	0.253	U	0.337	U	0.436	U	0.259	U	0.503	U	0.348	U	0.338	U	1.04	U	0.991	U	0.967	U
182-HpCB	0.458	U	0.516	U	0.367	U	0.496	U	0.42	U	0.668	U	0.488	U	0.357	U	0.942	U	1.38	U	1.4	U
183+185-HpCB	0.272	U	0.25	U	3.44		2.24	J	0.255	U	1.79	J	0.347	U	0.338	U	8.89		6.05		8.36	
184-HpCB	0.34	U	0.383	U	0.272	U	0.368	U	0.311	U	0.497	U	0.363	U	0.266	U	0.701	U	1.02	U	1.04	U
186-HpCB	0.363	U	0.409	U	0.291	U	0.394	U	0.333	U	0.541	U	0.395	U	0.289	U	0.763	U	1.12	U	1.13	U
187-HpCB	4.49		5.42		9.02		6.14		4.14		5.34		0.457	U	0.334	U	25		17		23	
188-HpCB	0.328	U	0.391	U	0.256	U	0.339	U	0.293	U	0.44	U	0.353	U	0.239	U	0.678	U	0.974	U	1.03	U
189-HpCB	0.352	U	0.26	U	0.443	U	0.487	U	0.322	U	0.516	U	0.633	U	0.528	U	0.549	U	1.58	U	0.939	U
190-HpCB	0.237	U	0.217	U	1.07	J	0.374	U	0.222	U	0.451	U	0.494	J	0.303	U	3.98		0.89	U	0.868	U
191-HpCB	0.22	U	0.202	U	0.269	U	0.348	U	0.206	U	0.435	U	0.301	U	0.292	U	0.9	U	0.858	U	0.837	U
192-HpCB	0.244	U	0.224	U	0.298	U	0.386	U	0.229	U	0.46	U	0.318	U	0.309	U	0.951	U	0.908	U	0.885	U
194-OcCB	1.35		1.93		3.01		0.721	U	0.397	U	1.89		0.423	U	1.04		7.95		1.47	U	3.61	
195-OcCB	0.477	U	0.379	U	0.811	U	0.85	J	0.419	U	0.599	U	0.468	U	0.497	J	3.97		2.26	J	1.54	U
196-OcCB	0.948		0.994		1.74		0.571	U	0.455	U	1.21	J	0.754	U	0.398	U	5.85		2.97		1.61	U
197+200-OcCB	0.292	U	0.372	J	0.312	U	0.438	U	0.349	U	0.762	U	0.58	U	0.306	U	0.83	U	1.1	J	1.54	J
198+199-OcCB	0.397	U	2.9		4.57		0.595	U	0.474	U	2.49	J	0.796	U	0.42	U	14.2		7.82		10.5	
201-OcCB	0.301	J	0.326	J	0.733	J	0.442	U	0.352	U	0.777	U	0.592	U	0.366	J	0.846	U	1.43	J	1.27	U
202-OcCB	0.531	J	0.228	U	1.14		0.45	U	0.347	U	0.778	U	0.6	U	0.303	U	3.41		1.13	U	3.09	
203-OcCB	0.362	U	1.28		0.387	U	1.53		0.829	J	0.968	U	0.933	J	1.03		7.3		4.02		1.58	U
204-OcCB	0.298	U	0.218	U	0.318	U	0.446	U	0.356	U	0.774	U	0.59	U	0.311	U	0.844	U	1.08	U	1.26	U
205-OcCB	0.404	U	0.3	U	0.66	U	0.626	U	0.354	U	0.481	U	0.37	U	0.354	U	1.31	U	1.25	U	1.28	U
206-NoCB	1.21		1.49		2.3		0.636	U	0.484	U	1.1	U	0.974	J	0.911	J	7.82		4.25		6.72	
207-NoCB	0.318	U	0.342	U	0.336	U	0.521	U	0.399	U	0.943	U	0.491	U	0.441	U	0.98	U	1.41	U	1.42	U
208-NoCB	0.305	U	0.333	U	0.333	U	0.517	U	0.472	J	0.957	U	0.484	U	0.452	U	0.967	U	1.98	J	2.63	
209-DeCB	0.303	U	2.39		4.7		0.627	U	0.898	J	0.719	U	0.42	U	1.07		8.35		1.23	U	1.31	U
Total PCBs (0 DL)	98.4		183.6		379.4		268.1		136.2		601.2		119.3		82.6		869.8		796.5		887.0	
TEQ WHO-05 (1 DL)	0.038		0.034		0.053		0.082		0.035		0.073		0.047		0.057		0.092		0.154		0.181	
TEQ WHO-05 (1/2 DL)	0.019		0.017		0.027		0.041		0.018		0.037		0.024		0.029		0.046		0.078		0.092	
TEQ WHO-05 (0 DL)	0.000		0.001		0.001		0.001		0.001		0.001		0.001		0.001		0.001		0.002		0.002	

Notes:

mg/kg = milligrams per kilogram

ug/kg = micrograms per kilogram

pg/g = picogram per gram

U = Result should be considered not-detected at the quantitation limit shown

J = Result is an estimated concentration

R = Rejected - Quality Control indicates the data is not usable

UJ = The compound was not detected and the sample detection limit should be considered an estimated value

TEF = Toxicity Equivancy Factor

Table A-12e. US EPA/USACE "Bold Study" Analytical Data-PCB Congeners

Sample ID	SPSB_3		SPSB_8_C		SS_0		SS_1		SS_2		SS_8_C		SS_9_C		CPS_3_Dup		HC_2_Dup		NCPS_2_Dup		PSPS_1_Dup		SPSB_0_Dup	
Analyte (pg/g)	8/3/2008	Q	8/3/2008	Q	8/4/2008	Q	8/4/2008	Q	8/4/2008	Q	8/4/2008	Q	8/4/2008	Q	7/31/2008	Q	8/3/2008	Q	8/3/2008	Q	8/3/2008	Q	8/3/2008	Q
1-MoCB	0.0433	U	0.0305	U	0.11	U	0.0255	U	0.0489	U	0.0387	U	2.34	J	0.088	U	0.346	U	3.5		2.26		3.34	
2-MoCB	0.0544	U	0.036	U	0.123	U	0.0319	U	0.0547	U	0.0468	U	2.63	J	0.105	U	0.359	U	2.98		0.227	U	1.95	J
3-MoCB	0.0494	U	0.0311	U	0.101	U	0.0286	U	0.0449	U	0.0413	U	0.121	U	0.104	U	0.318	U	2.91		2.99		2.75	
4-DiCB	1.36		1.08		4.63		0.993		3.15		4.72		8.91		0.565	U	1.38	U	5.88		3.7		1.35	U
5-DiCB	0.301	U	0.21	U	0.84	U	0.16	U	0.266	U	0.248	U	1.03	U	0.503	U	1.47	U	0.792	U	1.37	U	1.02	U
6-DiCB	0.279	U	0.195	U	0.779	U	0.149	U	0.246	U	0.23	U	3.48		0.458	U	1.34	U	2.45		2.39		0.963	U
7-DiCB	0.28	U	0.196	U	0.927	J	0.149	U	0.485	J	0.231	U	0.955	U	0.577	J	1.31	U	0.893	J	1.31	U	0.978	U
8-DiCB	0.261	U	0.183	U	17.5		0.139	U	0.231	U	0.215	U	24.9		0.41	U	1.2	U	0.682	U	1.18	U	0.88	U
9-DiCB	0.281	U	0.197	U	0.787	U	0.15	U	0.249	U	0.498	J	0.96	U	0.457	U	1.34	U	0.76	U	1.32	U	0.982	U
10-DiCB	0.383	U	0.304	U	0.901	U	0.277	U	0.277	U	0.404	U	0.789	U	0.418	U	1.08	U	0.325	U	1.04	U	1.2	U
11-DiCB	0.291	U	0.203	U	0.812	U	0.155	U	0.257	U	0.239	U	0.991	U	0.461	U	1.35	U	0.749	U	1.3	U	0.967	U
12+13-DiCB	0.287	U	0.201	U	1.74	J	0.395	J	1.03	J	1.37	J	0.978	U	1.48	J	1.36	U	0.754	U	2.28	J	0.974	U
14-DiCB	0.284	U	0.199	U	0.794	U	0.151	U	0.251	U	0.234	U	0.969	U	0.453	U	1.33	U	0.729	U	1.26	U	0.943	U
15-DiCB	0.319	U	0.218	U	0.894	U	0.16	U	0.271	U	0.252	U	22		0.501	U	1.52	U	0.833	U	1.39	U	14.4	
16-TrCB	2.43		1.3		4.63		1.06		2.62		4.16		6.24		0.298	U	1.68	U	3.77		4.38		3.7	
17-TrCB	1.99		1.4		0.577	U	1.18		3.59		5.88		7.66		0.256	U	1.44	U	6.69		5.59		4.39	
18+30-TrCB	0.143	U	0.128	U	8.92		0.0822	U	0.158	U	8.09		0.517	U	0.223	U	9.17		9.11		8.22		6.81	
19-TrCB	0.167	U	0.151	U	1.36	J	0.25	J	0.74	J	0.243	U	0.552	U	0.262	U	1.31	U	1.64		0.596	U	0.729	U
20+28-TrCB	0.121	U	0.109	U	45		0.0696	U	0.134	U	39.4		66		0.188	U	1.06	U	0.204	U	0.374	U	0.498	U
21+33-TrCB	0.115	U	0.104	U	0.406	U	0.0663	U	0.127	U	0.177	U	22		0.181	U	1.01	U	0.194	U	0.357	U	0.474	U
22-TrCB	0.133	U	0.12	U	0.47	U	0.0768	U	0.147	U	0.205	U	0.483	U	0.207	U	1.16	U	0.221	U	0.406	U	0.541	U
23-TrCB	0.127	U	0.114	U	0.448	U	0.0732	U	0.14	U	0.195	U	0.46	U	0.189	U	1.06	U	0.218	U	0.401	U	0.534	U
24-TrCB	1.62		0.112	U	0.439	U	0.0717	U	0.137	U	0.191	U	0.451	U	0.186	U	1.04	U	2.65		0.403	U	0.537	U
25-TrCB	0.0991	U	0.0892	U	2.57		0.0571	U	0.11	U	2.29		3.82		0.15	U	0.842	U	0.165	U	0.303	U	0.403	U
26+29-TrCB	0.119	U	0.107	U	0.42	U	0.0687	U	0.132	U	4.02		5.9		0.185	U	1.04	U	4.03		0.373	U	3.36	J
27-TrCB	0.117	U	0.105	U	0.413	U	0.19	J	0.646	J	1.11		1.78	J	0.188	U	1.06	U	1.19		0.377	U	0.502	U
31-TrCB	0.122	U	0.11	U	25.6		0.0701	U	0.135	U	0.187	U	36.5		0.19	U	1.06	U	0.204	U	0.375	U	0.499	U
32-TrCB	0.114	U	0.103	U	8.05		0.0658	U	4.55		7.65		12.5		0.176	U	5.18		9.22		5.42		5.15	
34-TrCB	0.126	U	0.114	U	0.446	U	0.0728	U	0.14	U	0.194	U	0.458	U	0.196	U	1.1	U	0.213	U	0.391	U	0.52	U
35-TrCB	0.331	U	0.207	U	1.63	U	0.122	U	0.531	U	0.721	U	1.51	U	0.545	U	2.18	U	0.369	U	1.04	U	1.09	U
36-TrCB	0.299	U	0.187	U	1.47	U	0.11	U	0.479	U	0.651	U	1.37	U	0.486	U	1.94	U	0.328	U	0.923	U	0.967	U
37-TrCB	0.319	U	0.199	U	1.64	U	0.119	U	0.549	U	0.721	U	21.7		0.507	U	2.19	U	15.9		0.939	U	13.2	
38-TrCB	0.325	U	0.203	U	1.6	U	0.119	U	0.521	U	0.707	U	1.48	U	0.522	U	2.08	U	0.34	U	0.958	U	1	U
39-TrCB	0.325	U	0.203	U	1.6	U	0.119	U	0.521	U	0.707	U	1.48	U	0.482	U	1.92	U	0.332	U	0.936	U	0.98	U
40+71-TeCB	0.119	U	0.113	U	8.65		0.0971	U	5.75		9.58		14.5		7.63		0.976	U	13.1		0.515	U	0.87	U
41-TeCB	0.586	J	0.135	U	0.339	U	0.116	U	0.765	J	1.12		1.62	J	0.379	U	1.3	J	0.294	U	1.59	J	1.72	J
42-TeCB	0.122	U	0.116	U	4.95		0.0998	U	0.121	U	6.18		0.27	U	3.85		1.01	U	7.6		0.524	U	4.36	
43-TeCB	0.163	U	0.155	U	0.389	U	0.133	U	0.162	U	0.66	J	0.36	U	0.394	U	1.18	U	1.09		0.895	J	1.18	U
44+47+65-TeCB	0.112	U	0.106	U	19.2		0.0913	U	12.5		20.2		34.9		13.8		11.9		24.8		18.4		13.8	
45+51-TeCB	0.787	U	0.194	U	0.282	U	0.413	J	2.13		3.86		5.17	J	2.5		1.95	J	4.86		0.429	U	2.37	J
46-TeCB	0.851	U	0.21	U	0.305	U	0.0804	U	0.227	U	1.43		1.53	J	1.04		0.86	J	1.5		0.98	J	1.66	U
48-TeCB	0.125	U	0.119	U	3.08		0.362	J	1.81		3.13		0.275	U	0.341	U	1.03	U	3.78		0.515	U	2.82	
49+69-TeCB	0.106	U	2.09		15.5		0.0862	U	9.41		16.5		26.5		9.82		6.78		18.2		12.5		10.2	
50+53-TeCB	0.848	J	0.183	U	0.266	U	0.312	J	1.82	J	3.24		0.609	U	2.27		1.67	J	3.4		0.413	U	1.43	U
52-TeCB	0.117	U	0.112	U	22.5		0.0956	U	13.3		22.9		46.5		15.8		18.4		26.7		20.1		17.1	
54-TeCB	0.378	U	0.0929	U	0.132	U	0.0332	U	0.104	U	0.205	U	0.317	U	0.0802	U	0.255	U	0.129	U	0.238	U	0.781	U
55-TeCB	0.241	U	0.358	U	1.2	U	0.308	U	0.198	U	0.473	U	0.536	U	0.475	J	0.863	U	0.308	U	1.26	U	1.03	U
56-TeCB	3.26		0.335	U	9.57		0.288	U	6.04		11.3		15.6		8.52		5.45		15.7		12.7		0.936	U
57-TeCB	0.228	U	0.34	U	1.13	U	0.292	U	0.188	U	0.449	U	0.509	U	0.321	U	0.792	U	0.273	U	1.12	U	0.918	U
58-TeCB	0.222	U	0.331	U	1.11	U	0.285	U	0.183	U	0.437	U	0.495	U	0.322	U	0.793	U	0.271	U	1.11	U	0.911	U
59+62+75-TeCB	0.549	J	0.394	J	0.226	U	0.212	J	1.28	J	0.158	U	3.36	J	0.255	U	0.768	U	2.37	J	0.395	U	0.667	U
60-TeCB	0.223	U	0.332	U	1.11	U	0.286	U	0.184	U	0.439	U	8.77		5.19		0.795	U	8.55		6.86		5.4	
61+70+74+76-TeCB	0.212	U	0.315	U	36.5		0.271	U	24.5		40.1		65.5		30.8		20.3		57		46.4		34.6	
63-TeCB	0.218	U	0.324	U	1.08	U	0.279	U	0.179	U	1.23		0.485	U	0.912	J	0.765	UJ	1.75		1.12	U	0.924	U
64-TeCB	2.48		1.5		6.38		0.0687	U	4.39		7.17		11.1		4.94		4.59		9.1		7.51		0.587	U
66-TeCB	0.217	U	0.322	U	21.7		0.277	U	15.5		26.1		40.9		20.5		0.758	U	38		29.3		21.5	
67-TeCB	0.192	U	0.285	U	0.953	U	0.246	U	0.158	U	0.893	J	0.427	U	0.76	J	0.68	U	0.245	U	0.999	U	0.823	U
68-TeCB	0.202	U	0.3	U	1	U	0.258	U	0.445	J	0.396	U	0.687	J	0.304	U	0.749	U	0.26	U	1.06	U	0.873	U
72-TeCB	0.215	U	0.32	U	1.07	U	0.275	U	0.177	U	0.423	U	0.479	U	0.299	U	0.736	U	0.707	J	1.07	U	0.881	U
73-TeCB	0.0906	U	0.0862	U	0.215	U	0.0737	U	0.0898	U	0.15	U	0.199	U	0.25	U	0.752	U	0.201	U	0.373	U	0.632	U
77-TeCB	0.253	U	0.642	J	3.88		0.326	U	2.26		4.14		6.29		3.46		0.904	U	5.95		4.09		3.21	
78-TeCB	0.23	U	0.341	U	1.14	U	0.294	U	0.189	U	0.451	U	0.511	U	0.347	U	0.854	U	0.282	U	1.15	U	0.946	U
79-TeCB	0.191	U	0.283	U	0.947	U	0.244	U	0.157	U	0.374	U	0.425	U	0.278	U	0.686	U	0.236	U	0.963	U	0.793	U
80-TeCB	0.209	U	0.311	U	1.04	U	0.268	U	0.232	J	0.411	U	0.466	U	0.29	U	0.714	U	0.252	U	1.03	U	0.846	U
81-TeCB	0.251	U	0.372	U	1.28	U	0.329	U	0.208	U	0.471	U	0.554	U	0.359	U	0.857	U	0.286	U	1.14	U	0.977	U
82-PeCB	0.206	U	0.423	J	0.623	U	0.165	U	0.229	U	4.45		9.28		3.41		1.69	J	7.54		4.43		1	U
83-PeCB	0.45	J	0.204	U	0.587	U	0.155	U	1.08		2.79		0.647	U	1.98		0.808	U	4.13		0.716	U	1.01	U
84-PeCB	2.28		0.208	U	0.597	U	0.158	U	4.5		8.08		17.5		6.46		1.03	U	14.8		7.69		7.47	
85+116+117-PeCB	0.155	U	0.163	U	0.469	U	0.124	U	4.55		8.45		15.6		0.273	U	3.85	J	11.5		7.38		5.98	
86+87+97+108+119+125-PeCB	0.156	U	0.164	U	23.7		2.01	J	14.3		25.5		52.8		20		15.2	J	42.3		26.4		21.4	
88+91-PeCB	1.53	J	0.192	U	5.62		0.146	U	3.83		6.03		10.7		4.03		2.16	J	8.64		4.7		4.57	
89-PeCB	0.195	U	0.206	U	0.592	U	0.157	U	0.217	U	0.225	U	0.652	U	0.347	U	0.999	U	0.366	U	0.669	U	0.943	U
90+101+113-PeCB	9.86		0.172	U	41.3		0.131	U	24.4		42.6		85.4		30.4		23		61		38		32.1	
92-PeCB	0.189	U	1.07		7.07		0.609	J	4.41		7.52		15		5.35		0.952	U	11.5		7.31		0.949	U
93+100-PeCB	0.166	U	0.174	U	0.501	U	0.133	U	0.184	U	0.191	U	0.553	U	0.294	U	0.844	U	0.844	J	0.617	U	0.869	U
94-PeCB	0.192	U	0.203	U	0.583	U	0.154	U	0.214	U	0.385	J	0.642	U	0.336	U	0.967	U	0.375	U	0.685	U	0.965	U
95-PeCB	0.178	U	0.188	U	22.4		0.143	U	14.3		25.2		55.4		18.1		14.1		40.2		24.3		22.4	
96-PeCB	0.15	U	0.125	U	0.397	U	0.121	U	0.139	U	0.157	U	0.381	U	0.239	U	0.757	U	0.25	U	0.494	U	0.726	U
98+102-PeCB	0.19	U	0.201	U	0.577	U	0.153	U	1.06	J	0.22	U	0.637	U	1.4	J	0.923	U	2.47		0.624	U	0.879	U
99-PeCB	4.93		0.156	U	22.2		0.119	U	14.1		24.6		39.5		16.2		10.6		33.9		19.8		16.6	
103-PeCB	0.168	U	0.177	U	0.509	U	0.135	U	0.478	J	0.193	U	1.05	J	0.283	U	0.815	U	1.04	J	0.575	U	0.81	U
104-PeCB	0.101	U	0.0862	U	0.286	U	0.0801	U	0.0984	U	0.12	U	0.271	U	0.165	U	0.6	U	0.169	U	0.368	U	0.569	U
105-PeCB	0.294	U	0.168	U	14.3		0.154	U	8.87		16.4		30		13.6		5.68		27.4		16.5		13.2	
106-PeCB	0.292	U	0.165	U	0.812	U	0.156	U	0.656	U	0.483	U	0.996	U	0.309	U	0.506	U	0.431	U	0.57	U	1.04	U
107+124-PeCB	0.276	U	0.156	U	1.28	J	0.147	U	0.62	U	1.62	J	0.941	U	0.3	U	0.491	U	2.65		0.552	U	1.79	J
109-PeCB	0.73	J	0.13	U	3.78		0.122	U	2.28		3.64		0.782	U	2.75		0.408	U	5.12		3.08		3.24	
110+115-PeCB	21.2		10.2		71.9		0.235	U	48.6		90		178		31.7		20.1		67.8		40.8		33.8	
111-PeCB	0.143	U	0.151	U	0.434	U	0.115	U	0.159	U	0.165	U	0.479	U	0.256	U	0.737	U	0.276	U	0.504	U	0.71	U
112-PeCB	0.161	U	0.17	U	0.487	U	0.129	U	0.179	U	0.185	U	0.538	U	0.279	U	0.803	U	0.299	U	0.548	U	0.771	U
114-PeCB	0.308	U	0.168	U	0.87	U	0.16	U	0.683	U	0.493	U	1.03	U	0.369	U	0.585	U	0.458	U	0.616	U	1.14	U
118-PeCB	7.3		0.156	U	38.8		0.147	U	24.3		46.5		78.6		34.8		14.7		67.9		40.3		35.1	
120-PeCB	0.133	U	0.141	U	0.404	U	0.107	U	0.149	U	0.154	U	0.446	U	0.241	U	0.693	U	0.626	J	0.484	U	0.681	U
121-PeCB	0.141	U	0.149	U	0.427	U	0.113	U	0.157	U	0.162	U	0.471	U	0.245	U	0.706	U	0.272	U	0.497	U	0.7	U
122-PeCB	0.285	U	0.161	U	0.792	U	0.152	U	0.639	U	0.471	U	0.971	U	0.31	U	0.508	U	0.415	U	0.548	U	0.997	U
123-PeCB	0.279	U	0.156	U	0.737	U	0.15	U	0.608	U	0.434	U	0.887	U	0.521	J	0.496	U	1.43		0.543	U	0.974	U

Table A-12e. US EPA/USACE "Bold Study" Analytical Data-PCB Congeners

Sample ID	SPSB_3		SPSB_8_C		SS_0		SS_1		SS_2		SS_8_C		SS_9_C		CPS_3_Dup		HC_2_Dup		NCPS_2_Dup		PSPS_1_Dup		SPSB_0_Dup	
Analyte (pg/g)	8/3/2008	Q	8/3/2008	Q	8/4/2008	Q	8/4/2008	Q	8/4/2008	Q	8/4/2008	Q	8/4/2008	Q	7/31/2008	Q	8/3/2008	Q	8/3/2008	Q	8/3/2008	Q	8/3/2008	Q
126-PeCB	0.374	U	0.202	U	1.07	U	0.194	U	0.74	U	0.587	U	1.25	U	0.402	U	0.652	U	0.529	U	0.712	U	1.24	U
127-PeCB	0.281	U	0.159	U	0.782	U	0.15	U	0.631	U	0.465	U	0.959	U	0.302	U	0.494	U	0.429	U	0.568	U	1.03	U
128+166-HxCB	1.64	J	0.779	J	9.22		0.384	J	5.8		10		17.6		7.79		1.35	U	16.1		9.33		7.87	
129+138+163-HxCB	10.4		0.377	U	50.1		0.152	U	29.6		56.9		98.5		47.7		20.4		90.8		56.8		45.8	
130-HxCB	0.206	U	0.505	U	0.635	U	0.204	U	1.87		4.61		1.08	U	3.76		1.7	U	7.17		1.1	U	3.35	
131-HxCB	0.172	U	0.42	U	0.528	U	0.169	U	0.601	U	0.88	U	0.899	U	0.5	U	1.43	U	0.667	U	0.889	U	1.67	U
132-HxCB	0.2	U	1.81		12.5		0.955		7.66		15.7		30.3		13.2		1.64	U	26.3		16.3		13.5	
133-HxCB	0.196	U	0.479	U	0.602	U	0.193	U	0.685	U	1.07		1.02	U	0.55	U	1.57	U	1.76		1.02	U	1.91	U
134-HxCB	0.428	J	0.402	U	0.505	U	0.162	U	0.861	J	1.76		3.82		0.492	U	1.41	U	3.23		0.888	U	1.91	J
135+151-HxCB	0.343	U	0.338	U	0.583	U	0.211	U	8.78		17.8		1.67	U	14.9		1.04	U	28.4		16.3		14.4	
136-HxCB	0.256	U	0.252	U	5.57		0.157	U	2.88		6.1		12		4.92		2.74	J	9.24		5.52		5.35	
137-HxCB	0.158	U	0.385	U	0.484	U	0.155	U	0.551	U	2.85		4.25		2.11		1.44	U	0.675	U	1.66	J	1.69	U
139+140-HxCB	0.174	U	0.424	U	0.77	J	0.171	U	0.607	U	1	J	0.908	U	0.502	U	1.43	U	2.04	J	0.922	JU	1.73	U
141-HxCB	0.203	U	0.497	U	4.86		0.2	U	2.61		6		15.2		0.564	U	2.78	J	9.49		6.96		2.07	U
142-HxCB	0.216	U	0.529	U	0.665	U	0.213	U	0.757	U	1.11	U	1.13	U	0.593	U	1.7	U	0.823	U	1.1	U	2.06	U
143-HxCB	0.222	U	0.544	U	0.684	U	0.219	U	0.778	U	1.14	U	1.16	U	0.587	U	1.68	U	0.827	U	1.1	U	2.07	U
144-HxCB	0.34	U	0.335	U	0.577	U	0.209	U	0.94	J	0.311	U	4.44		1.93		1.01	U	3.75		0.558	U	0.781	U
145-HxCB	0.262	U	0.258	U	0.443	U	0.16	U	0.399	U	0.239	U	1.27	U	0.275	U	0.795	U	0.244	U	0.435	U	0.609	U
146-HxCB	1.58		0.374	U	9.02		0.377	J	5.16		10.4		14.7		7.29		1.26	U	14.3		8.6		6.47	
147+149-HxCB	0.171	U	0.418	U	35.1		0.169	U	20.5		40.5		70.5		26.9		15.6		56.6		33.2		28.5	
148-HxCB	0.347	U	0.341	U	0.588	U	0.213	U	0.528	U	0.317	U	1.69	U	0.364	U	1.05	U	0.314	U	0.559	U	0.783	U
150-HxCB	0.256	U	0.253	U	0.435	U	0.157	U	0.39	U	0.234	U	1.25	U	0.264	U	0.765	U	0.235	U	0.418	U	0.586	U
152-HxCB	0.267	U	0.263	U	0.453	U	0.164	U	0.407	U	0.244	U	1.3	U	0.25	U	0.723	U	0.228	U	0.406	U	0.569	U
153+168-HxCB	10.9		0.359	U	51.5		0.145	U	31		58.5		94.7		45.4		20.2		85.2		55		41.8	
154-HxCB	0.299	U	0.294	U	0.506	U	0.183	U	1	J	1.57		1.45	U	1.23		0.882	U	2.32		0.495	U	0.981	J
155-HxCB	0.151	U	0.152	U	0.307	U	0.0955	U	0.281	U	0.181	U	0.948	U	0.152	U	0.587	U	0.152	U	0.246	U	0.433	U
156+157-HxCB	1.08	J	0.518	J	1.3	U	0.188	U	2.93		5.74		11.2		5.17		1.01	U	10.3		6.15		1.04	U
158-HxCB	0.131	U	0.32	U	3.71		0.129	U	2.38		4.85		9.86		4.48		1.83	J	8.53		5.34		1.31	U
159-HxCB	0.375	U	0.155	U	1.04	U	0.159	U	0.334	U	0.621	U	0.868	U	0.378	U	0.817	U	0.348	U	0.505	U	0.808	U
160-HxCB	0.178	U	0.436	U	0.548	U	0.176	U	0.624	U	0.913	U	0.933	U	0.484	U	1.38	U	0.678	U	0.904	U	1.69	U
161-HxCB	0.159	U	0.388	U	0.488	U	0.156	U	0.556	U	0.813	U	0.831	U	0.433	U	1.23	U	0.641	U	0.854	U	1.6	U
162-HxCB	0.385	U	0.159	U	1.07	U	0.164	U	0.343	U	0.638	U	0.892	U	0.387	U	0.836	U	0.365	U	0.53	U	0.848	U
164-HxCB	0.169	U	0.413	U	2.94		0.166	U	1.82		0.865	U	0.884	U	2.32		1.66	J	0.612	U	0.815	U	1.53	U
165-HxCB	0.159	U	0.389	U	0.49	U	0.157	U	0.557	U	0.815	U	0.833	U	0.441	U	1.26	U	0.62	U	0.826	U	1.55	U
167-HxCB	0.424	J	0.164	U	1.07	U	0.171	U	1.48		2.6		0.88	U	2.17		0.905	U	0.433	U	0.639	U	0.924	U
169-HxCB	0.398	U	0.178	U	1.12	U	0.17	U	0.338	U	0.648	U	0.908	U	0.427	U	0.882	U	0.401	U	0.602	U	0.899	U
170-HpCB	0.371	U	0.222	U	9.8		0.282	U	5.98		10.7		21.2		10.2		0.956	U	19		14.1		1.33	U
171+173-HpCB	0.81	J	0.211	U	3.54	J	0.268	U	2.52		0.582	U	1.45	U	4.18		1.03	U	7.49		5.68		4.19	J
172-HpCB	0.471	J	0.303	J	1.41	U	0.272	U	0.691	U	0.592	U	4.18		1.65		1.01	U	3.6		2.28		1.28	U
174-HpCB	0.346	U	0.207	U	9.9		0.262	U	0.666	U	12.5		21.2		11.5		1.05	U	19.7		13.1		10.7	
175-HpCB	0.244	U	0.242	U	0.7	U	0.189	U	0.27	U	0.628	J	0.751	U	0.836	J	1.29	U	0.4	U	0.857	U	1.16	U
176-HpCB	0.384	J	0.19	U	1.54	J	0.149	U	1.12		1.97		2.78		0.348	U	1.01	U	3.13		0.658	U	1.86	J
177-HpCB	1.55		0.815	J	7.85		0.267	U	4.89		9.43		14.7		8.37		1.03	U	15.5		10.5		8.75	
178-HpCB	0.664	J	0.258	U	4.02		0.201	U	0.287	U	7.07		0.799	U	3.99		1.35	U	7.37		0.906	U	3.92	
179-HpCB	0.188	U	0.602	J	5.39		0.281	J	3.55		6.33		0.579	U	6.02		0.995	U	10.8		6.7		5.7	
180+193-HpCB	0.261	U	0.156	U	19.1		0.198	U	11.2		22.3		40.4		18.6		8.32		34.2		25.2		18.4	
181-HpCB	0.318	U	0.191	U	1.26	U	0.242	U	0.614	U	0.526	U	1.3	U	0.43	U	0.96	U	0.379	U	0.917	U	1.18	U
182-HpCB	0.242	U	0.24	U	0.692	U	0.187	U	0.267	U	0.267	U	0.743	U	0.44	U	1.27	U	0.393	U	0.843	U	1.14	U
183+185-HpCB	0.31	U	0.186	U	8.16		0.236	U	5.32		10.9		15.5		7.06		0.917	U	13		7.83		6.91	
184-HpCB	0.186	U	0.185	U	0.534	U	0.145	U	0.206	U	0.206	U	0.574	U	0.332	U	0.959	U	0.299	U	0.641	U	0.869	U
186-HpCB	0.2	U	0.199	U	0.574	U	0.155	U	0.222	U	0.221	U	0.617	U	0.352	U	1.02	U	0.32	U	0.687	U	0.931	U
187-HpCB	4.13		0.23	U	23.8		0.18	U	13.7		23.9		34.7		21.4		7.59		38.4		24.5		18.6	
188-HpCB	0.176	U	0.177	U	0.485	U	0.144	U	0.212	U	0.195	U	0.543	U	0.309	U	0.829	U	0.287	U	0.576	U	0.863	U
189-HpCB	0.917	U	0.184	U	1.94	U	0.222	U	0.698	U	0.733	U	1.2	U	0.884	U	0.959	U	0.919	J	0.55	U	0.741	U
190-HpCB	0.288	U	0.173	U	1.94	J	0.219	U	1.14		2.15		4.99		0.33	U	0.737	U	3.69		0.806	U	1.04	U
191-HpCB	0.271	U	0.163	U	1.07	U	0.206	U	0.523	U	0.448	U	1.11	U	0.331	U	0.739	U	0.932	J	0.753	U	0.968	U
192-HpCB	0.291	U	0.175	U	1.15	U	0.221	U	0.562	U	0.481	U	1.19	U	0.37	U	0.826	U	0.334	U	0.809	U	1.04	U
194-OcCB	1.27		0.405	U	14.4		0.312	U	4.07		7.51		12.2		5.51		1.14	U	10.8		1.94	U	1.32	U
195-OcCB	1.11	U	0.436	U	1.85	U	0.335	U	1.07	U	3.17		4.95		0.498	U	1.26	U	4.31		3.62		2.51	
196-OcCB	0.702	J	0.271	U	8.44		0.237	U	0.288	U	5.24		6.91		4.08		1.34	UJ	7		1.45	U	4.48	
197+200-OcCB	0.223	U	0.2	U	2.65	J	0.175	U	0.213	U	1.73	J	2.51	J	1.56	J	1.14	U	2.5		1.85	J	1.67	J
198+199-OcCB	0.316	U	0.283	U	43		0.247	U	7.08		13.6		18.6		10.2		1.42	U	19.3		1.56	U	9.59	
201-OcCB	0.222	U	0.199	U	4.49		0.174	U	0.212	U	1.92		0.623	U	1.69		1.15	U	0.338	U	1.13	U	0.985	U
202-OcCB	0.556	J	0.226	J	0.617	U	0.179	U	2.19		3.97		0.641	U	2.16		1.02	U	4.52		1.11	U	2.5	
203-OcCB	1.17	J	0.267	U	29.2		0.233	U	3.35		0.686	U	9.78		5.07		1.29	U	9.23		7.22		1.25	U
204-OcCB	0.226	U	0.203	U	0.617	U	0.177	U	0.216	U	0.522	U	0.635	U	0.49	U	1.18	U	0.345	U	1.16	U	1.01	U
205-OcCB	0.888	U	0.34	U	1.49	U	0.263	U	0.791	U	1.37	U	3.4	U	0.413	U	1.04	U	0.691	U	1.66	U	1.12	U
206-NoCB	1.46		0.435	U	92.7		0.228	U	6.18		0.365	U	12.2		6.44		1.19	U	11.3		7.16		1.5	U
207-NoCB	0.325	U	0.341	U	0.841	U	0.187	U	0.279	U	1.14		1.9	J	0.369	U	1.02	U	1.56		0.948	J	1.3	U
208-NoCB	0.327	U	0.342	U	35.6		0.195	U	0.291	U	3.87		4.29		0.37	U	1.04	U	3.9		2.59		1.73	J
209-DeCB	0.308	U	0.632	J	33.8		0.225	U	6.3		12		11.2		6.33		4.24		12.6		6.58		5.62	
Total PCBs (0 DL)	103.0		25.8		1069.8		10.0		495.9		982.7		1751.4		653.1		284.0		1370.0		801.2		650.8	
TEQ WHO-05 (1 DL)	0.050		0.026		0.143		0.025		0.086		0.081		0.157		0.055		0.093		0.069		0.092		0.153	
TEQ WHO-05 (1/2 DL)	0.025		0.013		0.073		0.012		0.043		0.042		0.080		0.029		0.047		0.036		0.047		0.077	
TEQ WHO-05 (0 DL)	0.000		0.000		0.002		0.000		0.001		0.003		0.004		0.002		0.001		0.004		0.002		0.002	

Notes:

mg/kg = milligrams per kilogram

ug/kg = micrograms per kilogram

pg/g = picogram per gram

U = Result should be considered not-detected at the quantitation limit shown

J = Result is an estimated concentration

R = Rejected - Quality Control indicates the data is not usable

UJ = The compound was not detected and the sample detection limit should be considered an estimated value

TEF = Toxicity Equivancy Factor

Table A-12f. US EPA/USACE "Bold Study" Analytical Data-Dioxins and Furans

Sample ID		AI_1		AI_11_C		AI_13_C		AI_20_C_GS		AI_5_C		CPS_0		CPS_1		CPS_3		CPS_4		CPS_5		HC_0		HC_1		HC_2	
Analyte (pg/g)	**TEF**	**7/31/2008**	**Q**	**8/1/2008**	**Q**	**8/3/2008**	**Q**	**8/1/2008**	**Q**	**8/1/2008**	**Q**	**8/4/2008**	**Q**	**8/4/2008**	**Q**	**7/31/2008**	**Q**	**8/4/2008**	**Q**	**7/31/2008**	**Q**	**8/3/2008**	**Q**	**8/2/2008**	**Q**	**8/3/2008**	**Q**
% Solids		68.6		75.1		70		69.1		77.9		32.7		60.1		66.6		68.6		76		27.8		61.3		22.1	
2,3,7,8-TCDD	1	0.144	U	0.141	U	0.154	U	0.136	U	0.147	U	0.265	U	0.141	U	0.154	U	0.147	U	0.178	U	0.254	U	0.145	U	0.396	U
1,2,3,7,8-PeCDD	1	0.21	U	0.144	U	0.173	U	0.162	J	0.174	U	0.468	J	0.444	J	0.345	J	0.227	J	0.174	J	0.271	J	0.212	J	0.448	U
1,2,3,4,7,8-HxCDD	0.1	0.227	U	0.209	U	0.261	U	0.242	U	0.35	U	0.367	U	0.387	U	0.243	U	0.234	J	0.219	U	0.371	U	0.499	U	0.526	U
1,2,3,6,7,8-HxCDD	0.1	0.431	J	0.217	U	0.6	J	0.759	J	0.593	J	2.03	J	2.38	J	1.47	J	1.19	J	0.861	J	1.03	J	0.829	J	1	U
1,2,3,7,8,9-HxCDD	0.1	0.349	J	0.225	U	0.456	J	0.496	J	0.458	J	1.27	J	1.58	J	0.977	J	0.747	J	0.491	U	0.736	J	0.537	U	0.866	J
1,2,3,4,6,7,8-HpCDD	0.01	4.19	J	0.367	J	5.59		6.11		5.73		27		27.5		15.8		15.2		8.47		11.9		7.52		18.3	
OCDD	0.0003	24.5		2.22	U	36.5		34.9		36.6		197		193		113		115		54		84.1		43.8		111	
2,3,7,8-TCDF	0.1	0.404	J	0.192	J	0.522	J	0.54	J	0.458	J	1.23		1.21		0.891		0.703	U	0.516	J	0.799	U	0.966		0.715	U
1,2,3,7,8-PeCDF	0.03	0.122	U	0.118	U	0.114	U	0.139	J	0.126	J	0.441	J	0.843	J	0.29	J	0.347	J	0.105	U	0.234	U	0.253	J	0.303	U
2,3,4,7,8-PeCDF	0.3	0.269	J	0.117	U	0.243	J	0.294	J	0.243	J	0.88	J	1.13	J	0.592	J	0.555	U	0.3	J	0.401	J	0.459	J	0.463	J
1,2,3,4,7,8-HxCDF	0.1	0.264	J	0.174	U	0.26	J	0.248	J	0.23	U	1.12	J	1.97	J	0.796	J	0.735	J	0.314	J	0.26	J	0.29	J	0.406	J
1,2,3,6,7,8-HxCDF	0.1	0.317	J	0.163	U	0.157	J	0.178	U	0.169	U	0.375		0.705	J	0.385	J	0.295	J	0.185	U	0.196	U	0.205	J	0.291	J
1,2,3,7,8,9-HxCDF	0.1	0.275	U	0.243	U	0.224	U	0.241	U	0.321	U	0.537	U	0.388	J	0.166	J	0.178	J	0.267	U	0.355	U	0.469	U	0.548	U
2,3,4,6,7,8-HxCDF	0.1	0.315	J	0.171	U	0.154	J	0.201	J	0.146	J	0.572	U	0.68	J	0.405	J	0.344	J	0.237	J	0.303	J	0.272	J	0.374	J
1,2,3,4,6,7,8-HpCDF	0.01	1.92	J	0.225	U	2.05	J	1.58	J	1.71	J	6.04	J	8.3		4.02	J	4.13	J	2.35	J	2.53	J	1.82	J	3.26	J
1,2,3,4,7,8,9-HpCDF	0.01	0.383	U	0.348	U	0.388	U	0.351	U	0.36	U	0.765	U	0.674	J	0.422	U	0.354	J	0.405	U	0.574	U	0.46	U	0.969	U
OCDF	0.0003	2.57	J	0.54	J	3.83	J	2.32	J	3.44	J	14		17.4		8.35		9.34	J	4.21	J	4.81	J	3.11	J	7.09	J
Total TCDDs		0.656		0.141	U	0.298	J	0.565		0.773	J	3.31		5.8		2.3		1.76		1.21		0.898	J	6.02		1.32	J
Total PeCDDs		0.335	J	0.144	U	0.429	J	1.59	J	0.719	J	4.58	J	6.44		2.8	J	1.37	J	2.04	J	2.64	J	3.28	J	2.87	J
Total HxCDDs		3.05	J	0.209	U	6.14		6.44	J	6.08		19.1		25		14.3		12.3		7.45		9.55		5.98		9.41	
Total HpCDDs		9.84	J	0.758	J	13.8		14.7		14.1		66.5		66.3		39.1		36.7		19.5		28.3		19.3		46.5	
Total TCDFs		4.23	J	0.192	J	1.84	J	2.95	J	0.957	J	7.87	J	12.5	J	7.09	J	4.22	J	3.42	J	2.14	J	5.26	J	1.03	J
Total PeCDFs		5.29	J	0.117	U	1.59	J	2.15	J	1.66	J	7.23		12.5		5.55		4.87		2.82	J	2.16	J	3.09	J	2.44	J
Total HxCDFs		4.28	J	0.163	U	1.64	J	1.99	J	0.847	J	8.7		14.7		7.05		6.95		3.36	J	3.08	J	2.8	J	4.92	J
Total HpCDFs		1.92	J	0.225	U	3.97	J	3.43	J	4.34	J	16.7	J	22.3	J	10.1	J	11.4	J	5.39	J	2.53	J	4.06	J	7.89	J
TEQ WHO-05 (1 DL)		0.77		0.49		0.76		0.77		0.76		2.16		2.31		1.46		1.23		0.88		1.23		1.02		1.73	
TEQ WHO-05 (1/2 DL)		0.56		0.26		0.57		0.67		0.54		1.95		2.22		1.37		1.04		0.73		1.01		0.87		1.15	
TEQ WHO-05 (0 DL)		0.36		0.02		0.38		0.57		0.33		1.74		2.13		1.27		0.84		0.58		0.80		0.72		0.58	

Notes:

mg/kg = milligrams per kilogram

ug/kg = micrograms per kilogram

pg/g = picogram per gram

U = Result should be considered not-detected at the quantitation limit shown

J = Result is an estimated concentration

R = Rejected - Quality Control indicates the data is not usable

UJ = The compound was not detected and the sample detection limit should be considered an estimated value

TEF = Toxicity Equivancy Factor

Table A-12f. US EPA/USACE "Bold Study" Analytical Data-Dioxins and Furans

Sample ID		HC_3		HC_6		NCPS_0		NCPS_1		NCPS_2		NCPS_3		NCPS_4		PSPS_1		PSPS_2		PSPS_3		PSPS_8		PSPS_9		R_CAR_0	
Analyte (pg/g)	**TEF**	**8/2/2008**	**Q**	**8/2/2008**	**Q**	**7/31/2008**	**Q**	**7/31/2008**	**Q**	**8/3/2008**	**Q**	**7/31/2008**	**Q**	**7/31/2008**	**Q**	**8/3/2008**	**Q**	**8/3/2008**	**Q**	**8/3/2008**	**Q**	**8/3/2008**	**Q**	**8/3/2008**	**Q**	**8/4/2008**	**Q**
% Solids		48.6		39.6		56.4		79		63.2		54.8		73.8		35		41.8		39.2		78.5		37.3		63.4	
2,3,7,8-TCDD	1	0.228	U	0.278	U	0.147	U	0.135	U	0.203	U	0.163	U	0.171	U	0.361	J	0.438	U	0.142	U	0.138	U	0.17	U	0.202	U
1,2,3,7,8-PeCDD	1	0.226	U	0.308	U	0.22	U	0.155	U	0.374	U	0.24	J	0.2	U	0.521	U	0.743	U	0.388	U	0.174	U	0.482	U	0.277	U
1,2,3,4,7,8-HxCDD	0.1	0.295	U	0.315	U	0.241	U	0.224	U	0.282	J	0.148	J	0.478	J	0.587	U	0.823	J	0.231	J	0.246	U	0.476	J	0.393	U
1,2,3,6,7,8-HxCDD	0.1	0.621	J	0.794	J	0.952	J	0.232	U	1.31	J	0.71	J	0.441	J	2.56	J	3.85	J	1.14	J	0.263	U	1.84	J	0.979	J
1,2,3,7,8,9-HxCDD	0.1	0.447	J	0.443	J	0.66	J	0.24	U	0.979	J	0.487	U	0.262	U	1.72	J	2.77	J	0.834	J	0.268	U	1.39	J	0.691	U
1,2,3,4,6,7,8-HpCDD	0.01	5.93		8.65		8.85		1.07	J	17		7.36		3.86	J	30.3		46.1		14.2		2.08	J	24.5		13.7	
OCDD	0.0003	41.4		64.8		58.9		6.57	U	111		44.8		23.4		220		335		99.9		14		172		95.9	
2,3,7,8-TCDF	0.1	0.734	J	0.836		0.77	J	0.225	U	0.962	J	0.683	J	0.385	J	2.01		3.11		1.26		0.43	U	1.9		0.535	J
1,2,3,7,8-PeCDF	0.03	0.13	J	0.138	J	0.168	J	0.114	U	0.292	J	0.146	U	0.149	U	0.455	J	0.56	J	0.194	J	0.138	U	0.362	J	0.19	J
2,3,4,7,8-PeCDF	0.3	0.28	J	0.353	U	0.399	J	0.117	U	0.66	J	0.313	J	0.191	J	0.906	J	1.27	J	0.508	J	0.138	J	0.793	J	0.382	U
1,2,3,4,7,8-HxCDF	0.1	0.211	U	0.256	U	0.284	U	0.155	U	0.526	J	0.303	U	0.238	U	0.67	J	0.895	J	0.398	J	0.171	U	0.694	J	0.536	J
1,2,3,6,7,8-HxCDF	0.1	0.21	U	0.263	U	0.159	J	0.146	U	0.276	J	0.133	U	0.221	U	0.432	J	0.588	J	0.218	U	0.163	U	0.373	J	0.217	U
1,2,3,7,8,9-HxCDF	0.1	0.302	U	0.393	U	0.284	U	0.216	U	0.348	U	0.288	U	0.34	U	0.42	U	0.343	J	0.256	U	0.231	U	0.331	U	0.289	U
2,3,4,6,7,8-HxCDF	0.1	0.213	U	0.223	J	0.233	J	0.149	U	0.352	J	0.187	J	0.226	U	0.586	J	0.929	J	0.326	U	0.179	U	0.583	J	0.277	J
1,2,3,4,6,7,8-HpCDF	0.01	1.43	J	1.82	J	2.24	J	0.344	J	4.2	J	2.21	J	0.943	J	6.18		9.05		3.06	J	0.555	U	5.11	J	3.76	J
1,2,3,4,7,8,9-HpCDF	0.01	0.454	U	0.665	U	0.477	U	0.389	U	0.437	U	0.435	U	0.465	U	0.724	U	0.59	U	0.364	U	0.381	U	0.469	U	0.473	U
OCDF	0.0003	2.92	J	2.97	J	3.98	J	0.758	U	8.05	J	4.11	J	1.96	J	14.1		19.8		6.24	J	1	J	11.2		8.74	J
Total TCDDs		0.43	J	5.23		1.82		0.135	U	2.93		1.62		0.309	J	3.89		13.7		1.09		0.138	U	2.74		0.499	J
Total PeCDDs		0.903	J	3.75	J	2.02	J	0.155	U	4.57	J	2.17	J	0.138	J	8.32		14.6		3.34	J	0.174	U	6.68		1.05	J
Total HxCDDs		6.04		8.3		9.69		0.872	J	15.4		7.72		3.85	J	28.2		42.9		12.7		0.724	J	22.3		4.85	
Total HpCDDs		18.4		23.5		22.1		1.07	J	39.7		18.3		9.29		70.9		111		33.3		4.63		56		33.5	
Total TCDFs		3.19	J	4.64	J	5.55	J	0.185	J	7.21	J	4.22	J	0.916	J	11.4	J	20.6	J	7.61	J	0.909	J	6.43	J	1.93	J
Total PeCDFs		1.42	J	2.48	J	3.16	J	0.159	J	6.24		2.4	J	0.519	J	8.71		13		4.23	J	0.138	J	7.7		2.9	J
Total HxCDFs		1.67	J	2.09	J	3.18	J	0.196	J	6.73		1.98	J	1.22	J	6.5		14.8		4.04	J	0.708	J	8.12		4.89	
Total HpCDFs		3.39	J	4.46	J	5.1	J	0.72	J	10.6	J	4.59	J	2.26	J	15.9	J	24.6		7.36	J	0.266	U	13.7	J	10.5	
TEQ WHO-05 (1 DL)		0.94		1.18		0.98		0.51		1.54		0.91		0.75		2.51		3.57		1.36		0.59		2.02		1.20	
TEQ WHO-05 (1/2 DL)		0.65		0.77		0.76		0.26		1.23		0.76		0.50		2.19		2.98		1.06		0.33		1.67		0.82	
TEQ WHO-05 (0 DL)		0.35		0.36		0.53		0.01		0.92		0.62		0.24		1.88		2.39		0.75		0.07		1.33		0.44	

Notes:

mg/kg = milligrams per kilogram

ug/kg = micrograms per kilogram

pg/g = picogram per gram

U = Result should be considered not-detected at the quantitation limit shown

J = Result is an estimated concentration

R = Rejected - Quality Control indicates the data is not usable

UJ = The compound was not detected and the sample detection limit should be considered an estimated value

TEF = Toxicity Equivancy Factor

Table A-12f. US EPA/USACE “Bold Study” Analytical Data-Dioxins and Furans

Sample ID		R_CAR_1		R_CAR_4		R_CAR_5		R_CAR_6_C		R_DAB_0		R_DAB_1		R_DAB_2		R_DAB_5		R_DAB_7_C		R_HOL_0		R_HOL_1		R_HOL_3		R_HOL_4	
Analyte (pg/g)	**TEF**	**8/4/2008**	**Q**	**8/4/2008**	**Q**	**8/4/2008**	**Q**	**8/4/2008**	**Q**	**8/2/2008**	**Q**	**8/2/2008**	**Q**	**8/2/2008**	**Q**	**8/2/2008**	**Q**	**8/2/2008**	**Q**	**8/3/2008**	**Q**	**8/3/2008**	**Q**	**8/3/2008**	**Q**	**8/3/2008**	**Q**
% Solids		67.3		45		34.8		75.4		68		34.5		34.1		39.2		43.6		76.3		70.6		78.2		30	
2,3,7,8-TCDD	1	0.239	U	0.244	U	0.363	U	0.234	U	0.221	U	0.338	U	0.311	U	0.333	U	0.0985	U	0.164	U	0.0921	U	0.0974	U	0.182	U
1,2,3,7,8-PeCDD	1	0.3	U	0.311	U	0.838	J	0.282	U	0.299	U	0.49	J	0.69	U	0.611	U	0.347	J	0.137	U	0.0851	J	0.113	U	0.388	U
1,2,3,4,7,8-HxCDD	0.1	0.347	U	0.259	J	0.622	J	0.32	U	0.529	U	0.363	J	0.54	J	0.452	U	0.387	U	0.153	U	0.145	U	0.222	U	0.436	U
1,2,3,6,7,8-HxCDD	0.1	1.56	J	1.25	J	4.19	J	0.371	J	0.428	J	1.46	J	2.64	J	2.6	J	1.3	J	0.159	U	0.34	J	0.235	U	1.86	U
1,2,3,7,8,9-HxCDD	0.1	0.954	J	0.908	U	2.61	J	0.35	U	0.572	U	1.12	J	1.88	J	1.8	J	0.929	J	0.165	U	0.28	J	0.241	U	1.25	J
1,2,3,4,6,7,8-HpCDD	0.01	18		20.5		51		4.83		5.82		18.7		23.4		24.1		15		2.21	J	4.84		0.858	J	24	
OCDD	0.0003	121		136		386		29.9		32.6		105		134		139		83.1		12.6		29.6		4.82	J	148	
2,3,7,8-TCDF	0.1	0.81	J	0.604	U	1.73		0.265	J	0.296	J	0.878	J	0.296		1.62		0.848	J	0.266	U	0.314	J	0.211	J	1.28	
1,2,3,7,8-PeCDF	0.03	0.313	U	0.312	J	0.996	J	0.188	U	0.179	U	0.307	U	0.328	U	0.464	J	0.231	J	0.0855		0.0764	J	0.0844	U	0.346	J
2,3,4,7,8-PeCDF	0.3	0.584	J	0.513	J	1.6	J	0.194	U	0.176	U	0.707	J	0.875	J	0.8	J	0.567	J	0.124	J	0.205	J	0.086		0.851	J
1,2,3,4,7,8-HxCDF	0.1	0.854	U	0.525	U	2.56	J	0.239	U	0.402	U	0.617	J	0.653	U	0.613	J	0.408	J	0.163	U	0.141	J	0.179	U	0.617	J
1,2,3,6,7,8-HxCDF	0.1	0.303	J	0.31	U	1.02	U	0.215	U	0.38	U	0.328	J	0.421	J	0.389	J	0.235	J	0.15	U	0.0816	J	0.173	U	0.425	J
1,2,3,7,8,9-HxCDF	0.1	0.329	U	0.354	U	0.537	J	0.3	U	0.496	U	0.431	U	0.375	U	0.375	U	0.0973	J	0.211	U	0.16	U	0.232	U	0.286	U
2,3,4,6,7,8-HxCDF	0.1	0.459	J	0.469	J	1.34	J	0.232	U	0.384	U	0.515	J	0.587	J	0.703	U	0.408	J	0.0811	J	0.129	U	0.163	U	0.564	J
1,2,3,4,6,7,8-HpCDF	0.01	5.67		4.27	J	154		1.3	J	1.06	J	3.56	J	5.31	J	5.49		3.12	J	0.597	J	0.933	J	0.399	J	5	J
1,2,3,4,7,8,9-HpCDF	0.01	0.408	J	0.505	U	1.43	J	0.497	U	0.423	U	0.709	U	0.633	U	0.664	U	0.195	J	0.254	U	0.233	U	0.234	U	0.335	J
OCDF	0.0003	12.1		9.72		110		2.79	J	1.72	J	5.75	J	9.01	J	9.81	J	5.01	J	1	J	1.8	J	0.557	J	9	J
Total TCDDs		1.56		0.974		1.41		0.234	U	0.221	U	0.58		3.04	J	4.58		2.07		0.164	U	0.528	J	0.0974	U	4.37	
Total PeCDDs		2.93	J	2.51	J	10.8		0.302	J	0.299	U	3.32	J	5.72	J	5.11		3.93	J	0.171	J	0.325	J	0.113	U	6.55	J
Total HxCDDs		14		13.1		43.3		1.43	J	4.28		16.1	J	28.5	J	27.9		13.8		1.7	J	3.8	J	0.344	J	14.6	
Total HpCDDs		41.8		48.7		124		11		16.9		47.1		57		58		34.8		5.18		12.3		1.87	J	56.7	
Total TCDFs		5.61	J	5.49	J	16.2	J	0.265	J	0.576	J	7.64	J	11.9	J	19.1	J	6.65	J	0.545	J	1.66	J	0.354	J	12.6	J
Total PeCDFs		4.74		5.1		16		0.928	J	0.615	J	5.16	J	7.74	J	8.97		4.65		0.364	J	1.14	J	0.383	J	8.47	
Total HxCDFs		6.75		6.08		41.7		1.31	J	1.03	J	6.23		7.01		7.93		4.93		0.671	J	0.566	J	0.182	J	8.05	
Total HpCDFs		15.1		11	J	262	J	3.16	J	2.32	J	7.6	J	11.9	J	12.3	J	7.22	J	1.2	J	0.933	J	0.399	J	12.7	J
TEQ WHO-05 (1 DL)		1.57		1.48		5.38		0.89		1.01		1.88		2.35		2.40		1.29		0.51		0.47		0.42		1.85	
TEQ WHO-05 (1/2 DL)		1.22		1.07		5.15		0.51		0.58		1.68		1.79		1.85		1.22		0.30		0.40		0.24		1.43	
TEQ WHO-05 (0 DL)		0.86		0.65		4.92		0.13		0.15		1.49		1.23		1.30		1.16		0.08		0.33		0.06		1.02	

Notes:
mg/kg = milligrams per kilogram
ug/kg = micrograms per kilogram
pg/g = picogram per gram
U = Result should be considered not-detected at the quantitation limit shown
J = Result is an estimated concentration
R = Rejected - Quality Control indicates the data is not usable
UJ = The compound was not detected and the sample detection limit should be considered an estimated value
TEF = Toxicity Equivancy Factor

Table A-12f. US EPA/USACE "Bold Study" Analytical Data-Dioxins and Furans

Sample ID		R_HOL_7		R_SAM_0		R_SAM_1		R_SAM_3		R_SAM_4		R_SAM_5		SCPS_1		SCPS_10_C		SCPS_2		SCPS_3		SCPS_5		SJF_10_C	
Analyte (pg/g)	**TEF**	**8/3/2008**	**Q**	**8/1/2008**	**Q**	**8/1/2008**	**Q**	**8/1/2008**	**Q**	**8/1/2008**	**Q**	**8/1/2008**	**Q**	**8/4/2008**	**Q**	**8/5/2008**	**Q**	**8/4/2008**	**Q**	**8/4/2008**	**Q**	**8/4/2008**	**Q**	**8/1/2008**	**Q**
% Solids		33.9		37.5		49.7		46.3		45.5		32.7		33.4		68.9		78.5		83.2		29.7		71.6	
2,3,7,8-TCDD	1	0.171	U	0.138	U	0.108	U	0.114	U	0.112	U	0.23	U	0.243	U	0.11	U	0.126	U	0.122	U	0.29	U	0.141	U
1,2,3,7,8-PeCDD	1	0.224	J	0.468	J	0.524	J	0.402	J	0.126	U	0.52	J	0.806	J	0.309	J	0.115	J	0.158	U	0.909	J	0.155	U
1,2,3,4,7,8-HxCDD	0.1	0.271	J	0.447	U	0.484	J	0.369	J	0.206	U	0.562	J	0.635	J	0.243	U	0.192	U	0.228	J	0.7	J	0.234	U
1,2,3,6,7,8-HxCDD	0.1	0.96	J	1.79	J	2.03	J	1.93	J	2.18	J	2.55	J	3.91	J	1.29	J	0.609	J	0.223	J	4.46	J	0.487	J
1,2,3,7,8,9-HxCDD	0.1	0.651	J	1.25	J	1.36	J	1.29	J	1.41	J	1.64	J	2.46		0.885	U	0.397	J	0.214	U	2.78	J	0.414	J
1,2,3,4,6,7,8-HpCDD	0.01	12.8		14		17.1		14.5		15.9		20.1		44.9		14.8		6.47		2.81	J	53		4.09	J
OCDD	0.0003	77.8		72.9		94.5		96.3		83.5		104		319		102		44.6		19.3		369		21.2	
2,3,7,8-TCDF	0.1	0.771	J	1.47		1.72		1.7		1.73		2.09		2.32		0.841	J	0.532	U	0.404	U	2.42	U	0.529	U
1,2,3,7,8-PeCDF	0.03	0.224	J	0.206	J	0.189	J	0.234	U	0.213	U	0.254	U	0.687	J	0.327	J	0.124	U	0.115	U	0.732	J	0.175	U
2,3,4,7,8-PeCDF	0.3	0.474	U	0.366	J	0.435	J	0.36	J	0.397	U	0.518	J	1.47	J	0.511	J	0.256	J	0.129	J	1.66	J	0.249	J
1,2,3,4,7,8-HxCDF	0.1	0.408	J	0.315	J	0.345	J	0.343	U	0.363	J	0.401	J	1.66	J	0.734	J	0.35	J	0.188	U	2.13	J	0.184	J
1,2,3,6,7,8-HxCDF	0.1	0.255	J	0.208	U	0.252	J	0.217	U	0.228	J	0.308	J	0.775	J	0.29	U	0.148	J	0.182	U	0.652	J	0.165	U
1,2,3,7,8,9-HxCDF	0.1	0.195	U	0.211	U	0.203	U	0.158	U	0.232	U	0.278	U	0.336	J	0.257	U	0.244	U	0.244	U	0.504	J	0.225	U
2,3,4,6,7,8-HxCDF	0.1	0.373	J	0.315	U	0.35	U	0.349	J	0.319	U	0.447	J	0.973	J	0.349	J	0.185	U	0.183	U	1.17	J	0.166	U
1,2,3,4,6,7,8-HpCDF	0.01	2.58	J	3.06	J	3.93	J	3.33	J	3.73	J	4.34	J	13.4		4.24	J	2.03	J	0.814	J	14.5		1.55	J
1,2,3,4,7,8,9-HpCDF	0.01	0.298	U	0.3	U	0.238	J	0.215	J	0.266	U	0.36	U	0.802	U	0.33	U	0.266	U	0.303	U	0.767	J	0.347	U
OCDF	0.0003	4.61	J	5.91	J	7.63	J	5.43	J	6.16	J	8.47	J	26.5		8.67	J	4.45	J	1.51	J	31		2.17	J
Total TCDDs		2.96		8.74		6.6		3.61		8.03		18.6		7.64		2.19		1		0.122	U	7.39		0.196	J
Total PeCDDs		2.25	J	11.2		14		7.95		11		17.9		10.4		2.87	J	0.887	J	0.134	J	9.97		0.579	J
Total HxCDDs		11.3		24.9		31.1		23.6		27.1		37.2		41.1		11.9		6.1		1.39	J	46.4		4.91	
Total HpCDDs		31.5		29.4		36.2		32.6		34.6		43.2		108		33.6		15		6.57		125		9.03	
Total TCDFs		6.72	J	4.73	J	6.93	J	7.16	J	7.81	J	9.4	J	17.5	J	5.6	J	2.37	J	0.473	J	15	J	2.44	J
Total PeCDFs		4.07	J	3.31	J	4.49	J	3.72	J	3.25	J	4.39	J	14.8		5.66		2.22	J	0.787	J	17.1		0.696	J
Total HxCDFs		4.61	J	3.73	J	4.55		3.94	J	4.87		5.42	J	18		6.21		2.74	J	0.907	J	22.1		1.61	J
Total HpCDFs		6.1	J	7.22	J	9.86	J	8.03	J	8.91	J	10.7	J	32.8	J	10.5	J	5.14	J	1.85	J	37.6		2.87	J
TEQ WHO-05 (1 DL)		1.11		1.52		1.69		1.48		1.26		2.02		3.51		1.30		0.69		0.55		4.00		0.68	
TEQ WHO-05 (1/2 DL)		0.95		1.39		1.60		1.38		1.04		1.89		3.39		1.16		0.57		0.34		3.74		0.46	
TEQ WHO-05 (0 DL)		0.78		1.26		1.52		1.28		0.81		1.75		3.26		1.02		0.44		0.13		3.47		0.25	

Notes:
mg/kg = milligrams per kilogram
ug/kg = micrograms per kilogram
pg/g = picogram per gram
U = Result should be considered not-detected at the quantitation limit shown
J = Result is an estimated concentration
R = Rejected - Quality Control indicates the data is not usable
UJ = The compound was not detected and the sample detection limit should be considered an estimated value
TEF = Toxicity Equivancy Factor

Table A-12f. US EPA/USACE "Bold Study" Analytical Data-Dioxins and Furans

Sample ID		SJF_12_C_GS		SJF_2		SJF_3		SJF_9_C		SJI_0		SJI_1		SJI_20_C_GS		SJI_3		SJI_8_C		SPSB_0		SPSB_1	
Analyte (pg/g)	**TEF**	**8/2/2008**	**Q**	**8/1/2008**	**Q**	**8/1/2008**	**Q**	**8/1/2008**	**Q**	**8/1/2008**	**Q**	**8/2/2008**	**Q**	**8/2/2008**	**Q**	**8/2/2008**	**Q**	**8/2/2008**	**Q**	**8/3/2008**	**Q**	**8/3/2008**	**Q**
% Solids		31.1		71		73.4		65.2		53.3		62.5		42.7		59		70.2		33.5		30.4	
2,3,7,8-TCDD	1	0.252	U	0.177	U	0.182	U	0.209	U	0.171	U	0.181	U	0.158	U	0.17	U	0.162	U	0.18	U	0.216	U
1,2,3,7,8-PeCDD	1	0.522	J	0.218	U	0.187	U	0.312	U	0.407	U	0.252	J	0.452	U	0.257	U	0.222	U	0.351	J	0.329	
1,2,3,4,7,8-HxCDD	0.1	0.404	U	0.3	U	0.271	U	0.37	U	0.318	U	0.263	U	0.291	J	0.275	U	0.314	U	0.41	U	0.427	U
1,2,3,6,7,8-HxCDD	0.1	2.02	J	0.524	J	0.496	J	1.05	J	1.7	J	1.19	J	2.08	J	0.983	J	1.17	J	1.82	J	1.4	J
1,2,3,7,8,9-HxCDD	0.1	1.4	J	0.434	J	0.293	U	0.852	U	1.22	U	0.865	J	1.25	J	0.748	J	0.836	J	1.36	J	0.965	J
1,2,3,4,6,7,8-HpCDD	0.01	17.9		5.06		3.51	J	9.81		11.9		8		19		7.08		7.82		22.1		18.8	
OCDD	0.0003	101		28.6		19.7		55.4		76.6		42.2		200		38.9		42		148		114	
2,3,7,8-TCDF	0.1	1.54		0.422	J	0.321	J	0.667	J	1.3		0.814	J	1.4		0.66	U	0.9		1.14	J	1	U
1,2,3,7,8-PeCDF	0.03	0.326	U	0.133	U	0.156	U	0.201	U	0.193	J	0.14	U	0.235	J	0.132	U	0.168	U	0.294	U	0.333	U
2,3,4,7,8-PeCDF	0.3	0.614	J	0.128	U	0.158	U	0.347	J	0.394	U	0.256	J	0.45	J	0.257	J	0.287	U	0.817	J	0.75	J
1,2,3,4,7,8-HxCDF	0.1	0.447	J	0.239	U	0.231	U	0.286	U	0.378	J	0.21	J	0.351	J	0.237	U	0.198	J	0.538	J	0.558	J
1,2,3,6,7,8-HxCDF	0.1	0.283		0.225	U	0.224	U	0.273	U	0.254	U	0.118	U	0.244	J	0.225	U	0.15	J	0.306	U	0.269	U
1,2,3,7,8,9-HxCDF	0.1	0.362	U	0.328	U	0.306	U	0.396	U	0.362	U	0.303	U	0.303	U	0.324	U	0.336	U	0.403	U	0.369	U
2,3,4,6,7,8-HxCDF	0.1	0.434	J	0.254	U	0.236	U	0.22	U	0.318	U	0.199	J	0.315	J	0.232	U	0.212	U	0.44	U	0.479	J
1,2,3,4,6,7,8-HpCDF	0.01	4.48	J	1.39	J	1.21	U	2.53	J	2.94	J	1.97	J	3.2	J	1.82	J	2.15	J	5.2	J	4.51	J
1,2,3,4,7,8,9-HpCDF	0.01	0.566	U	0.418	U	0.483	U	0.535	U	0.523	U	0.382	U	0.503	U	0.479	U	0.483	U	0.497	U	0.692	U
OCDF	0.0003	6.94	J	2.4	J	1.65	J	4.43	J	5	J	3.15	J	5.48	J	2.98	J	3.09	J	10.7	J	8.68	J
Total TCDDs		5.03		0.274	J	0.182	U	0.501		1.41		0.524		3.41		0.539	J	0.408	J	5.68		2.29	
Total PeCDDs		6.26	J	0.661	J	0.302	J	2.09	J	5.54		2.21	J	4.85		1.87	J	2.28	J	6.54		4.59	J
Total HxCDDs		22.2		5.41		3.97	J	10.6	J	16.6		11.6	J	21.1		7.43		11.3		19.5		15.3	
Total HpCDDs		44.6		11.1		7.59		21.9		29.1		18.3		45.6		16.2		17.9		48.8		41.8	
Total TCDFs		8.66	J	1.43	J	1.24	J	4.18	J	7.7	J	2.76	J	6.56	J	2.14	J	3.12	J	9.16	J	7.69	J
Total PeCDFs		6.14	J	0.952	J	0.156	U	1.56	J	3.75	J	1.93	J	4.11	J	1.84	J	1.89	J	7.65		6.44	J
Total HxCDFs		5.18	J	1.21	J	0.224	U	2.65	J	3.94	J	2.77	J	5.06		0.93	J	2.53	J	6.51		6.3	J
Total HpCDFs		9.67	J	3.09	J	1.29	J	5.5	J	6.84	J	4.42	J	7.63	J	3.99	J	4.75	J	13	J	10.6	J
TEQ WHO-05 (1 DL)		1.92		0.79		0.72		1.19		1.47		1.03		1.66		0.98		1.00		1.75		1.60	
TEQ WHO-05 (1/2 DL)		1.75		0.50		0.42		0.80		0.99		0.90		1.34		0.67		0.72		1.58		1.38	
TEQ WHO-05 (0 DL)		1.57		0.21		0.12		0.42		0.52		0.77		1.02		0.35		0.44		1.40		1.16	

Notes:

mg/kg = milligrams per kilogram

ug/kg = micrograms per kilogram

pg/g = picogram per gram

U = Result should be considered not-detected at the quantitation limit shown

J = Result is an estimated concentration

R = Rejected - Quality Control indicates the data is not usable

UJ = The compound was not detected and the sample detection limit should be considered an estimated value

TEF = Toxicity Equivancy Factor

Table A-12f. US EPA/USACE “Bold Study” Analytical Data-Dioxins and Furans

Sample ID		SPSB_2		SPSB_3		SPSB_8_C		SS_0		SS_1		SS_2		SS_8_C		SS_9_C		CPS_3_Dup		HC_2_Dup		NCPS_2_Dup		PSPS_1_Dup		SPSB_0_Dup	
Analyte (pg/g)	**TEF**	**8/3/2008**	**Q**	**8/3/2008**	**Q**	**8/3/2008**	**Q**	**8/4/2008**	**Q**	**8/4/2008**	**Q**	**8/4/2008**	**Q**	**8/4/2008**	**Q**	**8/4/2008**	**Q**	**7/31/2008**	**Q**	**8/3/2008**	**Q**	**8/3/2008**	**Q**	**8/3/2008**	**Q**	**8/3/2008**	**Q**
% Solids		30.5		56.2		68.7		35.4		72.1		64.5		63.5		27.2		66.6		24.1		61.5		35.7		34	
2,3,7,8-TCDD	1	0.224	U	0.18	U	0.175	U	0.308	U	0.164	U	0.14	U	0.149	U	0.544	U	0.183	U	0.215	U	0.126	U	0.172	U	0.19	U
1,2,3,7,8-PeCDD	1	0.735	J	0.205	U	0.185	U	1.28	J	0.182	U	0.299	J	0.23	U	2.05	J	0.405	J	0.843	J	0.323	U	0.334	U	0.373	J
1,2,3,4,7,8-HxCDD	0.1	0.646	U	0.265	U	0.241	U	1.92	J	0.244	U	0.26	U	0.289	J	2.81	J	0.321	U	1.25	J	0.269	J	0.328	U	0.343	U
1,2,3,6,7,8-HxCDD	0.1	2.25	J	0.269	U	0.243	U	9.11		0.217	J	1.45	J	1.44	J	12.8		1.7	J	3.06	J	1.22	J	1.28	J	1.71	J
1,2,3,7,8,9-HxCDD	0.1	1.56	J	0.281	U	0.255	U	5.04	J	0.397	J	0.88	J	0.878	J	7.94		1.18	J	3.21	J	0.796	J	0.859	J	1.24	J
1,2,3,4,6,7,8-HpCDD	0.01	30.2		3.89	J	1.96	J	186		2.21	J	22		20.7		227		21.8		58.7		15.3		15.7		22	
OCDD	0.0003	197		24.3		11.3		1320		20.8		148		145		1570		189		350		101		119		146	
2,3,7,8-TCDF	0.1	1.87		0.253	J	0.191	U	1.63		0.187	U	0.664	J	0.699	J	3.66		1.22		1.5	J	1.07		1.42		1.52	
1,2,3,7,8-PeCDF	0.03	0.369	J	0.172	U	0.145	U	1.15	U	0.315	J	0.309	J	0.299	J	2.02	J	0.33	J	0.567	J	0.227	U	0.235	U	0.343	U
2,3,4,7,8-PeCDF	0.3	1.03	U	0.169		0.137	U	2.21	J	0.254	J	0.555	J	0.563	J	3.86	J	0.72	J	1.28	J	0.608	J	0.532	J	0.83	J
1,2,3,4,7,8-HxCDF	0.1	0.735	J	0.227	U	0.188	U	6.71		0.2	J	0.884	J	0.851	J	7.97		0.618	J	1.02	J	0.477	J	0.41	J	0.633	J
1,2,3,6,7,8-HxCDF	0.1	0.476	J	0.233	U	0.177	U	2.45	J	0.254	J	0.35	J	0.361	J	3.3	J	0.347	J	0.866	J	0.236	J	0.218	U	0.324	U
1,2,3,7,8,9-HxCDF	0.1	0.238	J	0.325	U	0.243	U	1.06	J	0.564	J	0.207	J	0.363	U	1.36	J	0.286	U	0.455	U	0.171	U	0.298	U	0.262	U
2,3,4,6,7,8-HxCDF	0.1	0.735	J	0.238	U	0.183	U	3.74	J	0.403	J	0.47	U	0.478	U	4.8	J	0.518	U	1.21	J	0.353	U	0.377	J	0.521	J
1,2,3,4,6,7,8-HpCDF	0.01	7.07		0.944	J	0.537	J	70.3		0.823	J	7.02		6.48		77.8		5.27		8.98		3.76	J	3.06	J	5.4	J
1,2,3,4,7,8,9-HpCDF	0.01	0.685	U	0.423	U	0.386	U	3.78	U	0.355	J	0.422	U	0.437	J	4.34	J	0.344	J	0.624	U	0.198	J	0.433	U	0.377	U
OCDF	0.0003	13.8		1.99	J	1.19	J	176		4.11	J	18.6		16.7		198		12.9		15.5	J	7.46	J	7.76	J	10.2	J
Total TCDDs		3.69		0.194	J	0.175	U	27.7		0.164	U	2.1		2.44		27.9		2.8		2.1		2.19		2.27		2.51	
Total PeCDDs		8.62		0.542	J	0.126	J	44.7		0.182	U	2.8	J	1.6	J	45.1		5.81		10.6		3.27	J	4.85	J	7.45	
Total HxCDDs		25.3		2.81	J	0.918	J	145		0.614	J	16.1		16.2		173		16.8		42.6		13.2		14.2		20.3	
Total HpCDDs		68		8.51		3.97	J	433		4.25	J	49.6		49.1		526		50.3		144		35		37.3		49.3	
Total TCDFs		14.4	J	0.819	J	0.202	U	19.2	J	0.202	U	5.02	J	6.66	J	42.6	J	8.35	J	10.3	J	7.3	J	6.2	J	9.76	J
Total PeCDFs		8.58		0.817	J	0.173	J	30.6		0.569	J	5.31		6.44		50.6		6.23		10.6		5.62		4.33	J	7.26	
Total HxCDFs		10.1		0.718	J	0.177	U	91.3		1.73	J	8.3		9.03		108		7.26		15.1		5.54		3.21	J	7.73	
Total HpCDFs		17.8	J	2.21	J	1.2	J	215	J	3.26	J	20.9	J	19.2	J	242	J	13.8	J	20.9	J	9.73	J	8.29	J	13.4	J
TEQ WHO-05 (1 DL)		2.57		0.71		0.61		8.50		0.72		1.48		1.42		11.90		1.77		3.51		1.32		1.42		1.80	
TEQ WHO-05 (1/2 DL)		2.27		0.42		0.32		8.31		0.53		1.37		1.19		11.63		1.62		3.38		1.07		1.12		1.65	
TEQ WHO-05 (0 DL)		1.97		0.13		0.03		8.12		0.33		1.26		0.95		11.35		1.47		3.24		0.81		0.82		1.51	

Notes:

mg/kg = milligrams per kilogram

ug/kg = micrograms per kilogram

pg/g = picogram per gram

U = Result should be considered not-detected at the quantitation limit shown

J = Result is an estimated concentration

R = Rejected - Quality Control indicates the data is not usable

UJ = The compound was not detected and the sample detection limit should be considered an estimated value

TEF = Toxicity Equivancy Factor

Table A-12g. US EPA/USACE "Bold Study" Analytical Data-TOC and Grain Size

Sample ID	**AI_1**		**AI_11_C**		**AI_13_C**		**AI_20_C_GS**		**AI_5_C**		**CPS_0**		**CPS_1**		**CPS_3**		**CPS_4**		**CPS_5**		**HC_0**		**HC_1**		**HC_2**		**HC_3**		**HC_6**	
Analyte (%)	**7/31/2008**	**Q**	**8/1/2008**	**Q**	**8/3/2008**	**Q**	**8/1/2008**	**Q**	**8/1/2008**	**Q**	**8/4/2008**	**Q**	**8/4/2008**	**Q**	**7/31/2008**	**Q**	**8/4/2008**	**Q**	**7/31/2008**	**Q**	**8/3/2008**	**Q**	**8/2/2008**	**Q**	**8/3/2008**	**Q**	**8/2/2008**	**Q**	**8/2/2008**	**Q**
Total Organic Carbon	0.691		0.193		0.717		0.602	J	1.1		2.75		0.729		1.55		1.19		0.994		0.864		0.798		3.65		0.978		1.86	
Total Solids	69.1		77		71.3		67.8		73.9		31.7		60.4		66.5		70.3		76.4		25.8		62.1		22.6		48.9		37.7	
Gravel	0.1	U	1.2		26.2		0.2		0.9		4		0.1		12.5		28.5		4.1		0.5		0.5		0.1	U	0.1		0.2	
Very Coarse Sand	0.2		0.5		7.4		0.3		1.6		4.8		0.4		4.2		8		2.3		0.5		0.1	U	0.1		0.2		0.2	
Coarse Sand	0.4		7.1		18.5		0.4		6		1.9		0.7		7.2		14.2		11.7		0.5		0.3		0.3		0.4		0.2	
Medium Sand	5.8		88.7		28.3		1		16.8		1.2		1.5		22		27.9		46.8		0.6		0.6		0.3		0.6		0.8	
Fine Sand	71.1		1.5		5.7		45		44.7		1.3		26.3		23.7		14.8		22.7		0.5		8.1		0.4		1		0.8	
Very Fine Sand	13.9		0.1		2		32.6		16.1		3		48.6		10.5		2.1		3.5		0.8		57.5		0.4		25.5		4.6	
Coarse Silt	0.2				2		5.3		2.6		2.3		3.9		0.5				1.1		1.9		11.4		3.2		26.5		15.9	
Medium Silt	1.1				1.7		2.4		2.3		11.5		2.2		3				0.9		8		5.2		9.7		12.5		22.4	
Fine Silt	0.8				0.9		2.1		0.8		11.2		2.4		2.8				0.8		13.7		3.1		20		7.1		12.4	
Very Fine Silt	0.9				1.2		1.5		1.3		12.3		2		2.3				1.1		17.2		2.2		17.6		4.6		10.1	
8-9 Phi Clay	0.7				1.2		1.4		1.2		11.7		2.3		1.9				0.8		15.8		1.7		15.2		5.4		7.8	
9-10 Phi Clay	0.9				1.3		1.4		1.2		8.6		2.4		2.4				1		12.1		2.1		9.8		4.4		7.2	
> 10 Phi Clay	3.9				3.6		6.5		4.6		26.2		7.2		7				3.4		27.9		7.3		23		11.7		17.5	
Total Fines	8.6		1		11.9		20.5		14		83.8		22.4		19.9		4.4		9		96.7		33		98.5		72.2		93.1	

Sample ID	**NCPS_0**		**NCPS_1**		**NCPS_2**		**NCPS_3**		**NCPS_4**		**PSPS_1**		**PSPS_2**		**PSPS_3**		**PSPS_8**		**PSPS_9**		**R_CAR_0**		**R_CAR_1**		**R_CAR_4**		**R_CAR_5**		**R_CAR_6_C**	
Analyte (%)	**7/31/2008**	**Q**	**7/31/2008**	**Q**	**8/3/2008**	**Q**	**7/31/2008**	**Q**	**7/31/2008**	**Q**	**8/3/2008**	**Q**	**8/3/2008**	**Q**	**8/3/2008**	**Q**	**8/3/2008**	**Q**	**8/3/2008**	**Q**	**8/4/2008**	**Q**	**8/4/2008**	**Q**	**8/4/2008**	**Q**	**8/4/2008**	**Q**	**8/4/2008**	**Q**
Total Organic Carbon	0.802		0.204		0.64		1.11		1.4		2.31		2.64		1.74		0.262	J	1.56		0.59		0.644		1.05		1.82		0.653	
Total Solids	56.7		78.6		62.7		55.2		76		34.1		40.4		37.1		74.6		34.3		62.2		68.5		59.7		33.1		73.2	
Gravel	0.1		0.3		0.1		0.1		47.8		2.2		2.9		0.3		0.1		0.6		0.3		2.5		1.3		2.9		0.1	U
Very Coarse Sand	0.1		1.2		0.3		0.1		2.9		2.1		4.2		1.2		0.2		2		0.5		2		2.5		3		0.1	
Coarse Sand	0.2		2.5		0.9		0.2		7.8		1.1		1.9		0.8		2.7		0.9		0.5		7.3		1.5		3.2		2.1	
Medium Sand	0.7		49.4		5.3		0.8		23		0.9		1.8		0.4		48.5		0.5		1.3		19.7		3.1		5.2		32.7	
Fine Sand	7.4		43.3		24.6		25.2		5.5		0.4		1		0.3		40.4		0.2		6.9		14.8		5.2		3.1		49.7	
Very Fine Sand	48.1		0.7		39.4		32.7		2.1		0.6		3.2		0.2		3.7		0.4		38.9		28.2		15.4		10.5		8.7	
Coarse Silt	13.7		1.3	J	7.3		9.7		3.5		0.6		7.4		2.3		1.2	J	3.2		24.8		10.2		18.7		6.1		1	
Medium Silt	6.3		0.1	J	3.1		5.8		1.2		5.6		15.7		2.3		0.3	J	4		12.4		2.7		20		9.3		0.6	
Fine Silt	4		0.1	J	3.1		4.2		1		13.7		15.4		12.1		0.2	J	10.9		3.9		1.7		11.3		8.6		0.5	
Very Fine Silt	4.3		0.1	UJ	2.2		3.7		0.9		17		12.2		17.1		0.2	J	19.8		2.1		1.8		4.8		9.8		0.6	
8-9 Phi Clay	1.7		0.1	UJ	3.3		3.9		1		16.5		9.3		21.3		0.2	J	16.9		1.7		1.7		3.8		8.4		0.6	
9-10 Phi Clay	3.4		0.1	J	2.9		3.3		0.7		13.4		8.1		14.9		0.3	J	14.7		1.6		1.8		3.2		8.6		0.8	
> 10 Phi Clay	10		1	J	7.3		10.4		2.4		25.8		17		26.8		1.8	J	26		5.3		5.6		9.3		21.1		2.6	
Total Fines	43.4		2.6		29.3		40.9		10.8		92.7		85.1		96.7		4.3		95.4		51.7		25.5		71		71.9		6.7	

Sample ID	**R_DAB_0**		**R_DAB_1**		**R_DAB_2**		**R_DAB_5**		**R_DAB_7_C**		**R_HOL_0**		**R_HOL_1**		**R_HOL_3**		**R_HOL_4**		**R_HOL_7**		**R_SAM_0**		**R_SAM_1**		**R_SAM_3**		**R_SAM_4**		**R_SAM_5**	
Analyte (%)	**8/2/2008**	**Q**	**8/2/2008**	**Q**	**8/2/2008**	**Q**	**8/2/2008**	**Q**	**8/2/2008**	**Q**	**8/3/2008**	**Q**	**8/3/2008**	**Q**	**8/3/2008**	**Q**	**8/3/2008**	**Q**	**8/3/2008**	**Q**	**8/1/2008**	**Q**	**8/1/2008**	**Q**	**8/1/2008**	**Q**	**8/1/2008**	**Q**	**8/1/2008**	**Q**
Total Organic Carbon	0.55		2.44		1.27		1.54		1.39		0.349		0.989		0.28		4.44		3.32		2.63		1.75		1.24		1.06		1.64	
Total Solids	69		33.1		33.2		39		43.5		77.3		71.1		80.6		17.4		30.8		36		51.8		48.3		44.3		33.7	
Gravel	0.1		30.4		2.7		5.9		5		0.1		0.1		0.1		27.6		12		4.8		0.4		0.3		1.3		14.4	
Very Coarse Sand	0.6		0.8		2		5		3.4		0.4		0.3		2.5		1.6		3.7		3.9		0.8		0.5		2		3.2	
Coarse Sand	3.3		0.3		0.9		2		1.9		6.4		4.6		16.2		0.4		2.1		1.8		1.6		0.4		1.3		1.2	
Medium Sand	7.1		0.4		1.1		2.6		3.8		32.5		32.2		54.1		0.6		3.6		1.3		11.4		0.8		1.6		2.4	
Fine Sand	17.9		0.4		0.7		1.9		5.1		36		31.1		22.1		0.3		2.5		1.1		25.4		1.6		2.3		0.3	
Very Fine Sand	54.2		0.4		2		5		15.9		17.3		14		2.4		0.6		4		5		15.2		11.2		7.8		3.4	
Coarse Silt	7.8		3		4.3		11.3		16.4		3.5		7.3		0.2	J	1.7		4.8		5.2		3.4		21.2		18.5		1.8	
Medium Silt	1.9		12.3		13.4		15.6		9.7		0.3		2.1		0.1	J	6.4		9.6		17.1		8.1		19.9		20		14.8	
Fine Silt	1.1		12.3		15.8		10.6		6.8		0.3		1.4		0.1	UJ	8.7		12.6		15.4		7.8		8.9		10.6		18.8	
Very Fine Silt	0.7		9.2		14		8.4		6.6		0.2		1		0.1	J	10.5		10.1		10.5		6.3		7.2		7.7		10.2	
8-9 Phi Clay	0.5		7		10		6.4		6.3		0.5		1.5		0.4	J	11.9		9.4		8.3		4.7		5.5		4.9		6.8	
9-10 Phi Clay	0.7		6.2		9.4		6.5		5.7		0.5		1.1		0.3	J	9.1		7.8		7		4.5		5.5		5.9		6.4	
> 10 Phi Clay	4		17.3		23.7		18.9		13.4		2.2		3.4		1.4	J	20.4		17.8		18.5		10.4		17.2		16.1		16.3	
Total Fines	16.8		67.3		90.5		77.7		64.9		7.4		17.8		2.6		68.8		72.1		82		45.2		85.3		83.7		75.1	

Notes:
mg/kg = milligrams per kilogram
ug/kg = micrograms per kilogram
U = Result should be considered not-detected at the quantitation limit shown
J = Result is an estimated concentration
R = Rejected - Quality Control indicates the data is not usable
UJ = The compound was not detected and the sample detection limit should be considered an estimated value

Table A-12g. US EPA/USACE "Bold Study" Analytical Data-TOC and Grain Size

Sample ID	SCPS_1		SCPS_10_C		SCPS_2		SCPS_3		SCPS_5		SJF_10_C		SJF_12_C_GS		SJF_2		SJF_3		SJF_9_C		SJI_0		SJI_1		SJI_20_C_GS		SJI_3	
Analyte (%)	**8/4/2008**	**Q**	**8/5/2008**	**Q**	**8/4/2008**	**Q**	**8/4/2008**	**Q**	**8/4/2008**	**Q**	**8/1/2008**	**Q**	**8/2/2008**	**Q**	**8/1/2008**	**Q**	**8/1/2008**	**Q**	**8/1/2008**	**Q**	**8/1/2008**	**Q**	**8/2/2008**	**Q**	**8/2/2008**	**Q**	**8/2/2008**	**Q**
Total Organic Carbon	1.38		0.629		0.461		0.354		1.71		0.795		2.64		1.16		0.914		1.54		1.18		0.964		1.73		1.05	
Total Solids	34		74.7		74.9		80.5		29		73.8		29.8		71.9		73.6		53.8		53.1		62.2		43.3		58.3	
Gravel	7.1		25		0.1		0.6		0.7		0.6		13.1		38.6		32.3		28.1		1.6		1.2		0.8		0.5	
Very Coarse Sand	5.9		5.5		0.9		1.6		1.1		0.5		4.6		0.5		2.9		2.3		0.4		0.7		1.6		0.9	
Coarse Sand	2.1		7.4		3.8		16.7		1.9		5.4		1.3		5.3		3.7		3.6		0.3		1		1.4		1.5	
Medium Sand	2.6		16.2		15.8		51.7		3.1		34.6		0.7		10.2		26.1		7.4		0.7		13.5		3.3		6.9	
Fine Sand	2.6		20.2		65.7		22.2		2.1		40		0.5		16.3		20.4		22		2.2		40.3		3.3		26.3	
Very Fine Sand	4.3		13.9		7.9		4.5		2.4		7.2		0.8		8.8		3.3		11.7		26		14.2		5.7		27.1	
Coarse Silt	2.8		1.1		0.3				1		0.8		2		6.9		2.2		3.7		26.6		4.7		14.9		9.9	
Medium Silt	9		1		0.2				6.2		1.8		9.7		2.7		1.8		4.3		11.9		4.8		22.4		4.9	
Fine Silt	11.3		1.1		0.3				12.2		1.5		16.1		1.8		1.5		3.4		5		3.2		12.6		4.1	
Very Fine Silt	9.9		1.4		0.5				15.4		1.1		13.7		1.6		1		2.6		4.6		2.7		7.2		3.1	
8-9 Phi Clay	8.7		1.5		0.5				11.9		1		7.3		1.3		0.9		1.9		3.4		2.4		5.5		2.5	
9-10 Phi Clay	9.3		1.7		0.6				12.1		1.3		6.9		1.3		1		2.1		3.7		2.6		5.1		2.7	
> 10 Phi Clay	24.2		4		3.3				29.8		4.2		23.2		4.7		3		6.9		13.7		8.8		16.1		9.7	
Total Fines	75.3		11.8		5.7		2.8		88.6		11.7		78.9		20.2		11.4		24.9		69		29.2		83.9		36.9	

Sample ID	SJI_8_C		SPSB_0		SPSB_1		SPSB_2		SPSB_3		SPSB_8_C		SS_0		SS_1		SS_2		SS_8_C	
Analyte (%)	**8/2/2008**	**Q**	**8/3/2008**	**Q**	**8/3/2008**	**Q**	**8/3/2008**	**Q**	**8/3/2008**	**Q**	**8/3/2008**	**Q**	**8/4/2008**	**Q**	**8/4/2008**	**Q**	**8/4/2008**	**Q**	**8/4/2008**	**Q**
Total Organic Carbon	1.47		2.24		1.85		2.09		1.02		0.409		2.51		0.217		0.737		0.795	
Total Solids	67.8		31.9		29.9		29.7		58		70.8		32.1		72.9		65.8		63.3	
Gravel	3.4		14.4		6.8		16.8		0.2		0.1		1.6		0.2		0.1		0.1	U
Very Coarse Sand	1.3		4		3.4		4.1		0.4		0.1		2.5		0.2		0.2		0.1	
Coarse Sand	3.6		1		1.3		0.5		0.3		0.2		1.8		7.8		0.4		0.6	
Medium Sand	45.4		1.1		1		0.6		0.4		0.4		2.2		67.6		2.8		13.8	
Fine Sand	17.7		1.3		0.5		0.5		1.4		12.4		2.5		22.1		33.4		42.1	
Very Fine Sand	4.6		1.9		0.5		1		16.9		51.9		6		0.2		43.1		24.9	
Coarse Silt	2.8		0.4		0.3		0.7		24.2		13.9		4.7				5.9		3.3	
Medium Silt	4.3		5.8		5.2		5.8		18.3		6.1		16.3				2.1		1.9	
Fine Silt	3.1		8.7		8.7		7.6		10.9		3.8		16.7				1.4		0.7	
Very Fine Silt	2.4		14.3		16.8		12		6.8		2.5		12.5				1.4		2.4	
8-9 Phi Clay	1.9		11.5		14.9		11.7		4.3		1.8		9.4				1.7		1.8	
9-10 Phi Clay	2		10.5		12.7		12.6		4.9		1.7		6.5				1.8		2	
> 10 Phi Clay	7.5		25.2		28		26.1		10.9		5.1		17.3				5.7		6.3	
Total Fines	24.1		76.4		86.5		76.4		80.4		34.9		83.4		1.9		20		18.5	

Sample ID	SS_9_C		CPS_3_Dup		HC_2_Dup		NCPS_2_Dup		PSPS_1_Dup		SPSB_0_Dup	
Analyte (%)	**8/4/2008**	**Q**	**7/31/2008**	**Q**	**8/3/2008**	**Q**	**8/3/2008**	**Q**	**8/3/2008**	**Q**	**8/3/2008**	**Q**
Total Organic Carbon	0.38		1.49		4.33		0.949		2.03		2.07	
Total Solids	25.2		64.7		22.5		62.7		33		31.6	
Gravel	0.1	U	11.4		17.7		0.3		0.1	U	7.1	
Very Coarse Sand	0.1		4.2		3.9		1		0.6		4.6	
Coarse Sand	0.4		7.2		0.8		2.5		0.9		0.9	
Medium Sand	1.4		21.7		0.5		6.6		0.9		0.6	
Fine Sand	1.6		24.3		0.3		23.2		0.6		1.4	
Very Fine Sand	3.1		10.6		0.3		41.1		0.7		2.3	
Coarse Silt	4.8		1.2		7.5		5.2		2.2		1	
Medium Silt	13.5		3.1		6.4		2.8		6.7		4.9	
Fine Silt	18.5		2.7		13		2.1		13.4		11.7	
Very Fine Silt	13.4		2.3		12.9		2.7		17.6		13.1	
8-9 Phi Clay	10.5		2.4		9.5		2.3		14.6		13	
9-10 Phi Clay	9.7		2.3		6.4		2.5		14.2		11.7	
> 10 Phi Clay	23.1		6.8		20.8		7.7		27.6		27.8	
Total Fines	93.4		20.7		76.5		25.4		96.3		83.2	

Notes:
mg/kg = milligrams per kilogram
ug/kg = micrograms per kilogram
U = Result should be considered not-detected at the quantitation limit shown
J = Result is an estimated concentration
R = Rejected - Quality Control indicates the data is not usable
UJ = The compound was not detected and the sample detection limit should be considered an estimated value

Table A-13. PSR Sediment Monitoring Data from 2007 OMMP

	Sediment Quality Standards (SQS)	Cleanup Screening Levels (CSL)	PSR07-OSA-1-S 8/7/07	Q	PSR07-OSA-2-S 8/7/07	Q	PSR07-OSA-3-S 8/7/07	Q	PSR07-OSA-4-S 8/7/07	Q	PSR07-OSA-5-S 8/7/07	Q	PSR07-OSA-6-S 8/7/07	Q	PSR07-OSA-7-S 8/7/07	Q	PSR07-RA2B-1-S 8/7/07	Q	PSR07-RA4-2-S 8/7/07	Q	PSR07-RA4-3-S 8/9/07	Q	PSR07-RA4-6-S 8/8/07	Q	PSR07-RA4-9-S 8/7/07	Q
Metals (mg/kg dry wt)																										
Arsenic	57	93	4.63	D	6.39	D	5.43	D	5.24	D	11.6	D	4.97	D	13.3	D	23.9	D	4.4	D	5	D	5.5	D	4.25	D
Cadmium	5.1	6.7	0.26	D	0.233	D	0.187	D	0.182	D	0.16	D	0.117	D	0.357	D	0.071	D	0.112	D	0.161	D	0.145	D	0.101	D
Chromium	260	270	26.1	D	29.4	D	25.8	D	26.4	D	17.3	D	8.52	D	293	D	7.33	D	19.8	D	23.1	D	30.4	D	21.3	D
Copper	390	390	51.2	D	32.5	D	27	D	27	D	20.2	D	17.7	D	212	D	9.1	D	16.7	D	22.8	D	28.5	D	19.8	D
Lead	450	530	193	D	12.8	D	10.5	D	13.8	D	9.25	D	10.6	D	109	D	3.42	D	5.62	D	7.24	D	8.88	D	6.17	D
Mercury	0.41	0.59	0.189		0.104		0.079		0.121		0.128		0.1		0.243		0.021		0.045		0.064		0.072		0.054	
Silver	6.1	6.1	0.2	D	0.12	D	0.1	D	0.16	D	0.11	D	0.06	D	0.33	D	0.03	D	0.08	D	0.07	D	0.11	D	0.06	D
Zinc	410	960	70.7	D	57.7	D	51.4	D	52.7	D	37.7	D	28.2	D	452	D	16.9	D	35.3	D	40.1	D	55.4	D	38.8	D
Non-Ionizable Organic Compounds (mg/kg OC)																										
Naphthalene	99	170	9.92		0.82		4.27		1.29		0.26		7.00		10.34		22.14		1.25	J	1.46		2.11		4.12	
Acenaphthylene	66	66	8.26		0.43		1.37		0.86		0.11	J	3.25		6.64		3.11	J	0.96	J	0.42	J	0.26	U	0.56	J
Acenaphthene	16	57	5.29		0.31	J	1.07		0.34	J	0.11	J	3.25		12.07		12.14		0.81	J	0.64	J	0.43	J	0.65	J
Fluorene	23	79	7.93		0.39		1.30		0.52	J	0.14	J	4.25		12.93		12.50		1.21	J	0.60	J	0.54	J	0.88	
Phenanthrene	100	480	52.07		1.87		6.03		3.79		0.66		25.00		71.55		46.43		4.23		1.99		1.58		2.63	
Anthracene	220	1200	28.93		0.79		3.36		1.98		0.29		8.25		19.83		13.57		3.08		1.06		1.08	J	0.96	
2-Methylnaphthalene	38	64	3.39		0.24	J	1.15		0.43	J	0.09	J	2.75	J	4.31		6.79		0.62	J	0.49	J	0.74	J	1.05	
Total LPAH[2/]	370	780	112.40		4.61	J	17.40		8.79	J	1.56	J	51.00		133.36		109.89	J	11.54	J	6.17	J	5.74	J	9.81	J
Fluoranthene	160	1200	65.29		3.61		13.74		7.67		1.13		27.50		137.93	D	46.43		11.35		5.30		2.50		7.11	
Pyrene	1000	1400	70.25		3.15		16.79		5.95		1.02		27.50		112.07	D	42.86		9.04		5.03		3.42		3.95	
Benz(a)anthracene	110	270	57.85		1.34		8.40		4.05		0.50		10.00		43.97		16.43		6.35		2.12		1.01	J	1.58	
Chrysene	110	460	90.91	D	2.13		7.63		6.98		0.81		17.25		69.83		23.93		8.65		3.11		1.84		2.63	
Total Benzofluoranthene	230	450	133.06	D	3.48		18.47		9.05		1.22		28.50		125.86	D	31.79		9.81		4.30		2.29	J	3.69	J
Benzo(a)pyrene	99	210	60.33		1.18		6.56		2.84		0.37		9.25		37.07		10.71		3.46		1.85		0.83	J	0.96	
Indeno(1,2,3-cd)pyrene	34	88	42.15		1.18		5.04		3.19		0.43		10.75		35.34		8.21		2.50		1.59		0.70	J	1.23	
Dibenz(a,h)anthracene	12	33	2.81		0.10	U	0.20	U	0.74	J	0.04	U	2.23	J	1.55		2.25	J	0.71	J	0.17	U	0.33	J	0.25	J
Benzo(g,h,i)perylene	31	78	34.71		1.05		4.12		2.84		0.38		9.75		29.31		6.79		2.50		1.06		0.62	J	1.05	
Total HPAH[3/]	960	5300	557.36	D	17.11		80.76		42.59	J	5.86		142.73	J	592.93	D	189.39	J	54.37	J	24.37		13.54	J	22.45	J
Chlorinated Benzenes (mg/kg OC)																										
1,2-Dichlorobenzene	2.3	2.3	0.37	U	0.19	U	0.38	U	0.48	U	0.09	U	1.00	U	0.43	U	1.21	U	0.77	U	0.33	U	0.62	U	0.38	U
1,4-Dichlorobenzene	3.1	9	0.37	U	0.19	U	0.38	U	0.48	U	0.09	U	1.00	U	0.43	U	1.21	U	0.77	U	0.33	U	0.62	U	0.38	U
1,2,4-Trichlorobenzene	0.81	1.8	0.34	U	0.17	U	0.34	U	0.43	U	0.08	U	0.90	U	0.39	U	1.11	U	0.69	U	0.29	U	0.55	U	0.33	U
Hexachlorobenzene	0.38	2.3	0.16	U	0.08	U	0.16	U	0.20	U	0.04	U	0.43	U	0.18	U	0.50	U	0.33	U	0.14	U	0.26	U	0.16	U
Phthalate Esters (mg/kg OC)																										
Dimethyl Phthalate	53	53	0.13	U	0.07	U	0.13	U	0.17	U	0.03	U	0.43	J	0.15	U	0.43	U	0.27	U	0.11	U	0.21	U	0.13	U
Diethyl Phthalate	61	110	0.18	J	0.09	U	0.18	U	0.22	J	0.04	U	0.45	U	0.20	U	0.61	J	0.42	J	0.17	J	0.28	U	0.17	U
Di-n-butyl Phthalate	220	1700	1.65	B	0.85	B	2.82	B	2.59	B	0.44	B	5.25	BJ	2.07	B	7.86	B	4.04	B	2.19	B	2.37	BJ	2.54	B
Butyl Benzyl Phthalate	4.9	64	0.41	U	0.20	U	0.42	U	0.53	U	0.09	U	1.10	U	0.47	U	1.36	U	0.85	U	0.36	U	0.67	U	0.41	U
Bis(2-ethylhexyl) Phthalate	47	78	3.97	J	1.11	J	1.53	J	2.67	J	0.29	J	5.00	J	9.48		5.36	J	1.85	J	1.06	J	1.58	U	0.96	U
Di-n-octyl Phthalate	58	4500	0.22	U	0.11	U	0.22	U	0.28	U	0.05	U	0.60	U	0.25	U	0.71	U	0.44	U	0.19	U	0.37	U	0.22	U
Miscellaneous Extractable Compounds (mg/kg OC)																										
Dibenzofuran	15	58	4.63		0.29	J	1.30		0.36	J	0.09	J	4.00		8.10		10.71		0.88	J	0.50	J	0.47	J	1.23	
Hexachlorobutadiene	3.9	6.2	0.32	U	0.16	U	0.33	U	0.41	U	0.07	U	0.88	U	0.37	U	1.07	U	0.65	U	0.28	U	0.53	U	0.32	U
N-Nitrosodiphenylamine	11	11	0.21	U	0.10	U	0.21	U	0.27	U	0.05	U	0.55	U	0.24	U	0.68	U	0.42	U	0.19	U	0.34	U	0.21	U
Aroclor 1016			0.22	U	0.11	U	0.22	U	0.28	U	0.05	U	0.60	U	0.25	U	0.71	U	0.44	U	0.19	U	0.37	U	0.22	U
Aroclor 1221			0.22	U	0.11	U	0.22	U	0.28	U	0.05	U	0.60	U	0.25	U	0.71	U	0.44	U	0.19	U	0.37	U	0.22	U
Aroclor 1232			0.22	U	0.11	U	0.22	U	0.28	U	0.05	U	0.60	U	0.25	U	0.71	U	0.44	U	0.19	U	0.37	U	0.22	U
Aroclor 1242			0.22	U	0.11	U	0.22	U	0.28	U	0.05	U	0.60	U	0.25	U	0.71	U	0.44	U	0.19	U	0.37	U	0.22	U
Aroclor 1248			0.22	U	0.11	U	0.22	U	0.28	U	0.05	U	0.60	U	0.25	U	0.71	U	1.92	Ui	0.19	U	0.37	U	0.22	U
Aroclor 1254			4.96		0.26	Ui	0.99		1.72		0.56		8.75		12.07		0.71	U	2.31	Ui	0.44	Ui	0.37	U	0.22	U
Aroclor 1260			0.22	U	0.46	Ui	0.69	Ui	0.28	U	0.05	U	0.60	U	0.25	U	0.71	U	1.92	Ui	0.19	U	0.37	U	0.22	U
Total PCBs[4/]	12	65	4.96		0.46	U	0.99		1.72		0.56		8.75		12.07		0.71	U	2.31	U	0.44	U	0.37	U	0.22	U
Ionizable Organic Compounds (ug/kg dry wt)																										
Phenol	420	1200	23	J	14	J	18	J	7.9	J	230		23	J	28	J	12	J	14	J	48		19	J	35	
2-Methylphenol	63	63	2.4	U	3	U	2.6	U	2.9	U	2.9	U	2.1	U	2.6	U	1.8	U	2.1	U	13		2.4	U	2.2	U
4-Methylphenol	670	670	5.4	J	10		4.6	J	4.3	J	10		2.1	U	8.2	J	1.8	U	2.1	U	16		5.9	J	11	
2,4-Dimethylphenol	29	29	8.6	U	11	U	9.4	U	11	U	11	U	7.6	U	9.4	U	6.4	U	7.5	U	9.4	U	8.8	U	8	U
Pentachlorophenol (PCP)	360	690	31	U	39	U	34	U	39	U	39	U	28	U	34	U	24	U	27	U	34	U	32	U	30	U
Benzyl Alcohol	57	73	7.1	J	13	J	3.6	U	7.2	J	10	J	6.7	J	3.6	U	4.4	J	5.1	J	3.6	U	6.2	J	5.6	J
Benzoic Acid	650	650	150	U	190	U	170	U	190	U	190	U	140	U	170	U	120	U	130	U	170	U	160	U	140	U

Data Qualifiers

B - The analyte was found in the associated method blank at a level that is significant relative to the sample result.

D - The reported result is from a dilution

J - The result is an estimated concentration that is less than the MRL but greater than or equal to the MDL

P - The GC or HPLC confirmation criteria were exceeded. The relative percent difference is greater than 40% between the two analytical results (25% for CLP pesticides).

U - The compound was analyzed for, but was not detected ("non-detect") at or above the MRL/MDL.

i - the MRL/MDL is elevated due to matrix or chromatographic interference

Notes

1/ Duplicate sample

2/ Sum of low molecular weight PAH results for naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, and anthracene

3/ Sum of high molecular weight PAH results for fluoranthene, pyrene, benz(a)anthracene, chrysene, total benzofluoranthenes, benzo(a)pyrene, indeneo(1,2,3-c,d)pyrene, dibenzo(a,h)anthracene, and benzo(g,h,i)perylene

4/ Sum of Aroclors 1016, 1221, 1232, 1242, 1248, 1254, 1260

Table A-13. PSR Sediment Monitoring Data from 2007 OMMP

	Sediment Quality Standards (SQS)	Cleanup Screening Levels (CSL)	PSR07-RA4-10S 8/7/07	Q	PSR07-RA5-1-S 8/9/07	Q	PSR07-RA5-2-S 8/8/07	Q	PSR07-RA5-3-S 8/8/07	Q	PSR07-RA5-4-S 8/9/07	Q	PSR07-RA5-5-S 8/8/07	Q	PSR07-RA5-6-S 8/9/07	Q	PSR07-RA5-7-S 8/8/07	Q	PSR07-RA5-8-S 8/8/07	Q	PSR07-RA5-8-S-D 8/8/07	Q	PSR07-RA5-9-S 8/9/07	Q	PSR07-RA5-10-S 8/8/07	Q
Metals (mg/kg dry wt)																										
Arsenic	57	93	4.42	D	6.34	D	5.86	D	5.66	D	4.1	D	4.02	D	4.95	D	5.45	D	4.64	D	5.12		6.64	D	5.42	D
Cadmium	5.1	6.7	0.102	D	0.218	D	0.146	D	0.171	D	0.106	D	0.129	D	0.161	D	0.173	D	0.142	D	0.148		0.204	D	0.16	D
Chromium	260	270	25.8	D	33.6	D	24.3	D	26.6	D	21.2	D	22.3	D	29.9	D	23.5	D	22.8	D	23.3		30.8	D	28.4	D
Copper	390	390	20.2	D	31.6	D	22.7	D	27.2	D	19.6	D	21	D	27	D	23.6	D	21.7	D	22.4		29.1	D	28	D
Lead	450	530	6.06	D	11.4	D	6.38	D	9.51	D	6.54	D	7.56	D	9.53	D	7.04	D	7.26	D	7.52		10.6	D	10.4	D
Mercury	0.41	0.59	0.079		0.084		0.06		0.101		0.07		0.07		0.083		0.074		0.078		0.078		0.089		0.212	
Silver	6.1	6.1	0.05	D	0.11	D	0.06	D	0.11	D	0.08	D	0.25	D	0.11	D	0.11	D	0.09	D	0.08		0.11	D	0.1	D
Zinc	410	960	42.4	D	56.3	D	44.3	D	49.5	D	37.2	D	41	D	53.7	D	43.6	D	41.9	D	43.1		54.8	D	54.3	D
Non-Ionizable Organic Compounds (mg/kg OC)																										
Naphthalene	99	170	0.59	J	1.12		1.24		1.73		2.77		7.88		0.52	J	2.48		0.88		0.39	JT	2.60		6.11	
Acenaphthylene	66	66	0.37	J	0.59		0.28	J	0.73		0.62	J	1.53		0.65	J	0.56	J	0.26	J	0.43	JT	0.71		2.00	
Acenaphthene	16	57	0.29	U	0.36	J	0.39	J	0.87		0.92		4.47		0.27	J	1.10		0.27	J	0.19	JT	1.12		2.21	
Fluorene	23	79	0.29	J	0.49	J	0.45	J	0.93		1.01		3.65		0.52	J	1.52		0.36	J	0.34	JT	1.60		2.74	
Phenanthrene	100	480	1.43	J	2.61		1.52		3.53		3.78		10.82		5.08		5.31		1.24		1.58		5.21		11.58	
Anthracene	220	1200	0.71	J	1.06		0.69		1.73		1.43		6.35		1.59		1.66		0.57		0.89		2.19		4.42	
2-Methylnaphthalene	38	64	0.46	U	0.33	J	0.40	J	0.61	J	0.84		1.88		0.29	U	0.90		0.28	J	0.14	JT	0.89		1.79	
Total LPAH[2/]	370	780	3.38	J	6.23	J	4.57	J	9.53		10.54	J	34.71		8.63	J	12.63	J	3.58	J	3.96		13.43		29.05	
Fluoranthene	160	1200	2.94		7.98		3.10		9.33		4.79		12.94		9.52		8.28		2.18		7.89		7.69		14.74	
Pyrene	1000	1400	2.50		6.38		2.48		8.67		5.88		17.65		7.70		6.90		2.12		6.32		9.47		13.68	
Benz(a)anthracene	110	270	1.13	J	2.87		1.03		3.20		2.10		9.06		3.02		3.93		0.93		2.58		3.08		6.32	
Chrysene	110	460	2.21		4.31		1.79		4.53		3.53		15.29		6.27		4.69		1.19		5.26		4.38		7.47	
Total Benzofluoranthene	230	450	2.81	J	6.01		2.38	J	7.07		4.71		20.71		5.71		5.93		2.28		5.68		6.04		11.89	
Benzo(a)pyrene	99	210	1.13	J	2.61		0.83		2.67		2.27		7.18		2.30		2.21		1.04		2.16		2.84		5.47	
Indeno(1,2,3-cd)pyrene	34	88	1.07	J	1.65		0.76		2.20		1.51		4.59		1.90		1.38		0.73		1.79		1.95		4.00	
Dibenz(a,h)anthracene	12	33	0.32	U	0.36	J	0.16	U	0.61	J	0.21	U	1.11	J	0.20	U	0.18	U	0.21	J	0.51	JT	0.17	U	0.26	U
Benzo(g,h,i)perylene	31	78	1.06	J	1.60		0.67	J	1.93		1.43		3.65		1.75		1.17		0.73		1.53		1.78		3.37	
Total HPAH[3/]	960	5300	14.85	J	33.76	J	13.05	J	40.21	J	26.22		92.16	J	38.17		34.48		11.40	J	33.72		37.22		66.95	
Chlorinated Benzenes (mg/kg OC)																										
1,2-Dichlorobenzene	2.3	2.3	0.60	U	0.29	U	0.31	U	0.35	U	0.40	U	0.54	U	0.37	U	0.34	U	0.25	U	0.15	U	0.33	U	0.49	U
1,4-Dichlorobenzene	3.1	9	0.60	U	0.29	U	0.31	U	0.35	U	0.40	U	0.54	U	0.37	U	0.34	U	0.25	U	0.15	U	0.33	U	0.49	U
1,2,4-Trichlorobenzene	0.81	1.8	0.54	U	0.26	U	0.28	U	0.31	U	0.36	U	0.48	U	0.33	U	0.31	U	0.23	U	0.14	U	0.29	U	0.45	U
Hexachlorobenzene	0.38	2.3	0.25	U	0.12	U	0.13	U	0.15	U	0.17	U	0.22	U	0.16	U	0.14	U	0.11	U	0.06	U	0.14	U	0.21	U
Phthalate Esters (mg/kg OC)																										
Dimethyl Phthalate	53	53	0.22	U	0.10	U	0.11	U	0.13	U	0.14	U	0.19	U	0.13	U	0.12	U	0.09	U	0.05	U	0.11	U	0.18	U
Diethyl Phthalate	61	110	0.29	J	0.13	U	0.14	J	0.17	J	0.18	U	0.25	U	0.17	U	0.16	U	0.11	U	0.21	JT	0.17	J	0.32	J
Di-n-butyl Phthalate	220	1700	3.24	B	1.44	B	1.45	B	2.00	B	2.02	B	3.06	B	1.75	B	1.31	BJ	1.19	B	0.68	JT	1.89	B	2.63	B
Butyl Benzyl Phthalate	4.9	64	0.68	U	0.32	U	0.34	U	0.61	J	0.45	U	0.60	U	0.41	U	0.38	U	0.28	U	0.17	U	0.36	U	0.55	U
Bis(2-ethylhexyl) Phthalate	47	78	1.46	U	1.49	J	0.76	J	1.67	J	1.43	J	1.88	J	1.51	J	1.24	J	1.55	J	0.84	JT	2.13	J	2.53	J
Di-n-octyl Phthalate	58	4500	0.35	U	0.17	U	0.18	U	0.21	U	0.24	U	0.32	U	0.22	U	0.20	U	0.15	U	0.09	U	0.19	U	0.29	U
Miscellaneous Extractable Compounds (mg/kg OC)																										
Dibenzofuran	15	58	0.26	J	0.37	J	0.37	J	0.87		1.09		3.41		0.28	J	1.45		0.33	J	0.16	JT	1.18		2.32	
Hexachlorobutadiene	3.9	6.2	0.53	U	0.25	U	0.27	U	0.31	U	0.35	U	0.47	U	0.33	U	0.30	U	0.22	U	0.13	U	0.28	U	0.43	U
N-Nitrosodiphenylamine	11	11	0.34	U	0.16	U	0.19	J	0.19	U	0.23	U	0.31	U	0.21	U	0.19	U	0.14	U	0.08	U	0.18	U	0.27	U
Aroclor 1016			0.35	U	0.17	U	0.18	U	0.21	U	0.24	U	0.32	U	0.22	U	0.20	U	0.15	U	0.09	U	0.19	U	0.29	U
Aroclor 1221			0.35	U	0.17	U	0.18	U	0.21	U	0.24	U	0.32	U	0.22	U	0.20	U	0.15	U	0.09	U	0.19	U	0.29	U
Aroclor 1232			0.35	U	0.17	U	0.18	U	0.21	U	0.24	U	0.32	U	0.22	U	0.20	U	0.15	U	0.09	U	0.19	U	0.29	U
Aroclor 1242			0.35	U	0.17	U	0.18	U	0.21	U	0.24	U	0.32	U	0.22	U	0.20	U	0.15	U	0.09	U	0.19	U	0.29	U
Aroclor 1248			0.35	U	0.17	U	0.18	U	0.21	U	0.24	U	0.32	U	0.22	U	0.20	U	0.15	U	0.09	U	0.19	U	0.29	U
Aroclor 1254			0.35	U	0.41	Ui	0.18	U	0.21	U	0.78	Ui	1.01	Ui	1.03		0.20	U	0.15	U	0.27	JT	1.36		2.00	
Aroclor 1260			0.35	U	0.17	U	0.18	U	0.21	U	0.24	U	1.53	Ui	0.22	U	0.20	U	0.15	U	0.27	JT	0.19	U	1.47	
Total PCBs[4/]	12	65	0.35	U	0.41	U	0.18	U	0.21	U	0.78	U	1.53	U	1.03		0.20	U	0.15	U	0.54		1.36		3.47	
Ionizable Organic Compounds (ug/kg dry wt)																										
Phenol	420	1200	30	J	18	J	24	J	17	J	21	J	8.7	J	19	J	16	J	16	J	17	JT	22	J	33	
2-Methylphenol	63	63	2.2	U	2.8	U	2.3	U	2.8	U	2.5	U	2.4	U	2.5	U	2.6	U	2.6	U	1.5	U	2.8	U	2.5	U
4-Methylphenol	670	670	19		2.8	U	27		12		18		2.4	U	2.5	U	8	J	3.9	J	6.5	JT	21		11	
2,4-Dimethylphenol	29	29	7.8	U	11	U	8.4	U	10	U	9.1	U	8.7	U	8.9	U	9.4	U	9.3	U	5.5	U	11	U	8.9	U
Pentachlorophenol (PCP)	360	690	29	U	38	U	31	U	37	U	34	U	32	U	33	U	34	U	34	U	20	U	38	U	33	U
Benzyl Alcohol	57	73	8.1	J	4	U	9.4	J	9.4	J	3.5	U	3.3	U	7.4	J	9.7	J	8.2	J	6.7	JT	4	U	10	J
Benzoic Acid	650	650	140	U	180	U	150	U	180	U	160	U	160	U	160	U	170	U	170	U	96	U	180	U	160	U

Data Qualifiers

B - The analyte was found in the associated method blank at a level that is significant relative to the sample result.

D - The reported result is from a dilution

J - The result is an estimated concentration that is less than the MRL but greater than or eaul to the MDL

P - The GC or HPLC confirmation criteria were exceeded. The relative percent difference is greater than 40% between the two analytical results (25% for CLP pesticides).

U - The compound was analyzed for, but was not detected ("non-detect") at or above the MRL/MDL.

i - the MRL/MDL is elevated due to matrix or chromatographic interference

Notes

1/ Duplicate sample

2/ Sum of low molecular weight PAH results for naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, and anthracene

3/ Sum of high molecular weight PAH results for fluoranthene, pyrene, benz(a)anthracene, chrysene, total benzofluoranthenes, benzo(a)pyrene, indeneo(1,2,3-c,d)pyrene, dibenzo(a,h)anthracene, and benzo(g,h,i)perylene

4/ Sum of Aroclors 1016, 1221, 1232, 1242, 1248, 1254, 1260

Table A-13. PSR Sediment Monitoring Data from 2007 OMMP

	Sediment Quality Standards (SQS)	Cleanup Screening Levels (CSL)	PSR07-RA5-11-S 8/9/07	Q	PSR07-RA5-12-S[1/] 8/8/07	Q	PSR07-RA5-13-S 8/8/07	Q	PSR07-RA5-14A-S 8/8/07	Q	PSR07-RA5-14A-S-D 8/8/07	Q	PSR07-RA5-15-S 8/9/07	Q	PSR07-RA5-20-S 8/8/07	Q	PSR07-RA5-21-S 8/8/07	Q
Metals (mg/kg dry wt)																		
Arsenic	57	93	5.42	D	5.76	D	5.79	D	7.6	D	9.75		4.49	D	4.4	D	5.01	D
Cadmium	5.1	6.7	0.146	D	0.176	D	0.167	D	0.994	D	2.25		0.157	D	0.137	D	0.132	D
Chromium	260	270	25.3	D	25.3	D	25.3	D	38.4	D	62.60		21.9	D	18.6	D	23.1	D
Copper	390	390	24.4	D	26.4	D	26.4	D	44.5	D	70.30		24.9	D	21	D	23.8	D
Lead	450	530	11.1	D	13.9	D	13	D	42.4	D	86.30		12.7	D	9.3	D	10.2	D
Mercury	0.41	0.59	0.29		0.086		0.167		0.117		0.12		0.094		0.132		0.078	
Silver	6.1	6.1	0.1	D	0.11	D	0.11	D	1.63	D	0.36		0.14	D	0.11	D	0.09	D
Zinc	410	960	52	D	54.4	D	49.8	D	89.8	D	150.00		48.5	D	39.1	D	47	D
Non-Ionizable Organic Compounds (mg/kg OC)																		
Naphthalene	99	170	3.61		13.49		1.85		1.78		3.81		1.53		1.08		2.04	
Acenaphthylene	66	66	0.39	J	1.98		0.85	J	3.93		0.85		0.59	J	0.37	J	0.52	J
Acenaphthene	16	57	0.88		3.89		0.71	J	0.81		0.97		0.33	J	0.63	J	0.87	J
Fluorene	23	79	1.06		4.44		0.88	J	1.04		1.36		0.65	J	0.62	J	1.02	
Phenanthrene	100	480	3.33		14.29		4.35		4.30		5.17		2.70		2.30		3.67	
Anthracene	220	1200	1.20		5.63		1.85		9.63		2.27		1.71		1.01		1.63	
2-Methylnaphthalene	38	64	1.11		4.21		0.65	J	0.61	J	0.85		0.42	J	0.39	J	0.53	J
Total LPAH[2/]	370	780	10.49	J	43.73		10.50	J	21.48		15.28		7.52	J	6.00	J	9.76	J
Fluoranthene	160	1200	4.63		15.87		6.76		19.26		11.93		5.59		4.60		6.94	
Pyrene	1000	1400	4.58		16.67		5.28		27.41		18.75		7.93		4.75		9.29	
Benz(a)anthracene	110	270	1.90		6.51		2.22		17.78		5.28		3.42		1.94		3.37	
Chrysene	110	460	2.96		8.73		3.33		22.22		7.39		5.41		3.31		5.31	
Total Benzofluoranthene	230	450	4.03		13.97		5.56		27.63		11.99		5.95		4.89		6.43	
Benzo(a)pyrene	99	210	1.85		6.35		2.31		11.85		6.25		2.61		1.87		2.86	
Indeno(1,2,3-cd)pyrene	34	88	1.20		4.13		2.04		6.52		4.66		1.89		1.29		2.24	
Dibenz(a,h)anthracene	12	33	0.13	U	1.19		0.23	U	1.78		1.25		0.50	J	0.50	J	0.94	J
Benzo(g,h,i)perylene	31	78	1.16		3.97		1.76		5.26		4.49		1.71		1.15		1.94	
Total HPAH[3/]	960	5300	22.31		77.38		29.26		139.70		71.99		35.01	J	24.32	J	39.31	J
Chlorinated Benzenes (mg/kg OC)																		
1,2-Dichlorobenzene	2.3	2.3	0.24	U	0.40	U	0.45	U	0.36	U	0.16	U	0.47	U	0.37	U	0.50	U
1,4-Dichlorobenzene	3.1	9	0.24	U	0.40	U	0.45	U	0.36	U	0.20	JT	0.47	U	0.37	U	0.50	U
1,2,4-Trichlorobenzene	0.81	1.8	0.22	U	0.37	U	0.41	U	0.33	U	0.15	U	0.42	U	0.33	U	0.45	U
Hexachlorobenzene	0.38	2.3	0.10	U	0.17	U	0.19	U	0.16	U	0.07	U	0.20	U	0.16	U	0.20	U
Phthalate Esters (mg/kg OC)																		
Dimethyl Phthalate	53	53	0.08	U	0.14	U	0.16	U	0.27	J	0.22	JT	0.16	U	0.13	U	0.17	U
Diethyl Phthalate	61	110	0.13	J	0.18	U	0.20	U	0.27	J	0.24	JT	0.22	U	0.17	U	0.22	U
Di-n-butyl Phthalate	220	1700	1.20	B	2.30	B	2.31	B	2.30	B	0.97	JT	1.80	B	1.37	BJ	2.14	B
Butyl Benzyl Phthalate	4.9	64	0.27	U	0.45	U	1.67		0.40	U	1.08		0.52	U	0.41	U	0.55	U
Bis(2-ethylhexyl) Phthalate	47	78	2.55	J	1.83	J	2.04	J	22.96		15.91		4.50	J	1.01	J	1.43	J
Di-n-octyl Phthalate	58	4500	0.14	U	0.24	U	0.27	U	0.21	U	0.10	U	0.28	U	0.22	U	0.30	U
Miscellaneous Extractable Compounds (mg/kg OC)																		
Dibenzofuran	15	58	1.30		5.00		0.69	J	0.67	J	0.97		0.51	J	0.55	J	0.74	J
Hexachlorobutadiene	3.9	6.2	0.21	U	0.35	U	0.39	U	0.31	U	0.14	U	0.41	U	0.32	U	0.43	U
N-Nitrosodiphenylamine	11	11	0.13	U	0.23	U	0.25	U	0.20	U	0.09	U	0.26	U	0.21	U	0.28	U
Aroclor 1016			0.14	U	0.24	U	0.27	U	0.21	U	0.10	U	0.28	U	0.22	U	0.30	U
Aroclor 1221			0.14	U	0.24	U	0.27	U	0.21	U	0.10	U	0.28	U	0.22	U	0.30	U
Aroclor 1232			0.14	U	0.24	U	0.27	U	0.21	U	0.10	U	0.28	U	0.22	U	0.30	U
Aroclor 1242			0.14	U	0.24	U	0.27	U	0.21	U	3.41		0.28	U	0.22	U	0.30	U
Aroclor 1248			0.14	U	0.24	U	0.27	U	0.21	U	0.10	U	0.28	U	0.22	U	0.30	U
Aroclor 1254			0.44	Ui	0.87		1.67		9.63		9.09		6.04		0.79		1.22	
Aroclor 1260			0.14	U	0.87		0.93	P	0.21	U	5.51		0.28	U	0.72	J	0.85	J
Total PCBs[4/]	12	65	0.44	U	1.75		2.59	P	9.63		18.01		6.04		1.51	J	2.07	J
Ionizable Organic Compounds (ug/kg dry wt)																		
Phenol	420	1200	15	J	37		17	J	19	J	13	JT	3.6	U	13	J	16	J
2-Methylphenol	63	63	2.7	U	2.7	U	2.5	U	2.6	U	1.5	U	2.7	U	2.7	U	2.5	U
4-Methylphenol	670	670	8.8	J	15		11		7.7	J	9.8	JT	2.7	U	3	J	7.8	J
2,4-Dimethylphenol	29	29	9.9	U	9.7	U	9.2	U	9.2	U	5.5	U	9.9	U	9.7	U	9.2	U
Pentachlorophenol (PCP)	360	690	36	U	36	U	34	U	34	U	20	U	36	U	36	U	34	U
Benzyl Alcohol	57	73	8.8	J	14	J	12	J	10	J	7.3	JT	3.8	U	9	J	7.4	J
Benzoic Acid	650	650	180	U	170	U	160	U	170	U	96	U	180	U	170	U	160	U

Data Qualifiers

B - The analyte was found in the associated method blank at a level that is significant relative to the sample result.

D - The reported result is from a dilution

J - The result is an estimated concentration that is less than the MRL but greater than or eaul to the MDL

P - The GC or HPLC confirmation criteria were exceeded. The relative percent difference is greater than 40% between the two analytical results (25% for CLP pesticides).

U - The compound was analyzed for, but was not detected ("non-detect") at or above the MRL/MDL.

i - the MRL/MDL is elevated due to matrix or chromatographic interference

Notes

1/ Duplicate sample

2/ Sum of low molecular weight PAH results for naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, and anthracene

3/ Sum of high molecular weight PAH results for fluoranthene, pyrene, benz(a)anthracene, chrysene, total benzofluoranthenes, benzo(a)pyrene, indeneo(1,2,3-c,d)pyrene, dibenzo(a,h)anthracene, and benzo(g,h,i)perylene

4/ Sum of Aroclors 1016, 1221, 1232, 1242, 1248, 1254, 1260

Table A-13. PSR Sediment Monitoring Data

			PSR07-OSA-1-S 8/7/07	PSR07-OSA-2-S 8/7/07	PSR07-OSA-3-S 8/7/07	PSR07-OSA-4-S 8/7/07	PSR07-OSA-5-S 8/7/07	PSR07-OSA-6-S 8/7/07	PSR07-OSA-7-S 8/7/07	PSR07-RA2B-1-S 8/7/07	PSR07-RA4-2-S 8/7/07	PSR07-RA4-2-S-D 8/7/07	PSR07-RA4-2-S-T 8/7/07	PSR07-RA4-3-S 8/9/07	PSR07-RA4-6-S 8/8/07	PSR07-RA4-9-S 8/7/07	PSR07-RA4-10S 8/7/07	PSR07-RA5-1-S 8/9/07	PSR07-RA5-2-S 8/8/07	PSR07-RA5-3-S 8/8/07	PSR07-RA5-4-S 8/9/07	PSR07-RA5-5-S 8/8/07
	Total Solids (% ww)		64.7	51.7	59	52.3	52	72.8	58.9	86.1	74.1			59.1	62.8	68.9	71	53.8	65.6	55.5	60.6	63.9
	Total Organic Carbon (%)		1.21	3.05	1.31	1.16	6.55	0.4	1.16	0.28	0.52			1.51	0.76	1.14	0.68	1.88	1.45	1.5	1.19	0.85
	Grain Size Distribution																					
Phi	**Sieve Size (mm)**	**Fraction**																				
<-1	>2	Gravel	2.45	2.69	1.21	5.7	10.2	2.24	4.29	43.3	0.71	0.30	0.37	4.12	0.28	1.44	0.88	6.9	1.94	3.03	3.67	2.35
-1	2	Very Coarse Sand	0.69	2.12	0.68	4.59	3.59	1.98	3.87	14.7	0.55	0.50	0.59	1.93	0.59	0.8	0.98	1.78	1.77	3.09	1.32	0.92
0	1	Coarse Sand	1.34	3.52	1.91	9.24	9.39	3.43	7.76	12.9	21.9	4.09	4.48	2.27	0.89	3.28	29.8	4.23	35.1	13	5.39	16.8
1	0.5	Medium Sand	5.65	11.3	11.6	30.5	27.4	16.3	14.9	9.17	0.03	16.00	17.70	14.7	7.51	16.9	0.03	14.7	0.03	20.8	32.6	0.11
2	0.25	Fine Sand	19.2	25.2	27.1	17.5	17.4	32.2	22.1	7.12	35.1	35.60	35.10	42	55.6	42.7	40.6	24.1	32.6	12.3	33.4	40.1
3	0.125	Very Fine Sand	33.1	24.5	30.4	9.1	7.95	22.4	17.5	5.38	21.6	22.40	22.70	24.2	29.5	19	18.7	22	13.2	16.7	15.9	21.9
4	0.063	Silt	31.4	24.6	25	26.2	12.4	17.2	26.1	6.67	11	12.30	12.10	10.7	9.46	7.91	9.11	25.8	10.6	32.1	7.94	16.5
>8	<0.004	Clay	6.05	6.9	7.22	10.1	6.42	3.87	7.82	1.96	3.34	3.50	3.46	3.3	3.75	3.79	3.64	6.49	4.27	6.79	4.48	5.2

			PSR07-RA5-6-S 8/9/07	PSR07-RA5-7-S 8/8/07	PSR07-RA5-8-S 8/8/07	PSR07-RA5-8-S-D 8/8/07	PSR07-RA5-8-S-T 8/8/07	PSR07-RA5-9-S 8/9/07	PSR07-RA5-10-S 8/8/07	PSR07-RA5-11-S 8/9/07	PSR07-RA5-12-S 8/8/07	PSR07-RA5-13-S 8/8/07	PSR07-RA5-14A-S 8/8/07	PSR07-A5-14A-S- 8/8/07	PSR07-A5-14A-S- 8/8/07	PSR07-RA5-15-S 8/9/07	PSR07-RA5-20-S 8/8/07	PSR07-RA5-21-S 8/8/07	CR02 7/13/07	CR23 7/13/07	MSMP-43 7/13/07
	Total Solids (% ww)		62	58.9	59.7	60.20	59.20	53.7	61.8	56.1	57	60.4	59.8	60.60	59.10	55.9	56.9	60.2	45.8	63.9	74.7
	Total Organic Carbon (%)		1.26	1.45	1.93	1.90	1.82	1.69	0.95	2.16	1.26	1.08	1.35	1.76	1.60	1.11	1.39	0.98	1.31	0.56	0.23
	Grain Size Distribution																				
Phi	**Sieve Size (mm)**	**Fraction**																			
<-1	>2	Gravel	2.15	2.7	0.73	1.01		4.02	0.9	3.74	1.87	4.39	19.7			7.09	4.31	0.47	0.02	0.04	0.52
-1	2	Very Coarse Sand	0.74	1.55	2.03	1.28		1.84	1.78	2.31	2.59	3.39	7.71			7.62	3.57	0.64	↓	↓	↓
0	1	Coarse Sand	1.4	4.98	4.94	4.26		2.49	6.09	8.3	4.49	13.3	8.1			10.3	8.19	6.14	↓	↓	↓
1	0.5	Medium Sand	12.6	17.6	17.3	17.1		12.7	19.6	29.9	19.9	25.3	11.4			39.8	24.4	29.7	↓	↓	↓
2	0.25	Fine Sand	48.7	20.7	29.2	27.9		29.2	34.6	26.4	30.1	13.5	21			15.9	29.4	31.4	↓	↓	↓
3	0.125	Very Fine Sand	22.6	20.9	26.9	26.8		30.5	20.5	12.8	26.1	14.3	13			6.92	20.4	18.6	11.52	53.42	93.71
4	0.063	Silt	11.3	28.2	17.1	18.8		21.1	19.4	17.2	20.2	24.2	23.6			20.1	19	18.6	78.1	44.7	2.63
>8	<0.004	Clay	4.49	6.07	5.45	6.76		6.45	5.5	6.19	5.41	5.87	6.4			7.84	6.88	6.04	13.1	6.16	3.07

Table A-14 Final Progress Sampling Results

Analytes	Units	Compliance Criteria[2]	Sampling Locations[1]						
			SMA 1						
			TSP-01-01	TSP-01-02	TSP-01-03	TSP-01-04	TSP-01-05	TSP-01-06	TSP-01-07
			9/21/2004	9/27/2004	9/27/2004	10/4/2004	10/4/2004	10/13/2004	10/13/2004
Metals									
Arsenic	(mg/kg)	57	13	3	4	3	4	3	6
Copper	(mg/kg)	390	105	18	27	22	36	23	58
Lead	(mg/kg)	450	109	5	12	4	10	6	24
Mercury	(mg/kg)	0.41	**0.68**	0.06	0.40	<0.06 U	0.09	0.14	0.30
Zinc	(mg/kg)	410	132	26	38	30	40	33	62
TOC	(%)	-	1.07	0.634	0.843	0.957	1.63	0.845	1.38
PCBs	(mg/kg - OC Normalized)	12	3 J	*	*	*	4	*	7
PCBs	(µg/kg - Dry Weight)	130[3]	*	<20 U	110	<20 U	*	42	*
LPAHs	(mg/kg - OC Normalized)	370	150	*	*	*	0.42	*	12
LPAHs	(µg/kg - Dry Weight)	5200[3]	*	235	1219	<6.3 U	*	9	*
HPAHs	(mg/kg - OC Normalized)	960	243	*	*	*	5	*	72
HPAHs	(µg/kg - Dry Weight)	12000[3]	*	464	1786	<6.3 U	*	242	*
TBT	(mg/kg - OC Normalized)	76[4]	NA	*	*	*	NA	*	NA
TBT	(µg/kg - Dry Weight)	1335[5]	*	NA	NA	NA	*	NA	*
Bioassay	-	SMS[6]	NA	NA	NA	NA	NA	NA	NA

Table A-14
Final Progress Sampling Results

Analytes	Units	Compliance Criteria[2]	Sampling Locations[1]						
			SMA 2						
			TSP-02-01[7]	TSP-02-02[7]	TSP-02-03	TSP-02-04	TSP-02-05	TSP-02-06	TSP-02-07
			10/24/2004	10/24/2004	9/27/2004	9/27/2004	10/4/2004	10/4/2004	10/13/2004
Metals									
Arsenic	(mg/kg)	57	NR	NR	34 J	4	12	6	5
Copper	(mg/kg)	390	NR	NR	86	17	47	49	21
Lead	(mg/kg)	450	NR	NR	61 J	10	32	20	12
Mercury	(mg/kg)	0.41	NR	NR	0.27 J	<0.06 U	0.28	**0.71**	0.18
Zinc	(mg/kg)	410	NR	NR	214	29	76	58	36
TOC	(%)	-	NR	NR	0.772	0.273	0.968	1.18	1.56
PCBs	(mg/kg - OC Normalized)	12	NR	NR	*	*	*	<2 U	3
PCBs	(µg/kg - Dry Weight)	130[3]	NR	NR	74	<19 U	42	*	*
LPAHs	(mg/kg - OC Normalized)	370	NR	NR	*	*	*	3	4
LPAHs	(µg/kg - Dry Weight)	5200[3]	NR	NR	225	57	180	*	*
HPAHs	(mg/kg - OC Normalized)	960	NR	NR	*	*	*	10	19
HPAHs	(µg/kg - Dry Weight)	12000[3]	NR	NR	1915	367	825	*	*
TBT	(mg/kg - OC Normalized)	76[4]	NR	NR	*	*	*	<0.45 U	0.77
TBT	(µg/kg - Dry Weight)	1335[5]	NR	NR	150 J	<5.6 U	58	*	*
Bioassay	-	SMS[6]	Pass	**Fail**	NA	NA	NA	NA	NA

Table A-14
Final Progress Sampling Results

Analytes	Units	Compliance Criteria[2]	Sampling Locations[1]						
			SMA 2		SMA 3				
			TSP-02-08	TSP-02-09	TSP-03-01	TSP-03-02	TSP-03-03	TSP-03-04	TSP-03-05
			10/13/2004	10/13/2004	2/11/2005	2/11/2005	12/8/2004	12/9/2004	2/11/2005
Metals									
Arsenic	(mg/kg)	57	8	6	7	7	7	<7 U	7
Copper	(mg/kg)	390	59	41	29	62	81	31	46.8
Lead	(mg/kg)	450	31	14 J	5	27	19 J	6	69
Mercury	(mg/kg)	0.41	**0.48**	0.18	0.07	**0.85**	0.35	0.08	0.38
Zinc	(mg/kg)	410	72	48	37	76.8	66	42	142
TOC	(%)	-	1.59	2.78	0.944	0.768	0.727	0.738	0.773
PCBs	(mg/kg - OC Normalized)	12	2	2	*	*	*	*	*
PCBs	(µg/kg - Dry Weight)	130[3]	*	*	<20 U	32	108 J	<20 U	17 J
LPAHs	(mg/kg - OC Normalized)	370	10	6	*	*	*	*	*
LPAHs	(µg/kg - Dry Weight)	5200[3]	*	*	<6.6 U	336	414	41	354
HPAHs	(mg/kg - OC Normalized)	960	44	16	*	*	*	*	*
HPAHs	(µg/kg - Dry Weight)	12000[3]	*	*	35	1872	1409 J	187	1446
TBT	(mg/kg - OC Normalized)	76[4]	6	0.86	*	*	*	*	*
TBT	(µg/kg - Dry Weight)	1335[5]	*	*	<4.3 U	36	79	5	7.6
Bioassay	-	SMS[6]	NA	NA	NA	NA	NA	NA	NA

Table A-14
Final Progress Sampling Results

Analytes	Units	Compliance Criteria[2]	Sampling Locations[1]						
			SMA 3						
			TSP-03-06	TSP-03-07	TSP-03-08	TSP-03-09	TSP-03-10	TSP-03-11	TSP-03-12
			2/23/2005	2/11/2005	12/13/2004	12/13/2004	12/22/2004	12/13/2004	12/13/2004
Metals									
Arsenic	(mg/kg)	57	<6 U	14	12	8	7	<7 U	<7 U
Copper	(mg/kg)	390	47	112	30	59	33	16	13
Lead	(mg/kg)	450	17	48	15	16	9	4	9
Mercury	(mg/kg)	0.41	**1.04**[8]	**0.66**	<0.07 U	0.22	0.07	<0.07 U	<0.06 U
Zinc	(mg/kg)	410	42	109	74	65	56	29	26
TOC	(%)	-	0.882	1.22	0.388	0.791	1.07	0.742	1.6
PCBs	(mg/kg - OC Normalized)	12	*	6 J	*	*	<2 U	*	<1 U
PCBs	(μg/kg - Dry Weight)	130[3]	<20 U	*	20	74	*	<20 U	*
LPAHs	(mg/kg - OC Normalized)	370	*	24	*	*	2	*	<0.41 U
LPAHs	(μg/kg - Dry Weight)	5200[3]	16	*	163	38	*	15	*
HPAHs	(mg/kg - OC Normalized)	960	*	103	*	*	14	*	<0.41 U
HPAHs	(μg/kg - Dry Weight)	12000[3]	410	*	78	251	*	105	*
TBT	(mg/kg - OC Normalized)	76[4]	*	34.43	*	*	<0.38 U	*	<0.27 U
TBT	(μg/kg - Dry Weight)	1335[5]	<4.2 U	*	<4.3 U	10	*	<4.1 U	*
Bioassay	-	SMS[6]	NA	NA	NA	NA	NA	NA	NA

Table A-14
Final Progress Sampling Results

Analytes	Units	Compliance Criteria[2]	Sampling Locations[1]						
			SMA 3	SMA 4					
			TSP-03-13	TSP-04-01	TSP-04-02	TSP-04-03	TSP-04-04	TSP-04-05	TSP-04-06
			12/22/2004	1/20/2005	2/4/2005	1/24/2005	1/7/2005	1/20/2005	1/7/2005
Metals									
Arsenic	(mg/kg)	57	<6 U	<6 U	7	14	8	7	<7 U
Copper	(mg/kg)	390	10	84	25	90	55	54	17
Lead	(mg/kg)	450	3	10	5	26	17	14	<3 U
Mercury	(mg/kg)	0.41	<0.04 U	0.24	<0.06 U	0.21	0.25	0.17	<0.07 U
Zinc	(mg/kg)	410	22	53	32	100	48	50	23
TOC	(%)	-	0.869	0.404	0.592	0.509	1.04	0.809	0.703
PCBs	(mg/kg - OC Normalized)	12	*	*	*	*	<1.83 U	*	*
PCBs	(µg/kg - Dry Weight)	130[3]	<19 U	<20 U	<19 U	87[9]	*	<20 U	<19 U
LPAHs	(mg/kg - OC Normalized)	370	*	*	*	*	10.57	*	*
LPAHs	(µg/kg - Dry Weight)	5200[3]	11	80	133	131	*	12	<6 U
HPAHs	(mg/kg - OC Normalized)	960	*	*	*	*	48	*	*
HPAHs	(µg/kg - Dry Weight)	12000[3]	25	204	27	511	*	125	<6 U
TBT	(mg/kg - OC Normalized)	76[4]	*	*	*	*	7	*	*
TBT	(µg/kg - Dry Weight)	1335[5]	<4.3 U	92 J	6	150	*	34	<4 U
Bioassay	-	SMS[6]	NA	NA	NA	NA	NA	NA	NA

Table A-14
Final Progress Sampling Results

Analytes	Units	Compliance Criteria2	Sampling Locations[1]				
			SMA 4				
			TSP-04-07	TSP-04-08	TSP-04-09	TSP-04-10	TSP-04-11
			1/12/2005	2/4/2005	1/20/2005	1/14/2005	1/14/2005
Metals							
Arsenic	(mg/kg)	57	<6 U	7	<6 U	8.82	12
Copper	(mg/kg)	390	31	25	18	45.3	120
Lead	(mg/kg)	450	5	3	4	13	17
Mercury	(mg/kg)	0.41	<0.06 U	<0.07 U	0.3	0.31	0.10
Zinc	(mg/kg)	410	31	30	31	50	122
TOC	(%)	-	0.727	0.554	0.904	1.37	0.863
PCBs	(mg/kg - OC Normalized)	12	*	*	*	<1 U	*
PCBs	(µg/kg - Dry Weight)	130[3]	<20 U	<19 U	<20 U	*	<20 U
LPAHs	(mg/kg - OC Normalized)	370	*	*	*	4	*
LPAHs	(µg/kg - Dry Weight)	5200[3]	20	<6 U	28	*	16
HPAHs	(mg/kg - OC Normalized)	960	*	*	*	28	*
HPAHs	(µg/kg - Dry Weight)	12000[3]	279	<6 U	62 J	*	177
TBT	(mg/kg - OC Normalized)	76[4]	*	*	*	1	*
TBT	(µg/kg - Dry Weight)	1335[5]	4	<4.1 U	5	*	90
Bioassay	-	SMS[6]	NA	NA	NA	NA	NA

Table A-14
Final Progress Sampling Results

Analytes	Units	Compliance Criteria[2]	Sampling Locations[1]			
			SMA 5			
			TSP-05-01	TSP-05-02	TSP-05-03	TSP-05-04
			11/30/2004	11/30/2004	2/21/2005	11/30/2004
Metals						
Arsenic	(mg/kg)	57	<7 U	10	<7 U	7
Copper	(mg/kg)	390	16	29	31	21
Lead	(mg/kg)	450	4	13	3	6
Mercury	(mg/kg)	0.41	<0.05 U	<0.1 U	<0.07 U	<0.05 U
Zinc	(mg/kg)	410	26	78	34	43
TOC	(%)	-	1.25	0.993	0.840	0.786
PCBs	(mg/kg – OC Normalized)	12	<2 U	*	*	*
PCBs	(μg/kg – Dry Weight)	130[3]	*	<20 U	<19 U	<20 U
LPAHs	(mg/kg – OC Normalized)	370	1	*	*	*
LPAHs	(μg/kg – Dry Weight)	5200[3]	*	<7 U	38	<7 U
HPAHs	(mg/kg – OC Normalized)	960	<1 U	*	*	*
HPAHs	(μg/kg – Dry Weight)	12000[3]	*	<7 U	38	<7 U
TBT	(mg/kg – OC Normalized)	76[4]	<0.47 U	*	*	*
TBT	(μg/kg – Dry Weight)	1335[5]	*	20	<4 U	<5.9 U
Bioassay	-	SMS[6]	NA	NA	NA	NA

Table A-14
Final Progress Sampling Results

			Sampling Locations[1]				
			SMA 6				
			TSP-06-01	TSP-06-05	TSP-06-06	TSP-06-07	TSP-06-08
Analytes	**Units**	**Compliance Criteria[2]**	**9/9/2005**	**9/14/2005**	**9/27/2005**	**9/27/2005**	**9/27/2005**
Metals							
Arsenic	(mg/kg)	57	13	10	11	21	30
Copper	(mg/kg)	390	40	26	43	111	**569**
Lead	(mg/kg)	450	24	97	116	227	**454**
Mercury	(mg/kg)	0.41	**0.64**	**0.50**	**0.92**	**1.56**	**12.60**
Zinc	(mg/kg)	410	78	84 J	215	334	**485**
TOC	(%)	-	0.60	2.35	1.20	1.28	1.34
PCBs	(mg/kg - OC Normalized)	12	*	3	<2 U	<1 U	4.78
PCBs	(µg/kg - Dry Weight)	130[3]	<19 U	*	*	*	*
LPAHs	(mg/kg - OC Normalized)	370	*	127	325	**598**	**443**
LPAHs	(µg/kg - Dry Weight)	5200[3]	4,208	*	*	*	*
HPAHs	(mg/kg - OC Normalized)	960	*	145	286	919	**2,114**
HPAHs	(µg/kg - Dry Weight)	12000[3]	2,078	*	*	*	*
TBT	(mg/kg - OC Normalized)	76[4]	*	<0.2 U	<0.3 U	<0.3 U	<0.3 U
TBT	(µg/kg - Dry Weight)	1335[5]	<3.7 U	*	*	*	*
Bioassay	-	SMS[6]	NA	NA	NA	NA	NA

Table A-14
Final Progress Sampling Results

Analytes	Units	Compliance Criteria[2]	Sampling Locations[1]						
			SMA 7						
			TSP-07-01	TSP-07-02	TSP-07-03	TSP-07-04	TSP-07-05	TSP-07-06	TSP-07-07
			9/30/2005	9/30/2005	10/12/2005	10/12/2005	9/30/2005	10/12/2005	9/29/2005
Metals									
Arsenic	(mg/kg)	57	17	11	8	8	10	<6 U	53
Copper	(mg/kg)	390	87	31	15	13	48	9	96
Lead	(mg/kg)	450	49	14	<3 U	<3 U	31	<2 U	95
Mercury	(mg/kg)	0.41	**0.43**	0.25	<0.06 U	<0.06 U	**0.53**	<0.06 U	0.35
Zinc	(mg/kg)	410	118	45	26	24	68	22	378
TOC	(%)	-	1.07	0.896	1.93	3.9	0.353	0.269	0.457
PCBs	(mg/kg - OC Normalized)	12	6	*	<1.0 U	<0.49 U	*	*	*
PCBs	(µg/kg - Dry Weight)	130[3]	*	<19 U	*	*	52	<20 U	100
LPAHs	(mg/kg - OC Normalized)	370	52	*	0.44	<0.17 U	*	*	*
LPAHs	(µg/kg - Dry Weight)	5200[3]	*	120	*	*	550	<6.0 U	420
HPAHs	(mg/kg - OC Normalized)	960	257	*	1.2	0.26	*	*	*
HPAHs	(µg/kg - Dry Weight)	12000[3]	*	585	*	*	1,448	<6.0 U	2,783
TBT	(mg/kg - OC Normalized)	76[4]	24	*	<0.18 U	<0.09 U	*	*	*
TBT	(µg/kg - Dry Weight)	1335[5]	*	14	*	*	48	<3.4 U	33
Bioassay	-	SMS[6]	NA	NA	NA	NA	NA	NA	NA

Table A-14
Final Progress Sampling Results

Analytes	Units	Compliance Criteria[2]	Sampling Locations[1]						
			SMA 8						
			TSP-08-01	TSP-08-02	TSP-08-03	TSP-08-04	TSP-08-05	TSP-08-06	TSP-08-07
			10/18/2005	10/28/2005	10/18/2005	10/28/2005	10/28/2005	10/20/2005	10/28/2005
Metals									
Arsenic	(mg/kg)	57	8	7	15	10	10	29	34
Copper	(mg/kg)	390	19	19	30	64	25	65	66
Lead	(mg/kg)	450	8	23	21	33	10	128	121
Mercury	(mg/kg)	0.41	<0.06 U	<0.06 U	0.06	0.12	0.15	0.22	**0.43**
Zinc	(mg/kg)	410	73	51 J	84	74 J	44 J	237	270 J
TOC	(%)	-	0.866	0.672	0.177	0689	0.56	0.596	0.387
PCBs	(mg/kg - OC Normalized)	12	*	*	*	*	*	*	*
PCBs	(μg/kg - Dry Weight)	130[3]	<33 U	<20 U	<34 U	47	<19 U	53	30
LPAHs	(mg/kg - OC Normalized)	370	*	*	*	*	*	*	*
LPAHs	(μg/kg - Dry Weight)	5200[3]	57	213	37	**9,219**	681	644	94
HPAHs	(mg/kg - OC Normalized)	960	*	*	*	*	*	*	*
HPAHs	(μg/kg - Dry Weight)	12000[3]	448	639	484	7,715	866	2,181	926
TBT	(mg/kg - OC Normalized)	76[4]	*	*	*	*	*	*	*
TBT	(μg/kg - Dry Weight)	1335[5]	<6 U	<4 U	43	6	<4 U	12	<4 U
Bioassay	-	SMS[6]	NA	NA	NA	NA	NA	NA	NA

Table A-14
Final Progress Sampling Results

Analytes	Units	Compliance Criteria[2]	Sampling Locations[1]			
			SMA 8	SMA 9		
			TSP-08-08	TSP-09-01	TSP-09-02	TSP-09-03
			11/16/2005	11/11/2005	11/2/2005	11/2/2005
Metals						
Arsenic	(mg/kg)	57	<7 U	<7 U	<7 U	25
Copper	(mg/kg)	390	27	12	25	66
Lead	(mg/kg)	450	4	4	4	46
Mercury	(mg/kg)	0.41	<0.05 U	<0.06 U	<0.05 U	0.38
Zinc	(mg/kg)	410	32	26	30	167
TOC	(%)	-	0.614	0.832	1.08	0.931
PCBs	(mg/kg - OC Normalized)	12	*	*	<2 U	*
PCBs	(μg/kg - Dry Weight)	130[3]	<20 U	<18 U	*	<20 U
LPAHs	(mg/kg - OC Normalized)	370	*	*	1	*
LPAHs	(μg/kg - Dry Weight)	5200[3]	<6 U	146	*	99
HPAHs	(mg/kg - OC Normalized)	960	*	*	3	*
HPAHs	(μg/kg - Dry Weight)	12000[3]	13	382	*	836
TBT	(mg/kg - OC Normalized)	76[4]	*	*	<0.3 U	*
TBT	(μg/kg - Dry Weight)	1335[5]	<4 U	<3.4 U	*	<3.7 U
Bioassay	-	SMS[6]	NA	NA	NA	NA

Notes:

*	Sample result not compared to compliance criteria (dependent on TOC value).
NA	Analysis not performed (per RASAP requirements).
NR	Chemical analysis not reported due to results being superceded by bioassay results.
U	Compound undetected at the reported concentration.
1	Sampling locations based on RASAP Figure 5.1.
2	Compliance criteria based on SQS chemical criteria per Washington State Sediment Management Standards (SMS; Chapter 173-204 WAC), unless otherwise noted.
3	Compliance criteria based on Lowest Apparent Effects Threshold (LAET) chemical criteria per "1988 Update and Evaluation of Puget Sound AET" (Barrick, Becker, Brown, Beller, and Pastorak) where total organic carbon value is less than 1%.
4	Compliance criteria based on confirmational number stated in the 2002 Explanation of Significant Differences.
5	Compliance criteria based on the dry weight concentration is used when the total organic carbon value is less than 1%.
6	Compliance criteria based on SMS Bioassay Testing Results.
7	Results are for a sediment composite sample collected in the vicinity of the sample location for bioassay testing.
8	Sample re-analyzed for mercury. Initial concentration was 5.13 ppm.
9	Sample re-analyzed for PCBs. Initial concentration was 136 ppb.

Bold indicates analytical result exceeds compliance criteria.
Table from Todd Shipyard OMMP (Floyd|Snyder 2007)

Table A-15. Washington Department of Ecology Elliott Bay Urban Initiatives Analytical Data

Chemical	Chemistry Results Deep Basin 172	Lab Dup	Lab Trip	173	avg	min	max	Chemistry Results Urban Bay 176	177	178	185	186	Field Rep	Lab Dup	187	Lab Dup	Lab Trip
Priority Pollutant Metals (mg/kg dry weight)																	
Silver	0.32			0.28	0.3	0.28	0.32	0.18	0.1 U	0.13	0.39	0.62	0.64		0.29		
Arsenic	9.13			9.01	9.07	9.01	9.13	3.56	3.13	5.24	9.9	6.84	7.34		7.74		
Cadmium	0.29			0.25	0.27	0.25	0.29	0.11	0.14	0.1 U	0.28	0.21	0.21		0.18		
Chromium	42.2			38.1	40.15	38.1	42.2	21.6	27.9	18.8	42.9	28.6	29.9		22.4		
Copper	41.1			35.3	38.2	35.3	41.1	17.1	6.51	8.22	45.6	23.6	23.9		32.3		
Mercury	0.16			0.175	0.1675	0.16	0.175	0.116	0.048	0.044	0.237	0.182	0.196		0.162		
Nickel	36.2			33.9	35.05	33.9	36.2	20.7	20.5	14.2	35	24.2	25.2		16.9		
Lead	26.9			22	24.45	22	26.9	16.8	6.99	10.6	28.2	24.5	25.7		27.2		
Selenium	0.99			0.7	0.845	0.7	0.99	0.5 U	0.5 U	0.5 U	0.83	0.5 U	0.5 U		0.5 U		
Zinc	90.6			83.5	87.05	83.5	90.6	51.4	32	31	98.8	54.5	55.2		82.4		
Trace Elements																	
Tin	2.42			2.7	2.56	2.42	2.7	1.6	0.76	0.88	3.14	2.77	2.3		3.69		
Organic Compounds (ug/kg dry weight)																	
Chlorinated Alkanes																	
Hexachlorobutadiene	20 U			16 U	18	16	20	8.1 U	8.5 U	8.3 U	19 U	40 U	36 U		72 UJ		
Chlorinated and Nitro-Substituted Phenols																	
Pentachlorophenol	80 U			64 U	72	64	80	32 U	34 U	33 U	76 U	159 UJ	145 UJ		286 UJ		
Chlorinated Aromatic Compounds																	
1,2,4-Trichlorobenzene	20 U			16 U	18	16	20	8.1 U	8.5 U	8.3 U	19 U	40 U	36 U		72 UJ		
1,2-Dichlorobenzene	20 U			16 U	18	16	20	8.1 U	8.5 U	8.3 U	19 U	40 U	36 UJ		72 UJ		
1,3-Dichlorobenzene	20 U			16 U	18	16	20	8.1 U	8.5 U	8.3 U	19 U	40 U	36 UJ		72 UJ		
1,4-Dichlorobenzene	20 U			16 U	18	16	20	7.5 J	8.5 U	8.3 U	19 U	16 J	36 UJ		72 UJ		
2-Chloronaphthalene	5.3 U			5.1 UJ	5.2	5.1	5.3	5.1 U	5.2 UJ	5.1 U	5.1 U	5 U	4.7 U		5.1 U		
Hexachlorobenzene	0.53 U			1.1	0.815	0.53	1.1	0.51 U	0.52 U	0.51 U	0.51 U	0.5 U	0.47 U		0.51 U		
Chlorinated Pesticides																	
2,4'-DDD	0.53 U			0.51 U	0.52	0.51	0.53	0.51 U	0.52 U	0.51 U	0.51 U	0.51	0.47 U		0.51 U		
2,4'-DDE	0.53 U			0.51 U	0.52	0.51	0.53	0.51 U	0.52 U	0.51 U	0.52 UJ	0.5 U	0.77 UJ		0.51 U		
2,4'-DDT	0.53 U			0.51 U	0.52	0.51	0.53	0.51 U	0.52 U	0.51 U	0.51 U	0.5 U	0.47 U		0.51 U		
4,4'-DDD	0.53 U			0.51 U	0.52	0.51	0.53	1.6	0.52 U	0.51 U	0.56	2	1.8		1		
4,4'-DDE	0.53 U			0.68	0.605	0.53	0.68	0.62	0.52 U	0.51 U	0.76	1	0.95		1		
4,4'-DDT	0.53 U			0.89 J	0.71	0.53	0.89	0.98 J	0.52 U	0.51 U	0.86 J	1.7 J	1.5 J		1.8 J		
Aldrin	0.53 U			0.51 U	0.52	0.51	0.53	0.51 U	0.52 U	0.51 U	0.51 U	0.5 U	0.47 U		0.51 U		
Cis-Chlordane (Alpha-Chlordane)	0.53 U			0.51 U	0.52	0.51	0.53	0.51 U	0.52 U	0.51 U	0.51 U	0.5 U	0.47 U		0.51 U		
Dibutylchlorendate								87					90				
Dieldrin	0.53 U			0.51 U	0.52	0.51	0.53	0.51 U	0.52 U	0.51 U	0.51 U	0.5 U	0.47 U		0.51 U		
Endosulfan I	0.53 U			0.51 U	0.52	0.51	0.53	0.51 U	0.52 U	0.51 U	0.51 U	0.5 UJ	0.47 UJ		0.51 UJ		
Endosulfan II	0.53 U			0.51 U	0.52	0.51	0.53	0.51 U	0.52 U	0.51 U	0.51 U	0.5 UJ	0.47 UJ		0.51 UJ		
Endosulfan Sulfate	0.53 U			0.51 U	0.52	0.51	0.53	0.51 U	0.52 U	0.51 U	0.51 U	0.5 U	0.47 U		0.51 U		
Endrin	0.53 U			0.51 U	0.52	0.51	0.53	0.51 U	0.52 U	0.51 U	0.51 U	0.5 U	0.47 U		0.51 U		
Endrin Aldehyde	0.53 UJ			0.51 UJ	0.52	0.51	0.53	0.51 UJ	0.52 UJ	0.51 UJ	0.51 UJ	0.5 UJ	0.47 UJ		0.51 UJ		
Endrin Ketone	0.53 U			0.51 U	0.52	0.51	0.53	0.51 U	0.52 U	0.51 U	0.51 U	0.5 U	0.47 U		0.54 UJ		
Gamma-BHC (Lindane)	0.53 U			0.51 U	0.52	0.51	0.53	0.51 U	0.52 U	0.51 U	0.51 U	0.5 U	0.47 U		0.51 U		
Heptachlor	0.53 U			0.51 U	0.52	0.51	0.53	0.51 U	0.52 U	0.51 U	0.51 U	0.5 U	0.47 U		0.51 U		
Heptachlor Epoxide	0.53 U			0.51 U	0.52	0.51	0.53	0.51 U	0.52 U	0.51 U	0.51 U	0.5 U	0.47 U		0.51 U		
Mirex	0.53 U			0.51 U	0.52	0.51	0.53	0.51 U	0.52 U	0.51 U	0.51 U	0.5 U	0.47 U		0.51 U		
Oxychlordane	0.53 U			0.51 U	0.52	0.51	0.53	0.51 U	0.52 U	0.51 U	0.51 U	0.5 U	0.47 U		0.51 U		
Toxaphene	11 U			10 U	10.5	10	11	10 U	10 U	10 U	10 U	20 UJ	19 UJ		20 UJ		
Trans-Chlordane (Gamma)	0.53 U			0.51 U	0.52	0.51	0.53	0.51 U	0.52 U	0.51 U	0.51 U	0.5 U	0.47 U		0.51 U		
Polynuclear Aromatic Hydrocarbons																	
LPAHs																	
Biphenyl	15			14	14.5	14	15	4.6	2.7 UJ	4	17	14	15		18		
1,6,7-Trimethylnaphthalene	20			16	18	16	20	6	4.3	5.5	20	10	10		19		
1-Methylnaphthalene	35			31	33	31	35	5.7	1.6	4.9	37	25 J	22		30		
2,6-Dimethylnaphthalene	78			53	65.5	53	78	12	6.7	6.5	67	32	31		53		
2-Methylnaphthalene	47			41	44	41	47	9.6 J	2.6	8.8	53	45 J	43		48		
2-Methylphenanthrene	57			47	52	47	57	16	1.1	8	59	46	39		55		
Acenaphthene	6.4			12	9.2	6.4	12	4.5	1.1	3.1 J	16 J	23	21		22		
Acenaphthylene	27			28	27.5	27	28	26 J	4.3	13	37	70	61		55		
Anthracene	41			43	42	41	43	33	3.5	19	67	115	104		97		
Dibenzothiophene	13			7.7	10.35	7.7	13	4.9	0.59 J	2.9	15	16	14		18		
Fluorene	23			21	22	21	23	8.5	1.9	5.3	33	32	32		39		
Naphthalene	50			73	61.5	50	73	31 J	5 UJ	29	112	151 J	145		95		
Phenanthrene	118			101	109.5	101	118	71	5.2	31	163	185	171		178		
Retene	177 J			160	168.5	160	177	19 J	2.2	14 J	96 J	64	74		200		
LPAHs	125			122.93	123.965	122.9	125	118	7.351	49.65	211.73	72.95	264.68		291.29		
Benzo(a)anthracene	64			58	61	58	64	62	3.4	20	93	132	107		129		
Benzo(a)pyrene	96			87	91.5	87	96	82	4.9	36	147		194		204		
Benzo(b)fluoranthene				111	111	111	111	102	8.9	46	193	277	175 J		268		
Benzo(ghi)perylene	97			76	86.5	76	97	56	4.5	26	123	157	125		151		
Benzo(k)fluoranthene	50			42	46	42	50	38 J	3.7	17	71	120	89		102		
Benzo[e]pyrene	70			66	68	66	70	59	4.6	27	104	164	126		152		
Carbazole	9.2 J			8.8 J	9	8.8	9.2	9 J	3 UJ	5.5 J	14 J	30	19		20		
Chrysene	100			83	91.5	83	100	100	5.1	35	143	245	108		199		
Dibenzo(a,h)anthracene	18			17	17.5	17	18	22	1 J	5.5	36	44	45		47		
Fluoranthene	165			146	155.5	146	165	138	9.9	48	227	284	256		281		

Table A-15. Washington Department of Ecology Elliott Bay Urban Initiatives Analytical Data

Chemistry Results Deep Basin / Chemistry Results Urban Bay

Chemical	172			173				176	177	178	185	186			187		
		Lab Dup	Lab Trip		avg	min	max						Field Rep	Lab Dup		Lab Dup	Lab Trip
Indeno(1,2,3-cd)pyrene	94			72	83	72	94	60	4	28	132		145 J		166		
Perylene	169			128	148.5	128	169	41 J	9.3	20	204	139	112		293		
Pyrene	186			188	187	186	188	134	9.8	59	250	342	321		343		
Miscellaneous Extractable Compounds																	
2,4-Dimethylphenol	84 J			67 J	75.5	67	84	16 UJ	17 U	30 J	66 J	172	158		305 J		
2-Methylphenol	99			16 U	57.5	16	99	39	8.5 U	39 U	88	193 J	36 UJ		350 J		
3B-Coprostanol	860 J			542 J	701	542	860	81 UJ	85 UJ	110 J	864 J	397 U	363 U		715 UJ		
4-Methylphenol	79			61	70	61	79	27	26	17 U	78	198	167		289 J		
Benzoic Acid	444 UJ			346 UJ	395	346	444	547 J	701 J	375 J	1120 J	397 UJ	363 UJ		715 UJ		
Benzyl Alcohol	201 U			161 U	181	161	201	81 U	85 U	83 U	190 U	397 U	363 U		715 UJ		
Bis(2-Ethylhexyl) Phthalate	65 UJ			52 UJ	58.5	52	65	26 UJ	17 UJ	17 U	118	1640	868		229 J		
Butylbenzylphthalate	40 U			32 U	36	32	40	16 U	17 UJ	17 U	38 U	79 U	73 U		143 UJ		
Caffeine	20 U			16 U	18	16	20	8.1 U	8.5 U	8.3 U	19 U	40 U	36 U		72 UJ		
Cholesterol	14300 J			3460 J	8880	3460	14300	1560 J	784 J	1030 J	26600 J	9180 J	2060 J		11800 J		
Dibenzofuran	20			22	21	20	22	9.3	3.2	7.2 J	39	51	33		41		
Diethylphthalate	40 U			32 U	36	32	40	16 U	17 U	17 U	38 U	79 U	73 U		143 UJ		
Dimethylphthalate	40 U			32 U	36	32	40	16 U	17 U	17 U	38 U	79 U	73 U		143 UJ		
Di-N-Butylphthalate	80 U			32 U	56	32	80	32 U	34 U	33 U	57 J	159 U	73 U		286 UJ		
Di-N-Octyl Phthalate	40 U			32 U	36	32	40	16 U	17 UJ	17 U	38 U	79 U	73 U		143 UJ		
Hexachlorobenzene	20 U			16 U	18	16	20	8.1 U	8.5 U	8.3 U	19 U	40 U	36 U		72 UJ		
Isophorone	57			45	51	45	57	17	17 U	17 U	51	79 U	76		164 J		
N-Nitrosodiphenylamine	40 UJ			32 UJ	36	32	40	16 UJ	17 UJ	17 UJ	38 UJ	79 UJ	73 UJ		143 UJ		
Phenol	145 UJ			105 UJ	125	105	145	52 UJ	52 UJ	49 UJ	154 UJ	288 UJ	230 UJ		412 UJ		
Phenol, 4-Nonyl-	40 U			32 U	36	32	40	16 U	17 U	17 U	38 U	79 U	73 U		143 UJ		
Polycyclic Chlorinated Biphenyls																	
PCB Aroclors								35	10	10	70	99	86		116		
PCB Aroclor 1016	11 U			10 U	10.5	10	11	10 U	10 U	10 U	10 U	10 U	9.4 U		10 U		
PCB Aroclor 1221	11 U			10 U	10.5	10	11	10 U	10 U	10 U	10 U	10 U	9.4 U		10 U		
PCB Aroclor 1232	11 U			10 U	10.5	10	11	10 U	10 U	10 U	10 U	10 U	9.4 U		10 U		
PCB Aroclor 1242	11 U			10 U	10.5	10	11	10 U	10 U	10 U	13 J	11 J	9.4 U		15 J		
PCB Aroclor 1248	11 UJ			16 UJ	13.5	11	16	11 UJ	10 U	10 U	21 UJ	22 UJ	22 UJ		27 UJ		
PCB Aroclor 1254	14 J			26	20	14	26	22 A	10 U	10 U	28 A	46 A	45 A		44 A		
PCB Aroclor 1260	11 U			22	16.5	11	22	13 A	10 U	10 U	29 A	42 A	41 A		57 A		
PCB Aroclor 1262	11 U			41 UJ	26	11	41	11 UJ	10 U	10 U	21 UJ	33 UJ	33 UJ		40 UJ		
PCB Aroclor 1268	11 U			10 U	10.5	10	11	10 U	10 U	10 U	10 U	10 U	9.4 U		10 U		
PCB Congeners																	
PCB congener 8	0.53 U			0.51 U	0.52	0.51	0.53	0.51 U	0.52 U	0.51 U	0.52 J	0.54 J	0.56 J		0.63		
PCB congener 18	0.53 U			0.51 U	0.52	0.51	0.53	0.51 U	0.52 U	0.51 U	0.51 U	0.5 U	0.47 U		0.51 U		
PCB congener 28	0.53 U			0.69	0.61	0.53	0.69	0.51 U	0.52 U	0.51 U	1.1	1.1	1		1.3		
PCB congener 44	0.53 U			0.57	0.55	0.53	0.57	0.51 U	0.52 U	0.51 U	0.79	0.94	0.91		0.94		
PCB congener 52	0.53 U			0.9	0.715	0.53	0.9	0.84	0.52 U	0.51 U	1.1	1.4	1.4		1.9		
PCB congener 66	0.53 U			0.75 J	0.64	0.53	0.75	0.51 U	0.52 U	0.51 U	1.1 J	1.4 J	1.4 J		1.6		
PCB congener 77	0.53 U			0.69	0.61	0.53	0.69	0.67	0.52 U	0.51 U	0.85 J	0.61 J	1.3		1.6 J		
PCB congener 101	0.64			2.2	1.42	0.64	2.2	2.1	0.52 U	0.51 U	2.3	3.6	3.5		3.7		
PCB congener 105	0.53 U			0.87	0.7	0.53	0.87	0.77	0.52 U	0.51 U	0.93	1.7	1.6		1.4 J		
PCB congener 118	0.93			2.4	1.665	0.93	2.4	1.6	0.52 U	0.51 U	2.4	3.5	3.3		3.3		
PCB congener 126	0.53 U			0.51 U	0.52	0.51	0.53	0.51 U	0.52 U	0.51 U	0.51 U	0.5 U	0.47 U		0.51 U		
PCB congener 128	0.53 U			0.6	0.565	0.53	0.6	0.51 U	0.52 U	0.51 U	0.61	1.1	1		0.98		
PCB congener 138	1.2			3.2	2.2	1.2	3.2	2.5	0.52 U	0.85	3.5	5.8	5.7		6.4		
PCB congener 153	1.2			3	2.1	1.2	3	2.1	0.52 U	0.9	3.9	5.4	5.2		7.6		
PCB congener 169	0.53 UJ			0.51 UJ	0.52	0.51	0.53	0.51 UJ	0.52 UJ	0.51 UJ	0.51 UJ	0.5 U	0.47 U		0.51 U		
PCB congener 170	0.53 U			0.79 J	0.66	0.53	0.79	0.63	0.52 U	0.51 U	1.3	2.1	2.1		2.9		
PCB congener 180	0.53 U			1.8	1.165	0.53	1.8	1.1	0.52 U	0.72	2	4	4		4.9		
PCB congener 187	0.57			1.9	1.235	0.57	1.9	0.66	0.52 U	0.51 U	1.6	2.4	2.4		3.3		
PCB congener 195	0.53 U			0.51 U	0.52	0.51	0.53	0.51 U	0.52 U	0.51 U	0.51 U	0.5 U	0.47 U		0.55		
PCB congener 206	0.53 U			1.9	1.215	0.53	1.9	0.51 UJ	0.52 UJ	0.51 UJ	0.51 U	0.75	0.9		0.73		
PCB congener 209	0.53 UJ			0.51 UJ	0.52	0.51	0.53	0.51 UJ	0.52 UJ	0.51 UJ	0.51 UJ	0.5 U	0.64		0.57		
Polybrominated Diphenylethers																	
PBDE- 47	1.8			1.2	1.5	1.2	1.8	0.26	0.09 NJ	0.18 J	1.5	0.77	0.54		1.7		
PBDE- 49	0.84			0.62	0.73	0.62	0.84	0.2 U	0.21 U	0.2 U	0.81	0.2 U	0.19 U		1.3 J		
PBDE- 66	0.21 U			0.2 U	0.205	0.2	0.21	0.2 U	0.21 U	0.2 U	0.2 U	0.2 U	0.19 U		0.2 U		
PBDE- 71	0.21 U			0.2 U	0.205	0.2	0.21	0.2 U	0.21 U	0.2 U	0.2 U	0.2 U	0.19 U		0.2 U		
PBDE- 99	1.4			0.88	1.14	0.88	1.4	0.2 U	0.21 U	0.16 J	1.8	0.2 U	0.19 U		1.1		
PBDE-100	0.21 U			0.2 U	0.205	0.2	0.21	0.2 U	0.21 U	0.2 U	0.32	0.2 U	0.19 U		0.2 U		
PBDE-138	0.43 U			0.41 U	0.42	0.41	0.43	0.4 U	0.42 U	0.41 U	0.41 U	0.4 U	0.37 U		0.4 U		
PBDE-153	0.43 U			0.41 U	0.42	0.41	0.43	0.4 U	0.42 U	0.41 U	0.41 U	0.4 U	0.37 U		0.4 U		
PBDE-154	0.43 U			0.41 U	0.42	0.41	0.43	0.4 U	0.42 U	0.41 U	0.29 J	0.4 U	0.37 U		0.4 U		
PBDE-183	0.43 U			0.41 U	0.42	0.41	0.43	0.4 U	0.42 U	0.41 U	0.41 U	0.4 U	0.37 U		0.4 U		
PBDE-184	0.43 U			0.41 U	0.42	0.41	0.43	0.4 U	0.42 U	0.41 U	0.41 U	0.4 U	0.37 U		0.4 U		
PBDE-191	0.85 U			0.82 U	0.835	0.82	0.85	0.81 U	0.84 U	0.82 U	0.82 U	0.8 U	0.75 U		0.81 U		
PBDE-209	6.8 J			27 J	16.9	6.8	27	5.1 U	5.2 U	5.1 U	5.1 U	16	16		5.1 U		

Notes:

mg/kg = milligrams per kilogram

ug/kg = micrograms per kilogram

U = Result should be considered not-detected at the quantitation limit shown

J = Result is an estimated concentration

R = Rejected - Quality Control indicates the data is not usable

UJ = The compound was not detected and the sample detection limit should be considered an estimated value

Table A-15. Washington Department of Ecology Elliott Bay Urban Initiatives Analytical Data

Chemistry Results Urban Bay

Chemical	188	188 Lab Dup	189	189 Lab Dup	190	190 Lab Dup	192	194	195	196	avg	min	max
Priority Pollutant Metals (mg/kg dry weight)													
Silver	1.31		0.12		0.1 U		0.17	1.13	0.32	0.77	0.38	0.1	1.31
Arsenic	10.8		4.55		1.74		7.71	10.2	7.8	10.8	7.46	3.13	10.8
Cadmium	0.43		0.1 U		0.1 U		0.19	0.41	0.41	0.33	0.22	0.1	0.43
Chromium	38.3		24.6		18.5		29.4	39.6	28.8	38.5	32.55	18.8	42.9
Copper	64.8		25.5		5.67		18.8	74.2	40	94.6	31.32	6.51	64.8
Mercury	0.599		0.198		0.645		0.122	0.599	0.221	0.482	0.19	0.044	0.599
Nickel	29.6		23.5		16.9		24.9	31.3	22.7	29.3	27.50	14.2	36.2
Lead	82.5		25.8		6.75		31	79	25.7	44.4	26.47	6.99	82.5
Selenium	0.59		0.5 U		0.5 U		0.5 U	0.67	0.52	0.65	0.65	0.5	0.99
Zinc	110		49		27		54.5	130	82.1	110	71.40	31	110
Trace Elements													
Tin	9		2.27		0.48		1.5	6.69	2.78	5.41	2.80	0.76	9
Organic Compounds (ug/kg dry weight)													
Chlorinated Alkanes													
Hexachlorobutadiene	56 U		9.2 U	9.1 U	8.1 U		9.6 U	16 U	14 U	53 U	23.75	8.1	72
Chlorinated and Nitro-Substituted Phenols													
Pentachlorophenol	223 UJ		37 U	36 U	33 U		38 U	63 U	54 U	210 UJ	94.73	32	286
Chlorinated Aromatic Compounds													
1,2,4-Trichlorobenzene	56 U		9.2 U	9.1 U	8.1 U		9.6 U	16 U	14 U	53 U	23.75	8.1	72
1,2-Dichlorobenzene	56 U		9.2 U	9.1 U	8.1 U		9.6 U	16 U	14 U	53 U	23.75	8.1	72
1,3-Dichlorobenzene	56 U		9.2 U	9.1 U	8.1 U		9.6 U	16 U	14 U	53 U	23.75	8.1	72
1,4-Dichlorobenzene	27 J		5 J	9.1 U	8.1 U		3.2 J	10 J	4.9 J	53 U	19.89	5	72
2-Chloronaphthalene	5.1 U		5.1 UJ	5.1 UJ	4.8 UJ	5 UJ	4.9 U	5.2 UJ	5 UJ	5.3 U	5.11	4.7	5.3
Hexachlorobenzene	0.51 U		0.51 U	0.51 U	0.49 U		0.49 U	0.52 U	0.5 U	0.53 U	0.61	0.47	1.1
Chlorinated Pesticides													
2,4'-DDD	0.89		0.51 U	0.51 U	0.49 U		0.49 U	0.6	0.5 U	0.53 U	0.54	0.47	0.89
2,4'-DDE	1.4 UJ		0.51 U	0.51 U	0.49 U		0.49 U	0.52 U	1.5 UJ	0.91 UJ	0.59	0.5	1.4
2,4'-DDT	0.51 U		0.51 U	0.51 U	0.49 U		0.49 U	0.52 U	0.64	0.53 U	0.51	0.47	0.53
4,4'-DDD	5.2		0.77	0.78	0.49 U		1	2.2	7.9	1.5	1.16	0.51	5.2
4,4'-DDE	1.7		0.51 U	0.51 U	0.49 U		0.49 U	1.7	2.7	1.3	0.74	0.51	1.7
4,4'-DDT	3.5 J		0.51 U	0.53 J	0.49 U		0.57 J	3.2 J	404	2.4 J	1.06	0.51	3.5
Aldrin	0.51 U		0.51 U	0.51 U	0.49 U		0.49 U	0.52 U	0.5 U	0.53 U	0.51	0.47	0.53
Cis-Chlordane (Alpha-Chlordane)	0.52		0.51 U	0.51 U	0.49 U		0.49 U	0.52 U	0.5 U	0.53 U	0.51	0.47	0.53
Dibutylchlorendate											88.50	87	90
Dieldrin	0.51 U		0.51 U	0.51 U	0.49 U		0.49 U	0.52 U	0.5 U	0.53 U	0.51	0.47	0.53
Endosulfan I	0.51 UJ		0.51 U	0.51 U	0.49 U		0.49 U	0.52 U	0.5 U	0.53 UJ	0.51	0.47	0.53
Endosulfan II	0.51 UJ		0.51 U	0.51 U	0.49 U		0.49 U	0.52 U	0.5 U	0.53 UJ	0.51	0.47	0.53
Endosulfan Sulfate	0.51 U		0.51 U	0.51 U	0.49 U		0.49 U	0.52 U	0.5 U	0.53 U	0.51	0.47	0.53
Endrin	0.51 U		0.51 U	0.51 U	0.49 U		0.49 U	0.52 U	0.5 U	0.53 U	0.51	0.47	0.53
Endrin Aldehyde	0.51 UJ		0.51 UJ	0.51 UJ	0.49 UJ		0.49 UJ	0.52 UJ	0.5 UJ	0.53 UJ	0.51	0.47	0.53
Endrin Ketone	0.51 U		0.51 U	0.51 U	0.49 U		0.49 U	0.52 U	0.5 U	0.53 U	0.51	0.47	0.54
Gamma-BHC (Lindane)	0.51 U		0.51 U	0.51 U	0.49 U		0.49 U	0.52 U	0.5 U	0.53 U	0.51	0.47	0.53
Heptachlor	0.51 U		0.51 U	0.51 U	0.49 U		0.49 U	0.52 U	0.5 U	0.53 U	0.51	0.47	0.53
Heptachlor Epoxide	0.51 U		0.51 U	0.51 U	0.49 U		0.49 U	0.52 U	0.5 U	0.53 U	0.51	0.47	0.53
Mirex	0.51 U		0.51 U	0.51 U	0.49 U		0.49 U	0.52 U	0.5 U	0.53 U	0.51	0.47	0.53
Oxychlordane	0.51 U		0.51 U	0.51 U	0.49 U		0.49 U	0.52 U	0.5 U	0.53 U	0.51	0.47	0.53
Toxaphene	102 UJ		10 U	10 U	9.8 U		9.7 U	10 U	10 U	21 UJ	18.23	10	102
Trans-Chlordane (Gamma)	0.83 J		0.51 U	0.51 U	0.49 U		0.49 U	0.52 U	0.5 U	0.53 U	0.53	0.47	0.83
Polynuclear Aromatic Hydrocarbons													
LPAHs													
Biphenyl	112		27 J	34 J	9.6 UJ	3.4 UJ	19	44	20	34	21.39	2.7	112
1,6,7-Trimethylnaphthalene	50		11	13 J	5.4 J	4.2	12	19	15	22	15.92	4.3	50
1-Methylnaphthalene	186		28 J	40 J	7.9 J	2.2	27	75	34	57 J	36.35	1.6	186
2,6-Dimethylnaphthalene	192		35	39 J	10 J	4.7	27	76	54	61 J	53.45	6.5	192
2-Methylnaphthalene	307		47 J	55 J	10 J	4.1	45	119	64	81 J	55.93	2.6	307
2-Methylphenanthrene	272		47	40	2	3.2	35	84	54	82	56.21	1.1	272
Acenaphthene	224		60 J	65 J	7.1 J	1.4	19 J	95	40	48	32.38	1.1	224
Acenaphthylene	513		186	357 J	25 J	4.6	75	102	51	94	97.32	4.3	513
Anthracene	1320		197	333 J	8.8	8.2	95	278	101	184	166.57	3.5	1320
Dibenzothiophene	179		20	34 J	1.8 J	1.2 J	13	27	16	31	23.74	0.59	179
Fluorene	409		58	86 J	8.1 J	2.8	28	115	62	76	54.31	1.9	409
Naphthalene	796		234 J	378 J	32 UJ	17	249	388	164	306 J	152.23	5	796
Phenanthrene		1740	287	281 J	13	12	193	495	221	325	243.98	5.2	1740
Retene	780		21	11 J	0.48 J	6.6	77 J	308	179	307	141.58	2.2	780
LPAHs	2126.8		311.23	294.67	8.527	9.32	163.64	595.62	231.33	528.03	291.21	7.351	2126.8
Benzo(a)anthracene	1000		142	130	4.7	6.3	83	244	122	200	141.56	3.4	1000
Benzo(a)pyrene	1600		228	205	5.8	6.3	118	447	165	385	225.60	4.9	1600
Benzo(b)fluoranthene	1600	1600	280	271	9.9	10	142	475	226	444	350.99	8.9	1600
Benzo(ghi)perylene	947		143	138	4.3	4.4	101	270	118	258	153.53	4.5	947
Benzo(k)fluoranthene	800		108	99	4	4.7	58	228	90	176	111.85	3.7	800
Benzo[e]pyrene	968		162	153	5.3	5.8	87	296	131	265	150.64	4.6	968
Carbazole	201		55	259 J	8 J	3.6 J	16 J	42 J	18 J	38	44.03	3	259
Chrysene	1680		243	247	6.7	12	114	372	193	313	230.84	5.1	1680
Dibenzo(a,h)anthracene	100		29	52	1 J	1 J	15	57	25	69	31.27	1	100
Fluoranthene		1980	452	386	17	16	270	586	311	477	322.63	9.9	1980

Table A-15. Washington Department of Ecology Elliott Bay Urban Initiatives Analytical Data

Chemistry Results Urban Bay

Chemical	188	188 Lab Dup	189	189 Lab Dup	190	190 Lab Dup	192	194	195	196	avg	min	max
Indeno(1,2,3-cd)pyrene	1300		162	164	4	4	102	274	106	303	184.00	4	1300
Perylene	525		106	98	7.2	9.6	77	251	357	260	152.65	9.3	525
Pyrene		2220	493	456	18	20	354	746	372	598	370.85	9.8	2220
Miscellaneous Extractable Compounds													
2,4-Dimethylphenol	328		31 J	29 J	16 UJ		19 UJ	59 J	46 J	105 U	101.97	16	328
2-Methylphenol	308 J		42	41	35		41	72	71	53 UJ	95.47	8.5	350
3B-Coprostanol	558 UJ		324 J	424 J	178 J		257 J	156 UJ	136 UJ	526 UJ	495.07	81	864
4-Methylphenol	421		42	32	24		29	84	65	229	109.80	17	421
Benzoic Acid	645 UJ		1060 J	705 J	444 J		775 J	981 J	735 J	507 UJ	573.53	346	1120
Benzyl Alcohol	558 U		92 U	91 U	81 U		96 U	156 U	136 U	526 U	237.33	81	715
Bis(2-Ethylhexyl) Phthalate	538		136	93	21 UJ		36	112	73	190	264.97	17	1640
Butylbenzylphthalate	112 U		18 U	18 U	16 UJ		19 U	31 U	27 U	105 U	47.40	16	143
Caffeine	56 U		9.2 U	9.1 U	8.1 U		9.6 U	16 U	14 U	53 U	23.75	8.1	72
Cholesterol	7940 J		3380 J	2160 J	1340 J		1910 J	2080 J	1980 J	3100 J	7392.93	784	26600
Dibenzofuran	353		148 J	88 J	11 UJ	5	41	158	63	151	58.51	3.2	353
Diethylphthalate	112 U		18 U	18 U	16 U		19 U	31 U	27 U	105 U	47.40	16	143
Dimethylphthalate	112 U		18 U	18 U	16 U		19 U	31 U	27 U	115	47.40	16	143
Di-N-Butylphthalate	223 U		18 U	18 U	16 UJ		19 U	63 U	54 U	210 U	80.87	18	286
Di-N-Octyl Phthalate	112 U		18 U	18 U	16 U		19 U	31 U	27 U	105 U	47.40	16	143
Hexachlorobenzene	56 U		9.2 U	9.1 U	8.1 U		9.6 U	16 U	14 U	53 U	23.75	8.1	72
Isophorone	144		18 U	18 U	16 U		19 U	37	32	129	57.07	17	164
N-Nitrosodiphenylamine	112 UJ		18 UJ	18 UJ	16 UJ		19 UJ	31 UJ	27 UJ	105 UJ	47.40	16	143
Phenol	444 UJ		77 UJ	67 UJ	49 UJ		55 UJ	110 UJ	104 UJ	302 UJ	163.33	49	444
Phenol, 4-Nonyl-	112 U		18 U	18 U	33 U		19 U	31 U	17 U	105 U	47.40	16	143
Polycyclic Chlorinated Biphenyls													
PCB Aroclors	193		28	31	9.8		49	193	141	153	67.80	10	193
PCB Aroclor 1016	10 U		10 U	10 U	9.8 U		9.7 U	10 U	10 U	11 U	10.13	9.4	11
PCB Aroclor 1221	10 U		10 U	10 U	9.8 U		9.7 U	10 U	10 U	11 U	10.13	9.4	11
PCB Aroclor 1232	10 U		10 U	10 U	9.8 U		9.7 U	10 U	10 U	21 UJ	10.13	9.4	11
PCB Aroclor 1242	15 J		10 U	10 U	9.8 U		10 J	11 J	12 J	15 J	11.06	9.4	15
PCB Aroclor 1248	28 UJ		12 UJ	14 UJ	9.8 U		15 UJ	37 UJ	40 UJ	30 UJ	16.30	10	28
PCB Aroclor 1254	77 A		16 A	18 A	9.8 U		21 A	73 A	54 J	59 A	27.73	10	77
PCB Aroclor 1260	101 A		12 A	13 A	9.8 U		18 A	109 A	75 A	79 A	27.37	10	101
PCB Aroclor 1262	71 UJ		10 U	10 U	9.8 U		13 UJ	74 UJ	48 UJ	57 UJ	25.27	10	71
PCB Aroclor 1268	10 U		10 U	10 U	9.8 U		9.7 U	10 U	10 U	11 U	10.13	9.4	11
PCB Congeners													
PCB congener 8	0.51 U		0.51 U	0.51 U	0.49 U		0.49 U	0.76 J	0.67 J	0.7 J	0.53	0.51	0.63
PCB congener 18	0.51 U		0.51 U	0.51 U	0.49 U		0.49 U	0.52 U	0.63	0.53 U	0.51	0.47	0.53
PCB congener 28	1.3		0.51 U	0.57	0.49 U		0.57	1.7	1.3	1.5	0.76	0.51	1.3
PCB congener 44	1.4		0.51 U	0.51 U	0.49 U		0.49 U	1.5	1.3	1.2	0.69	0.51	1.4
PCB congener 52	2.1		0.53	0.63	0.49 U		0.73	2.3	5	2.1	0.97	0.51	2.1
PCB congener 66	2.4 J		0.61 J	0.65 J	0.49 U		0.72 J	2.5 J	1.6 J	2.2 J	0.93	0.51	2.4
PCB congener 77	1.7 J		0.56 J	0.64	0.49 U		0.8	2.9 J	2.9 J	2.3 J	0.80	0.51	1.7
PCB congener 101	6.3		1.3	1.5	0.49 U		1.7	6.6	6.1	4.8	2.16	0.51	6.3
PCB congener 105	3.1		0.55	0.58	0.49 U		0.69	2.5 J	1.2 J	2 J	1.01	0.51	3.1
PCB congener 118	6		1.2	1.3	0.49 U		1.6	5.8	3.1	4.5	2.13	0.51	6
PCB congener 126	0.51 U		0.51 U	0.51 U	0.49 U		0.49 U	0.52 U	0.5 U	0.53 U	0.51	0.47	0.53
PCB congener 128	1.9		0.51 U	0.51 U	0.49 U		0.49 U	1.9	0.95	1.2	0.73	0.51	1.9
PCB congener 138	12		1.8	2.1	0.49 U		2.6	13	0.5 U	9.3	3.48	0.52	12
PCB congener 153	12		1.7	1.9	0.49 U		2.7	14	12	11	3.45	0.52	12
PCB congener 169	0.51 U		0.51 UJ	0.51 UJ	0.49 U		0.49 UJ	0.52 UJ	0.5 UJ	0.53 U	0.51	0.47	0.53
PCB congener 170	5.2		0.59	0.63	0.49 U		0.82	5.2	3.2	4.2	1.32	0.51	5.2
PCB congener 180	9.7		1.1	1.1	0.49 U		1.5	9.9	6.2	7.5	2.33	0.52	9.7
PCB congener 187	5.2		0.67	0.7	0.49 U		0.97	5.6	4.3	4.4	1.61	0.51	5.2
PCB congener 195	0.92		0.51 U	0.51 U	0.49 U		0.49 U	0.88	0.65	0.76	0.54	0.47	0.92
PCB congener 206	1.3		0.51 U	0.51 U	0.49 U		0.49 U	1	0.62	1	0.86	0.51	1.9
PCB congener 209	1.1 J		0.51 UJ	0.51 UJ	0.49 U		0.49 UJ	0.7 J	0.52 J	0.89	0.57	0.5	1.1
Polybrominated Diphenylethers													
PBDE- 47	6.4		0.2 U	0.2 U	0.2 U		0.44	1.4	0.82	2	1.29	0.09	6.4
PBDE- 49	0.2 U		0.2 U	0.2 U	0.2 U		0.19 U	2.5 NJ	1.9 NJ	2.3 J	0.49	0.19	1.3
PBDE- 66	0.2 U		0.2 U	0.2 U	0.2 U		0.19 U	0.21 U	0.2 U	0.21 U	0.20	0.19	0.21
PBDE- 71	0.2 U		0.2 U	0.2 U	0.2 U		0.19 U	0.21 U	0.2 U	0.21 U	0.20	0.19	0.21
PBDE- 99	0.2 U		0.2 U	0.2 U	0.2 U		0.19 U	0.21 U	0.56	0.21 U	0.68	0.16	1.8
PBDE-100	0.2 U		0.2 U	0.2 U	0.2 U		0.19 U	0.21 U	0.2 U	0.21 U	0.21	0.19	0.32
PBDE-138	0.41 U		0.41 U	0.41 U	0.39 U		0.39 U	0.41 U	0.4 U	0.42 U	0.41	0.37	0.43
PBDE-153	0.41 U		0.41 U	0.41 U	0.39 U		0.39 U	0.41 U	0.4 U	0.42 U	0.41	0.37	0.43
PBDE-154	0.41 U		0.41 U	0.41 U	0.39 U		0.39 U	0.41 U	0.4 U	0.42 U	0.40	0.29	0.43
PBDE-183	0.41 U		0.41 U	0.41 U	0.39 U		0.39 U	0.41 U	0.4 U	0.42 U	0.41	0.37	0.43
PBDE-184	0.41 U		0.41 U	0.41 U	0.39 U		0.39 U	0.41 U	0.4 U	0.42 U	0.41	0.37	0.43
PBDE-191	0.82 U		0.82 U	0.81 U	0.78 U		0.78 U	0.83 U	0.8 U	0.84 U	0.82	0.75	0.85
PBDE-209	5.1 U		5.1 U	5.1 U	4.9 U		4.9 U	5.2 U	5 U	5.3 U	10.49	5.1	27

Notes:

mg/kg = milligrams per kilogram

ug/kg = micrograms per kilogram

U = Result should be considered not-detected at the quantitation limit shown

J = Result is an estimated concentration

R = Rejected - Quality Control indicates the data is not usable

UJ = The compound was not detected and the sample detection limit should be considered an estimated value

Table A-15. Washington Department of Ecology Elliott Bay Urban Initiatives Analytical Data

Chemical Results Industrial Harbor

Chemical	114	115	115 Lab Dup	115 Lab Trip	180	181	181 Field Rep	182	182 Lab Dup	183	183 Lab Dup	184	184 Lab Dup	197	197 Lab Dup	197 Lab Trip	199	200
Priority Pollutant Metals (mg/kg dry weight)																		
Silver	0.15	0.79			0.34	1.04	1	1		0.28		0.6		0.1 U			0.1 U	0.56
Arsenic	7.09	13.7			5.97	11.1	11	11.2		9.29		23		186			6.5	7.28
Cadmium	0.16	0.57			0.14	0.31	0.26	0.3		0.17		0.41		0.1 U			0.1 U	0.39
Chromium	18.9	33			23.8	49.9	49.8	39		22		30.6		45.8			14.1	26.3
Copper	41.5	59.1			19.8	49.5	49.1	62.5		36.6		352		158			25.6	51.6
Mercury	0.0962	0.26			0.154	0.052	0.418	0.853		0.12		0.303 J		0.221			0.107	0.16
Nickel	11.4	64			22.2	43.2	43.2	30.1		20.7		21.8		17.9			5.77	19.1
Lead	21	48.8			19.4	47	47.6	82		26.4		55.5		188			14.6	33.1
Selenium	0.5 U	0.55			0.5 U	0.5 U	0.5 U	0.51		0.5 U		0.53		0.5 U			0.5 U	0.5 U
Zinc	71.5	111			47	110	120	98.4		82.6		250		577			37	110
Trace Elements																		
Tin	2.47	130			2.41	5.94	6.04	8.82		3.19		17.3		4.35			1	3.9
Organic Compounds (ug/kg dry weight)																		
Chlorinated Alkanes																		
Hexachlorobutadiene	43 U	12 U			9.3 U	44 U	43 U	13 U		10 U		49 U		9 U			9.1 U	46 U
Chlorinated and Nitro-Substituted Phenols																		
Pentachlorophenol	170 UJ	46 U			37 U	177 UJ	171 UJ	50 U		40 U		195 UJ		36 U			36 U	182 UJ
Chlorinated Aromatic Compounds																		
1,2,4-Trichlorobenzene	43 U	12 U			9.3 U	44 U	43 U	13 U		10 U		49 U		9 U			9.1 U	9.6 J
1,2-Dichlorobenzene	43 U	12 U			9.3 U	44 U	43 U	13 U		10 U		39 U		9 U			9.1 U	46 U
1,3-Dichlorobenzene	43 U	12 U			9.4 U	44 U	43 U	13 U		10 U		49 U		9 U			9.1 U	7.6 J
1,4-Dichlorobenzene	43 U	11 J			9.4	44 U	28 J	11 J		4.6 J		39 J		9 U			9.1 U	52
2-Chloronaphthalene	5 U	5 UJ			4.9 UJ	5 U	4.8 U	5 UJ		4.5 UJ		5.1 U		5 UJ			4.8 UJ	5.3 U
Hexachlorobenzene	0.5 UJ	0.49 U			0.5 U	0.5 U	0.48 U	0.5 UJ		0.45 U		0.51 U		0.49 UJ			0.48 U	0.53 U
Chlorinated Pesticides																		
2,4'-DDD	0.5 UJ	2.4			0.5 U	0.93	1	1.2 J		0.45 U		0.51 U		0.49 UJ			0.48 U	0.53 U
2,4'-DDE	0.5 UJ	0.49 U			0.5 U	0.5 U	1.6 UJ	1.4 UJ		0.45 U		0.51 U		0.52 UJ			0.71 UJ	2.5 UJ
2,4'-DDT	0.5 UJ	0.49 U			0.5 U	0.5 U	0.48	0.5 UJ		0.45 U		0.51 U		0.49 UJ			0.48 U	0.53 U
4,4'-DDD	0.6 J	6.7			1.4	4.4	4.5	6.3 J		1.5		2.5		0.49 UJ			0.71	3.5 J
4,4'-DDE	0.55 J	1.8			0.72	2	1.8	1.6 J		0.75		0.86 UJ		0.73 J			0.97	3.3
4,4'-DDT	0.83 J	2 J			0.99 J	3.3 J	3.3 J	3.4 J		1.1 J		1.3 J		0.75 J			1.1 J	9.1 J
Aldrin	0.5 UJ	0.49 U			0.5 U	0.5 U	0.48 U	0.5 UJ		0.45 U		0.51 U		0.49 UJ			0.48 U	0.53 U
Cis-Chlordane (Alpha-Chlordane)	0.5 UJ	0.51			0.5 U	0.5 U	0.48 U	0.5 UJ		0.45 U		0.51 U		0.49 UJ			0.48 U	0.53 U
Dibutylchlorendate																		
Dieldrin	0.5 U	0.49 U			0.5 U	0.5 U	0.48 U	0.5 U		0.45 U		0.51 U		0.49 U			0.48 U	0.53 U
Endosulfan I	0.5 UJ	0.49 U			0.5 UJ	0.5 UJ	0.48 UJ	0.5 U		0.45 U		0.51 UJ		0.49 U			0.48 U	0.53 UJ
Endosulfan II	0.5 UJ	0.49 U			0.5 UJ	0.5 UJ	0.48 UJ	0.5 U		0.45 U		1.6 UJ		0.49 U			0.48 U	0.53 UJ
Endosulfan Sulfate	0.5 U	0.61 UJ			0.67	0.5 U	0.48 U	0.89 UJ		0.52 UJ		0.51 U		0.49 U			0.48 U	0.53 U
Endrin	0.5 U	0.49 U			0.5 U	0.5 U	0.48 U	0.5 U		0.45 U		0.51 U		0.49 U			0.48 U	0.53 U
Endrin Aldehyde	0.5 UJ	0.49 UJ			0.5 UJ	0.5 UJ	0.48 UJ	0.5 UJ		0.45 UJ		0.51 UJ		0.49 UJ			0.48 UJ	0.53 UJ
Endrin Ketone	0.5 U	0.49 U			0.5 U	0.5 U	0.48 U	0.5 U		0.45 U		35 UJ		0.49 U			0.48 U	0.56 UJ
Gamma-BHC (Lindane)	0.5 UJ	0.49 U			0.5 U	0.5 U	0.48 U	0.5 UJ		0.45 U		0.51 U		0.49 UJ			0.48 U	0.53 U
Heptachlor	0.5 UJ	0.49 U			0.5 U	0.5 U	0.48 U	0.5 UJ		0.45 U		0.51 U		0.49 UJ			0.48 U	0.53 U
Heptachlor Epoxide	0.5 U	0.49 U			0.5 U	0.5 U	0.48 U	0.5 U		0.45 U		0.51 U		0.49 UJ			0.48 U	0.53 U
Mirex	0.5 UJ	0.49 U			0.5 U	0.5 U	0.48 U	0.5 UJ		0.45 U		0.51 U		0.49 UJ			0.48 U	0.53 U
Oxychlordane	0.5 UJ	0.49 U			0.5 U	0.5 U	0.48 U	0.5 UJ		0.45 U		0.51 U		0.49 UJ			0.48 U	0.53 U
Toxaphene	20 UJ	20 UJ			9.9 U	9.9 U	58 UJ	10 UJ		9 U		20 UJ		9.9 UJ			9.6 U	107 UJ
Trans-Chlordane (Gamma)	0.5 UJ	0.94 J			0.5 U	0.55 J	0.62 J	0.75 J		0.45 U		1.6 UJ		0.49 UJ			0.48 U	0.53 U
Polynuclear Aromatic Hydrocarbons																		
LPAHs																		
Biphenyl	12	45			21	24	20	114		17		101		9.8			28 J	21
1,6,7-Trimethylnaphthalene	10	13			9.6	14	14	26		26		35		6.5			9.8 J	12
1-Methylnaphthalene	18 J	54			32	37	29 J	105		36 J		142		11 J			35 J	27 J
2,6-Dimethylnaphthalene	34	90			35	53	40 J	135		62 J		229		23 J			38 J	41 J
2-Methylnaphthalene	26 J	113			61	71	50 J	225		45 J		192		16 J			55 J	45 J
2-Methylphenanthrene	25	126			43	54	64	192		113 J		1070		26			28	62
Acenaphthene	9.1	104			40	30	23	139		71		319		31			81 J	69
Acenaphthylene	37	353			84	83	92	336		363		1240		44			227 J	106
Anthracene	58	1160			184	188	175	609		659			1100 J	91			270	232
Dibenzothiophene	9.9	42			15	25	21	73		41		749		11			26	43
Fluorene	17	231			53	47	42	220		108		970		38			94 J	90
Naphthalene	45 J	293			183	197	148 J	938		105 J		397 J		48 J			234 J	156 J
Phenanthrene	93	749			234	290	244		1080	463			4660 J	172			246	338
Retene	96	111			78	153	129	368		380			212 J	24			9.6	79
LPAHs	209.28	2437.9			334.48	484.94	482.82	1131.21		1172.2			2665	194.24			206.94	619.2
Benzo(a)anthracene	95	770			152	207	188	497		513			1970 J	153			94	328
Benzo(a)pyrene	145	1890	1890		249	341	349	816		871			1670 J	135			149	430
Benzo(b)fluoranthene	216	2340		2340	293	464	436	1160	1160	1210	1210		4680 J	201			213	661
Benzo(ghi)perylene	92	784			154	258	249	625		397			935 J	62			88	226
Benzo(k)fluoranthene	79	815			115	168	145	469		430			1450 J	81			78	288
Benzo[e]pyrene	119		1110		159	279	267	614		606				108			109	350
Carbazole	18	189 J			26 J	34	38	102 J		84 J				19 J			106 J	61
Chrysene	178	1920	1920		278	354	332	881		1270	1270		5570 J	254			174	540
Dibenzo(a,h)anthracene	33	149 J			33	67	65	88		77			298 J	17			23	71
Fluoranthene	189		1450		319	461	387		1250		1160		40500 J	552			286	1080

Table A-15. Washington Department of Ecology Elliott Bay Urban Initiatives Analytical Data

Chemical Results Industrial Harbor

Chemical	114	115	115 Lab Dup	115 Lab Trip	180	181	181 Field Rep	182	182 Lab Dup	183	183 Lab Dup	184	184 Lab Dup	197	197 Lab Dup	197 Lab Trip	199	200
Indeno(1,2,3-cd)pyrene	103	766			135	297	276	586		424 J			101 J	64			85	277
Perylene	134	556			100	422	458	342		369				86			115	279
Pyrene	198			2880	433	537	444		1660		880		25500 J	370			310	1350
Miscellaneous Extractable Compounds																		
2,4-Dimethylphenol	85 U	55 J			18 UJ	193	195	57 J		53 J		304		28 J			18 UJ	218
2-Methylphenol	206 J	62			9.3 U	222 J	219 J	66		56		283 J		41			41	235 J
3B-Coprostanol	1320	1030 J			93 UJ	1280 UJ	427 U	361 J		943 J		3180 J		570 J			197 J	2320
4-Methylphenol	174	80			36	189	206	84		79		388		35			39	239
Benzoic Acid	626 UJ	293 UJ			398 J	644 UJ	528 UJ	1040 J		1160 J		486 UJ		411 J			444 J	531 UJ
Benzyl Alcohol	426 U	116 U			93 U	443 U	427 U	126 U		58 J		388 U		90 U			90 U	455 U
Bis(2-Ethylhexyl) Phthalate	697	304 J			70	595	644	186		179		1480 J		59			45	1230
Butylbenzylphthalate	85 U	23 U			18 U	65 J	85 U	25 U		20 U		97 UJ		18 U			18 U	91 U
Caffeine	43 U	12 U			9.3 U	44 U	43 U	13 U		10 U		49 U		9 U			9.1 U	46 U
Cholesterol	2300 J	13800 J			1240 J	1860 J	9920 J	2260 J		22100 J		4680 J		16200 J			1370 J	10900 J
Dibenzofuran	30	149			47	46	92	623		184		831		90			99 J	171
Diethylphthalate	85 U	23 U			18 U	89 U	85 U	25 U		20 U		97 U		18 U			18 U	91 U
Dimethylphthalate	85 U	23 U			18 U	89 U	85 U	25 U		20 U		262		18 U			18 U	91 U
Di-N-Butylphthalate	170 U	46 U			37 U	610	171 U	61		39 J		195 U		36 U			36 U	182 U
Di-N-Octyl Phthalate	85 U	23 UJ			18 U	89 U	85 U	25 U		20 U		97 UJ		18 U			18 U	91 U
Hexachlorobenzene	43 U	12 U			9.3 U	44 U	43 U	13 U		10 U		49 U		9 U			9.1 U	46 U
Isophorone	85 U	47			21	114	85 U	27		28		97 U		19			19	138
N-Nitrosodiphenylamine	85 UJ	23 UJ			18 UJ	89 UJ	85 UJ	25 UJ		20 UJ		97 UJ		18 UJ			18 UJ	91 UJ
Phenol	277 UJ	100 UJ			64 UJ	246 UJ	295 UJ	154 UJ		128 UJ		530 UJ		66 UJ			61 UJ	324 UJ
Phenol, 4-Nonyl-	85 U	23 U			18 U	89 U	85 U	25 U		20 U		97 U		18 U			18 U	91 U
Polycyclic Chlorinated Biphenyls																		
PCB Aroclors	46	125			53	195	184	176		59		97		43			60	778
PCB Aroclor 1016	9.9 UJ	9.8 U			9.9 U	9.9 U	9.7 U	10 UJ		9 U		10 U		9.9 UJ			9.6 U	21 UJ
PCB Aroclor 1221	9.9 UJ	9.8 U			9.9 U	9.9 U	9.7 U	10 UJ		9 U		10 U		9.9 UJ			9.6 U	21 UJ
PCB Aroclor 1232	9.9 UJ	9.8 U			9.9 U	20 UJ	9.7 U	10 UJ		9 U		10 U		9.9 UJ			9.6 U	21 UJ
PCB Aroclor 1242	9.9 UJ	10 J			9.9 U	10 J	10 J	13 J		9 U		14 J		9.9 UJ			9.6 U	24 J
PCB Aroclor 1248	20 UJ	39 UJ			12 UJ	31 UJ	30 UJ	40 UJ		18 UJ		20 UJ		14 UJ			16 UJ	87 UJ
PCB Aroclor 1254	24 J	61 A			28 A	90 A	84 A	73 J		31 A		38 J		30 J			39 A	271 A
PCB Aroclor 1260	22 J	54 A			25 A	95 A	90 A	90 J		28 A		45 A		13 J			21 A	483 A
PCB Aroclor 1262	20 UJ	40 UJ			21 UJ	72 UJ	69 UJ	61 UJ		21 UJ		36 UJ		11 UJ			16 UJ	266 UJ
PCB Aroclor 1268	9.9 UJ	9.8 U			9.9 U	9.9 U	9.7 U	10 UJ		9 U		10 U		9.9 UJ			9.6 U	11 U
PCB Congeners																		
PCB congener 8	0.5 UJ	0.49 U			0.5 U	0.59 J	0.61 J	0.71 J		0.45 U		0.51 U		0.49 UJ			0.48 U	1.3 J
PCB congener 18	0.5 UJ	0.49 U			0.5 U	0.5 U	0.48 U	0.61 J		0.45 U		0.51 U		0.49 UJ			0.48 U	1.8
PCB congener 28	0.77 J	0.74			0.5 U	1.5	1.5	1.7 J		0.45 U		0.66		0.49 UJ			0.48 U	3.1
PCB congener 44	0.64 J	1.1			0.5 U	1.5	1.4	1.5 J		0.51		0.69		0.68 J			0.85	4.7
PCB congener 52	0.98 J	1.7			0.76	2.2	2	2 J		0.96		1.1		1.3 J			1.6	11
PCB congener 66	1 J	2.6			0.77 J	2.5 J	2.5 J	2.4 J		0.71 J		0.95 J		0.63 J			0.84 J	5 J
PCB congener 77	0.69 J	2			0.96	3.3	3.2	2.8 J		1.1		0.51 U		0.69 J			1.1	7.6 J
PCB congener 101	1.9 J	5.6			2.1	6.6	6.2	6.1 J		2.9		1.1 J		2.6 J			3.5	17
PCB congener 105	0.76 J	2.3			1.2	3.7	3.5	2.7 J		1.2		1.5		0.92 J			1.2	4.6 J
PCB congener 118	1.6 J	4.5			2.2	7.3	6.8	5.6 J		2.5		3.3		2.1 J			2.8	11
PCB congener 126	0.5 UJ	0.49 U			0.5 U	0.5 U	0.48 U	0.5 UJ		0.45 U		0.51 U		0.49 UJ			0.48 U	0.53 U
PCB congener 128	0.5 J	1.2			0.67	2.4	2.3	1.7 J		0.84		1.1		0.55 J			0.83	3.6
PCB congener 138	3 J	7.1			3.7	13	12	11 J		4.5		5.8		2.9 J			4.4	31
PCB congener 153	2.8 J	6.9			3.2	12	11	12 J		4.3		5.8		2.4 J			3.7	50
PCB congener 169	0.5 UJ	0.49 UJ			0.5 U	0.5 U	0.48 U	0.5 UJ		0.45 UJ		0.51 U		0.49 UJ			0.48 UJ	0.53 U
PCB congener 170	1.1 J	2			1.3	4.8	4.6	4.2 J		1.3		2.3		0.67 J			1.1	18
PCB congener 180	1.9 J	3.7			2.4	9.3	8.7	8.1 J		2.4		4.1		1.2 J			1.9	37
PCB congener 187	1.2 J	2.4			1.4	5.1	5	4.3 J		1.4		2.4		0.69 J			1.1	18
PCB congener 195	0.5 UJ	0.49 U			0.5 U	0.89	0.85	0.68 J		0.45 U		0.62		0.49 UJ			0.48 U	3.2
PCB congener 206	0.5 UJ	0.97			0.64	1.8	1.8	0.86 J		0.45		0.51 U		0.49 UJ			0.48 UJ	2
PCB congener 209	0.5 UJ	0.99 J			0.62	1.2	1.1	0.71 J		0.45 UJ		0.51 U		0.49 UJ			0.48 UJ	0.61 J
Polybrominated Diphenylethers																		
PBDE- 47	0.73	7.3			0.96	0.52	1.8	0.2 U		4.3		5.3		0.2 U			0.19 U	0.86
PBDE- 49	0.62 J	0.19 U			0.59 NJ	0.2 U	0.19 U	0.2 U		0.18 U		0.2 U		0.2 U			0.56 NJ	3 J
PBDE- 66	0.2 U	0.19 U			0.2 U	0.2 U	0.19 U	0.2 U		0.18 U		0.2 U		0.2 U			0.19 U	0.21 U
PBDE- 71	0.2 U	0.19 U			0.2 U	0.2 U	0.19 U	0.2 U		0.18 U		0.2 U		0.2 U			0.19 U	0.21 U
PBDE- 99	0.96	4.4			0.2 U	0.2 U	0.19 U	0.2 U		0.18 U		0.2 U		0.2 U			0.22	0.99
PBDE-100	0.2 U	0.19 U			0.2 U	0.2 U	0.19 U	0.2 U		0.18 U		0.2 U		0.2 U			0.19 U	0.21 U
PBDE-138	0.4 U	0.39 U			0.4 U	0.4 U	0.39 U	0.4 U		0.36 U		0.41 U		0.4 U			0.38 U	0.43 U
PBDE-153	0.4 U	0.39 U			0.4 U	0.4 U	0.39 U	0.4 U		0.36 U		0.41 U		0.4 U			0.38 U	0.43 U
PBDE-154	0.4 U	0.39 U			0.4 U	0.4 U	0.39 U	0.4 U		0.36 U		0.41 U		0.4 U			0.38 U	0.43 U
PBDE-183	0.4 U	0.39 U			0.4 U	0.4 U	0.39 U	0.4 U		0.36 U		0.41 U		0.4 U			0.38 U	0.43 U
PBDE-184	0.4 U	0.39 U			0.4 U	0.4 U	0.39 U	0.4 U		0.36 U		0.41 U		0.4 U			0.38 U	0.43 U
PBDE-191	0.79 U	0.78 U			0.79 U	0.79 U	0.78 U	0.8 U		0.72 U		0.82 U		0.79 U			0.76 U	0.86 U
PBDE-209	5 U	4.9 U			5 U	5 U	4.8 U	5 U		4.5 U		5.1 U		4.9 U			4.8 U	15 NJ

Notes:

mg/kg = milligrams per kilogram

ug/kg = micrograms per kilogram

U = Result should be considered not-detected at the quantitation limit shown

J = Result is an estimated concentration

R = Rejected - Quality Control indicates the data is not usable

UJ = The compound was not detected and the sample detection limit should be considered an estimated value

Table A-15. Washington Department of Ecology Elliott Bay Urban Initiatives Analytical Data

Chemical Results Industrial Harbor

Chemical	201	202	Lab Dup	Lab Trip	Field Rep	Lab Dup	Lab Trip	203	Lab Dup	204	205	avg	min	max
Priority Pollutant Metals (mg/kg dry weight)														
Silver	0.77	0.63			0.62			0.17		0.23	0.16	0.43	0.1	1.31
Arsenic	9.55	13.6			13.7			9.13		10.8	8.3	7.46	1.74	10.8
Cadmium	0.91	0.64			0.63			0.25		0.24	0.17	0.24	0.1	0.43
Chromium	32.4	35.8			35.6			20.6		26.3	21.9	32.04	18.5	42.9
Copper	64.4	78.7			81.9			40.3		67.2	41.9	35.20	5.67	94.6
Mercury	0.37	0.341			0.313			0.11		0.289	0.103	0.25	0.044	0.645
Nickel	20.2	22.4			29.1			15.5		15.9	15.6	26.73	14.2	36.2
Lead	43	46.2			46.1			33.4		40.1	19.3	30.61	6.75	82.5
Selenium	0.5 U	0.55			0.53			0.5 U		0.5 U	0.5 U	0.64	0.5	0.99
Zinc	140	180			258			85.3		116	80.4	73.43	27	130
Trace Elements														
Tin	4.58	5.15			5.58			2.25		2.9	1.6	3.12	0.48	9
Organic Compounds (ug/kg dry weight)														
Chlorinated Alkanes														
Hexachlorobutadiene	52 U	72 U			77 U			44 U	43 U	13 U	46 U	24.38	8.1	72
Chlorinated and Nitro-Substituted Phenols														
Pentachlorophenol	207 UJ	289 UJ			310 UJ			176 UJ	171 UJ	52 U	183 UJ	97.03	32	286
Chlorinated Aromatic Compounds														
1,2,4-Trichlorobenzene	12 J	72 U			7.5 J			44 U	43 U	13 U	46 U	24.38	8.1	72
1,2-Dichlorobenzene	52 U	72 U			77 U			44 U	43 U	13 U	46 U	24.38	8.1	72
1,3-Dichlorobenzene	52 U	72 U			77 U			44 U	43 U	13 U	46 U	24.38	8.1	72
1,4-Dichlorobenzene	137	31 J			79			44 U	43 U	13 U	46 U	20.63	3.2	72
2-Chloronaphthalene	5 U	4.9 U			5.3 U			5.1 UJ	5 U	5.2 U	5.2 U	5.08	4.7	5.3
Hexachlorobenzene	0.5 U	0.49 U			0.53 U			0.51 UJ	0.51 U	0.52 U	0.53 U	0.60	0.47	1.1
Chlorinated Pesticides														
2,4'-DDD	0.5 U	0.49 U			0.53 U			0.51 UJ	0.51 U	0.52 U	0.53 U	0.55	0.47	0.89
2,4'-DDE	2.2 UJ	2.4 UJ			2.6 UJ			0.51 UJ	1.2 UJ	0.52 U	0.53 U	0.66	0.49	1.5
2,4'-DDT	0.5 U	0.49 U			0.53 U			0.51 UJ	0.51 U	0.52 U	0.53 U	0.51	0.47	0.64
4,4'-DDD	3.3 J	3.5			4.2			0.78 J	0.97	1.8	1.2	1.62	0.49	7.9
4,4'-DDE	3.8	3.1			3.3			0.92 J	1.9	1.8	1	0.90	0.49	2.7
4,4'-DDT	12 J	9.5 J			9.2 J			1.2 J	2.6 J	2.1 J	1.4 J	18.77	0.49	404
Aldrin	0.5 U	0.49 U			0.53 U			0.51 UJ	0.51 U	0.52 U	0.53 U	0.51	0.47	0.53
Cis-Chlordane (Alpha-Chlordane)	0.5 U	0.75			0.68			0.51 UJ	0.51 U	0.52 U	0.53 U	0.51	0.47	0.53
Dibutylchlorendate														
Dieldrin	0.5 U	0.49 U			0.53 U			0.51 U	0.51 U	0.52 U	0.53 U	0.51	0.47	0.53
Endosulfan I	0.5 UJ	0.49 UJ			0.53 UJ			0.51 UJ	0.51 UJ	0.52 U	0.53 UJ	0.51	0.47	0.53
Endosulfan II	0.5 UJ	0.49 UJ			0.53 UJ			0.51 UJ	0.51 UJ	0.52 U	0.53 UJ	0.51	0.47	0.53
Endosulfan Sulfate	0.5 U	0.5 UJ			0.56 UJ			0.51 U	0.51 U	0.52 U	0.53 U	0.51	0.47	0.53
Endrin	0.5 U	0.49 U			0.53 U			0.51 U	0.51 U	0.52 U	0.53 U	0.51	0.47	0.53
Endrin Aldehyde	0.5 UJ	0.49 UJ			0.53 UJ			0.51 UJ	0.51 UJ	0.52 UJ	0.53 UJ	0.51	0.47	0.53
Endrin Ketone	0.5 U	1.3 UJ			1.9 UJ			0.51 U	0.51 U	0.52 U	0.53 U	0.51	0.47	0.54
Gamma-BHC (Lindane)	0.5 U	0.49 U			0.53 U			0.51 UJ	0.51 U	0.52 U	0.53 U	0.51	0.47	0.53
Heptachlor	0.5 U	0.49 U			0.53 U			0.51 UJ	0.51 U	0.52 U	0.53 U	0.51	0.47	0.53
Heptachlor Epoxide	0.5 U	0.49 U			0.53 U			0.51 U	0.51 U	0.52 U	0.53 U	0.51	0.47	0.53
Mirex	0.5 U	0.49 U			0.53 U			0.51 UJ	0.51 U	0.52 U	0.53 U	0.51	0.47	0.53
Oxychlordane	0.5 U	0.49 U			0.53 U			0.51 UJ	0.51 U	0.52 U	0.53 U	0.51	0.47	0.53
Toxaphene	101 UJ	97 UJ			64 UJ			10 UJ	10 U	21 UJ	11 U	20.18	9.7	102
Trans-Chlordane (Gamma)	0.71 J	0.6 J			0.58 J			0.51 UJ	0.51 U	0.52 U	0.53 U	0.54	0.47	0.83
Polynuclear Aromatic Hydrocarbons														
LPAHs														
Biphenyl	15	26			34			8.9	10	20	10	24.45	2.7	112
1,6,7-Trimethylnaphthalene	14	24			33			9.2	11	14	10	16.11	4.2	50
1-Methylnaphthalene	25 J	48			61 J			12	16	28	16	40.51	1.6	186
2,6-Dimethylnaphthalene	57 J	92			128			23	28	50	42	53.60	4.7	192
2-Methylnaphthalene	42 J	83			102			18	26	48	29	63.65	2.6	307
2-Methylphenanthrene	60	86			187			26	24	53	29	59.69	1.1	272
Acenaphthene	35	52			140			26	33	58	16	39.74	1.1	224
Acenaphthylene	75	110			136			24	23	66	34	101.08	4.3	513
Anthracene	180	465			589			65	67	212	81	194.32	3.5	1320
Dibenzothiophene	28	46			132			9.4	15	36	15	27.06	0.59	179
Fluorene	57	111			284			31	34	81	26	65.49	1.9	409
Naphthalene	103 J	156 J			190 J			32	46	121	50	183.03	5	796
Phenanthrene	308	525			1480			197	130	377	146	287.83	5.2	1740
Retene	138	290			322			94	133	113 J	96	163.57	0.48	780
LPAHs	440.36	853.1			961			314.96	214	548.14	241.15	347.08	7.351	2126.8
Benzo(a)anthracene	205	468			635			178	113	261	125	163.68	3.4	1000
Benzo(a)pyrene	308	587			663			234	145	391	167	265.91	4.9	1600
Benzo(b)fluoranthene	439	939			1000			358	230	572	237	355.49	8.9	1600
Benzo(ghi)perylene	196	376			425			90	95	226	112	173.49	4.3	947
Benzo(k)fluoranthene	198	323			329			83	89	202	113	131.41	3.7	800
Benzo[e]pyrene	247	497			572			106	120	293	128	173.87	4.6	968
Carbazole	46	78			88			21 J	20	44 J	24	45.51	3	259
Chrysene	446	1100			1110			316	210	484	265	266.22	5.1	1680
Dibenzo(a,h)anthracene	52	86			92			18	31	53	29	32.05	1	100
Fluoranthene	759	1110				1720		526	300	745	322	367.87	9.9	1980

Table A-15. Washington Department of Ecology Elliott Bay Urban Initiatives Analytical Data

Chemical Results Industrial Harbor

Chemical	201	202						203		204	205			
			Lab Dup	Lab Trip	Field Rep	Lab Dup	Lab Trip		Lab Dup			avg	min	max
Indeno(1,2,3-cd)pyrene	229	477			537			87	113	276	124	211.17	4	1300
Perylene	346	521			536			207	191	284	147	164.11	7.2	525
Pyrene	646	906				1180		598	297	755	275	427.98	9.8	2220
Miscellaneous Extractable Compounds														
2,4-Dimethylphenol	239	330			366			181	186	58 J	196	96.54	16	328
2-Methylphenol	266 J	372 J			407 J			220 J	212 J	68	232 J	93.82	8.5	350
3B-Coprostanol	5760 J	6150			7340 J			440 U	2950	554 J	2650	439.96	81	864
4-Methylphenol	324	404			480			266	314	72	178	114.17	17	421
Benzoic Acid	1090 UJ	2040 J			774 UJ			440 UJ	427 UJ	686 J	1230 UJ	612.37	346	1120
Benzyl Alcohol	517 U	723 U			678 J			382 J	371 J	130 U	457 U	242.97	81	715
Bis(2-Ethylhexyl) Phthalate	1660	2150			2930			1020	1020	182	1390	275.15	17	1640
Butylbenzylphthalate	103 U	86 J			142 J			88 U	85 U	26 U	92 U	48.50	16	143
Caffeine	52 U	72 U			77 U			44 U	43 U	13 U	46 U	24.38	8.1	72
Cholesterol	39600 J	6010 J			8980 J			3190 J	2530 J	20400 J	2920 J	6786.13	784	26600
Dibenzofuran	106	133			309			29	35	98	23	71.73	3.2	353
Diethylphthalate	103 U	144 U			155 U			88 U	85 U	26 U	92 U	48.50	16	143
Dimethylphthalate	103 U	144 U			155 U			88 U	85 U	26 U	92 U	48.93	16	143
Di-N-Butylphthalate	207 U	475			310 U			88 U	85 U	31 J	183 U	85.21	16	286
Di-N-Octyl Phthalate	103 U	144 U			155 U			88 U	85 U	26 U	92 U	48.50	16	143
Hexachlorobenzene	52 U	72 U			77 U			44 U	43 U	13 U	46 U	24.38	8.1	72
Isophorone	156	146			155 U			98	91	28	92 U	57.70	16	164
N-Nitrosodiphenylamine	103 UJ	144 UJ			155 UJ			88 UJ	85 UJ	26 U	92 UJ	48.50	16	143
Phenol	311 UJ	539 UJ			596 UJ			345 UJ	353 UJ	121 UJ	295 UJ	162.01	49	444
Phenol, 4-Nonyl-	103 U	144 U			155 U			88 U	85 U	26 U	92 U	48.80	16	143
Polycyclic Chlorinated Biphenyls														
PCB Aroclors	700	574			670			84	145	161	90	83.03	9.8	193
PCB Aroclor 1016	20 UJ	9.7 U			11 U			10 UJ	10 U	10 U	11 U	10.13	9.4	11
PCB Aroclor 1221	20 UJ	19 UJ			11 U			10 UJ	10 U	10 U	21 UJ	10.13	9.4	11
PCB Aroclor 1232	20 UJ	19 UJ			21 UJ			20 UJ	10 U	10 U	21 UJ	10.56	9.4	21
PCB Aroclor 1242	26 J	17 J			18 J			12 J	15 J	25 J	17 J	11.27	9.4	15
PCB Aroclor 1248	102 UJ	55 UJ			59 UJ			32 UJ	40 UJ	65 UJ	36 UJ	18.72	9.8	40
PCB Aroclor 1254	145 A	129 A			138 A			43 J	84 A	82 A	40 A	32.50	9.8	77
PCB Aroclor 1260	529 A	428 A			514 A			29 J	46 A	54 A	33 A	36.51	9.8	109
PCB Aroclor 1262	297 UJ	243 UJ			285 UJ			20 UJ	30 UJ	47 UJ	21 UJ	29.87	9.8	74
PCB Aroclor 1268	10 U	9.7 U			21 UJ			10 UJ	10 U	10 U	11 U	10.13	9.4	11
PCB Congeners														
PCB congener 8	1.3 J	0.9 J			1 J			0.54 J	0.68 J	0.83 J	1 J	0.55	0.49	0.76
PCB congener 18	1.5	0.72			0.95			0.79 J	1	1.1	0.91	0.51	0.47	0.63
PCB congener 28	3.3	2.3			2.5			1.5 J	1.9	2.3	1.7	0.85	0.49	1.7
PCB congener 44	3.1	2.1			2.2			1.4 J	1.9	2.5	1.3	0.78	0.49	1.5
PCB congener 52	6.8 J	4.8			5			2.1 J	2.9	3.4	1.8	1.25	0.49	5
PCB congener 66	4.4 J	3.5 J			3.7 J			1.9 J	2.7 J	3 J	1.6 J	1.10	0.49	2.5
PCB congener 77	8.9 J	6.8 J			7.2 J			1 J	0.51 U	2.2	0.99	1.06	0.49	2.9
PCB congener 101	15	14			15			3.3 J	6.4	6.6	3	2.66	0.49	6.6
PCB congener 105	3.8 J	3.6 J			3.8 J			1.3 J	3.1	2.4 J	1.2 J	1.16	0.49	3.1
PCB congener 118	8.3	8.2			8.7			2.8 J	6.7	5.5	2.4	2.44	0.49	6
PCB congener 126	0.5 U	0.49			0.53 U			0.51 UJ	0.51 U	0.52 U	0.53 U	0.51	0.47	0.53
PCB congener 128	3.2	3.2			3.8			0.81 J	2	1.5	0.71	0.83	0.49	1.9
PCB congener 138	31	30			34			4.4 J	9.9	8.3	4.2	4.09	0.49	13
PCB congener 153	55	47			54			4 J	7.7	7.7	3.9	4.69	0.49	14
PCB congener 169	0.5 U	0.49 U			0.53 U			0.51 UJ	0.51 U	0.52 UJ	0.53 U	0.51	0.47	0.53
PCB congener 170	21	18			20			1.5 J	2.4	2.5	1.5	1.77	0.49	5.2
PCB congener 180	42	34			37			2.6 J	4.4	4.7	2.7	3.18	0.49	9.9
PCB congener 187	22	18			20			1.6 J	2.3	3	1.6	2.05	0.49	5.6
PCB congener 195	3.9	3.1			3.5			0.51 UJ	0.51 U	0.52 U	0.53 U	0.58	0.47	0.92
PCB congener 206	2.4	2.1			2.3			0.51 UJ	0.51 U	1.1 J	0.53 U	0.86	0.49	1.9
PCB congener 209	0.76	0.77 J			0.85 J			0.51 UJ	0.51 U	0.52 UJ	0.53	0.60	0.49	1.1
Polybrominated Diphenylethers														
PBDE- 47	0.2 U	2.2			2.7			1.3	1.4	0.72	1.5	1.39	0.09	6.4
PBDE- 49	8.9 J	0.19 U			4.5 J			0.62 J	0.76 J	1.5 NJ	0.21 U	0.71	0.19	2.5
PBDE- 66	0.2 U	0.19 U			0.21 U			0.2 U	0.2 U	0.21 U	0.21 U	0.20	0.19	0.21
PBDE- 71	0.2 U	0.19 U			0.21 U			0.2 U	0.2 U	0.21 U	0.21 U	0.20	0.19	0.21
PBDE- 99	0.2 U	0.19 U			0.21 U			0.99	1.2	0.75	0.95	0.62	0.16	1.8
PBDE-100	0.2 U	0.19 U			0.21 U			0.2 U	0.2 U	0.21 U	0.21 U	0.21	0.19	0.32
PBDE-138	0.4 U	0.39 U			0.43 U			0.41 U	0.4 U	0.41 U	0.42 U	0.41	0.37	0.43
PBDE-153	0.4 U	0.39 U			0.43 U			0.41 U	0.4 U	0.41 U	0.42 U	0.41	0.37	0.43
PBDE-154	0.4 U	0.39 U			0.43 U			0.41 U	0.4 U	0.41 U	0.42 U	0.40	0.29	0.43
PBDE-183	0.4 U	0.88			0.43 U			0.41 U	0.4 U	0.41 U	0.42 U	0.41	0.37	0.43
PBDE-184	0.4 U	0.39 U			0.43 U			0.41 U	0.4 U	0.41 U	0.42 U	0.41	0.37	0.43
PBDE-191	0.8 U	0.78 U			0.85 U			0.81 U	0.81 U	0.83 U	0.84 U	0.81	0.75	0.85
PBDE-209	25 NJ	4.9 U			5.3 U			20	20	23.1 J	19	9.80	4.9	27

Notes:

mg/kg = milligrams per kilogram

ug/kg = micrograms per kilogram

U = Result should be considered not-detected at the quantitation limit shown

J = Result is an estimated concentration

R = Rejected - Quality Control indicates the data is not usable

UJ = The compound was not detected and the sample detection limit should be considered an estimated value

ATTACHMENT 1

WASHINGTON DEPARTMENT OF ECOLOGY ELLIOTT BAY URBAN INITIATIVES ANALYTICAL DATA ProUCL OUTPUT

1	**General UCL Statistics for Data Sets with Non-Detects**			
2	**User Selected Options**			
3	From File	WorkSheet.wst		
4	Full Precision	OFF		
5	Confidence Coefficient	95%		
6	Number of Bootstrap Operations	2000		
7	**Ellioot Bay - Ecology Urban Waters Initiative, 2007. Sediment Quality in Elliott Bay (2009)**			
8	**Urban Area Sampling Location Data (number = 13)**			
9	**Arsenic**			
10				
11	**General Statistics**			
12	Number of Valid Observations	13	Number of Distinct Observations	12
13				
14	**Raw Statistics**		**Log-transformed Statistics**	
15	Minimum	1.74	Minimum of Log Data	0.554
16	Maximum	10.8	Maximum of Log Data	2.38
17	Mean	6.924	Mean of log Data	1.814
18	Median	7.71	SD of log Data	0.559
19	SD	3.065		
20	Coefficient of Variation	0.443		
21	Skewness	-0.241		
22				
23	**Relevant UCL Statistics**			
24	**Normal Distribution Test**		**Lognormal Distribution Test**	
25	Shapiro Wilk Test Statistic	0.932	Shapiro Wilk Test Statistic	0.889
26	Shapiro Wilk Critical Value	0.866	Shapiro Wilk Critical Value	0.866
27	**Data appear Normal at 5% Significance Level**		**Data appear Lognormal at 5% Significance Level**	
28				
29	**Assuming Normal Distribution**		**Assuming Lognormal Distribution**	
30	95% Student's-t UCL	8.439	95% H-UCL	10.2
31	**95% UCLs (Adjusted for Skewness)**		95% Chebyshev (MVUE) UCL	12.01
32	95% Adjusted-CLT UCL	8.262	97.5% Chebyshev (MVUE) UCL	14.15
33	95% Modified-t UCL	8.43	99% Chebyshev (MVUE) UCL	18.34
34				
35	**Gamma Distribution Test**		**Data Distribution**	
36	k star (bias corrected)	3.341	**Data appear Normal at 5% Significance Level**	
37	Theta Star	2.072		
38	nu star	86.87		
39	Approximate Chi Square Value (.05)	66.39	**Nonparametric Statistics**	
40	Adjusted Level of Significance	0.0301	95% CLT UCL	8.322
41	Adjusted Chi Square Value	63.84	95% Jackknife UCL	8.439
42			95% Standard Bootstrap UCL	8.282
43	Anderson-Darling Test Statistic	0.457	95% Bootstrap-t UCL	8.408
44	Anderson-Darling 5% Critical Value	0.737	95% Hall's Bootstrap UCL	8.24
45	Kolmogorov-Smirnov Test Statistic	0.189	95% Percentile Bootstrap UCL	8.268

	A	B	C	D	E	F	G	H	I	J	K	L
46					Kolmogorov-Smirnov 5% Critical Value	0.238					95% BCA Bootstrap UCL	8.298
47	**Data appear Gamma Distributed at 5% Significance Level**										95% Chebyshev(Mean, Sd) UCL	10.63
48											97.5% Chebyshev(Mean, Sd) UCL	12.23
49	**Assuming Gamma Distribution**										99% Chebyshev(Mean, Sd) UCL	15.38
50					95% Approximate Gamma UCL	9.06						
51					95% Adjusted Gamma UCL	9.422						
52												
53	**Potential UCL to Use**										Use 95% Student's-t UCL	8.439
54												
55												
56	**Copper**											
57												
58	**General Statistics**											
59					Number of Valid Observations	13					Number of Distinct Observations	13
60												
61	**Raw Statistics**						**Log-transformed Statistics**					
62					Minimum	5.67					Minimum of Log Data	1.735
63					Maximum	94.6					Maximum of Log Data	4.55
64					Mean	35.15					Mean of log Data	3.223
65					Median	25.5					SD of log Data	0.912
66					SD	27.86						
67					Coefficient of Variation	0.793						
68					Skewness	0.983						
69												
70	**Relevant UCL Statistics**											
71	**Normal Distribution Test**						**Lognormal Distribution Test**					
72					Shapiro Wilk Test Statistic	0.898					Shapiro Wilk Test Statistic	0.952
73					Shapiro Wilk Critical Value	0.866					Shapiro Wilk Critical Value	0.866
74	**Data appear Normal at 5% Significance Level**						**Data appear Lognormal at 5% Significance Level**					
75												
76	**Assuming Normal Distribution**						**Assuming Lognormal Distribution**					
77					95% Student's-t UCL	48.92					95% H-UCL	77.48
78	**95% UCLs (Adjusted for Skewness)**										95% Chebyshev (MVUE) UCL	79.53
79					95% Adjusted-CLT UCL	50.11					97.5% Chebyshev (MVUE) UCL	98.16
80					95% Modified-t UCL	49.27					99% Chebyshev (MVUE) UCL	134.7
81												
82	**Gamma Distribution Test**						**Data Distribution**					
83					k star (bias corrected)	1.307	**Data appear Normal at 5% Significance Level**					
84					Theta Star	26.89						
85					nu star	33.99						
86					Approximate Chi Square Value (.05)	21.66	**Nonparametric Statistics**					
87					Adjusted Level of Significance	0.0301					95% CLT UCL	47.86
88					Adjusted Chi Square Value	20.26					95% Jackknife UCL	48.92
89											95% Standard Bootstrap UCL	47.43
90					Anderson-Darling Test Statistic	0.196					95% Bootstrap-t UCL	53.87

	A–E	F	G–K	L
91	Anderson-Darling 5% Critical Value	0.748	95% Hall's Bootstrap UCL	50.69
92	Kolmogorov-Smirnov Test Statistic	0.118	95% Percentile Bootstrap UCL	47.97
93	Kolmogorov-Smirnov 5% Critical Value	0.241	95% BCA Bootstrap UCL	49.24
94	**Data appear Gamma Distributed at 5% Significance Level**		95% Chebyshev(Mean, Sd) UCL	68.83
95			97.5% Chebyshev(Mean, Sd) UCL	83.4
96	**Assuming Gamma Distribution**		99% Chebyshev(Mean, Sd) UCL	112
97	95% Approximate Gamma UCL	55.16		
98	95% Adjusted Gamma UCL	58.96		
99				
100	**Potential UCL to Use**		Use 95% Student's-t UCL	48.92
101				
102				
103	**Mercury**			
104				
105	**General Statistics**			
106	Number of Valid Observations	13	Number of Distinct Observations	12
107				
108	**Raw Statistics**		**Log-transformed Statistics**	
109	Minimum	0.044	Minimum of Log Data	-3.124
110	Maximum	0.645	Maximum of Log Data	-0.439
111	Mean	0.281	Mean of log Data	-1.593
112	Median	0.198	SD of log Data	0.89
113	SD	0.219		
114	Coefficient of Variation	0.778		
115	Skewness	0.775		
116				
117	**Relevant UCL Statistics**			
118	**Normal Distribution Test**		**Lognormal Distribution Test**	
119	Shapiro Wilk Test Statistic	0.837	Shapiro Wilk Test Statistic	0.922
120	Shapiro Wilk Critical Value	0.866	Shapiro Wilk Critical Value	0.866
121	**Data not Normal at 5% Significance Level**		**Data appear Lognormal at 5% Significance Level**	
122				
123	**Assuming Normal Distribution**		**Assuming Lognormal Distribution**	
124	95% Student's-t UCL	0.389	95% H-UCL	0.599
125	**95% UCLs (Adjusted for Skewness)**		95% Chebyshev (MVUE) UCL	0.624
126	95% Adjusted-CLT UCL	0.395	97.5% Chebyshev (MVUE) UCL	0.769
127	95% Modified-t UCL	0.391	99% Chebyshev (MVUE) UCL	1.052
128				
129	**Gamma Distribution Test**		**Data Distribution**	
130	k star (bias corrected)	1.353	**Data appear Gamma Distributed at 5% Significance Level**	
131	Theta Star	0.208		
132	nu star	35.17		
133	Approximate Chi Square Value (.05)	22.6	**Nonparametric Statistics**	
134	Adjusted Level of Significance	0.0301	95% CLT UCL	0.381
135	Adjusted Chi Square Value	21.17	95% Jackknife UCL	0.389

	A	B	C	D	E	F	G	H	I	J	K	L
136											95% Standard Bootstrap UCL	0.376
137					Anderson-Darling Test Statistic	0.465					95% Bootstrap-t UCL	0.425
138					Anderson-Darling 5% Critical Value	0.748					95% Hall's Bootstrap UCL	0.372
139					Kolmogorov-Smirnov Test Statistic	0.174					95% Percentile Bootstrap UCL	0.382
140					Kolmogorov-Smirnov 5% Critical Value	0.24					95% BCA Bootstrap UCL	0.391
141	**Data appear Gamma Distributed at 5% Significance Level**										95% Chebyshev(Mean, Sd) UCL	0.546
142											97.5% Chebyshev(Mean, Sd) UCL	0.66
143	**Assuming Gamma Distribution**										99% Chebyshev(Mean, Sd) UCL	0.885
144					95% Approximate Gamma UCL	0.438						
145					95% Adjusted Gamma UCL	0.467						
146												
147	**Potential UCL to Use**										Use 95% Approximate Gamma UCL	0.438
148												
149												
150	**Lead**											
151												
152						**General Statistics**						
153					Number of Valid Observations	13					Number of Distinct Observations	13
154												
155	**Raw Statistics**						**Log-transformed Statistics**					
156					Minimum	6.75					Minimum of Log Data	1.91
157					Maximum	82.5					Maximum of Log Data	4.413
158					Mean	31.5					Mean of log Data	3.183
159					Median	25.8					SD of log Data	0.783
160					SD	24.21						
161					Coefficient of Variation	0.769						
162					Skewness	1.381						
163												
164						**Relevant UCL Statistics**						
165	**Normal Distribution Test**						**Lognormal Distribution Test**					
166					Shapiro Wilk Test Statistic	0.812					Shapiro Wilk Test Statistic	0.929
167					Shapiro Wilk Critical Value	0.866					Shapiro Wilk Critical Value	0.866
168	**Data not Normal at 5% Significance Level**						**Data appear Lognormal at 5% Significance Level**					
169												
170	**Assuming Normal Distribution**						**Assuming Lognormal Distribution**					
171					95% Student's-t UCL	43.46					95% H-UCL	57.65
172	**95% UCLs (Adjusted for Skewness)**										95% Chebyshev (MVUE) UCL	63.7
173					95% Adjusted-CLT UCL	45.29					97.5% Chebyshev (MVUE) UCL	77.48
174					95% Modified-t UCL	43.89					99% Chebyshev (MVUE) UCL	104.5
175												
176	**Gamma Distribution Test**						**Data Distribution**					
177					k star (bias corrected)	1.611	**Data appear Gamma Distributed at 5% Significance Level**					
178					Theta Star	19.55						
179					nu star	41.88						
180					Approximate Chi Square Value (.05)	28.04	**Nonparametric Statistics**					

	A	B	C	D	E	F	G	H	I	J	K	L
181					Adjusted Level of Significance	0.0301					95% CLT UCL	42.54
182					Adjusted Chi Square Value	26.44					95% Jackknife UCL	43.46
183											95% Standard Bootstrap UCL	42.15
184					Anderson-Darling Test Statistic	0.469					95% Bootstrap-t UCL	53.97
185					Anderson-Darling 5% Critical Value	0.743					95% Hall's Bootstrap UCL	113.4
186					Kolmogorov-Smirnov Test Statistic	0.185					95% Percentile Bootstrap UCL	42.64
187					Kolmogorov-Smirnov 5% Critical Value	0.239					95% BCA Bootstrap UCL	45.08
188	**Data appear Gamma Distributed at 5% Significance Level**										95% Chebyshev(Mean, Sd) UCL	60.77
189											97.5% Chebyshev(Mean, Sd) UCL	73.43
190	**Assuming Gamma Distribution**										99% Chebyshev(Mean, Sd) UCL	98.31
191					95% Approximate Gamma UCL	47.03						
192					95% Adjusted Gamma UCL	49.89						
193												
194	**Potential UCL to Use**										Use 95% Approximate Gamma UCL	47.03
195												
196												
197	**Zinc**											
198												
199	**General Statistics**											
200					Number of Valid Observations	13					Number of Distinct Observations	11
201												
202	**Raw Statistics**						**Log-transformed Statistics**					
203					Minimum	27					Minimum of Log Data	3.296
204					Maximum	130					Maximum of Log Data	4.868
205					Mean	70.21					Mean of log Data	4.131
206					Median	54.5					SD of log Data	0.526
207					SD	34.17						
208					Coefficient of Variation	0.487						
209					Skewness	0.36						
210												
211	**Relevant UCL Statistics**											
212	**Normal Distribution Test**						**Lognormal Distribution Test**					
213					Shapiro Wilk Test Statistic	0.922					Shapiro Wilk Test Statistic	0.929
214					Shapiro Wilk Critical Value	0.866					Shapiro Wilk Critical Value	0.866
215	**Data appear Normal at 5% Significance Level**						**Data appear Lognormal at 5% Significance Level**					
216												
217	**Assuming Normal Distribution**						**Assuming Lognormal Distribution**					
218					95% Student's-t UCL	87.1					95% H-UCL	98.92
219	**95% UCLs (Adjusted for Skewness)**										95% Chebyshev (MVUE) UCL	116.8
220					95% Adjusted-CLT UCL	86.81					97.5% Chebyshev (MVUE) UCL	136.8
221					95% Modified-t UCL	87.26					99% Chebyshev (MVUE) UCL	176
222												
223	**Gamma Distribution Test**						**Data Distribution**					
224					k star (bias corrected)	3.37	**Data appear Normal at 5% Significance Level**					
225					Theta Star	20.83						

	A–E	F	G–K	L
226	nu star	87.62		
227	Approximate Chi Square Value (.05)	67.04	**Nonparametric Statistics**	
228	Adjusted Level of Significance	0.0301	95% CLT UCL	85.8
229	Adjusted Chi Square Value	64.48	95% Jackknife UCL	87.1
230			95% Standard Bootstrap UCL	85.28
231	Anderson-Darling Test Statistic	0.401	95% Bootstrap-t UCL	89.16
232	Anderson-Darling 5% Critical Value	0.737	95% Hall's Bootstrap UCL	85.71
233	Kolmogorov-Smirnov Test Statistic	0.172	95% Percentile Bootstrap UCL	85.79
234	Kolmogorov-Smirnov 5% Critical Value	0.238	95% BCA Bootstrap UCL	85.89
235	**Data appear Gamma Distributed at 5% Significance Level**		95% Chebyshev(Mean, Sd) UCL	111.5
236			97.5% Chebyshev(Mean, Sd) UCL	129.4
237	**Assuming Gamma Distribution**		99% Chebyshev(Mean, Sd) UCL	164.5
238	95% Approximate Gamma UCL	91.76		
239	95% Adjusted Gamma UCL	95.4		
240				
241	**Potential UCL to Use**		Use 95% Student's-t UCL	87.1
242				
243				
244	**cPAHs**			
245				
246			**General Statistics**	
247	Number of Valid Observations	13	Number of Distinct Observations	13
248				
249	**Raw Statistics**		**Log-transformed Statistics**	
250	Minimum	7.351	Minimum of Log Data	1.995
251	Maximum	2127	Maximum of Log Data	7.662
252	Mean	362.8	Mean of log Data	4.98
253	Median	211.7	SD of log Data	1.605
254	SD	560.8		
255	Coefficient of Variation	1.546		
256	Skewness	2.977		
257				
258			**Relevant UCL Statistics**	
259	**Normal Distribution Test**		**Lognormal Distribution Test**	
260	Shapiro Wilk Test Statistic	0.604	Shapiro Wilk Test Statistic	0.938
261	Shapiro Wilk Critical Value	0.866	Shapiro Wilk Critical Value	0.866
262	**Data not Normal at 5% Significance Level**		**Data appear Lognormal at 5% Significance Level**	
263				
264	**Assuming Normal Distribution**		**Assuming Lognormal Distribution**	
265	95% Student's-t UCL	640	95% H-UCL	3325
266	**95% UCLs (Adjusted for Skewness)**		95% Chebyshev (MVUE) UCL	1387
267	95% Adjusted-CLT UCL	755.9	97.5% Chebyshev (MVUE) UCL	1797
268	95% Modified-t UCL	661.4	99% Chebyshev (MVUE) UCL	2603
269				
270	**Gamma Distribution Test**		**Data Distribution**	

	A–E	F	G–K	L
271	k star (bias corrected)	0.563	**Data appear Gamma Distributed at 5% Significance Level**	
272	Theta Star	643.8		
273	nu star	14.65		
274	Approximate Chi Square Value (.05)	7.019	**Nonparametric Statistics**	
275	Adjusted Level of Significance	0.0301	95% CLT UCL	618.6
276	Adjusted Chi Square Value	6.28	95% Jackknife UCL	640
277			95% Standard Bootstrap UCL	601.8
278	Anderson-Darling Test Statistic	0.306	95% Bootstrap-t UCL	1084
279	Anderson-Darling 5% Critical Value	0.777	95% Hall's Bootstrap UCL	1576
280	Kolmogorov-Smirnov Test Statistic	0.153	95% Percentile Bootstrap UCL	641.5
281	Kolmogorov-Smirnov 5% Critical Value	0.247	95% BCA Bootstrap UCL	794.7
282	**Data appear Gamma Distributed at 5% Significance Level**		95% Chebyshev(Mean, Sd) UCL	1041
283			97.5% Chebyshev(Mean, Sd) UCL	1334
284	**Assuming Gamma Distribution**		99% Chebyshev(Mean, Sd) UCL	1910
285	95% Approximate Gamma UCL	757.2		
286	95% Adjusted Gamma UCL	846.3		
287				
288	**Potential UCL to Use**		Use 95% Approximate Gamma UCL	757.2
289				
290				
291	**Benzo(a)pyrene**			
292				
293	**General Statistics**			
294	Number of Valid Observations	12	Number of Distinct Observations	12
295	Number of Missing Values	1		
296				
297	**Raw Statistics**		**Log-transformed Statistics**	
298	Minimum	4.9	Minimum of Log Data	1.589
299	Maximum	1600	Maximum of Log Data	7.378
300	Mean	285.2	Mean of log Data	4.699
301	Median	156	SD of log Data	1.693
302	SD	436.5		
303	Coefficient of Variation	1.531		
304	Skewness	2.886		
305				
306	**Relevant UCL Statistics**			
307	**Normal Distribution Test**		**Lognormal Distribution Test**	
308	Shapiro Wilk Test Statistic	0.613	Shapiro Wilk Test Statistic	0.92
309	Shapiro Wilk Critical Value	0.859	Shapiro Wilk Critical Value	0.859
310	**Data not Normal at 5% Significance Level**		**Data appear Lognormal at 5% Significance Level**	
311				
312	**Assuming Normal Distribution**		**Assuming Lognormal Distribution**	
313	95% Student's-t UCL	511.5	95% H-UCL	4140
314	**95% UCLs (Adjusted for Skewness)**		95% Chebyshev (MVUE) UCL	1222
315	95% Adjusted-CLT UCL	604.7	97.5% Chebyshev (MVUE) UCL	1592

	A–E	F	G–K	L
316	95% Modified-t UCL	529	99% Chebyshev (MVUE) UCL	2319
317				
318	**Gamma Distribution Test**		**Data Distribution**	
319	k star (bias corrected)	0.536	**Data appear Gamma Distributed at 5% Significance Level**	
320	Theta Star	531.8		
321	nu star	12.87		
322	Approximate Chi Square Value (.05)	5.808	**Nonparametric Statistics**	
323	Adjusted Level of Significance	0.029	95% CLT UCL	492.5
324	Adjusted Chi Square Value	5.101	95% Jackknife UCL	511.5
325			95% Standard Bootstrap UCL	486.8
326	Anderson-Darling Test Statistic	0.324	95% Bootstrap-t UCL	894.5
327	Anderson-Darling 5% Critical Value	0.774	95% Hall's Bootstrap UCL	1263
328	Kolmogorov-Smirnov Test Statistic	0.15	95% Percentile Bootstrap UCL	510.7
329	Kolmogorov-Smirnov 5% Critical Value	0.256	95% BCA Bootstrap UCL	652.5
330	**Data appear Gamma Distributed at 5% Significance Level**		95% Chebyshev(Mean, Sd) UCL	834.5
331			97.5% Chebyshev(Mean, Sd) UCL	1072
332	**Assuming Gamma Distribution**		99% Chebyshev(Mean, Sd) UCL	1539
333	95% Approximate Gamma UCL	632.2		
334	95% Adjusted Gamma UCL	719.8		
335				
336	**Potential UCL to Use**		Use 95% Approximate Gamma UCL	632.2
337				
338				
339	**Total PCBs**			
340				
341	**General Statistics**			
342	Number of Valid Observations	13	Number of Distinct Observations	11
343				
344	**Raw Statistics**		**Log-transformed Statistics**	
345	Minimum	9.8	Minimum of Log Data	2.282
346	Maximum	193	Maximum of Log Data	5.263
347	Mean	85.14	Mean of log Data	3.982
348	Median	70	SD of log Data	1.136
349	SD	68.57		
350	Coefficient of Variation	0.805		
351	Skewness	0.424		
352				
353	**Relevant UCL Statistics**			
354	**Normal Distribution Test**		**Lognormal Distribution Test**	
355	Shapiro Wilk Test Statistic	0.893	Shapiro Wilk Test Statistic	0.876
356	Shapiro Wilk Critical Value	0.866	Shapiro Wilk Critical Value	0.866
357	**Data appear Normal at 5% Significance Level**		**Data appear Lognormal at 5% Significance Level**	
358				
359	**Assuming Normal Distribution**		**Assuming Lognormal Distribution**	
360	95% Student's-t UCL	119	95% H-UCL	281.9

	A–E	F	G–K	L
361	**95% UCLs (Adjusted for Skewness)**		95% Chebyshev (MVUE) UCL	237.6
362	95% Adjusted-CLT UCL	118.8	97.5% Chebyshev (MVUE) UCL	299.3
363	95% Modified-t UCL	119.4	99% Chebyshev (MVUE) UCL	420.4
364				
365	**Gamma Distribution Test**		**Data Distribution**	
366	k star (bias corrected)	0.991	**Data appear Normal at 5% Significance Level**	
367	Theta Star	85.9		
368	nu star	25.77		
369	Approximate Chi Square Value (.05)	15.2	**Nonparametric Statistics**	
370	Adjusted Level of Significance	0.0301	95% CLT UCL	116.4
371	Adjusted Chi Square Value	14.06	95% Jackknife UCL	119
372			95% Standard Bootstrap UCL	114.9
373	Anderson-Darling Test Statistic	0.455	95% Bootstrap-t UCL	121.5
374	Anderson-Darling 5% Critical Value	0.754	95% Hall's Bootstrap UCL	115.5
375	Kolmogorov-Smirnov Test Statistic	0.153	95% Percentile Bootstrap UCL	114.9
376	Kolmogorov-Smirnov 5% Critical Value	0.242	95% BCA Bootstrap UCL	118.2
377	**Data appear Gamma Distributed at 5% Significance Level**		95% Chebyshev(Mean, Sd) UCL	168
378			97.5% Chebyshev(Mean, Sd) UCL	203.9
379	**Assuming Gamma Distribution**		99% Chebyshev(Mean, Sd) UCL	274.4
380	95% Approximate Gamma UCL	144.3		
381	95% Adjusted Gamma UCL	156.1		
382				
383	**Potential UCL to Use**		Use 95% Student's-t UCL	119

APPENDIX B— BASELINE ECOLOGICAL RISK ASSESSMENT

ECOLOGICAL RISK ASSESSMENT FOR LOCKHEED WEST SEATTLE SUPERFUND SITE

FINAL

Prepared for

LOCKHEED MARTIN

Prepared by

TETRA TECH

and

PASCOE environmental consulting

June 2009

EXECUTIVE SUMMARY

This document presents the baseline Ecological Risk Assessment (ERA) for the Lockheed West Seattle Superfund Site (Site). The Site is located at the West Waterway mouth of the Duwamish waterway system, with the West Waterway along the eastern boundary of the Site and Elliott Bay on the northern side. The ERA is based on the U.S. Environmental Protection Agency (EPA)-approved work plan developed for the Remedial Investigation/Feasibility Study (RI/FS) of the Site. Lockheed Martin Corporation recognizes that "no action" and natural recovery are not likely to meet Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) criteria for remedy selection, and is focused on active remediation of the entire Lockheed West Site, as described in the RI/FS work plan. Although the remedy will result in a clean surface across the entire Site below risk levels for all contaminants, the presence of site contamination requires performance of a baseline risk assessment to indicate the potential extent of risks to ecological organisms under present site conditions, and to support the remedy selection for the site sediments that will mitigate the risks. The sources of the chemicals for which risks are estimated are not identified or assumed in this risk assessment, but will be evaluated in the RI.

Consistent with the EPA approved RI/FS work plan, the approach to the ERA for the Lockheed West Site uses a combination of site-specific exposure parameters (e.g., surface sediment data collected from the site and identification of intertidal habitat at the Site), parameters from nearby sites, and EPA guidance on literature values. In particular, technical information from the ERA performed at the Lower Duwamish Waterway (LDW) CERCLA site, which is upstream from the Lockheed West Site on the West Waterway, was used extensively in the ERA. The LDW site is a 5-mile-long segment of the Duwamish waterway, with a downstream boundary about 1 mile upstream of the West Waterway portion of the Lockheed West Site. The presence of similar estuarine aquatic habitat and ecological receptors at the upstream site was the basis for applying the technical approach and specific exposure and toxicity parameters to the Lockheed West ERA.

The ERA focuses on the same ecological receptors that were identified as having the highest risks at the LDW site and that might use the Lockheed West Site. To quantify exposures, the ERA uses the same exposure parameter values that were used in the LDW ERA, regardless of any differences in size of the exposure area at Lockheed West or availability of ecological habitat under present conditions. Use of the LDW exposure scenarios and all inherent assumptions and exposure parameters is a health-protective approach to the Lockheed West ERA. This approach to the ERA is appropriate for the potential ecological receptors, potential future exposure conditions, and planned remediation at the Site. In particular, the ERA is designed to conservatively estimate risks to ecological receptors, including aquatic organisms and shoreline birds that may use the Site. The Lockheed West Site is one of many cleanup sites affecting the larger Elliott Bay/Duwamish environment, and the use of the LDW exposure assumptions ensures consistency in how the sources of contamination in this larger area are addressed.

The baseline ERA presents risk estimates for benthic invertebrate, fish, and bird species that may be exposed to chemicals of potential concern (COPCs) found in sediment and potentially in the food chain at the Site. The baseline ERA follows EPA guidance and consists of separate sections on problem formulation, exposure assessment, effects assessment, risk characterization, and uncertainty analysis, each of which is briefly summarized below.

ES.1 PROBLEM FORMULATION

The Problem Formulation step establishes the ecological scope of the assessment. The ERA focuses on receptor species that have the highest potential exposures to site-related chemicals and that serve to represent other species or groups of organisms that may also be exposed. These receptors of concern (ROCs) are selected based on the site habitat characteristics and the pathways of exposure to site-related chemicals. For the Lockheed West Site ERA, representative ROCs are the benthic invertebrate community, which is used to evaluate direct exposures of lower trophic benthic organisms to chemicals in site sediments; crabs to evaluate exposures of benthic invertebrates through bioaccumulation of sediment chemicals; and English sole and Pacific staghorn sculpin to evaluate exposures to higher trophic fish through bioaccumulation. These ROCs are evaluated for exposures to site chemicals in both subtidal and intertidal sediments. Spotted sandpiper is evaluated as a higher trophic ROC for exposures to site-related chemicals from the ingestion of benthic invertebrates present in intertidal sediment.

In addition to selecting ROCs on which to focus the assessment, the Problem Formulation evaluates the suitability of the site data for risk assessment purposes, and selects a list of COPCs through a conservative screening process that focuses the assessment on chemicals likely to pose an ecological risk. The site-related data used in the ERA consist of surface sediment chemical concentrations, collected in 2007 from 42 subtidal and 9 intertidal stations in both the West Waterway and Elliott Bay areas of the Site, and sediment porewater tributyltin (TBT) concentrations from a limited number of stations.

COPCs that were identified include 11 metals, TBT, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), several other semi-volatile organic chemicals, and organochlorine pesticides (e.g., DDT). All of the organochlorine pesticides that were detected were qualified as estimated concentrations and only tentatively identified as present in the sediment sample.

The Problem Formulation also identified the characteristics of the ROCs that are considered of importance in evaluating risks to populations, such as growth, survival, and reproduction, and identified the means to measure these effects, called the assessment and measurement endpoints, respectively. The ERA focused on endpoints that integrate an exposure to an individual and on those effects that could affect aquatic populations at the site.

ES.2 EXPOSURE ASSESSMENT

The Exposure Assessment estimates the potential exposure of each ROC to the COPCs identified in the Problem Formulation through direct contact and/or ingestion of sediment and ingestion of contaminated prey. All of the exposure pathways and parameters for quantifying exposure were taken from the ERA performed for the LDW site. The quantitation of exposures depends on the types of toxic effects data that are used to assess risks for the ROC. For the benthic invertebrate community, because effects are evaluated through sediment chemical criteria, exposures to COPCs are assessed by quantifying chemical concentrations at each of the 51 surface sediment sample locations. For crabs, and benthic invertebrates (including gastropods) exposed to tributyltin, effects are evaluated using toxicity data based on tissue concentrations, and exposures are evaluated by quantifying concentrations in their tissues. Exposure of gastropods to tributyltin was also evaluated with sediment porewater concentrations.

Two methods are used for the evaluation of exposures of fish, based on two types of effects data. Fish exposure data consist of 1) estimated concentrations in fish tissue for chemicals evaluated using toxicity data related to whole body tissue concentrations, and 2) estimated concentrations in prey that fish consume for chemicals with toxicity data related to dietary exposures. Fish dietary prey consisted of benthic invertebrates for English sole and benthic invertebrates, crab, and fish for Pacific staghorn sculpin. For spotted sandpiper, because toxicity effects data are related to the estimated intake or dose of a chemical, exposures were evaluated by quantifying intake of chemicals in intertidal sediment and in tissue of intertidal benthic invertebrates that they consume.

Concentrations of COPCs in tissues of ROCs and their prey were modeled from concentrations in site sediments. Modeling was performed in two ways: use of numerical biota-sediment accumulation factors (BSAFs), and regression equations. Both methods represent the relationship between a chemical concentration in sediment and its concentration in tissue of the ROC or its prey. BSAFs are single numerical values that were taken from multiple public databases (e.g., U.S. Army Corps of Engineers [USACE], Washington Department of Health) and scientific literature. The regression equations were taken from the ERA and from the food web model developed by the Lower Duwamish Work Group for the RI of the upstream LDW site. The food web model was calibrated with LDW site data on chemical concentrations in sediment and in tissues of fish, crabs, and clams. Based on similarities between the LDW and Lockheed West sites, and the evaluation of the same ROC species, information derived from the model was deemed appropriate and protective for use in the ERA for the Lockheed West Site.

ES.3 EFFECTS ASSESSMENT

The Effects Assessment identified the potential adverse effects to ecological ROCs related to the COPCs in site sediment. For the benthic invertebrate community, potential adverse effects for most COPCs were quantified using chemical criteria in the State of Washington Sediment Management Standards (SMS). For COPCs without SMS criteria, toxicologically based guidelines from the Dredged Material Management Program (DMMP) or toxicity information from the literature was used. The evaluation of TBT risks to benthic invertebrates used effects data related to tissue concentrations.

For crabs, fish, and sandpiper, effects data were identified for COPC concentrations in receptor tissue or as doses to the organism that were associated with the most sensitive endpoint that could affect populations of the organisms. Both no-observed-adverse-effect level (NOAEL) and lowest-observed-adverse-effect level (LOAEL) values were identified as toxicity reference values (TRVs). The TRVs were used as the toxicity criteria in the characterization of risks to crabs, fish, and sandpiper.

ES.4 RISK CHARACTERIZATION AND UNCERTAINTY ANALYSIS

The exposure and effects data were compared in the Risk Characterization to assess the potential for sediment-associated COPCs to cause adverse effects to the ROCs. The results of the risk characterization are summarized in Tables ES-1 and ES-2 for each of the ROCs, as described in the following:

- **Benthic Invertebrate Community —** The potential for adverse effects to benthic invertebrates differed between intertidal and subtidal sediments. Comparison of sediment chemical concentrations with sediment quality guidelines (SQGs), such as SMS, indicated that about 11 percent of the intertidal sediment area would show no adverse effects to benthic invertebrates (i.e., < sediment quality standards [SQS] and similar guidelines). Comparison of sediment concentrations with the higher sediment guidelines (i.e., > cleanup screening level [CSL] and similar guidelines) indicates potential adverse effects in two-thirds (67 percent) of the intertidal sediment stations, primarily due to concentrations of arsenic and copper. The remaining 22 percent of the intertidal sediment stations with concentrations between the low and high SQGs have less certain risks. Very low risks were predicted for exposure of benthic invertebrates to PAHs, PCBs, and other organic chemicals in intertidal sediments due to low concentrations.

In subtidal sediments, about 24 percent of the sediment stations would show no adverse effects to benthic invertebrates, with sediment concentrations below the SQS. Exceedances of the higher sediment guidelines showed that there is a potential for adverse effects in about one-half (48 percent) of the subtidal sediment stations, primarily due to mercury and, to a lesser extent, copper. Risks to gastropods from TBT exposure in subtidal sediment were low based on the tissue NOAEL-based hazard quotients (HQs) less than 1.0, but were higher based on TBT concentrations in sediment porewater.

- **Crabs —** Risk to crabs from exposure to TBT in site sediments were estimated to be high, with an HQ greater than 200 based on the NOAEL. The risk of actual effects is uncertain because of the lack of a LOAEL. The risks from exposure to TBT are based on modeled concentrations of TBT in crab tissue, which has high uncertainty due to the limited BSAF values for use in modeling and the lack of site-specificity in the modeling parameters. Risks from total PCBs that were modeled into crab tissue were estimated as low based on the LOAEL-HQ.
- **Fish —** Modeled exposure concentrations in fish tissue (English sole and Pacific staghorn sculpin) were found to present high risks for TBT, related to the LOAEL-based HQ of 18. Modeled exposure concentrations in fish tissue were found to present low risks for PCBs, related to the LOAEL-based HQs ranging from 1 to 6. Risks to fish due to dietary exposures were found to be high for copper that was modeled into dietary prey items for both English sole and Pacific staghorn sculpin (LOAEL-based HQs of 18 and 14, respectively).
- **Birds** — Risks to spotted sandpiper due to dietary exposure were found to be low for chromium and copper (LOAEL HQs of 1 and 3, respectively), but high for lead (LOAEL HQ of 14). Risks to spotted sandpiper from dietary exposure to TBT and organic compounds were found to be very low.

Table ES-1 lists the COPCs for benthic invertebrates that exceeded SQGs. Table ES-2 provides a summary of COPCs for crabs, fish, or sandpiper for which the HQs were greater than or equal to 1.0.

Table ES-1. Summary of Benthic Invertebrate Community COPCs with Exceedances of Sediment Quality Guidelines

COPC	Number of Detected Concentrations > High Sediment Guidelines (e.g., CSL) (No. of Stations = 51)	Number of Detected Concentrations > Low Sediment Guidelines (e.g., SQS) and ≤ High Sediment Guidelines (No. of Stations = 51)
Mercury	17	5
Copper	12	0
Arsenic	9	2
Total PCBs	7	20
Total benzofluoranthenes	2	7
Chromium	2	0
Zinc	1	12
Lead	1	1
Vanadium	0	12
Cobalt	0	11
Fluoranthene	0	10
Indeno(1,2,3-cd)pyrene	0	10
Benzo(g,h,i)perylene	0	9
Total HPAH	0	9
Chrysene	0	8
Selenium	0	8
Dibenzo(a,h)anthracene	0	6
Phenanthrene	0	6
Benzo(a)pyrene	0	4
Bis(2-ethylhexyl) phthalate	0	3
Acenaphthene	0	3
Benzo(a)anthracene	0	3
Pentachlorophenol	0	3
Nickel	0	2
Antimony	0	1

COPCs are ranked by number of sediment stations with concentrations > High Sediment Guidelines (e.g., CSL), then by number of stations with concentrations between High and Low Sediment Guidelines.
COPC – chemical of potential concern
CSL – cleanup screening level
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
SQS – sediment quality standards

Table ES-2. Summary of Hazard Quotients for Fish, Crabs, and Birds

COPC	ROC	NOAEL HQ	LOAEL HQ
COPCs with LOAEL HQs ≥ 1.0			
Chromium	spotted sandpiper	**6**	**1**
Copper	English sole	**36**	**18**
	Pacific staghorn sculpin	**28**	**14**
	spotted sandpiper	**4**	**3**
Lead	spotted sandpiper	**48**	**14**
TBT	English sole	**158**	**18**
PCBs	English sole	**6 to 31**	**1 to 6**
COPCs with NOAEL HQs ≥ 1.0 and LOAEL HQs < 1.0			
Total PCBs	crab	**9**	0.9
TBT	crab	**202**	not available
	spotted sandpiper	**1**	0.6
Organochlorine pesticides[1/]			

[1/] Organochlorine pesticide HQs are considered highly uncertain because of analytical interferences from PCBs in the pesticide analyses, resulting in a high bias in concentrations. The LOAEL-based HQs for total DDT were 7 for crab and 1 for English sole. The NOAEL-based HQs were ≥ 1 for the following COPC/ROC pairs: total DDT and crab (10); methoxychlor and crab (3); total DDT and English sole (1); methoxychlor and English sole (2).
COPC – chemical of potential concern
HQ – hazard quotient
LOAEL – low-observed-adverse-effect level
NOAEL – no-observed-adverse-effect level
PCB – polychlorinated biphenyl
ROC – receptor of concern
TBT – tributyltin
Bold identifies HQs greater than or equal to 1.

ES.5 RISK CONCLUSIONS FOR ECOLOGICAL RECEPTORS

Risks were estimated for the benthic invertebrate community, crabs, fish, and sandpipers that may be exposed to chemicals in prey or subtidal and intertidal sediments at the Lockheed West Site. Risk estimates were found to exceed regulatory criteria or thresholds for a number of chemicals.

For the benthic invertebrate community, sediment concentrations exceeded CSL or similar effects-based sediment guidelines in 67 percent of intertidal sediments and 48 percent of subtidal sediments, primarily due to arsenic, copper, and mercury.

For crab, TBT presented the highest potential for risk, with a NOAEL-based HQ of 202, although the risk related to an effects-based HQ could not be estimated. PCBs present low to insignificant risks for crab. There is uncertainty in the risk estimate because exposures were less than adverse effect levels, but above “no adverse effect” levels.

For fish, the highest risks were found for copper and TBT to English sole, with LOAEL-based HQs of 18 for both COPCs. Copper was also estimated to be a risk to sculpin. PCBs present low risks to fish. There is uncertainty in the risk estimate for fish exposures to PCBs because of uncertainties with both the TRV and the modeling of exposures.

For sandpiper, the highest risks were found for intertidal lead, with a LOAEL-based HQ of 14, with lesser but potential risks from copper and chromium. PCBs were not found to present a risk to sandpiper.

In summary, ecological risks were estimated to be above regulatory thresholds for the benthic invertebrate community, crab, fish, and sandpiper. The chemicals that are identified as drivers of the risk estimates are arsenic, copper, mercury, TBT, and PCBs. Uncertainties in the risk estimates are primarily related to the use of modeling to estimate exposures of crab, fish, and sandpiper prey to chemicals present in the sediment. Although the Lockheed West Site is smaller than the upstream LDW site, with smaller intertidal areas for sandpiper exposures and smaller areas for fish and crab to contact site sediments and take up site-related chemicals, the risks calculated for these ROCs are similar to or higher than the risks estimated for the LDW site. The use of the LDW exposure information provides consistency between the two sites in the identification of ecological risk drivers and future cleanup decisions. Comparison with the LDW ERA highlights the protective nature of the approach to the ERA for Lockheed West. This approach resulted in the determination of ecological risks that support active remediation for the Lockheed West Site.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACRONYMS AND ABBREVIATIONS

AET	Apparent Effects Threshold
BSAF	biota-sediment accumulation factor
BW	body weight
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cm	centimeter
COC	chemical of concern
COI	chemical of interest
COPC	chemical of potential concern
CSL	cleanup screening level
CSM	Conceptual Site Model
DFC	daily food consumption
DMMP	Dredged Material Management Program
DSC	daily sediment consumption
dw	dry weight
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
ERA	Ecological Risk Assessment
ERED	USACE Environmental Residue Effects Database
FIR	food ingestion rate
FWM	food web model
g/day	grams per day
GC/ECD	gas chromatography/electron capture detection
GC/MS	gas chromatography/mass spectrometry
HPAH	high-molecular weight polycyclic aromatic hydrocarbon
HQ	hazard quotient
km	kilometer
LAET	lowest apparent effects threshold

2LAET	second lowest apparent effects threshold
LC50	Concentration that is lethal to 50 percent of a population
LDW	Lower Duwamish Waterway
LOAEL	lowest observed adverse effect level
LOEC	lowest observed effect concentration
LPAH	low-molecular weight polycyclic aromatic hydrocarbon
µg/kg	micrograms per kilogram
µg/L	micrograms per liter
mg/kg	milligrams per kilogram
mg/kg-day	milligrams per kilograms per day
mg/kg-OC	milligrams per kilograms organic carbon normalized
mg/L	milligrams per liter
ML	maximum level
NMFS	National Marine Fisheries Service
NOAA	National Oceanic Atmospheric Association
NOAEL	no-observed-adverse-effect level
NOEC	no-observed-effect concentration
NPL	National Priorities List
OC	organic carbon
PAH	polycyclic aromatic hydrocarbons
PCB	polychlorinated biphenyls
PSDDA	Puget Sound Dredge Disposal Analysis
ODEQ	Oregon Department of Environmental Quality
QAPP	Quality Assurance Project Plan
RBC	risk-based concentration
RBTC	risk-based threshold concentration
RI/FS	Remedial Investigation/Feasibility Study
RL	reporting limit
ROC	receptor of concern
Site	Lockheed West Seattle Superfund Site

SMS	Washington State Sediment Management Standards
SQG	sediment quality guideline
SQS	sediment quality standard
SVOC	semivolatile organic compound
TBT	tributyltin
TRV	toxicity reference value
UCL	upper confidence limit on a mean value
USACE	U.S. Army Corps of Engineers
WAC	Washington Administrative Code
WDOH	Washington State Department of Health

1. INTRODUCTION

This document presents the baseline ecological risk assessment (ERA) as part of the remedial investigation and feasibility study (RI/FS) for the Lockheed West Site. The Lockheed West Site was added to the US Environmental Protection Agency (EPA) National Priorities List (NPL) under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), also known as Superfund, as the "Lockheed West Seattle Superfund Site" (herein referred to as the Lockheed West Site). The Site was formerly known as Lockheed Shipyard No. 2, and is located in West Seattle, WA (Figure 1-1).

The baseline ERA for the Lockheed West Site is performed as per Section II, Subtask 1.8 of the Statement of Work, Appendix A to the Administrative Settlement Agreement and Order on Consent for the Lockheed West Site. This introductory text describes the purpose and scope of the ERA and an overview of the technical approach to performing the ERA that is consistent with EPA guidance for performing risk assessments under CERCLA.

1.1 PURPOSE OF THE ECOLOGICAL RISK ASSESSMENT

Consistent with the EPA (1991) Office of Solid Waste and Emergency Response Directive 9355.0-30, the purposes of the baseline ERA for the Lockheed West Site are 1) to identify potential ecological risks at the Site, 2) to identify chemicals of concern (COCs) for ecological receptors, 3) to support remedy selection, and 4) to provide information for selecting risk-based cleanup levels and remediation monitoring criteria. Lockheed Martin Corporation recognizes that "no action" and natural recovery are not likely to meet CERCLA criteria for remedy selection, and is focused on active remediation of the entire Lockheed West Site. Although the remedy will result in a clean surface across the entire Site below risk levels for all contaminants, the presence of Site contamination requires performance of a baseline risk assessment to indicate the potential extent of risk under present site conditions, and to support the remedy selection for the sediments that will mitigate the risk.

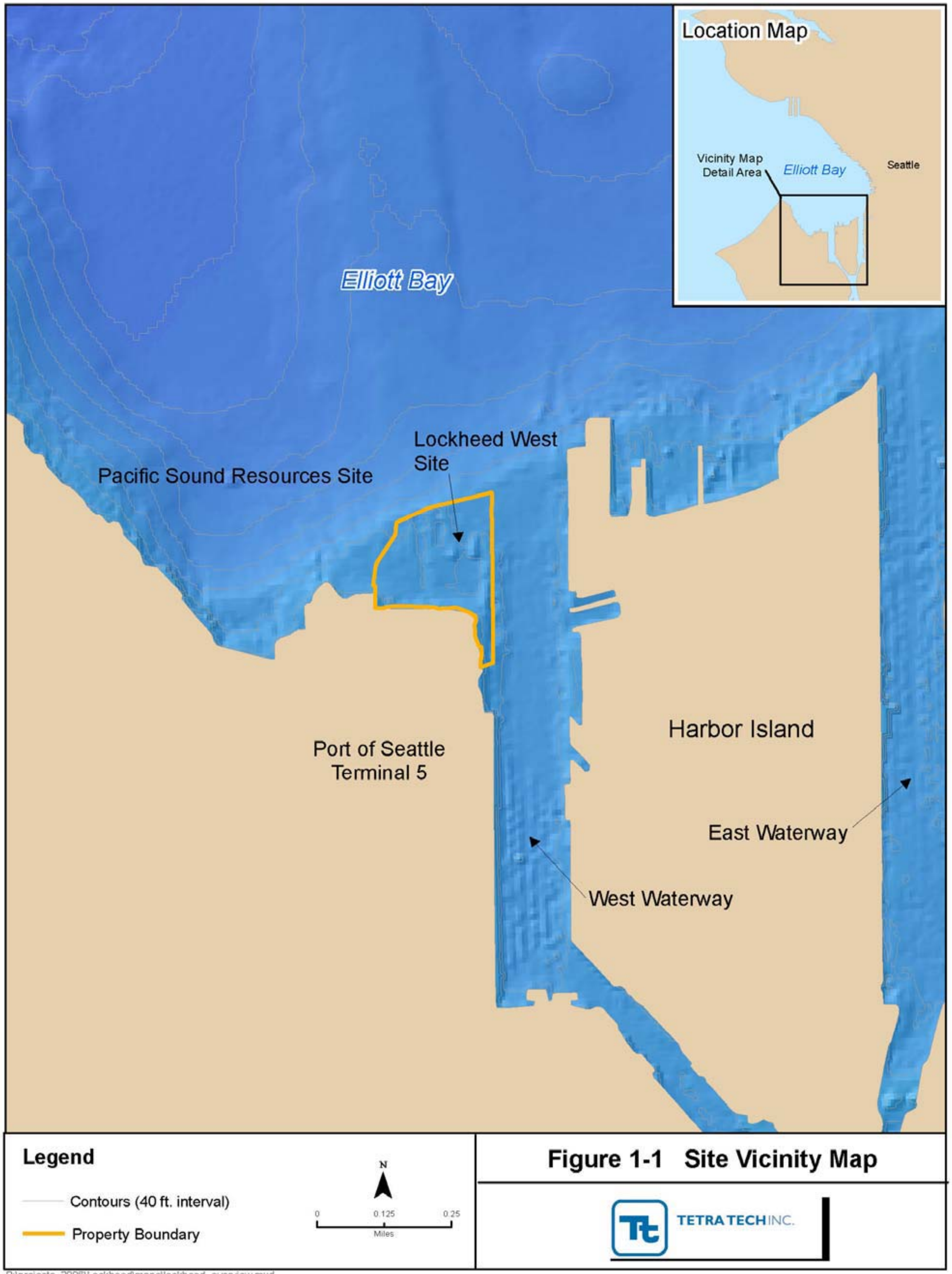


Figure 1-1 Site Vicinity Map

P:\projects_2006\Lockheed\maps\lockheed_overview.mxd

The plan to actively remediate the entire site minimizes the need to calculate site-specific risks at a level of specificity to demonstrate acceptability of the no-action alternative or natural recovery of sediments. As described in more detail below, the overall approach to this ERA is streamlined and is considered to be appropriate for the potential ecological receptors, potential future exposure conditions, and planned remediation at the Site. In particular, the ERA is designed to conservatively estimate risks to ecological receptors, including aquatic organisms and shoreline birds that may use the Site.

1.2 SCOPE OF THE STREAMLINED ECOLOGICAL RISK ASSESSMENT

The scope of the ERA consists of a baseline risk assessment, following EPA guidance for Superfund sites. An EPA-approved work plan was developed for the Lockheed West Site RI/FS and risk assessments (Tetra Tech 2008a), which forms the basis of this ERA. The ERA is based on site-specific surface sediment chemistry data and identification of subtidal and intertidal habitats at the Site. In development of the work plan, a preliminary comparison of sediment chemical concentrations with Washington Department of Ecology Sediment Management Standards (SMS) indicated that ecological risks would exceed EPA CERCLA regulatory threshold levels. Because of the benthic risks, and also because of the commitment of LMC to actively remediate the entire site and the potential for unacceptable human health risks, the approach to satisfy the risk assessment goals for the Lockheed West Site was to streamline the ERA design and to use technical information on exposure assessment from the ERA performed at the nearby Lower Duwamish Waterway (LDW) site, located upstream of the Lockheed West Site (Figure 1-2). Thus the approach to the ERA was designed to use exposure parameters taken from the LDW site together with sediment chemistry data collected from the Lockheed West Site.

The use of LDW ERA technical information for the Lockheed West ERA is based on the assumptions that the types of aquatic habitat and receptors at the Lockheed West Site are similar, or could be similar under future conditions, to those present or assumed for the LDW site. Uncertainties in this assumption are discussed in the Risk Characterization of Section 7 for fish, crab, and wildlife. The assumption that ecological resources are similar to those evaluated in the LDW ERA is based on the proximity of the Lockheed West Site downstream of the LDW site within the same water body (see Figure 1-2), and the presence of similar subtidal and intertidal habitat. The assumption is also supported by the results of several surveys of tissue contaminant data at the West Waterway site (EVS 1999, ESG 1999), which is located adjacent to the Lockheed West Site, and the Pacific Sound Resources CERCLA site (Weston 1998b), located on Elliott Bay adjacent to the western boundary of the Lockheed West Site.

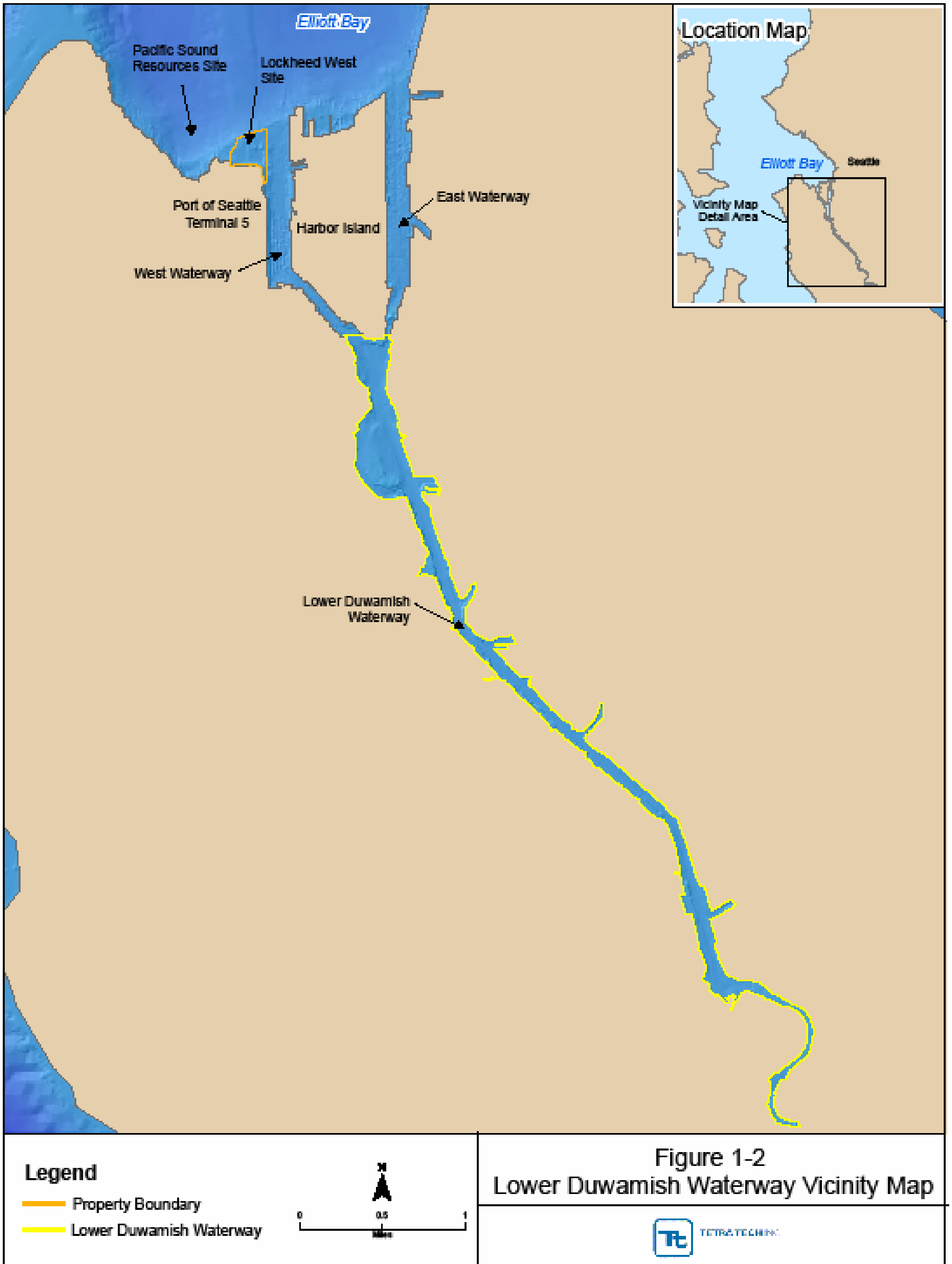


Figure 1-2
Lower Duwamish Waterway Vicinity Map

P:\projects_2008\Lockheed\maps\LDW_overview_1-2.mxd

The aquatic species that were documented as present in the West Waterway and lower Duwamish River were evaluated in the identification of ecological receptors for both the West Waterway ERA (Weston 1994) and the LDW ERA (Windward 2007), and are used in this ERA for the Lockheed West Site. The receptors selected for evaluation are those presenting unacceptable risk levels in the LDW ERA. Those receptors were identified in the work plan and are identified in the following section for each of habitats and general feeding guilds at the Site. The evaluation procedures and screening criteria for selecting chemicals of potential concern for each of the receptor types were identified in the work plan, and are also described in the following section. An earlier ERA performed for the Pacific Sound Resources CERCLA site (Weston 1998b), located on Elliott Bay adjacent to the western boundary of the Lockheed West Site, identified marine fish and benthic organisms typical of Puget Sound as aquatic receptors for evaluating risks at that site. As summarized in Windward (2007), available studies of aquatic organisms in the lower Duwamish waterways and nearby Elliott Bay identified typical Puget Sound benthic invertebrates and various clam species, shiner surfperch, snake prickleback, Pacific sandlance, Pacific staghorn sculpin, longfin smelt, English sole, and starry flounder as particularly abundant, as were juvenile Chinook, chum, and coho salmon.

Specific methods for estimating exposures of the ecological receptors were identified in the work plan. As described in the exposure assessment section of this ERA, because tissue data are not available for the Lockheed West Site, tissue concentrations of sediment chemicals are modeled. The procedures and parameter values used in the modeling are described herein for each receptor tissue type in the Exposure Assessment. No assumptions were made regarding the influence of size of the subtidal or intertidal sediment areas of the Lockheed West Site in quantifying the uptake of sediment chemicals into tissues of fish or wildlife. In other words, area use factors were not considered in assessing organism exposures to the site. Instead, all modeling of chemical uptake and exposures of fish and wildlife followed assumptions about site use and exposure estimates that were used in the LDW ERA. Uncertainties with these assumptions are explored in Section 7 of the Risk Characterization for the ecological receptors evaluated in the ERA.

As described more fully below, although the LDW site has more of a freshwater component than the Lockheed West Site, due to the inflow from the Duwamish River, the aquatic areas of both sites are considered estuarine. Ecological risks for the LDW site were evaluated using marine/estuarine species typical of Puget Sound bays. Thus, although the Lockheed West Site environment may be more saline than the LDW site due to the presence of Elliott Bay on the north side, the same marine/estuarine species that the LDW ERA evaluated are expected to be present at the Lockheed West Site as ecological receptors and as food sources for those receptors.

In summary, the ERA evaluates potential ecological risks by structuring the assessment to use technical information from the ERA performed at the LDW site, including exposure parameter values, regardless of any differences in size of the exposure area at Lockheed West or availability of ecological habitat under present conditions. The sources of the chemicals for which risks are estimated are not identified or assumed in this risk assessment, but will be evaluated in the RI. Use of the LDW exposure scenarios and all inherent assumptions and exposure parameters is a protective approach. Because the methodology for assessment of ecological risks is the same methodology used in the LDW ERA, subsequent cleanup decisions will be consistent with the larger LDW site. The Lockheed West Site is one of many cleanup sites affecting the larger Elliott Bay/Duwamish environment, and the use of the LDW exposure assumptions ensures consistency in how the sources of contamination in this larger area are addressed.

The Lockheed West ERA is consistent with EPA guidance for performing ERAs at Superfund sites (EPA 1992; 1997a,b; 1998). The framework of the ERA starts with the Problem Formulation step, where the ecological receptors, their habitats at the Site, and the sources and pathways of chemical exposures are developed. The Exposure and Effects Assessment step consists of an estimation of the exposures of ecological receptors to Site-related chemicals, and an evaluation of the potential adverse effects to ecological receptors from chemical exposures. The Risk Characterization step presents the risk results for the Site, discusses the level of certainty in their estimates, and identifies uncertainties in source information.

2. PROBLEM FORMULATION

The Problem Formulation establishes the problem to be evaluated and the ecological scope of the assessment, including identifying ecological receptors, chemicals of potential concern (COPCs), assessment endpoints, and exposure pathways. The area of investigation includes both the property occupied by the former shipyard and the areas of Elliott Bay and the West Waterway immediately adjacent to the former shipyard property. The Site is bounded by Elliott Bay on the north, Harbor Island West Waterway on the east, and Pacific Sound Resources (PSR) Superfund Site on the west (Figure 1-1). The aquatic property previously owned by LMC includes approximately 2,050 feet of shoreline and is approximately 27 acres in size. It includes approximately 7 acres of aquatic land now owned by the Port of Seattle (Port) (formerly owned by LMC) and approximately 20 acres owned by Washington Department of Natural Resources (DNR) and historically leased to LMC. A sheet pile bulkhead is in place across the apron of the former shipway in the western portion of the Site. The shoreline in the eastern portion consists of areas of open slope, riprap-reinforcement, and wooden or steel retaining walls in generally poor condition.

LMC discontinued operations at Lockheed Shipyard Number 2 in 1987 after approximately 45 years of continuous operations by Lockheed and others that included shipbuilding, ship repair, and ship maintenance. Past industrial practices at or adjacent to the facility have resulted in contamination of aquatic sediments. The contaminants found in the aquatic area include hazardous substances associated with shipbuilding, repair, and maintenance activities, consistent with the historical uses of the facility. Other contaminants not directly associated with shipyard activities may be present at the Site. Contaminants include, but are not limited to, polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), mercury, other metals, and other organic compounds.

The sediments at the Site provide habitat to numerous fish and other aquatic species, and are within a migratory corridor for endangered, threatened, and other anadromous fish. The habitat present at the Site is identified from existing information and survey information collected during RI activities. The ERA problem is that the presence of contaminants in sediments, related partly to past shipyard activities and other sources, has lead to concerns over potential risks to aquatic receptors. The goal of the ERA is to evaluate and where possible quantify risks to aquatic receptors and populations at the Site that may be due to exposures to chemical contamination in sediment.

2.1 AQUATIC HABITAT

Site-specific information collection related to this ERA consists primarily of the surface sediment chemistry data collection and a survey to document the presence of intertidal habitat at the Site. Information on the habitat at the Site is summarized from documents related to nearby sites on the Duwamish River, West Waterway, and Harbor Island.

The aquatic environment at the Lockheed West Site consists of estuarine waters and sediments. As mentioned above, the shoreline of the former shipyard is characterized by armoring or bulkheads, typical of the industrial shoreline in much of the Duwamish waterway. Benthic habitats include intertidal habitat (exposed by low tides) and subtidal habitat (never exposed by low tides). Intertidal habitat at the Site consists of about 2 acres located on West Waterway, with subtidal habitat making up 25 acres. Taylor et al. (1999) mentions the presence of a wide range of habitat types in the area, including a sandy pocket beach, cobble beach, boulders, rip rap, and pilings. Much of the subtidal habitat has been dredged at various times in the past, in both the north (Elliott Bay) and east (West Waterway) areas of the Site (Tetra Tech 2008a). The east subtidal habitat includes part of the deeper navigation channel of the West Waterway.

Although the sediments on the east portion of the Site lie in the West Waterway segment of the Duwamish River discharge, the sediments and bottom water column layer of the West Waterway area are estuarine in nature. The Duwamish Waterway is characterized by a salt-water wedge that originates in Elliott Bay and moves up and down the Waterway. The toe of the salt-water wedge is always located upstream of the Lockheed West Site in the LDW, even during ebb tides and high-flow conditions in the Duwamish River (Stoner et al. 1975).

Although freshwater overlies the saltwater wedge in the lower Duwamish, including the waterways around Harbor Island, there is little to no downward movement of water from the upper layer into the saltwater wedge (Santos and Stoner 1972). Also, at any given time and location along the Duwamish waterways, the salinity at a given depth is nearly the same from one side of the channel to the other (Santos and Stoner 1972). Based on this information, primary habitats for the aquatic lands at the Lockheed West Site can be identified as the intertidal marine sediments along the Site shoreline and the subtidal marine environment adjacent to the Site, both in the Elliott Bay and the West Waterway sides of the Site.

2.2 SELECTION OF RECEPTORS OF CONCERN

The selection of ecological receptors of concern (ROCs) for the ERA is summarized below. Because of the similarity of the aquatic habitat at the Site with the habitat of the lower Duwamish River, with both areas consisting of a mix of estuarine water column and bottom sediment and freshwater overlay (on the West Waterway portion of the Lockheed West Site), the ecological receptors are considered to be similar to those of the LDW site. Only those ROCs in the LDW ERA that pose the potential for highest exposure to sediment contaminants are selected as ROCs for the Lockheed West Site ERA.

Following EPA guidance, the following criteria were used to select ROCs:

- Potential for direct or indirect exposure to sediment-associated chemicals
- Human and ecological significance
- Available habitat and site usage
- Sensitivity to COPCs at the site
- Susceptibility to biomagnification of COPCs (i.e., higher-trophic-level species)
- Data availability

The key direct and indirect exposure routes from sediment were identified (e.g., direct exposure to sediment or indirect exposure through ingestion of prey associated with sediment). Groups of organisms that may be exposed via these pathways were then identified, and representative species that were thought to be most exposed were selected from these groups representing the greatest potential for exposure.

2.2.1 Benthic Invertebrates

Benthic invertebrate communities – Benthic invertebrate communities serve as a major food resource for commercially and recreationally important fish and wildlife, and they are active in detrital processing and nutrient cycling. The benthic invertebrate community as a whole is evaluated as an ROC. A wide variety of benthic invertebrates are expected to inhabit the sediments at Lockheed West, similar to population assemblages of Elliott Bay and adjacent West Waterway and LDW. Table 2-1 lists the macroinvertebrate species found in the LDW during sampling efforts for clams (Windward 2004a) and fish and crabs (Windward 2004b), as summarized in the ERA for the LDW site (Windward 2007).

Table 2-1. Macroinvertebrate Species Found in the Lower Duwamish Waterway

Common Name	Scientific Name
Anemone, plumose	*Metridium senile*
Anemone	Unknown
Ascidian	Unknown
Clam, Baltic macoma	*Macoma baltica*
Clam, bent-nosed	*Macoma nasuta*
Clam, eastern soft-shell	*Mya arenaria*
Clam, stained macoma	*Macoma inquinata*
Clam, white sand macoma	*Macoma secta*
Crab, black-clawed	*Lophopanopeus bellus*
Crab, decorator	*Loxorhynchus crispatus*
Crab, Dungeness	*Cancer magister*
Crab, hermit	*Pagurus* sp.
Crab, kelp	*Pugettia producta*
Crab, red rock	*Cancer productus*
Crab, slender	*Cancer gracilis*
Frilled dogwinkle	*Nucella lamellosa*
Mussel, blue	*Mytilus edulis*
Moon snail	*Polinices lewisii*
Nudibranch, striped	*Armina californica*
Sea star, mottled	*Evasterias troschelii*
Sea star, sunflower	*Pycnopodia helianthoides*
Sea star, sand	*Luidia*
Sea star	*Pisaster* sp.
Sea star, sun	*Solaster stimpsoni*
Sea pen	Unknown
Shrimp, coonstripe	*Pandalus danae*
Shrimp, crangon	*Crangon* sp.
Tunicate	Unknown
Urchin	Unknown

Source: Windward (2004a,b)

Most of the marine benthic invertebrate species are in direct contact with sediment year-round and have a limited home range. Benthic invertebrates are exposed to sediment through several different pathways, such as filter feeding and detritus feeding. Benthic invertebrates include sediment dwellers (benthic infauna, which includes clams) and organisms closely associated with the sediment surface (epibenthos).

In summary, the benthic invertebrate community is selected as a ROC for the Lockheed West ERA. The community consists of infauna and epibenthic organisms in intertidal and subtidal habitats.

Crabs **–** Crabs are selected as an ROC to represent higher-trophic-level benthic invertebrate species present at the Site. Evaluations of benthic invertebrates that use either State of Washington Sediment Management Standards (SMS) or toxicity-based criteria for sediments do not account for exposures or risks to higher trophic benthic organisms. Crabs were selected as an ROC to fill the role of higher trophic benthic invertebrate receptor.

2.2.2 Fish

A diversity of fish species is found in the lower Duwamish River and Elliott Bay, and available studies documenting fish communities have been summarized in the West Waterway Operable Unit risk assessments (ESG 1999, Weston 1994) and the LDW ERA (Windward 2007). Windward (2007) compiled a comprehensive list of fish species that have been observed in the LDW, and which is attached to this report as Appendix A. Shiner surfperch, snake prickleback, Pacific sandlance, Pacific staghorn sculpin, longfin smelt, English sole, and starry flounder were particularly abundant, as were juvenile Chinook, chum, and coho salmon.

English sole and Pacific staghorn sculpin are selected as the fish ROCs for this ERA. English sole is selected to represent benthivorous fish species, and Pacific staghorn sculpin is selected to represent upper trophic level fish. English sole and sculpin are selected largely because of their potential for exposure to sediment chemicals, based on their prey preferences and feeding behavior, and because of high abundances noted in West Waterway and Elliott Bay (ESG 1999, Weston 1994). Juvenile Chinook salmon were not selected as a ROC for the ERA because they would not be expected to be present at the Site for as long a duration non-migratory species such as the sculpin. Their exposures to sediment chemicals would be expected to be significantly less than those of sole or sculpin based on feeding behavior. Expected lower exposures for juvenile Chinook salmon was demonstrated in the LDW ERA, where dietary exposure estimates for juvenile salmon were less than those of English sole or sculpin, and were below risk thresholds. The highest risk estimates were for exposures to polycyclic aromatic hydrocarbons (PAHs) through dietary sources. The maximum total PAH concentration in sediment in the LDW at 133 milligrams per kilogram (mg/kg) dry weight is substantially higher than the maximum total PAH concentration in the Lockheed West Site sediment, at 73 mg/kg dry weight, which suggests lesser exposure of juvenile salmon to PAHs in sediment at the Lockheed West Site.

The evaluation of risks to fish is partly based on modeling tissue concentrations of sediment chemicals. As described in the exposure assessment section for fish (Section 4.1), the modeling is performed for tissue of a higher trophic level fish that is assumed to have the highest potential exposure to site sediments. This higher trophic level fish is considered to be representative of English sole and Pacific staghorn sculpin that are selected as fish ROCs. This modeling approach is more conservative than modeling specific species that may have less exposure. The amount of time that juvenile Chinook salmon would be expected to spend foraging at the Lockheed West Site is not known but is assumed to be low in comparison with the amount of time spent in the much larger upstream LDW, and their diet would consist partially of pelagic prey items with much less exposure to sediment chemicals than benthic invertebrate prey of English sole or the prey of sculpin. For these reasons, the exposures of juvenile Chinook salmon to Lockheed West sediment will be much lower than those of English sole and sculpin, and the risk estimates of English sole and Pacific staghorn sculpin will be protective of lesser exposed species, such as the juvenile salmon, which was not selected as an ROC.

Based on the above analyses, and in keeping with the streamlined approach to the ERA to focus on risk driver receptors and exposures, English sole and Pacific staghorn sculpin are the two fish species selected as ROCs for the Lockheed West risk assessment. Appendix A presents information on their habitat and dietary feeding preferences.

Fish ROCs for the Lockheed West Site ERA are grouped into two broad categories based on potential sediment exposure at the Site:

- Benthivorous fish— represented by English sole *(Parophrys vetulus)*, and including rock sole and starry flounder. This category is also considered to be protective of fish that prey on pelagic and encrusting organisms, such as Pacific herring and pile perch.
- Upper-trophic-level fish —represented by Pacific staghorn sculpin *(Leptocottus armatus)*, and including bull trout and sand sole. Pacific staghorn sculpin is used to represent piscivorous and omnivorous species that prey on other fish.

2.2.3 Wildlife

Potential wildlife uses of the Duwamish River estuary and Elliott Bay include a variety of bird species and waterfowl, and marine mammals. Wildlife species that may be exposed to the Site on an intermittent basis include herons, osprey, river otter, and harbor seals, and to a lesser extent, sea lions and orcas. The extent of Site use for foraging and resultant chronic exposures to sediment chemicals depends on the size of their foraging areas in relation to the available size of habitat at the Site (approximately 25 acres of subtidal aquatic lands and 2 acres of intertidal sediment). Marine mammals, such as seal and river otter, and large carnivorous birds such as osprey and great blue heron forage over much larger areas than the habitat available at the Lockheed West Site. For example, foraging areas for seal range from 5 to 55 kilometers (km) (EPA 1993), based on studies in California and Washington along the Columbia River. In Puget Sound, harbor seals generally forage within 8 to 13 km (5 to 8 miles) of their haulout areas established as pupping sites (Jeffries 2001, as reported in Windward 2007). For river otter, the LDW ERA assumed that the foraging area was 10 km (6 miles) for individuals, based on studies at the Hudson River Superfund site in New York State. EPA (1993) identifies river otter home ranges from 15 to 78 km. For osprey, EPA (1993) identifies foraging ranges from 1.7 to 10 km. Great blue herons typically forage in shallow waters, and foraging grounds are generally close to breeding colonies, with 15 to 20 km the farthest great blue herons might regularly travel from the colony to a foraging area (EPA 1993). The LDW ERA assumed that herons would forage over an area of about 10 miles based on studies of colonies in West Seattle, the Black River (City of Renton), and north Seattle. These foraging areas are substantially larger than the size of the aquatic habitat at the Lockheed West Site. ERAs for the nearby West Waterway and PSR sites did not evaluate potential risks to avian or mammalian species.

Avian exposures that may be more specific to the Lockheed West Site are best represented by waterfowl and shoreline birds that forage primarily in intertidal sediments. Waterfowl may feed on benthic invertebrates and may incidentally ingest sediment while foraging, but this exposure is assumed to be less than that of benthivorous birds such as shorebirds, which may ingest significant amounts of sediment while probing intertidal sediment for benthic invertebrates.

Spotted sandpipers (*Actitis macularia*) are a common shorebird in Puget Sound, and nests have been observed along the lower Duwamish River (Windward 2004c). Spotted sandpiper is selected as the avian ROC for the Lockheed West ERA. They feed primarily on insects, small crustaceans and mollusks, worms, and other invertebrates. Sandpipers have a higher incidental rate of sediment ingestion (some sandpiper species can have up to 30 percent in the diet) than other shoreline bird species, including ducks and geese (EPA 1993). Because of the high potential exposure through direct ingestion of sediment, protection of the spotted sandpiper will also be protective of other benthivorous birds such as scaup and scoters (i.e., diving ducks), as well as geese and dabbling ducks. Based on available information presented in EPA (1993) for birds that ingest aquatic invertebrates, spotted sandpipers have a higher food ingestion rate (FIR) than lesser scaups and mallards, contributing to higher exposure of spotted sandpipers. In addition, spotted sandpipers have higher exposure to sediment contaminants through consumption of invertebrates than herbivorous birds such as American coot, American widgeon, mallard, and geese because uptake of sediment chemicals is higher in invertebrates than in plants.

Spotted sandpipers are evaluated for exposures to all available intertidal sediment, without accounting for the presence of specific habitat under current conditions of the Site. Sixty-five percent of the LDW shoreline was found to contain sandpiper habitat, suggesting a high likelihood that any intertidal habitat at the Lockheed West Site would be sufficient for sandpiper foraging. ROCs do not include other birds such as bald eagle, osprey, or great blue heron; or mammals such as river otter and harbor seal; because of the combined limited exposure areas at the Lockheed West Site and relatively low risks calculated for these receptors at the LDW site when compared with shorebirds.

In support of this interpretation, risks presented for these other wildlife species were much smaller than the ROCs proposed herein at the LDW site (Windward 2007). Risk estimates for shorebirds are expected to be the driver ecological risks for intertidal sediment at the Lockheed West Site, similar to findings at the LDW site.

2.2.4 Summary of ROCs

Species selected as ROCs for the Lockheed West ERA are identified as the following:

- Benthic invertebrate community
- Crabs
- Fish – English sole, Pacific staghorn sculpin
- Birds – Spotted sandpiper

Other species that were evaluated but not selected as ROCs include rockfish; bull trout because sculpin are evaluated as representative of the feeding guild; aquatic plants, which were evaluated in the Phase 1 ERA for the LDW site and found to be well below any risk concern (Windward 2003); and reptiles and amphibians, which are not likely to be exposed to sediment contamination because habitat for these species is limited, and their presence has not been reported in any wildlife surveys conducted in the lower Duwamish area (Windward 2007). The ROCs selected above are the ROCs that had the highest risk estimates in the LDW site ERA. The ERAs for the adjacent West Waterway and PSR sites focused on the benthic invertebrate community as ROCs, including studies of sediment toxicity and bioaccumulation, and the PSR ERA included bottom fish (English sole) as a ROC that was evaluated through tissue modeling (EVS 1999, Weston 1998a, EPA 2003a).

2.3 ASSESSMENT ENDPOINTS

As defined in EPA (1992), assessment endpoints for ERA are explicit expressions of the actual environmental values that are to be protected, such as ecological resources. Ecological values include those roles and processes vital to ecosystem function, those providing critical resources such as habitat and fisheries, and the perception of value by humans (e.g., Threatened and Endangered [T&E] species). An assessment endpoint must define both the valued entity and the characteristic of the entity to be protected. They provide direction for the baseline ERA and are the basis for the risk analyses. Unless an ecological receptor is listed as a T&E species, assessment endpoints and associated measurement endpoints are selected that are relevant to population-level rather than individual effects.

Selection of assessment endpoints was based on available information regarding the ecological relevance of the endpoint and on societal values. In addition, assessment endpoints were evaluated to ensure their protection would likely result in protection of other valued entities within the system. Finally, endpoints selected must be amenable to measurement through data collection and evaluation. The assessment and measurement endpoints applicable to the Lockheed West ROCs are summarized in Table 2-2. For the Lockheed West Site ERA, the assessment endpoints are survival, growth, and reproduction of receptors that are representative of the highest exposed organisms within the various environmental niches at the Site, and those organisms that represent societal choices as important. The presentation of assessment endpoints is consistent with EPA (1997a) guidance for performing ERAs at Superfund sites. The measurement endpoints are described more fully below in the Exposure and Effects Assessment for each ROC.

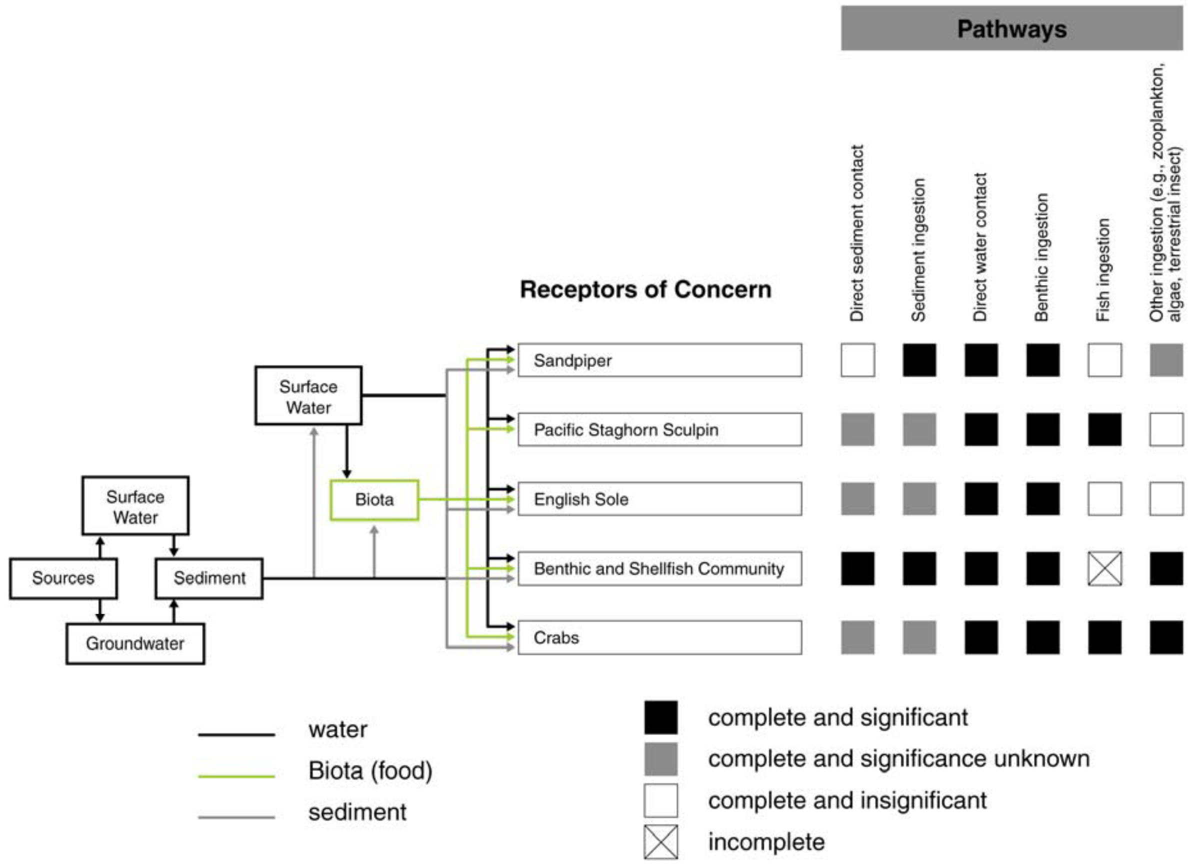
2.4 CONCEPTUAL SITE MODEL FOR ECOLOGICAL EXPOSURES

The ecological conceptual site model (CSM) is designed to identify whether complete exposure pathways are present between each COPC and the selected ecological receptor. A CSM is a risk assessment tool that identifies known or suspected contaminant sources, release and transport mechanisms, exposure routes/pathways, and receptors. The habitats, ROCs, sources of chemical contamination, and pathways of exposure for the ERA for the Lockheed West Site are graphically depicted in the CSM in Figure 2-1. The CSM is based on the descriptions of the site history, known or suspected contamination, habitat and receptors, and pathways of exposures, presented in preceding sections. EPA (1997a) guidance on performing ERAs at Superfund sites focuses on chemical stressors as separate from other non-contaminant stressors. Non-contaminant stressors on the aquatic ecosystem could include physical actions such as wave activity and currents. Pathways for the exposure of ROCs to sediment-associated chemicals at Lockheed West can be designated in one of four ways: complete and significant, complete and significance unknown, complete and insignificant, or incomplete.

Table 2-2. Assessment Endpoints for ROCs and Measures of Effect and Exposure

ROC	Assessment Endpoint	Assessment Scale	Measures of Effect	Measures of Exposure
Benthic				
Benthic invertebrate communities	survival, growth, reproduction	potential exposure area: small areas, surrounding individual sample stations assessment scale: individual sediment sample stations, subtidal and intertidal sediment	SMS and toxicologically based sediment guidelines or TRVs	chemical concentrations in sediment
Crabs	survival, growth, reproduction	potential exposure area: throughout the site assessment scale: subtidal and intertidal sediment	tissue-based TRVs for decapods	chemical concentrations modeled in crab tissue from subtidal and intertidal sediment concentrations
Fish				
English sole	survival, growth, reproduction	potential exposure area: English sole may forage throughout the site assessment scale: site-wide	tissue-based TRVs for chemicals evaluated using a critical tissue-residue approach dietary-based TRVs for chemicals evaluated using a dietary approach	chemical concentrations modeled from subtidal and intertidal sediment to English sole tissue and to English sole prey tissue
Pacific staghorn sculpin	survival, growth, reproduction	potential exposure area: sculpin may forage throughout the site assessment scale: site-wide	tissue-based TRVs for chemicals evaluated using a critical tissue-residue approach dietary-based TRVs for chemicals evaluated using a dietary approach	chemical concentrations modeled from subtidal and intertidal sediment to sculpin tissue and to sculpin prey tissue
Wildlife				
Spotted sandpiper	survival, growth, reproduction	potential exposure area: sandpiper forage in intertidal sediments throughout site assessment scale: intertidal sediment areas	dietary-based TRVs for birds	chemical concentrations in intertidal sediment and prey of sandpiper as modeled from intertidal sediment throughout the site

ROC – receptor of concern
SMS – Washington State Sediment Management Standards
TRV – toxicity reference value
Modified from Windward (2007)



Note: Groundwater at the adjacent PSR site may impact sediment benthos through transition zone water.

Figure 2-1. Conceptual Site Model for Benthic Invertebrates, Fish, and Wildlife at the Lockheed West Site

Each of the four designations for pathways of exposure is defined below, including whether it is further evaluated in the ERA.

- Complete and significant – There is a direct link between the receptor and chemical via this pathway, and the specific pathway is considered to be potentially important.
- Complete and significance unknown – There is a direct link between the receptor and the chemical via this pathway; however, there is insufficient data available to quantify the significance of the pathway in the overall assessment of exposure.
- Complete and insignificant – There is a direct link between the receptor and the chemical via this pathway; however, the significance of this pathway in terms of overall exposure is considered to be negligible. Pathways classified as complete and insignificant are not evaluated in the ERA.

- Incomplete – There is no direct pathway between the receptor and the chemical. Pathways classified as incomplete are not evaluated in the ERA.

As indicated above, mammalian and avian wildlife species other than spotted sandpiper are not identified as potential ROCs and are not evaluated in the Lockheed West Site ERA. Spotted sandpiper is included as a ROC and is assumed to be exposed to chemicals in the approximately two acres of intertidal sediment habitat at the Site. Groundwater and its resulting transition zone water may be a concern for direct toxicity of transition zone water to benthic organisms. An analysis of the uncertainties with existing groundwater data for evaluating risks from transition zone water to sediment benthos is presented in Section 7. Data from groundwater monitoring programs will be collected as part of RI activities, particularly for groundwater that may come from the adjacent Pacific Sound Resources site. Because the entire contaminated sediment area of the Site will be remediated, groundwater will be evaluated in the FS for its potential to impact the Lockheed West Site remediation. Surface water may present exposures of ROCs to site-related sediment chemicals. The potential for surface water exposures and risks is evaluated for each ROC. For some ROCs, the evaluation of tissue residue concentrations is designed to account for all pathways and media of exposure, including water.

2.5 DATA SELECTION, REDUCTION, AND SUITABILITY

This section presents the chemical data available for the Lockheed West Site and provides an evaluation of the relevance of these data to assess exposure of ROCs to sediment-associated chemicals.

2.5.1 Data Selection

The data selected for use in the ERA for the Lockheed West Site consist of results of the chemical analyses of the sediment sampling event of 2007, as described in the data report (Tetra Tech 2008b). Data prior to the 2007 environmental investigations are not considered to represent current conditions or were not collected with the intention for use in risk assessments, and are not used in this ERA.

Tissue data are not available to quantify exposures of ecological ROCs to sediment-related chemicals at the Lockheed West Site. Concentrations of sediment-related chemicals in tissue or relevant ecological organisms are modeled from the sediment data, as described more fully in subsequent sections of this ERA.

Sediment data were collected from 42 subtidal stations and 9 intertidal stations, for a total of 51 surface sediment samples. Surface sediment grabs were collected down to a 10-

centimer (cm) depth. Station locations are shown on the map of Figure 2-2. These data are further evaluated in the following sections.

2.5.2 Data Quality and Suitability for Risk Assessment

The sediment data collected in early 2007 at the Lockheed West Site were collected for use in the risk assessments and RI for the Site. The quality assurance project plan (QAPP) for their collection was presented in the RI work plan for the Site (Tetra Tech 2008a). The data underwent third party data validation and are considered suitable for use in the risk assessments for the Site. The only data qualified as rejected and unusable for risk assessment by the data validators were undetected concentrations for benzoic acid. Data qualified as unusable are not used in this ERA.

The analytical laboratory data reviewers and the data validators identified all organochlorine pesticide samples to have analytical interference from the presence of polychlorinated biphenyl (PCB) compounds. The organochlorine pesticides were analyzed using EPA Method 8081 (gas chromatography with electron capture detection [GC/ECD]), which is a standard method used in many environmental investigations for organochlorine pesticides. All detected results for organochlorine pesticide analyses in sediment samples were qualified JN, which indicates "the presence of an analyte that has been 'tentatively identified' and the associated numerical value represents its approximate concentration" (EPA 1999b). These data were qualified based on the probable interference in the analysis from PCB congeners. Similar interference and validation qualifiers occurred during the pesticide analysis of sediment and benthic invertebrate, fish, and crab tissues at the LDW site (Windward 2007).

The JN-qualified results in the 2007 sediment data set are highly uncertain and are considered to be biased high. The following comparative analysis of similarly qualified data at the nearby LDW site is presented as support for the likely high bias concentrations in the Lockheed West Site data. At the LDW site, the high bias for DDTs was confirmed by reanalyzing six sediment samples co-located with benthic invertebrate tissue samples, and eight fish and crab tissue samples that had high PCB and DDT concentrations, using a gas chromatography/mass spectrometry (GC/MS) method that is not susceptible to analytical interference by PCBs. The GC/MS method is less sensitive than EPA Method 8081, and therefore, could not be used for the original analyses of organochlorine pesticides and could only be used for confirmation in the high concentration samples.

The confirmation analysis results for the LDW samples confirmed the positive bias of the original sample results analyzed by GC/ECD. Specifically, all the results (i.e., concentration data) from the confirmation analyses were lower than the original results. The total DDT concentrations in the confirmation analyses for the LDW ranged from 4 to 60 percent of the original sediment results (Windward 2007). Thus, the original reported concentrations of DDT compounds reflected the presence of both PCB congeners and DDT isomers in the sample, and were elevated because of analytical interference.

The JN-qualified organochlorine pesticide results are used in the Lockheed West screening process to select chemicals for risk evaluation for each receptor (see following section). However, because of the high uncertainty inherent in the organochlorine pesticide concentrations, organochlorine pesticides that pass the screening step for evaluation in the risk assessment are evaluated in the uncertainty analysis section rather than the risk characterization section.

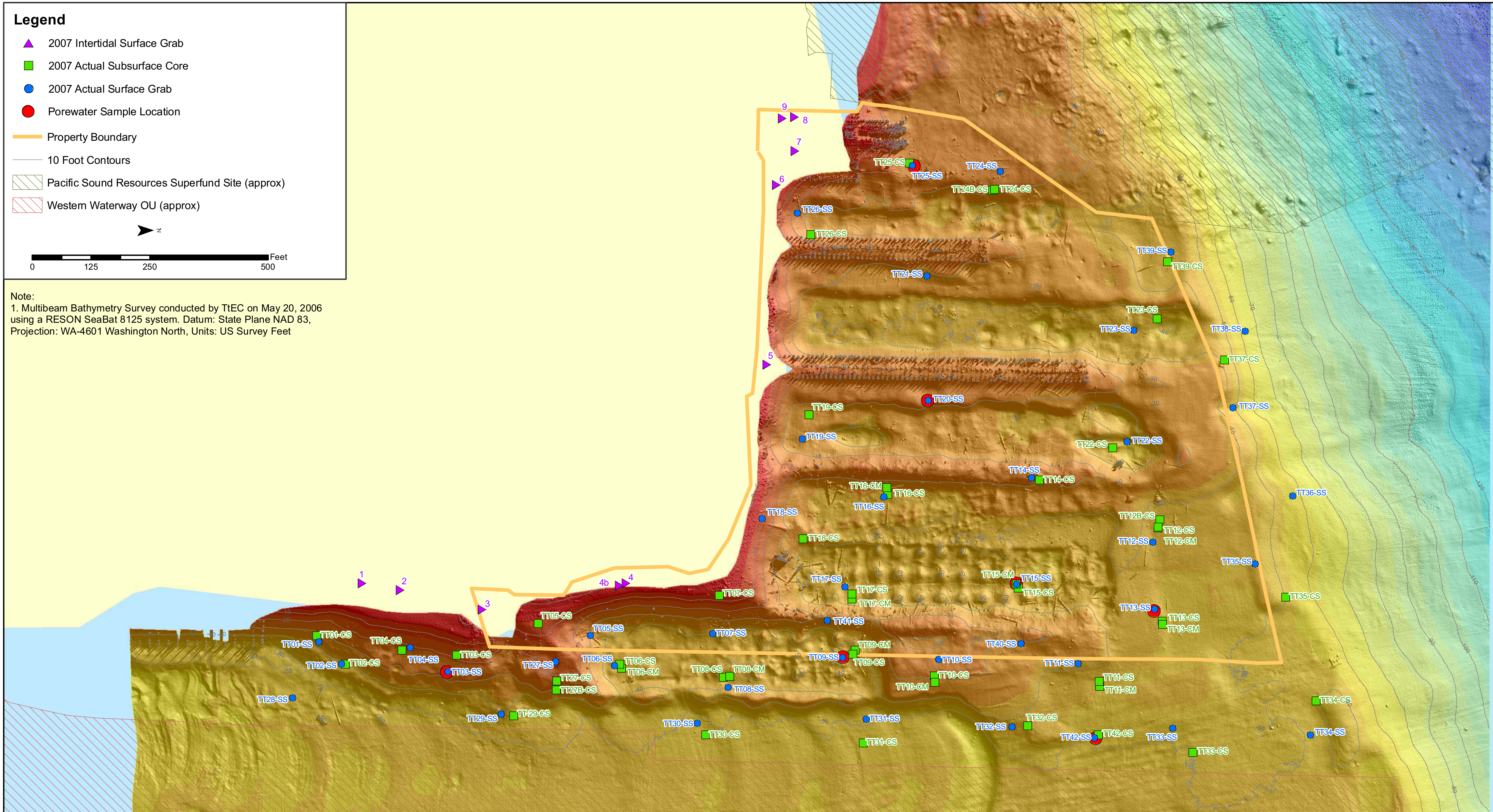
2.6 SELECTION OF CHEMICALS OF POTENTIAL CONCERN

Chemicals of potential concern (COPCs) for ecological risk are those chemicals related to the Site that may pose a risk to ecological receptors. COPCs are determined through a screen conducted using site-specific exposure data where available. The chemicals that were analyzed in sediment in the 2007 data set are identified as chemicals of interest (COI) for the ERA, and are listed by chemical group in Table 2-3. The COPCs for the ERA are selected from this list of COIs. The list of COIs was developed in the RI work plan based on historical uses of the site, previous sediment sampling results, and chemicals detected in sediment at nearby sites that may transport to the Lockheed West Site (e.g., West Waterway, LDW). The screen consists of comparisons of chemical concentrations in environmental media with screening criteria appropriate to the ROCs. Conservative exposure assumptions (e.g., maximum chemical concentrations) are used in this screen to determine which COPC will be relevant for which ROC.

Table 2-3. Chemical of Interest Groups for the Lockheed West Site

Analytical Group	Analysis	Sediment Target Detection Limit[1/]
TBT	Krone et al. 1989	1-5 μg/kg
Metals	SW846 6010B/6020	0.03 – 1 mg/kg
Mercury	SW846 7471A	0.003 μg/kg
PCB Aroclors[2/]	SW846 8082	0.98 μg/kg
Pesticides	SW846 8081A	0.024- 30 μg/kg
Semivolatiles	SW846 8270D	0.006 – 0.1 mg/kg
PAHs	SW846 8270-low level	0.001 – 0.05 μg/kg

1/ Detection limits vary and are dependent on total solids content. Target detection limits were set in the work plan to correspond with risk-based analytical concentrations goals for sediment.
2/ PCB Aroclors analyzed included 1016, 1221, 1232, 1242, 1248, 1254, and 1260 plus 1262 and 1268. Detected Aroclors were summed as total PCBs.



TETRA TECH INC.

Lockheed West Shipyard No. 2 Seattle, WA

Figure 2-2 Sediment Sampling Locations

Z:\projects_2006\Lockheed\maps\EA_figs_10-22-08\Figure_2-2_2007_samples.mxd

2.6.1 COPC Screening Steps

The process used to screen and select COPCs is consistent with EPA guidance. The screening process consists of the following steps:

1. Detection Limits for Undetected Chemicals – Chemicals that are always undetected are identified. Detection limits, or reporting limits (RLs), are compared with risk-based screening criteria described in the last step of the screening process, and undetected chemicals with detection limits exceeding screening criteria are evaluated in the uncertainty analysis of this ERA. Undetected chemicals with detection limits below risk-based screening criteria are screened out from further evaluation.

2. Frequency of Detection – Chemicals that are detected in less than 5 percent of sediment samples are screened out from further evaluation. EPA (1997a) guidance suggests excluding infrequently detected chemicals in order to focus the risk assessment. An infrequently detected chemical is rejected if it is not found in other environmental media, if there is no reason to believe that the contaminant should be found, and if there is not a unique site feature that may explain the presence of the contaminant. Past industrial uses of the site were considered in identifying chemicals that could be potential COPCs. Since past historical uses consisted primarily of shipyard activities, various metals are the main historical use-based chemicals identified as COPCs. Of the chemicals lacking toxicity values or for which screening criteria were exceeded by detection limits, none are identified as possible COPCs based on past activities at the site. Note that the full sediment data set collected in 2007 contains 51 stations, so only those chemicals detected in only one or two stations were rejected as below the frequency of detection criterion. No chemicals were rejected on the basis of frequency of detection for the intertidal data set, since nine sediment station samples comprise the intertidal sediment data set.

3. Comparison with risk-based screening criteria – Chemicals detected in site sediment samples that pass the above steps are screened against risk-based screening criteria. The risk-based criteria are based on acceptable risk levels associated with exposure of ecological ROCs to sediment chemicals. For fish and crab, screening is performed against criteria that identify the potential for a chemical to bioaccumulate from sediment into the organism; and for sandpiper, screening is performed against sediment risk-based concentrations (RBCs). Maximum concentrations in the top 10 cm of sediment are screened against the screening criteria.

Results of the screening steps for each of the ecological ROCs, and identification of the screening criteria for the screen in step 4 above, are presented below.

Concentrations of metals in sediments at the Site were also compared with available background concentrations. For the purpose of comparison, background is defined as the background concentrations identified in the LDW ERA; which are tabulated in the tables in the following sections. The background concentrations are considered tentative since EPA has not agreed to acceptable background concentrations for the Site. This comparison was not performed as part of the screening process, and no chemicals were eliminated from further evaluation based on this comparison. EPA risk assessments compute the risks for contaminants without respect to source (i.e., site or background associated).

2.6.2 Benthic Invertebrates Screening

This section presents results of the screening for benthic invertebrate exposures to chemicals in site sediments. For benthic invertebrates, including clams, maximum concentrations in surface sediments of chemicals detected in at least five percent of site sediment samples are first compared to Washington State Department of Ecology (Ecology) Sediment Quality Standards (SQS) (Ecology 2001). For chemicals with no SQS and detected in at least five percent of sediment samples, maximum concentrations are compared to alternative criteria.

The full set of criteria consists of the following:

- Ecology SQS (Ecology 2001)
- Lowest Apparent Effects Threshold (LAET) values identified by Ecology (Gries and Waldow 1996) – benzofluoranthenes
- Apparent Effects Threshold (AET) values listed in National Oceanic Atmospheric Administration (NOAA) (2008) – cobalt, selenium, vanadium, tributyltin, benzofluroanthenes
- Dredged Material Management Program (DMMP) screening level guidelines (U.S. Army Corps of Engineers [USACE] et al. 2000) that were determined in Windward (2007) to be toxicologically based for benthic invertebrates – antimony, nickel
- No-observed-adverse-effects level (NOAEL) and low-observed adverse effects level (LOAEL), identified in Windward (2007) – total DDTs, total chlordanes

Antimony and nickel were detected in all 51 sediment samples at the Site; however, no SQS is available for either antimony or nickel. Therefore, the DMMP screening level (SL) values were used as the screening criteria for antimony and nickel.

No SQS are available for total DDTs and chlordane. In a review of the available criteria for screening benthic invertebrates at the LDW site, Windward (2007) determined that the available DMMP values for total DDTs and chlordane are not toxicologically based. Sediment quality guidelines (SQGs) and AETs other than those used to set SMS were used to derive toxicity reference values (TRVs) for total DDTs and chlordane. Table 2-4 presents the basis for the SL and maximum level (ML) guidelines for antimony and nickel, and the selected TRVs for total DDTs and total chlordane.

Table 2-4. Biological Effect Endpoints for DMMP Guidelines and Selected TRVs

Chemical	Unit	SL, or NOAEL	ML, or LOAEL	Biological Endpoint Determining SL or NOAEL	Biological Endpoint Determining ML or LOAEL
Antimony	mg/kg dw	150[1/]	200[1/]	benthic AET	amphipod AET
Nickel	mg/kg dw	140[1/]	370[1/]	amphipod mortality and community abundance	not report
Total DDTs	µg/kg dw	567[2/]	1,063[2/]	amphipod mortality	amphipod mortality
Total chlordane	µg/kg dw	2.8[3/]	4.79[4/]	amphipod mortality	multiple ecosystem components

[1/] Source: USACE et al. (2000); Barrick et al. (1988).
[2/] Literature-based TRV – (Lotufo et al. 2001b).
[3/] Literature-based TRV – Puget Sound Dredge Disposal Analysis AET evaluation 1994 (Gries and Waldow 1996).
[4/] Literature-based TRV – probable effect levels for chlordane (CCME 2002).
AET – apparent effects threshold;
DMMP – Dredged Material Management Program
dw – dry weight
LOAEL – lowest-observed-adverse-effect level
ML – maximum level (DMMP)
NOAEL – no-observed-adverse-effect level
SL – screening level (DMMP)
Source: Windward (2007)

Chemicals exceeding the SQS, DMMP guidelines, or toxicologically based values are identified as COPCs for benthic invertebrates. For TBT, the sediment screening value is the sediment value NOAA has proposed as protecting prey species for endangered juvenile salmonids (Meador et al. 2002). Selection of TBT as a COPC is based on the maximum concentration exceedance of the NOAA screening value of 6 mg/kg OC.

Chemicals detected in greater than five percent of the sediment samples, but without SMS or toxicologically based guidelines or TRVs, are discussed in the uncertainty analysis. Detected chemicals with detection limits or RLs greater than the SQS are also discussed in the uncertainty analysis.

The SQS were promulgated to address risks to benthic invertebrate communities as a whole, and are not directly applicable to higher-trophic-level invertebrates, such as crabs, that may be at greater risk of exposure through bioaccumulation. Risks to crabs are evaluated using a tissue approach. Also, SMS are not intended to be protective of other receptors (such as fish and wildlife) exposed to sediment-associated COPCs through bioaccumulation. Exposures of these receptors are screened separately.

SQS values are based on AETs, which are defined as the highest "no effect" chemical concentration above which a significant adverse biological effect always occurred among the several hundred samples used for its derivation. Biological endpoints included in derivation of the SQS chemical standard were field measures of benthic infaunal abundance, laboratory toxicity tests with marine benthic invertebrate organisms (i.e., amphipods [survival] and oysters [percent abnormal development of oyster larvae]), and laboratory toxicity tests with bacteria (Microtox, decreased luminescence from the bacteria *Vibrio fisheri*). Under the provisions of the SMS, surface sediments with chemical concentrations equal to or less than all the SQS are designated as having no adverse effects on biological resources (Washington Administrative Code [WAC] 173-204-310(1)(a)).

Many SQS values are expressed as concentrations normalized to organic carbon (OC). At very low or high OC concentrations, normalization is not appropriate (Michelsen and Bragdon-Cook 1993). Concentrations of organic chemicals were not normalized to OC for samples with OC concentrations less than or equal to 0.5 percent. In these cases, maximum dry weight concentrations were compared to the LAET, which is functionally equivalent to the SQS. All intertidal stations were found to have OC less than 0.5 percent, as did subtidal Stations 3, 29, and 36. Sediment chemical concentrations of organic chemicals and organometals were not normalized to OC at these stations, and the LAETs in units of dry weight were used as the screening criteria.

Table 2-5 presents the screen of maximum chemical concentrations in the full set of surface sediment data collected in 2007 for 1) detection frequency, and 2) against the selection criteria to identify COPCs for benthic invertebrates. COPCs are retained for further evaluation in this ERA. A total of 27 chemicals were retained as COPCs for benthic invertebrates, which includes TBT and PCBs as total Aroclors. A summary of the results of the screen of COPCs for the benthic invertebrate community is presented in Table 2-6.

Maximum concentrations of numerous chlorinated pesticides exceeded screening criteria. However, chlorinated pesticides are not selected as COPCs for risk estimation but instead are evaluated in the uncertainty analysis due to their JN qualifiers. Pesticides qualified as JN are considered to be tentatively identified pending confirmation. As was observed at the LDW site, the presence of high concentrations of PCBs (congeners) in sediment and tissue samples results in over-quantitation of chlorinated pesticides. DDT was quantified in LDW tissues in confirmation analyses to range from 4 to 60 percent of the JN-qualified results. Because of the presence of PCBs in Lockheed West Site sediments, it is assumed that actual concentrations of chlorinated pesticides in Lockheed West Site sediments would be a fraction of the JN-qualified concentrations. This uncertainty is discussed further in the uncertainty analysis.

Table 2-5. Screen of COPCs for Benthic Invertebrates

Chemical	Detec. Freq.	Max. Conc.	Qual.	Units	Location of Max. Conc.	Total Organic Carbon Content (%)	Max. Conc. in Comparable Units	Units	Background Value[1/]	Screening Criteria	Source	COPC Flag (Y/N)[2/]	Rationale
Metals													
Antimony	51/51	194	J	mg/kg dw	11	1.12	194	mg/kg dw	0.23 / 0.44	150	SL	Y	ASV
Arsenic	51/51	330		mg/kg dw	IT-06	0.49	330	mg/kg dw	5.03 / 10.4	57	SQS	Y	ASV
Cadmium	51/51	0.73		mg/kg dw	9	1.37	0.73	mg/kg dw	0.36 / 1.12[3]	5.1	SQS	N	BSV
Chromium	51/51	504		mg/kg dw	18	0.81	504	mg/kg dw	NA	260	SQS	Y	ASV
Cobalt	51/51	38.6		mg/kg dw	IT-06	0.49	38.6	mg/kg dw	NA	10	AET[4/]	Y	ASV
Copper	51/51	1,900		mg/kg dw	15	1.7	1900	mg/kg dw	21.3 / 50.8	390	SQS	Y	ASV
Lead	51/51	1,420		mg/kg dw	IT-02	0.41	1420	mg/kg dw	15 / 45	450	SQS	Y	ASV
Mercury	51/51	2.94		mg/kg dw	17	1.99	2.94	mg/kg dw	0.0981 / 0.327	0.41	SQS	Y	ASV
Molybdenum	51/51	23.8		mg/kg dw	IT-06	0.49	-	-	NA	NA	-	N	NSV
Nickel	51/51	151		mg/kg dw	IT-08	0.32	151	mg/kg dw	26.8 / 41.7	140	SL	Y	ASV
Selenium	32/51	1.2		mg/kg dw	11, 14, 15	1.7	1.2	mg/kg dw	NA	1	AET[4/]	Y	ASV
Silver	51/51	0.703		mg/kg dw	10	1.02	0.703	mg/kg dw	0.28 / 0.74	6.1	SQS	N	BSV
Thallium	51/51	0.314		mg/kg dw	IT-06	0.49	-	-	0.252 / 1.79[3/]	NA	-	N	NSV
Vanadium	51/51	95.6		mg/kg dw	18	0.81	95.6	mg/kg dw	36 / 59.6	57	AET[4/]	Y	ASV
Zinc	51/51	1,430		mg/kg dw	11	1.12	1430	mg/kg dw	52.6 / 98.5	410	SQS	Y	ASV
Organometals													
Butyltin	50/51	200		µg/kg dw	31	1.35	-	-	NA	NA	-	N	NSV
Dibutyltin	51/51	1,400	D	µg/kg dw	31	1.35	-	-	NA	NA	-	N	NSV
Tetrabutyltin	43/51	120		µg/kg dw	9	1.37	-	-	NA	NA	-	N	NSV
Tributyltin	51/51	4,500	D	µg/kg dw	30	1.62	4500	µg/kg dw	NA	3400	AET[4/]	Y	ASV
Tributyltin	51/51	4,500	D	µg/kg dw	30	1.62	277.8	mg/kg OC	NA	6	NOAA[5/]	Y	ASV
PAHs													
Acenaphthene	48/51	450	D	µg/kg dw	25	2.7	16.7	mg/kg OC	NA	16	SQS	Y	ASV
Acenaphthylene	50/51	650	D	µg/kg dw	14	3.23	20.1	mg/kg OC	NA	66	SQS	N	BSV
Anthracene	50/51	2,500	D	µg/kg dw	26	1.96	127.6	mg/kg OC	NA	220	SQS	N	BSV
Benzo(a)-anthracene	51/51	2,700	D	µg/kg dw	26	1.96	137.8	mg/kg OC	NA	110	SQS	Y	ASV
Benzo(a)pyrene	51/51	2,000	D	µg/kg dw	17	1.99	100.5	mg/kg OC	NA	99	SQS	Y	ASV
Benzo(b)-fluoranthene	51/51	3,400	D	µg/kg dw	14	3.23	3,400	µg/kg dw	NA	1800	AET[7/]	Y	ASV
Benzo(g,h,i)-perylene	51/51	1,300	D	µg/kg dw	17	1.99	65.3	mg/kg OC	NA	31	SQS	Y	ASV
Benzo(k)-fluoranthene	50/51	1,500	D	µg/kg dw	31	1.35	1,500	µg/kg dw	NA	1800	AET[8/]	N	BSV
Benzo-fluoranthenes (total)	51/51	4,600		µg/kg dw	14	3.23	142.4	mg/kg OC	NA	230	SQS	N	BSV
Chrysene	51/51	5,800	D	µg/kg dw	14	3.23	179.6	mg/kg OC	NA	110	SQS	Y	ASV
Dibenzo(a,h)-anthracene	49/51	340	D	µg/kg dw	17	1.99	17.1	mg/kg OC	NA	12	SQS	Y	ASV
Fluoranthene	51/51	33,000	D	µg/kg dw	14	3.23	1,021.7	mg/kg OC	NA	160	SQS	Y	ASV
Fluorene	48/51	470	D	µg/kg dw	25	2.7	17.4	mg/kg OC	NA	23	SQS	N	BSV
Indeno(1,2,3-cd)pyrene	51/51	1,400	D	µg/kg dw	17	1.99	70.4	mg/kg OC	NA	34	SQS	Y	ASV
Naphthalene	46/51	610	D	µg/kg dw	25	2.7	22.6	mg/kg OC	NA	99	SQS	N	BSV
Phenanthrene	50/51	3,200	D	µg/kg dw	17	1.99	160.8	mg/kg OC	NA	100	SQS	Y	ASV
Pyrene	51/51	23,000	D	µg/kg dw	14	3.23	712.1	mg/kg OC	NA	1000	SQS	N	BSV
Total HPAH	51/51	70,740		µg/kg dw	14	3.23	2,190.1	mg/kg OC	NA	960	SQS	Y	ASV

Table 2-5. Screen of COPCs for Benthic Invertebrates (continued)

Chemical	Detec. Freq.	Max. Conc.	Qual.	Units	Location of Max. Conc.	Total Organic Carbon Content (%)	Max. Conc. in Comparable Units	Units	Background Value[1]	Screening Criteria	Source	COPC Flag (Y/N)[2]	Rationale
Total LPAH	50/51	4,765		µg/kg dw	17	1.99	239.4	mg/kg OC	NA	370	SQS	N	BSV
Total PAH	51/51	72,924		µg/kg dw	14	3.23	-	-	NA	NA	-	N	NSV
Phthalates													
bis(2-ethylhexyl)-phthalate	43/51	740	D	µg/kg dw	8	1.27	58.3	mg/kg OC	NA	47	SQS	Y	ASV
Butyl benzyl phthalate	30/51	96	JD	µg/kg dw	17	1.99	4.8	mg/kg OC	NA	4.9	SQS	N	BSV
Diethylphthalate	1/51	12		µg/kg dw	12	1.23	-	-	-	-	-	N	BDF
Dimethyl phthalate	2/51	11	JD	µg/kg dw	6	1.53	-	-	-	-	-	N	BDF
Di-n-butyl phthalate	47/51	69	JD	µg/kg dw	17	1.99	3.5	mg/kg OC	NA	220	SQS	N	BSV
Di-n-octyl phthalate	1/51	2,600	D	µg/kg dw	IT-08	0.32	-	-	-	-	-	N	BDF
Other SVOCs													
1,2-Dichloro-benzene	1/51	2.7	J	µg/kg dw	15	1.7	-	-	-	-	-	N	BDF
1,4-Dichloro-benzene	5/51	9.9	J	µg/kg dw	15	1.7	0.6	mg/kg OC	NA	3.1	SQS	N	BSV
1-Methyl-naphthalene	8/51	160	J	µg/kg dw	25	2.7	160	µg/kg dw	NA	670	ERM[6/]	N	BSV
2-Methyl-naphthalene	42/51	190	D	µg/kg dw	25	2.7	7.0	mg/kg OC	NA	38	SQS	N	BSV
2-Methylphenol	1/51	16		µg/kg dw	15	1.7	-	-	-	-	-	N	BDF
4-Methylphenol	20/51	83		µg/kg dw	13	1.06	83	µg/kg dw	NA	670	SQS	N	BSV
4-Nitroaniline	2/51	55	JD	µg/kg dw	40	1.02	-	-	-	-	-	N	BDF
Aniline	1/51	13	JD	µg/kg dw	6	1.53	-	-	-	-	-	N	BDF
Benzyl alcohol	6/51	14	J	µg/kg dw	15	1.70	14	µg/kg dw	NA	57	SQS	N	BSV
Dibenzofuran	47/51	400	D	µg/kg dw	25	2.70	14.8	mg/kg OC	NA	15	SQS	N	BSV
Hexachloro-benzene	2/51	2.9	JN	µg/kg dw	18	0.81	0.4	mg/kg OC	NA	0.38	SQS	N	BDF
N-Nitroso-dimethylamine	1/51	38	JN	µg/kg dw	15	1.70	-	-	-	-	-	N	BDF
Pentachloro-phenol	21/51	570	JD	µg/kg dw	30	1.62	570	µg/kg dw	NA	360	SQS	Y	ASV
Phenol	44/51	130		µg/kg dw	13	1.06	130	µg/kg dw	NA	420	SQS	N	BSV
PCBs													
PCB-1254	51/51	1,400	D	µg/kg dw	40	1.02	-	-	NA	NA	-	N	NSV
PCB-1260	46/51	900	J	µg/kg dw	17	1.99	-	-	NA	NA	-	N	NSV
PCB-1268	7/51	160	D	µg/kg dw	22	1.34	-	-	NA	NA	-	N	NSV
PCBs (total)	51/51	2,240		µg/kg dw	17	1.99	112.6	mg/kg OC	NA	12	SQS	Y	ASV
Organochlorine Pesticides													
Endosulfan I	1/51	16	JN	µg/kg dw	40	1.02	-	-	-	-	-	N	BDF
Endrin Aldehyde	12/51	17	JN	µg/kg dw	40	1.02	-	-	NA	NA	-	N	NSV
gamma-BHC	1/51	25	JN	µg/kg dw	17	1.99	-	-	-	-	-	N	BDF
gamma-Chlordane	29/51	46	JN	µg/kg dw	17	1.99	-	-	NA	NA	-	N	NSV
Heptachlor epoxide	1/51	0.5	JN	µg/kg dw	IT-07	0.34	-	-	-	-	-	N	BDF
Methoxychlor	4/51	15	JN	µg/kg dw	30	1.62	-	-	NA	NA	-	N	NSV
Mirex	5/51	3	JN	µg/kg dw	30	1.62	-	-	NA	NA	-	N	NSV
Nonachlor (cis)	1/51	15	JN	µg/kg dw	8	1.27	-	-	-	-	-	N	BDF
Nonachlor (trans)	2/51	7.5	JN	µg/kg dw	4	1.27	-	-	-	-	-	N	BDF
o,p-DDD	28/51	110	JN	µg/kg dw	17	1.99	-	-	NA	NA	-	N	NSV
o,p-DDT	42/51	90	JN	µg/kg dw	40	1.02	-	-	NA	NA	-	N	NSV

Table 2-5. Screen of COPCs for Benthic Invertebrates (continued)

Chemical	Detec. Freq.	Max. Conc.	Qual.	Units	Location of Max. Conc.	Total Organic Carbon Content (%)	Max. Conc. in Comparable Units	Units	Background Value[1]	Screening Criteria	Source	COPC Flag (Y/N)[2]	Rationale
p,p-DDD	12/51	14	JN	µg/kg dw	17	1.99	0.7	mg/kg OC	NA	1	AET[7/]	N	BSV
p,p-DDE	1/51	1.8	JN	µg/kg dw	5	1.91	-	-	-	-	-	N	BDF
p,p-DDT	41/51	97	JN	µg/kg dw	17	1.99	97	µg/kg dw	NA	567	(8)	N	BSV
Total DDT	49/51	294	JN	µg/kg dw	17	1.99	294	µg/kg dw	NA	567	(8)	N	BSV
Total Chlordanes	29/51	46	JN	µg/kg dw	17	1.99	46	µg/kg dw	NA	2.8	AET[4/]	Y	ASV

1/ Background values for the Duwamish Waterway taken from Windward (2007); COPCs were not screened against background in selection process.
2/ COPCs identified based on: 1) detection in at least 5% of subtidal plus intertidal samples, and 2) a comparison of maximum surface sediment concentrations to SMS SQS, or 3) for chemicals with no SQS, a comparison of maximum surface sediment concentrations to AET values, DMMP SL guidelines, or toxicologically based TRVs.
3/ Cadmium and thallium maximum concentrations are within the ranges of background values identified for the Duwamish Waterway in Windward (2007).
4/ NOAA (2008) SQuiRTs; cobalt based on AET for Neanthes bioassay, selenium based on AET for amphipod bioassay, vanadium based on AET for Neanthes bioassay, TBT based on AET for Neanthes bioassay (2004 SQuiRT)
5/ TBT screening value from Meador et al. (2002)
6/ ERM – Effects range medium for 2-methylnaphthalene as surrogate (NOAA 2008)
7/ AET evaluation 1994 (Gries and Waldow 1996).
8/ Literature based TRV, from Lotufo et al. (2001) as cited in Windward (2007).

ASV – Above Screening Value
BDF – Below 5% Detection Frequency
BSV – Below Screening Value
NSV – No Screening Value. Evaluated in the uncertainty analysis.
COPC – chemical of potential concern
DMMP – Dredged Material Management Program
dw – dry weight
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
J – estimated concentration
LAET – lowest apparent effects threshold
LPAH – low-molecular-weight polycyclic aromatic hydrocarbon
NA – not applicable
OC – organic carbon
SL – screening level (DMMP)
SMS – Washington State Sediment Management Standards
SQS – sediment quality standard (SMS)
TBT – tributyltin

Table 2-6. Summary of COPCs for Benthic Invertebrates

Metals	PAHs
Antimony	Acenaphthene
Arsenic	Benzo(a)anthracene
Chromium	Benzo(a)pyrene
Cobalt	Benzo(b)fluoranthene
Copper	Benzo(g,h,i)perylene
Lead	Chrysene
Mercury	Dibenzo(a,h)anthracene
Nickel	Fluoranthene
Selenium	Indeno(1,2,3-cd)pyrene
Vanadium	Phenanthrene
Zinc	Total HPAH
Organometals	**Other SVOCs**
Tributyltin	Pentachlorophenol
Phthalates	**PCBs**
bis(2-ethylhexyl)phthalate	PCBs (total Aroclors)
Organochlorine Pesticides	
Total Chlordanes[1/]	

[1/] Organochlorine pesticides were qualified with JN, indicating estimated and tentative identification, and are further evaluated in the uncertainty analysis.
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon

2.6.3 Sediment Screening for Fish and Crab

Chemicals are selected as COPCs for fish and crab exposures by screening sediment concentrations against the potential for these sediment chemicals to bioaccumulate into tissue. The COPC selection process consists of identifying bioaccumulative chemicals in sediments of the Lockheed West Site, and screening them against sediment bioaccumulation criteria that designate a potential concern for bioaccumulation into aquatic organisms.

For fish and crabs, chemicals in Lockheed West Site sediments were identified as COPCs by the following steps:

1. Detection in at least 5 percent of total intertidal plus subtidal surface sediment samples
2. Identification as a bioaccumulative chemical in EPA (2000a)
3. Comparison of their maximum sediment concentrations with risk-based sediment bioaccumulation criteria (USACE et al. 2000, Oregon Department of Environmental Quality [ODEQ] 2007)

Those chemicals that are identified as bioaccumulative and whose concentrations exceed one or more screening criteria for bioaccumulation are designated as COPCs for fish and crab. Bioaccumulative chemicals that are lacking bioaccumulation criteria are selected as COPCs for fish and crab. Only non-bioaccumulative chemicals and those bioaccumulative chemicals with concentrations below all the available bioaccumulation criteria are screened out.

In addition to the above steps, the work plan for the Lockheed West Site ERA (Tetra Tech 2008a) also identified an alternative screen of sediment concentrations using criteria developed as part of the LDW RI. The LDW RI developed RBCs for sediment that are protective of risks to ecological receptors, based on results from the baseline ERA. These RBCs are also referred to as risk-based threshold concentrations (RBTCs). The ERA RBTCs provide sediment concentrations specific to the LDW that are associated with regulatory risk levels for ecological receptors. However, the RBTCs in the LDW RI were developed only for a limited suite of chemicals, and bioaccumulation screening criteria are available for these chemicals. Consequently, the RBTCs in the LDW RI were not used as a source of screening levels to select COPCs for fish and crab.

The screening procedure for identifying tissue COPCs for sediment based on bioaccumulation potential into fish and crab tissue is shown in Table 2-7. A summary of the chemicals selected as COPCs for fish and crabs based on bioaccumulation potential is shown in Table 2-8.

Note in Table 2-7 that although the maximum concentration of benzo(a)pyrene in Site sediment is below the available screening criterion for bioaccumulation, it was retained as a COPC in order to maintain consistency with the bulk of PAHs that were retained due to lack of bioaccumulation screening criteria.

Table 2-7. Screen of Bioaccumulative COPCs for Fish and Crabs

Chemical	Detection Frequency	Maximum Concentration			Screening Criteria: EPA Bioaccumulation List[2/]	Screening Criteria: DMMP Bioaccumulation Trigger[3/]	Screening Criteria: ODEQ Bioaccumulation Trigger[4/]	COPC Flag[1/] (Y/N)	Rationale for Selection or Elimination
			Qualifier	Units					
Metals									
Antimony	51/51	194	J	mg/kg dw	N	150	NA	N	NB
Arsenic	51/51	330		mg/kg dw	Y	507.1	NA	N	BSV
Cadmium	51/51	0.73		mg/kg dw	Y	11.3	NA	N	BSV
Chromium	51/51	504		mg/kg dw	Y	267	NA	Y	ASV
Cobalt	51/51	38.6		mg/kg dw	N	NA	NA	N	NB
Copper	51/51	1,900		mg/kg dw	Y	1027	NA	Y	ASV
Lead	51/51	1,420		mg/kg dw	Y	975	NA	Y	ASV
Mercury	51/51	2.94		mg/kg dw	Y	1.5	NA	Y	ASV
Molybdenum	51/51	23.8		mg/kg dw	N	NA	NA	N	NB
Nickel	51/51	151		mg/kg dw	Y	370	NA	N	BSV
Selenium	32/51	1.2		mg/kg dw	Y	NA	NA	Y	B
Silver	51/51	0.703		mg/kg dw	Y	6.1	NA	N	BSV
Thallium	51/51	0.314		mg/kg dw	N	NA	NA	N	NB
Vanadium	51/51	95.6		mg/kg dw	N	NA	NA	N	NB
Zinc	51/51	1,430		mg/kg dw	Y	2783	NA	N	BSV
Organometals									
Butyltin	50/51	200		µg/kg dw	N	NA	NA	N	NB
Dibutyltin	51/51	1,400	D	µg/kg dw	N	NA	NA	N	NB
Tetrabutyltin	43/51	120		µg/kg dw	N	NA	NA	N	NB
Tributyltin	51/51	4,500	D	µg/kg dw	Y	NA	0.37	Y	ASV
PAHs									
Acenaphthene	48/51	450	D	µg/kg dw	Y	NA	NA	Y	B
Acenaphthylene	50/51	650	D	µg/kg dw	Y	NA	NA	Y	B
Anthracene	50/51	2,500	D	µg/kg dw	Y	NA	NA	Y	B
Benzo(a)anthracene	51/51	2,700	D	µg/kg dw	Y	NA	NA	Y	B
Benzo(a)pyrene	51/51	2,000	D	µg/kg dw	Y	3600	NA	N	BSV
Benzo(b)fluoranthene	51/51	3,400	D	µg/kg dw	Y	NA	NA	Y	B
Benzo(g,h,i)perylene	51/51	1,300	D	µg/kg dw	Y	NA	NA	Y	B
Benzo(k)fluoranthene	50/51	1,500	D	µg/kg dw	Y	NA	NA	Y	B

Table 2-7. Screen of Bioaccumulative COPCs for Fish and Crabs (continued)

Chemical	Detection Frequency	Maximum Concentration	Qualifier	Units	Screening Criteria: EPA Bioaccumulation List[2/]	DMMP Bioaccumulation Trigger[3/]	ODEQ Bioaccumulation Trigger[4/]	COPC Flag[1/] (Y/N)	Rationale for Selection or Elimination
Benzofluoranthenes (total)	51/51	4,600		µg/kg dw	Y	NA	NA	Y	B
Chrysene	51/51	5,800	D	µg/kg dw	Y	NA	NA	Y	B
Dibenzo(a,h)anthracene	49/51	340	D	µg/kg dw	Y	NA	NA	Y	B
Fluoranthene	51/51	33,000	D	µg/kg dw	Y	4600	37000	Y	ASV
Fluorene	48/51	470	D	µg/kg dw	Y	NA	NA	Y	B
Indeno(1,2,3-cd)pyrene	51/51	1,400	D	µg/kg dw	Y	NA	NA	Y	B
Naphthalene	46/51	610	D	µg/kg dw	N	NA	NA	N	NB
Phenanthrene	50/51	3,200	D	µg/kg dw	Y	NA	NA	Y	B
Pyrene	51/51	23,000	D	µg/kg dw	Y	11980	1900	Y	ASV
Total HPAH	51/51	70,740		µg/kg dw	N	NA	NA	N	NB
Total LPAH	50/51	4,765		µg/kg dw	N	NA	NA	N	NB
Total PAH	51/51	72,924		µg/kg dw	N	NA	NA	N	NB
Phthalates									
bis(2-ethylhexyl)phthalate	49/51	740	D	µg/kg dw	N	13870	NA	N	NB
Butyl benzyl phthalate	30/51	96	JD	µg/kg dw	N	NA	NA	N	NB
Diethylphthalate	1/51	12		µg/kg dw	N	NA	NA	N	BDF
Dimethyl phthalate	3/51	11	JD	µg/kg dw	N	NA	NA	N	NB
Di-n-butyl phthalate	47/51	69	JD	µg/kg dw	N	10220	NA	N	NB
Di-n-octyl phthalate	1/51	2,600	D	µg/kg dw	N	NA	NA	N	BDF
Other SVOCs									
1,2-Dichlorobenzene	1/51	2.7	J	µg/kg dw	Y	NA	NA	N	BDF
1,4-Dichlorobenzene	5/51	9.9	J	µg/kg dw	Y	120	NA	N	BSV
1-Methylnapthalene	8/51	160	J	µg/kg dw	N	NA	NA	N	NB
2-Methylnaphthalene	42/51	190	D	µg/kg dw	N	NA	NA	N	NB
2-Methylphenol	1/51	16		µg/kg dw	N	NA	NA	N	BDF
4-Methylphenol	20/51	83		µg/kg dw	N	NA	NA	N	NB
4-Nitroaniline	2/51	55	JD	µg/kg dw	N	NA	NA	N	BDF
Aniline	1/51	13	JD	µg/kg dw	N	NA	NA	N	BDF

Table 2-7. Screen of Bioaccumulative COPCs for Fish and Crabs (continued)

Chemical	Detection Frequency	Maximum Concentration			Screening Criteria: EPA Bioaccumulation List[2/]	Screening Criteria: DMMP Bioaccumulation Trigger[3/]	Screening Criteria: ODEQ Bioaccumulation Trigger[4/]	COPC Flag[1/] (Y/N)	Rationale for Selection or Elimination
			Qualifier	Units					
Benzyl alcohol	6/51	14	J	µg/kg dw	N	NA	NA	N	NB
Dibenzofuran	47/51	400	D	µg/kg dw	N	NA	NA	N	NB
Hexachlorobenzene	2/51	2.9	JN	µg/kg dw	Y	168	61000	N	BDF
N-Nitrosodimethylamine	1/51	38	JN	µg/kg dw	N	NA	NA	N	BDF
Pentachlorophenol	20/51	570	JD	µg/kg dw	Y	504	170	Y	ASV
Phenol	44/51	130		µg/kg dw	N	NA	NA	N	NB
PCBs									
PCB-1254	51/51	1,400	D	µg/kg dw	Y	NA	NA	Y	B
PCB-1260	45/51	900	J	µg/kg dw	Y	NA	NA	Y	B
PCB-1268	7/51	160	D	µg/kg dw	Y	NA	NA	Y	B
PCBs (total)	51/51	201		mg/kg OC	Y	38	-	Y	ASV
Organochlorine Pesticides									
Endosulfan I	1/51	16	JN	µg/kg dw	Y	NA	NA	N	BDF
Endrin Aldehyde	11/51	17	JN	µg/kg dw	N	NA	NA	N	NB
gamma-BHC	1/51	25	JN	µg/kg dw	Y	NA	NA	N	BDF
gamma-Chlordane	29/51	46	JN	µg/kg dw	Y	NA	0.47	Y	ASV
Heptachlor epoxide	1/51	0.5	JN	µg/kg dw	Y	NA	NA	N	BDF
Methoxychlor	4/51	15	JN	µg/kg dw	Y	NA	NA	Y	B
Mirex	5/51	3	JN	µg/kg dw	Y	NA	NA	Y	B
Nonachlor (cis)	1/51	15	JN	µg/kg dw	N	NA	NA	N	BDF
Nonachlor (trans)	2/51	7.5	JN	µg/kg dw	N	NA	NA	N	BDF
o,p-DDD	28/51	110	JN	µg/kg dw	N	NA	NA	N	NB
o,p-DDT	42/51	90	JN	µg/kg dw	N	NA	NA	N	NB
p,p-DDD	12/51	14	JN	µg/kg dw	Y	NA	NA	Y	B
p,p-DDE	1/51	1.8	JN	µg/kg dw	Y	NA	NA	N	BDF
p,p-DDT	41/51	97	JN	µg/kg dw	Y	NA	NA	Y	B

Table 2-7. Screen of Bioaccumulative COPCs for Fish and Crabs (continued)

Chemical	Detection Frequency	Maximum Concentration			Screening Criteria: EPA Bioaccumulation List[2/]	Screening Criteria: DMMP Bioaccumulation Trigger[3/]	Screening Criteria: ODEQ Bioaccumulation Trigger[4/]	COPC Flag[1/] (Y/N)	Rationale for Selection or Elimination
			Qualifier	Units					
Total DDT	49/51	294	JN	µg/kg dw	Y	50	0.39	Y	ASV
Total Chlordanes	24/42	46	JN	µg/kg dw	Y	NA	0.47	Y	ASV

1/ COPCs identified based on: 1) detection in at least 5% of samples, 2) identified in EPA (2000a) as a bioaccumulative chemical, and 3) above all bioaccumulation screening criteria, or lacking bioaccumulation screening criteria.
2/ EPA. 2000a. Bioaccumulation testing and interpretation for the purpose of sediment quality assessment: status and needs. EPA-823-R-00-001.
3/ USACE et al., 2000. Dredged material evaluation and disposal procedures. A user's manual for the Puget Sound Dredged Disposal Analysis Program. U.S. Army Corps of Engineers, Seattle District, Seattle, WA; EPA, Region 10, Seattle, WA; Washington Department of Natural Resources; and Washington Department of Ecology, Olympia, WA
4/ ODEQ. 2007. Guidance for Assessing Bioaccumulative Chemicals of Concern in Sediment. Final. Oregon Department of Environmental Quality, Environmental Cleanup Program, Portland, OR. Updated April 3.
ASV – Above Screening Value
B – Bioaccumulative chemical (EPA 2000a)
BDF – Below 5% Detection Frequency
BSV – Below Screening Value
NB – Not on Bioaccumulative List of EPA
NSV – No Screening Value. To be discussed in the uncertainty analysis.
COPC – chemical of potential concern
DMMP – Dredged Material Management Program
dw – dry weight
J – estimated concentration
JN - tentatively estimated pending confirmation; evaluated in the uncertainty analyses
NA – not applicable

Table 2-8. Summary of COPCs for Fish and Crabs Based on Bioaccumulation Potential

COPC	Rationale for Selection
Metals	
Chromium	Above Screening Value
Copper	Above Screening Value
Lead	Above Screening Value
Mercury	Above Screening Value
Selenium	Bioaccumulative chemical, no screening value
Organometals	
Tributyltin	Above Screening Value
PAHs	
Acenaphthene	Bioaccumulative chemical, no screening value
Acenaphthylene	Bioaccumulative chemical, no screening value
Anthracene	Bioaccumulative chemical, no screening value
Benzo(a)anthracene	Bioaccumulative chemical, no screening value
Benzo(a)pyrene	Below Screening Level[1]
Benzo(b)fluoranthene	Bioaccumulative chemical, no screening value
Benzo(g,h,i)perylene	Bioaccumulative chemical, no screening value
Benzo(k)fluoranthene	Bioaccumulative chemical, no screening value
Benzofluoranthenes (total)	Bioaccumulative chemical, no screening value
Chrysene	Bioaccumulative chemical, no screening value
Dibenzo(a,h)anthracene	Bioaccumulative chemical, no screening value
Fluoranthene	Above Screening Value
Fluorene	Bioaccumulative chemical, no screening value
Indeno(1,2,3-cd)pyrene	Bioaccumulative chemical, no screening value
Phenanthrene	Bioaccumulative chemical, no screening value
Pyrene	Above Screening Value
Other SVOCs	
Pentachlorophenol	Above Screening Value
PCBs	
PCB-1254	Bioaccumulative chemical, no screening value
PCB-1260	Bioaccumulative chemical, no screening value
PCB-1268	Bioaccumulative chemical, no screening value
PCBs (total)	Above Screening Value
Organochlorine Pesticides	
gamma-Chlordane	Above Screening Value
Methoxychlor	Bioaccumulative chemical, no screening value
Mirex	Bioaccumulative chemical, no screening value
p,p-DDD	Bioaccumulative chemical, no screening value
p,p-DDT	Bioaccumulative chemical, no screening value
Total DDT	Above Screening Value
Total Chlordanes	Above Screening Value

1/ Although the maximum concentration of benzo(a)pyrene was below the available screening criterion for bioaccumulation, it was retained as a COPC because most of the other PAHs were retained due to lack of bioaccumulation screening criteria.

Sediment PAHs are also screened for exposures of fish at the Lockheed West Site by comparison of total PAH concentrations in sediment with sediment thresholds for mixtures of PAHs that have been published by the National Marine Fisheries Service (NMFS) Northwest Fisheries Science Center. The NMFS thresholds are based on levels of PAHs that have been associated with adverse biological effects in English sole collected from

Puget Sound embayments (Johnson 2001). The NMFS paper evaluated available dose-response data on English sole exposures to sediment PAHs and predicted sediment concentrations or thresholds at which adverse biological effects may become detectable. The effects are related to the sum of concentrations of low and high molecular weight PAHs that were measured in the sediments from the embayments, which consisted of biphenyl, naphthalene, 1-methylnaphthalene, 2-methylnaphthalene, 2,6-dimethylnaphthalene, acenaphthene, fluorene, phenanthrene, 1-methylphenanthrene, anthracene, fluoranthene, pyrene, benz[*a*]anthracene, chrysene, benzo[*a*]pyrene, benzo[*e*]pyrene, perylene, and dibenz[a,h]anthracene.

The sediment thresholds identified by NMFS for the sum of these PAHs were based on DNA damage, liver disease, and growth and reproductive impairment in English sole, and range from 300 to 5,000 µg/kg dry wt. In comparison, the maximum Total PAH concentration of 72,924 µg/kg dry wt and the 95 percent upper confidence limit of the mean concentration (95 UCL) of 10,867 µg/kg dry wt for Total PAHs in the 2007 data set for Lockheed West Site surface sediment both clearly exceed the upper end of the range of the suggested threshold for effects of a mixture of PAHs on English sole.

2.6.4 Sandpiper Screening

For spotted sandpiper, the selection of COPCs was based on exposures to intertidal sediment only. Chemicals were identified as COPCs for spotted sandpiper based on the following criteria:

- Detection in at least 5 percent of intertidal surface sediment samples
- Identification as a bioaccumulative chemical in EPA (2000a)
- Maximum concentration exceeding its RBC for sandpiper.

Since only nine samples are available for intertidal sediment at the Lockheed West Site, the first step above was met by all detected chemicals (i.e., all detected chemicals were above the five percent detection frequency). Screening criteria for spotted sandpiper are NOAEL-based screening values adapted as RBCs from the quality assurance project plan for screening sediment chemical concentrations at the LDW site (Windward 2005a), as described more fully below. RBCs for the protection of spotted sandpipers are expressed as chemical concentrations in sediment that may be ingested incidentally while foraging. Sandpiper exposures are assumed to occur with all bioaccumulative chemicals that have been detected in intertidal sediment.

The use of sediment RBCs for screening sandpiper exposures is considered sufficiently conservative because the screening process resulted in more organic chemical COPCs for sandpiper at the Lockheed West Site than were identified for the LDW site, where the selection of COPCs was based on screening doses to sandpiper, as derived from measured concentrations in prey, against dose-based TRVs.

RBC derivation

The RBCs that are used as the screening criteria for sandpiper are based on dose-based TRVs for bird species, specifically the NOAELs, which are the highest doses at which no adverse effects were observed. Effects endpoints included growth, reproduction, and survival. The TRVs based on NOAELs and LOAELs are derived from the literature expressed as dietary doses in mg/kg body weight (BW)/day. Following the procedure in Windward (2007), these dietary doses were converted into RBCs in sediment in mg/kg dry weight using the receptor's sediment ingestion rate and BW. The TRV data that were used to develop screening criteria are shown in Table 2-9. The toxicity data in Table 2-9 are the TRVs provided in the LDW ERA (Windward 2007). The toxicity data for sandpiper are summarized further in Section 6 (Effects Assessment for Wildlife).

The dietary dose of each sediment chemical was converted to its RBC for ingested sediment using Equation 2-1:

$$RBC_{sed} = (Dose \times BW)/DSC \qquad \textbf{Equation 2-1}$$

where:

RBC_{sed} = risk-based concentration in sediment (mg/kg dw)
Dose = NOAEL or LOAEL (mg/kg BW/day)
BW = body weight (kg)
DSC = daily sediment consumption rate (kg dw/day)

For NOAELs or LOAELs that are based on a reproductive endpoint, the RBC_{sed} was calculated using the female BW and DSC. For NOAELs or LOAELs that are based on growth or mortality, RBC_{sed} was calculated using the male and female average for BW and DSC. The DSC was calculated as 18 percent of the daily food consumption (DFC) on a dry weight basis based on the average sediment ingestion by four species of sandpipers that feed on mud-dwelling invertebrates (EPA 1993).

The following BW, DFC, and DSC values were used in Equation 2-1:

- Female spotted sandpiper
  - BW = 0.0471 kg
  - DFC = 0.0074 kg dw/day
  - DSC = 0.00133 kg dw/day
- Average (male and female) spotted sandpiper
  - BW = 0.0425 kg
  - DFC = 0.0067 kg dw/day
  - DSC = 0.00121 kg dw/day

BWs for spotted sandpipers were obtained from studies by Maxson and Oring (1980), as cited in EPA (1993). The daily food consumption was calculated as a function of the metabolic rate and the caloric content of the spotted sandpiper prey, based on data from Nagy et al. (1999) and Nagy (1987).

The identification of TRVs and development of screening RBCs for sandpiper are presented in Table 2-9; the sandpiper COPC screening is performed in Table 2-10, using the screening criteria developed in Table 2-9. Table 2-11 presents the summary of the screening results for COPCs for sandpiper; COPCs consist of chromium, copper, lead, vanadium, TBT, benzo(a)pyrene, total PAHs, and Aroclor-1254/total PCBs. JN-qualified organochlorine pesticides identified as sandpiper COPCs include o,p-DDT, p,p'-DDT, and total DDT.

Table 2-9. Identification of Sandpiper TRVs and Development of Screening Criteria

Chemical	TRVs NOAEL (mg/kg bw/day)	TRVs LOAEL (mg/kg bw/day)	Endpoint	Sediment RBCs NOAEL (mg/kg dw)	Sediment RBCs LOAEL (mg/kg dw)
Metals					
Antimony	na	na	-	-	-
Arsenic	10	40	reproduction	354	1417
Cadmium	1.5	4	growth	53	140
Chromium	1	5	reproduction	35	177
Cobalt	2.31	23.1	growth	81	811
Copper	21	29	growth	738	1019
Lead	5.82	20	reproduction	206	708
Mercury	0.018	0.091	growth	1	3
Molybdenum	6	30	reproduction	211	1062
Nickel	77	107	growth/ mortality	2705	3758
Selenium	0.5	0.82	reproduction	18	29
Silver	na	na	-	-	-
Thallium	2.4	24	survival	84	843
Vanadium	1.2	2.3	growth	42	81
Zinc	82	123	growth	2880	4320
Organometals					
Butyltin	na	na	-	-	-
Dibutyltin	na	na	-	-	-
Tetrabutyltin	na	na	-	-	-
Tributyltin	1.4	3.6	reproduction	50	127
PAHs					
Acenaphthene	na	na	-	-	-
Acenaphthylene	na	na	-	-	-
Anthracene	na	na	-	-	-
Benzo(a)anthracene	na	na	-	-	-
Benzo(a)pyrene	0.28	1.4	reproduction	10	50
Benzo(b)fluoranthene	na	na	-	-	-
Benzo(g,h,i)perylene	na	na	-	-	-
Benzo(k)fluoranthene	na	na	-	-	-
Benzofluoranthenes (total)	na	na	-	-	-
Chrysene	na	na	-	-	-
Dibenzo(a,h)anthracene	na	na	-	-	-
Fluoranthene	na	na	-	-	-
Fluorene	na	na	-	-	-
Indeno(1,2,3-cd)pyrene	na	na	-	-	-
Naphthalene	na	na	-	-	-
Phenanthrene	na	na	-	-	-
Pyrene	na	na	-	-	-
Total HPAH	na	na	-	-	-
Total LPAH	na	na	-	-	-
Total PAH	8	40	growth	281	1405

Table 2-9. Identification of Sandpiper TRVs and Development of Screening Criteria (continued)

Chemical	TRVs NOAEL (mg/kg bw/day)	TRVs LOAEL (mg/kg bw/day)	TRVs Endpoint	Sediment RBCs NOAEL (mg/kg dw)	Sediment RBCs LOAEL (mg/kg dw)
Phthalates					
bis(2-ethylhexyl)phthalate	65.8	329	reproduction	2330	11651
Di-n-butyl phthalate	na	na	-	-	-
Other SVOCs					
1-Methylnapthalene	na	na	-	-	-
2-Methylnaphthalene	na	na	-	-	-
Dibenzofuran	na	na	-	-	-
Phenol	na	na	-	-	-
PCBs					
PCB-1254	0.41	0.94	reproduction	15	33
PCB-1260	na	na	-	-	-
PCBs (total)	0.41	0.94	reproduction	15	33
Organochlorine Pesticides					
Endrin Aldehyde	0.07	0.2	survival	2	7
gamma-Chlordane	0.6	2	mortality	21	70
Mirex	18	34	reproduction	637	1204
o,p-DDD	0.064	0.32	reproduction	2	11
o,p-DDT	0.064	0.32	reproduction	2	11
p,p-DDT	0.064	0.32	reproduction	2	11
Total DDT	0.064	0.32	reproduction	2	11
Total Chlordanes	0.6	2	mortality	21	70

Tissue TRVs from Windward (2007)
dw – dry weight
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
LPAH – low-molecular-weight polycyclic aromatic hydrocarbon
RBC – risk-based concentration, screening criteria for sediment
TRV – toxicity reference value
RBC_S – (Dose [TRV] x BW)/DSC

RBC_s = risk-based concentration in sediment
Average (male and female) spotted sandpiper BW (kg) 0.0425
Daily Food consumption rate (kg dw/day) 0.0067
DSC = daily sediment consumption rate (kg dw/day) 0.00121
DSC = 18% of the daily food consumption on a dry weight basis
Female spotted sandpiper BW (kg) 0.0471
Female Daily Food consumption rate (kg dw/day) 0.0074
Female DSC = daily sediment consumption rate (kg dw/day) 0.00133
Average male and female parameters used for non-reproductive endpoints; female used for reproductive endpoint.

Table 2-10. Screen of COPCs for Spotted Sandpiper

Chemical	Detection Frequency[1/]	Maximum Concentration	Qualifier	Units	Location of Maximum Concentration	Sediment RBC (mg/kg dw) NOAEL-based	Sediment RBC (mg/kg dw) LOAEL-based	COPC Flag (Y/N)	Rationale for Selection or Deletion[2/]
Metals									
Antimony	9/9	126	J	mg/kg dw	IT-O5	na	na	N	NSV
Arsenic	9/9	330		mg/kg dw	IT-06	354	1,417	N	BSV
Cadmium	9/9	0.65		mg/kg dw	IT-05	53	140	N	BSV
Chromium	9/9	289		mg/kg dw	IT-07	35	177	Y	ASV
Cobalt	9/9	38.6		mg/kg dw	IT-06	81	811	N	BSV
Copper	9/9	1,310		mg/kg dw	IT-08	738	1,019	Y	ASV
Lead	9/9	1,420		mg/kg dw	IT-02	206	708	Y	ASV
Mercury	9/9	0.42		mg/kg dw	IT-05	1	3	N	BSV
Molybdenum	9/9	23.8		mg/kg dw	IT-06	211	1062	N	BSV
Nickel	9/9	151		mg/kg dw	IT-08	2,705	3,758	N	BSV
Selenium	9/9	0.7		mg/kg dw	IT-06	18	29	N	BSV
Silver	9/9	0.67		mg/kg dw	IT-06	na	na	N	NSV
Thallium	9/9	0.31		mg/kg dw	IT-06	84	843	N	BSV
Vanadium	9/9	68.6		mg/kg dw	IT-08	42	81	Y	ASV
Zinc	9/9	1,360		mg/kg dw	IT-06	2,880	4,320	N	BSV
Organometals									
Butyltin	8/9	6	J	µg/kg dw	IT-05	na	na	N	NSV
Dibutyltin	9/9	34		µg/kg dw	IT-05	na	na	N	NSV
Tetrabutyltin	4/9	0.94	J	µg/kg dw	IT-07	na	na	N	NSV
Tributyltin	9/9	57		µg/kg dw	IT-07	50	127	Y	ASV
PAHs									
Acenaphthene	6/9	280		µg/kg dw	IT-06	na	na	N	NSV
Acenaphthylene	8/9	21	J	µg/kg dw	IT-06	na	na	N	NSV
Anthracene	8/9	66		µg/kg dw	IT-06	na	na	N	NSV
Benzo(a)anthracene	9/9	170		µg/kg dw	IT-07	na	na	N	NSV
Benzo(a)pyrene	9/9	260		µg/kg dw	IT-06	10	50	Y	ASV
Benzo(b)fluoranthene	9/9	340		µg/kg dw	IT-06	na	na	N	NSV
Benzo(g,h,i)perylene	9/9	110		µg/kg dw	IT-06	na	na	N	NSV
Benzo(k)fluoranthene	8/9	120		µg/kg dw	IT-06	na	na	N	NSV
Benzofluoranthenes (total)	9/9	460		µg/kg dw	IT-06	na	na	N	NSV

Table 2-10. Screen of COPCs for Spotted Sandpiper (continued)

Chemical	Detection Frequency[1/]	Maximum Concentration	Qualifier	Units	Location of Maximum Concentration	Sediment RBC (mg/kg dw) NOAEL-based	Sediment RBC (mg/kg dw) LOAEL-based	COPC Flag (Y/N)	Rationale for Selection or Deletion[2/]
Chrysene	9/9	200		µg/kg dw	IT-09	na	na	N	NSV
Dibenzo(a,h)anthracene	7/9	28		µg/kg dw	IT-06	na	na	N	NSV
Fluoranthene	9/9	610		µg/kg dw	IT-07	na	na	N	NSV
Fluorene	6/9	140		µg/kg dw	IT-06	na	na	N	NSV
Indeno(1,2,3-cd)pyrene	9/9	140		µg/kg dw	IT-06	na	na	N	NSV
Naphthalene	5/9	41		µg/kg dw	IT-08	na	na	N	NSV
Phenanthrene	8/9	240		µg/kg dw	IT-06	na	na	N	NSV
Pyrene	9/9	520		µg/kg dw	IT-07	na	na	N	NSV
Total HPAH	9/9	2,008		µg/kg dw	IT-07	na	na	N	NSV
Total LPAH	8/9	751		µg/kg dw	IT-06	na	na	N	NSV
Total PAH	9/9	2,461		µg/kg dw	IT-06	281	1,405	Y	ASV
Phthalates									
Bis(2-ethylhexyl) phthalate	3/9	670		µg/kg dw	IT-08	2,330	11,651	N	BSV
Di-n-butyl phthalate	9/9	6.4		µg/kg dw	IT-02	na	na	N	NSV
Other SVOCs									
1-Methylnapthalene	3/9	40		µg/kg dw	IT-06	na	na	N	NSV
2-Methylnaphthalene	2/9	4.5	J	µg/kg dw	IT-08	na	na	N	NSV
Dibenzofuran	6/9	67		µg/kg dw	IT-06	na	na	N	NSV
Phenol	4/9	21	J	µg/kg dw	IT-09	na	na	N	NSV
PCBs									
PCB-1254	9/9	77		µg/kg dw	IT-02	15	33	Y	ASV
PCB-1260	3/9	20		µg/kg dw	IT-03	na	na	N	NSV
PCBs (total)	9/9	77		µg/kg dw	IT-02	15	33	Y	ASV
Organochlorine Pesticides									
Endrin Aldehyde	1/9	0.82	JN	µg/kg dw	IT-02	2	7	N	BSV
gamma-Chlordane	4/9	1.1	JN	µg/kg dw	IT-02	21	70	N	BSV
Mirex	1/9	0.2	JN	µg/kg dw	IT-03	637	1,204	N	BSV
o,p-DDD	2/9	1.4	JN	µg/kg dw	IT-08	2	11	N	BSV
o,p-DDT	8/9	4.2	JN	µg/kg dw	IT-02	2	11	Y	ASV

Table 2-10. Screen of COPCs for Spotted Sandpiper (continued)

Chemical	Detection Frequency[1/]	Maximum Concentration	Qualifier	Units	Location of Maximum Concentration	Sediment RBC (mg/kg dw) NOAEL-based	Sediment RBC (mg/kg dw) LOAEL-based	COPC Flag (Y/N)	Rationale for Selection or Deletion[2/]
p,p-DDT	9/9	5.2	JN	µg/kg dw	IT-02	2	11	Y	ASV
Total DDT	9/9	9.4	JN	µg/kg dw	IT-02	2	11	Y	ASV
Total Chlordanes	4/9	1.1	JN	µg/kg dw	IT-02	21	70	N	BSV

1/ Intertidal sediment stations
2/ COPCs identified based on a comparison of maximum surface sediment concentrations to toxicity-based sediment screening values for sandpiper, adapted from the QAPP for benthic invertebrate sampling in the LDW (Windward 2004a).
3/ Screening value is soil NOAEL value for robin exposures, from ODEQ (2001).
COPC – chemical of potential concern
D – based on diluted sample
dw – dry weight
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
J – estimated concentration
JN – estimated concentration, tentatively identified pending confirmation analysis
LPAH – low-molecular-weight polycyclic aromatic hydrocarbon
na – toxicity data not available or not applicable if not a bioaccumulative chemical for indirect sediment exposures
ASV – Above Screening Value
BSV – Below Screening Value
NSV – No Screening Value. Discussed in the uncertainty analysis.

Table 2-11. Summary of COPCs for Spotted Sandpiper

Chemical	Maximum Sediment Concentration[1/]	Units
Metals		
Chromium	289	mg/kg dw
Copper	1,310	mg/kg dw
Lead	1,420	mg/kg dw
Vanadium	68.6	mg/kg dw
Organometals		
Tributyltin	57	µg/kg dw
PAHs		
Benzo(a)pyrene	260	µg/kg dw
Total PAH	2,461	µg/kg dw
PCBs		
PCB-1254	77	µg/kg dw

[1/] Intertidal sediment stations

3. EXPOSURE AND EFFECTS ASSESSMENT: BENTHIC INVERTEBRATE COMMUNITY

The benthic invertebrate community as a whole was selected as a ROC in the problem formulation to represent benthic invertebrates that may be exposed to sediment-associated chemicals at the Lockheed West Site. Twenty seven chemicals were identified as COPCs for the benthic invertebrate community, based on the maximum concentrations in the sediment chemistry data. This section presents the benthic invertebrate community exposure assessment and effects assessment. Because bioaccumulation and toxicity data are available for crabs as individual ROCs, they are evaluated in a subsequent section. The exposure and effects data presented in this section are combined in the risk characterization to present a quantitative estimation of risk to the benthic community at the Lockheed West Site.

3.1 BENTHIC INVERTEBRATE COMMUNITY EXPOSURE ASSESSMENT

In this section, surface sediment data for COPCs for the benthic invertebrate community are presented to characterize their exposure to site chemicals. Surface sediments in Puget Sound are defined by EPA (1997d) as the uppermost 10 cm of the sediments. While some species may be present at greater depths, 10 cm is generally assumed to represent a reasonable estimate of the biologically-active zone in Puget Sound. In addition, the top 10 cm are used for comparison to the applicable SMS criteria. COPCs for the benthic invertebrate community were identified in Section 2.6.2. Concentrations of benthic community COPCs in the surface sediment dataset are summarized in Table 3-1. Because benthic invertebrates have small home ranges, their exposures to sediment contaminants are represented by individual sediment sampling stations; i.e., sediment chemistry data are not averaged over an area of sediment but are evaluated on a station-by-station basis. Therefore, exposure of the benthic community is expressed as the concentration of each COPC in sediment at each individual station. Intertidal and subtidal sediment data collected in 2007 are used as the exposure concentrations for benthic invertebrates. The locations of surface sediment samples are shown on Figure 2-2.

Risk to benthic invertebrates from exposure to TBT is evaluated by a critical tissue residue approach, where exposures are based on modeled tissue concentrations rather than sediment concentrations. Modeling is based on a relationship between benthic invertebrate tissue concentrations and sediment concentrations established with data for the upstream LDW site.

Table 3-1. Concentrations of COPCs in Sediment for Benthic Invertebrate Community Exposures

COPC	Unit	Detected Concentration (Intertidal Plus Subtidal Sediments) Minimum	Maximum	Distribution[1]	95 UCL on Mean
Metals					
Antimony	mg/kg dw	0.43 J	194 J	Lognormal	37.0
Arsenic	mg/kg dw	4.56	330	Nonparametric	109
Chromium	mg/kg dw	14.4	504	Lognormal	90.0
Cobalt	mg/kg dw	3.18 J	38.6	Nonparametric	14.3
Copper	mg/kg dw	28.2	1,900	Nonparametric	618
Lead	mg/kg dw	15.9	1,420	Lognormal	200
Mercury	mg/kg dw	0.021	2.94	Gamma	0.61
Nickel	mg/kg dw	7.29 J	151	Nonparametric	48.2
Selenium	mg/kg dw	0.2	1.2	Nonparametric	0.67
Vanadium	mg/kg dw	22	95.6	Normal	52.8
Zinc	mg/kg dw	47.5	1,430	Nonparametric	473
Organometals					
TBT	µg/kg dw	0.81 J	4,500	Lognormal	2,810
PAHs					
Acenaphthene	µg/kg dw	2.8 J	450	Gamma	130
Benzo(a)anthracene	µg/kg dw	2.6 J	2,700	Gamma	709
Benzo(a)pyrene	µg/kg dw	2.6 J	2,000	Gamma	680
Benzo(b)fluoranthene	µg/kg dw	5	3,400	Gamma	1,110
Benzo(g,h,i)perylene	µg/kg dw	4.3 J	1,300	Gamma	379
Chrysene	µg/kg dw	3.1 J	5,800	Normal	1,123
Dibenzo(a,h)anthracene	µg/kg dw	3.6	340	Gamma	134
Fluoranthene	µg/kg dw	4.5 J	33,000	Gamma	2,381
Indeno(1,2,3-cd)pyrene	µg/kg dw	2.9 J	1,400	Gamma	422
Phenanthrene	µg/kg dw	4.5 J	3,200	Gamma	977
Total HPAH	µg/kg dw	28.8	70,740	Gamma	9,333
Phthalates					
Bis(2-ethylhexyl) phthalate	µg/kg dw	28 J	740	Gamma	250
Other SVOCs					
Pentachlorophenol	µg/kg dw	16	570 J	Nonparametric	123.8
PCBs					
Total PCBs	µg/kg dw	4.2	2,240	Gamma	498.3

1/ Data distribution and 95 UCL values determined with ProUCL 4.0 (Section 2.6.2).
COPC – chemical of potential concern
dw – dry weight
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
J – estimated value
PAH – polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
SVOC – semivolatile organic compound
TBT – tributyltin

The use of regression models for estimating tissue concentrations at the Lockheed West Site are described in more detail in Section 4.1. For TBT, a regression model was developed in the ERA for the LDW site, derived from data on co-located benthic invertebrate tissue and sediment samples from 20 locations (10 intertidal and 10 subtidal locations) throughout the

LDW (Windward 2007). The regression equation developed in Attachment 11 to the LDW ERA (Windward 2007) is as follows, with all units in µg/kg dw:

$$\text{Tissue concentration} = 145.4 \times \text{sediment}^{0.1801} \ (R^2 = 0.587)$$ **Equation 3-1**

Benthic invertebrate tissue concentrations were calculated for both the combined subtidal plus intertidal data set and the intertidal data set separately. Results of the estimation of TBT in tissue of benthic invertebrates at the Lockheed West Site are shown in Table 3-2.

Table 3-2. Modeled TBT Concentrations in Benthic Invertebrate Tissue

COPC	95 UCL Sediment Concentration (µg/kg dw)	Corresponding Tissue Concentration (µg/kg dw)	Corresponding Tissue Concentration (µg/kg ww)
Subtidal Plus Intertidal Sediment			
TBT	2,810	608	128
Intertidal Sediment			
TBT	36.4	280	58

COPC – chemical of potential concern
dw – dry weight
ww – wet weight, assuming 79% moisture, which is the average moisture content in benthic invertebrates collected at the LDW site (Windward 2007).
TBT – tributyltin
UCL – upper confidence limit on the mean

Benthic invertebrates were also evaluated for exposures to TBT in sediment porewater. Porewater concentration data are available for six subtidal stations in the Lockheed West 2007 data set, shown in Table 3-3. The maximum concentration detected was 1.9 micrograms per liter (µg/L).

Table 3-3. TBT Concentrations in Porewater

Station	3		9		13		15		25		42	
Tributyltin (µg/L)	0.36	J	0.71	J	0.47	J	1.9	J	0.02	J	0.22	J

J – Result is an estimated concentration
µg/L – micrograms per liter

Both the modeled tissue concentrations of TBT and measured TBT concentrations in porewater are used with TBT effects data for benthic invertebrates, described in the following section, in the estimation of risks to benthic invertebrates.

3.2 BENTHIC COMMUNITY EFFECTS ASSESSMENT

This section presents the effects assessment for the benthic community. The potential effects that sediment-associated COPCs may have on the benthic invertebrate community were evaluated through toxicity values and toxicity-based sediment criteria that are used in

Section 7 to estimate risks to benthos at the Lockheed West Site. Effects data for exposure of benthic invertebrates to TBT are based on toxicological data for tissue taken from the literature on benthic invertebrates.

3.2.1 Sediment Effects Assessment

For the benthic invertebrate community, SQGs form the basis of effects-based sediment concentrations. SQGs consist primarily of Washington State SMS, and for COPCs for which SMS are unavailable, dredge disposal guidelines from DMMP (USACE et al. 2000) or other federal agency guidelines for marine sediments (e.g., NOAA). For COPCs lacking SQGs, toxicity values compiled for application to benthic invertebrate community at the LDW site are used (Windward 2007).

Sediment effects information for the benthic community at the Lockheed West Site is largely summarized from the LDW ERA (Windward 2007). Washington State SMS were described above in Section 2 for screening COPCs for the benthic community. The SQS and cleanup screening level (CSL) criteria are based on AETs originally developed for the Puget Sound Estuary Program (Barrick et al. 1988) and adapted by Ecology (1991). An AET is the highest "no effect" chemical-specific sediment concentration above which a significant adverse biological effect always occurred among the several hundred samples used in its derivation. The methods used to calculate the AETs are described by Barrick et al. (1988) and Gries and Waldow (1996).

AETs were empirically derived using data from field-collected sediment samples that contained diverse chemical mixtures analyzed simultaneously for chemistry and toxicity. The data used to derive the 1988 AETs were collected from various locations in Puget Sound between March 1982 and September 1986. AETs were developed for 47 chemicals using four endpoints: amphipod mortality, abnormal development of oyster larvae, benthic community abundance, and Microtox® bioluminescence. In general, Ecology (1991) identified the LAET for each chemical as the SQS, and the second LAET as the CSL. The SQS corresponds to a sediment quality that will result in no adverse effects to biological resources; the CSL corresponds to a sediment quality that will result in minor adverse effects (WAC 173-204). Table 3-4 presents the biological effect endpoints that provide the basis for the SQS and CSL chemical criteria that are used as the primary toxicity values for evaluating risks from benthic community COPCs.

Table 3-4. Biological Effects Basis of the SQS and CSL Criteria for Benthic COPCs

COPC	SQS	CSL	Units	Biological Endpoint Used to Establish SQS	Biological Endpoint Used to Establish CSL
Metals					
Arsenic	57	93	mg/kg dw	community abundance	amphipod mortality
Chromium	260	270	mg/kg dw	community abundance	amphipod mortality
Copper	390	390	mg/kg dw	oyster abnormality	Microtox®
Lead	450	530	mg/kg dw	community abundance	Microtox®
Mercury	0.41	0.59	mg/kg dw	Microtox®	oyster abnormality
Zinc	410	960	mg/kg dw	community abundance	amphipod mortality
PAHs					
Acenaphthene	16	57	mg/kg OC	oyster abnormality	community abundance
Benzo(a)anthracene	110	270	mg/kg OC	oyster abnormality	amphipod mortality
Benzo(a)pyrene	99	210	mg/kg OC	oyster abnormality	amphipod mortality
Benzo(g,h,i)perylene	31	78	mg/kg OC	oyster abnormality	amphipod mortality
Chrysene	110	460	mg/kg OC	oyster abnormality	amphipod mortality
Dibenzo (a,h)anthracene	12	33	mg/kg OC	na	Microtox®
Fluoranthene	160	1,200	mg/kg OC	oyster abnormality	community abundance
Indeno (1,2,3,-c,d)pyrene	34[1/]	88	mg/kg OC	oyster abnormality	amphipod mortality
Phenanthrene	100[2/]	480	mg/kg OC	oyster abnormality	community abundance
HPAH	960	5,300	mg/kg OC	oyster abnormality	amphipod mortality
Phthalates					
Bis(2-ethylhexyl) phthalate	47	78	mg/kg OC	Microtox®	amphipod mortality
Other SVOCs					
Pentachlorophenol	360	690	µg/kg dw	amphipod mortality	community abundance
PCBs					
Total PCBs	12	65	mg/kg OC	Microtox®	community abundance

[1/] The SQS for indeno(1,2,3,-c,d)pyrene is 34 mg/kg OC, although the LAET, based on oyster abnormality, is 33 mg/kg OC.
[2/] SQS for phenanthrene is 100 mg/kg OC, although the LAET, based on oyster abnormality, is 120 mg/kg OC.
CSL – cleanup screening level (SMS)
dw – dry weight
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
OC – organic carbon
PAH – polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
SQS – sediment quality standards (SMS)
SVOC – semivolatile organic compound
Source: Washington State Sediment Management Standards (WAC 173-204); Barrick et al. (1988), Windward (2007).

The biological bases for sediment guidelines other than SMS, and used as effects criteria for benthic invertebrates, are shown in Table 3-5. Cobalt, selenium, and vanadium were identified as COPCs for benthic invertebrates in the screening process based on their exceedance of screening criteria using AET values. The LAET value was used for the screening criteria, and is shown as the toxicity value in Table 3-5.

Antimony, nickel, benzo(b)fluoranthene, and total chlordane were identified as additional COPCs for benthic invertebrates in the screening process, based on screening against criteria other than SQS. The toxicity values for antimony and nickel are the DMMP guidelines, whereas the toxicity values for benzo(b)fluoranthene are the lowest and second LAET values (Table 3-5). Because the DMMP guidelines for total chlordane is not toxicologically based, but instead is set at 5 times the instrument detection limit (Puget Sound Dredge Disposal Analysis [PSSDA] 1988), the TRV for total chlordane was selected from the scientific literature, as presented above in the screening step for benthic invertebrates. The lowest SQG (4.79 µg/kg dry weight) was selected as the LOAEL TRV for chlordane. The highest NOAEL (2.8 µg/kg dry weight) below the LOAEL was selected as the NOAEL TRV for chlordane. This value is also the AET for chlordane (Gries and Waldow 1996).

Table 3-5. Biological Criteria Other Than SMS for Benthic COPCs

COPC	Low Value	High Value	Unit	Basis of Biological Criteria	
Metals					
Antimony	150	200	mg/kg dw	SL (benthic AET)	ML (amphipod AET)
Cobalt	10	-	mg/kg dw	AET - lowest	-
Nickel	140	370	mg/kg dw	SL - amphipod mortality and community abundance	ML – not reported
Selenium	1	-	mg/kg dw	AET - lowest	-
Vanadium	57	-	mg/kg dw	AET - lowest	-
PAHs					
Benzo(b)fluoranthene	1,800	3,200	µg/kg dw	AET - lowest	AET – second lowest
Organochlorine pesticides					
Total DDTs	567	1,063		amphipod mortality	amphipod mortality
Total chlordane	2.8	4.79		amphipod mortality	multiple ecosystem components
Organometals					
Tributyltin	0.05	0.7	µg/L	Porewater – NOAEL for various marine species	Effect level for marine species

dw – dry weight
AET – apparent effects threshold
ML – maximum level (DMMP)
SL – screening level (DMMP)
Sources: AETs- Barrick et al. (1988), NOAA (2008), Gries and Waldow (1996); SL & ML- USACE et al. (2000); DDTs- Lotufo et al. (2001b), chlordane- Gries and Waldow (1996), CCME (2002).

3.2.2 TRVs for TBT

In the absence of SMS criteria or alternative SQGs, the potential effects from TBT exposure on survival, growth, and reproduction of benthic invertebrates are evaluated by two approaches: 1) effects-based concentrations in porewater, and 2) effects related to a critical tissue-residue concentration. The TRVs for TBT for both of these approaches are summarized below and listed in Table 3-6.

3.2.2.1 Porewater TRV

A sediment porewater concentration of TBT has been established as a screening trigger value by the EPA Interagency TBT work group. The consensus of the work group was that a porewater concentration for TBT of 0.05 µg/L corresponds to a no adverse effects level that would protect most (approximately 95 percent) of the Puget Sound species that have been tested (Michelsen et al., 1996, Appendix A). This value is conceptually equivalent to the SQS and is consistent with the EPA approach to developing water quality and sediment criteria. This level is selected as the NOAEL-based TRV for porewater.

A higher TRV for TBT in porewater is selected based on adverse effects to marine benthic invertebrates from exposure to TBT in porewater, which was identified by the EPA Interagency TBT work group at 0.7 µg/L. Significant chronic effects are considered likely at this concentration, particularly to bivalve species present in Puget Sound (PSSDA 1988).

3.2.2.2 Critical Tissue-Residue TRV

Five studies were identified in Windward (2007) that reported tissue concentrations of TBT in benthic invertebrates other than gastropods that were associated with adverse effects. The LOAELs for effects on growth and reproduction ranged from 2.36 to 5.44 mg/kg dw. The lowest LOAEL (2.36 mg/kg dw) was selected as the TRV because of the relevance of the sediment exposure as well as the polychaete growth endpoint. The juvenile polychaetes exhibited a reduction in growth of 25 percent relative to the control sediment at a TBT concentration of 101 ng/g dw in sediment, which resulted in a tissue concentration of 2.36 mg/kg dw (Meador and Rice 2001). The associated NOAEL of 0.97 mg/kg dw was the NOAEL selected below the LOAEL.

Table 3-6. TRVs for Benthic Invertebrate Exposures to TBT

Test Species	Exposure Medium	NOAEL/NOEC	LOAEL/LOEC	Source
Polychaete (*Armandia brevis*)	Tissue (mg/kg dw)	0.97	2.4	Meador and Rice (2001)
Various marine species	Porewater (µg/L)	0.05	0.7	Michelsen et al. (1996)

dw – dry weight
LOAEL – lowest-observed-adverse-effect level for tissue
LOEC – lowest-observed-effect concentration for porewater
NOAEL – no-observed-adverse-effect level for tissue
NOEC – no-observed-effect concentration for porewater

3.2.2.3 TBT TRVs for Imposex

In addition to the above TRV endpoints for TBT in porewater and critical tissue residues for benthic invertebrates, TBT is evaluated separately for imposex effects on specific gastropod species. The porewater and critical tissue residue values for TBT in benthic invertebrates are not applicable to the imposex endpoint in the gastropod species. Imposex is defined as the development of male sexual characteristics in females (Bauer et al. 1997). Imposex has only been observed in meso- and neogastropods, but not in other gastropods. Sterilization resulting from the advanced stages of imposex is considered a population-level effect (EPA 1999a).

Low-observed-effects concentration (LOEC) and no-observed-effects concentration (NOEC) values associated with sterilization resulting from imposex were reviewed in Windward (2003) as part of the Phase 1 ERA for the LDW site. LOECs associated with sterilization resulting from advanced stages of imposex are reproduced in Table 3-7. Tissue residue concentrations associated with sterilization due to imposex are available for three species (*Littorina littorea, Ocinebrina aciculate, Nucella lapillus*), which are members of the order Mesogastropodae or Neogastropodae. The NOEC of 0.61 mg/kg dw and LOEC of 0.72 mg/kg dw for sterilization effects in periwinkle (*Littorina littorea)* are used as TRVs for tissue concentrations for assessing risk of imposex to sensitive gastropods. The review of TRVs in EPA (1999a) also identified the LOEC of 0.72 mg/kg dw for sterilization effects in periwinkle.

Table 3-7. Summary of Available Toxicity Literature Related to TBT and Sterilization Resulting from Imposex

Species	Study conditions	Effects Concentration (mg/kg dw)	Effect Endpoint	Reference
Periwinkle (*Littorina littorea*)	Field collected organisms	LOEC: 0.72 [1/, 2/]	40% sterilization[3/]	Oehlmann et al. 1998
Snail (*Ocinebrina aciculate*)	Field collected organisms	LOEC: 1.1	Sterilization due to imposex	Oehlmann et al. 1998
Dogwhelk (*Nucella lapillus*)	Aqueous exposure to 7-12ng TBT/L	LOEC: 1.39	100% sterilization	Gibbs et al. 1988
Periwinkle (*Littorina littorea*)	Field collected organisms	LOEC: 1.4	60% sterilization[3/]	Bauer et al. 1997
Dogwhelk (*Nucella lapillus*)	Field collected organisms	LOEC: 2.65[a]	Sterilization due to imposex	Bailey and Davies 1991
Dogwhelk (*Nucella lapillus*)	Field transplanted mussels for 18 mo	LOEC: 3.39	Sterilization due to imposex	Bryan et al. 1987
Dogwhelk (*Nucella lapillus*)	Aqueous exposure to 107 ng TBT/L for 12 mo	LOEC: 8.52	Sterilization due to imposex	Bryan et al. 1987
Periwinkle (*Littorina littorea*)	Field collected organisms	NOEC: 0.3 [1/, 2/, 4/]	Sterilization due to imposex	Oehlmann et al. 1998
Dogwhelk (*Nucella lapillus*)	Aqueous exposure to 2-5 ng TBT/L	NOEC: 0.61	Sterilization due to imposex	Gibbs et al. 1988

1/ Concentration calculated assuming a moisture content of 80 percent.
2/ Value estimated from a non-linear regression presented in a figure in the original paper.
3/ Refers to the percent of sampled organisms that were found to be sterile due to imposex or intersex.
4/ No effects concentration was taken from background; therefore it may not represent the highest NOEC.
Source: Windward (2003)

4. EXPOSURE ASSESSMENT: FISH AND CRAB

This section presents the assessment of exposures of fish and crab ROCs to bioaccumulative COPCs that were identified above in the Problem Formulation step of this ERA. Fish and crab are evaluated together since the same set of COPCs is used in the quantitation of chemical exposures for both of them. Concentrations of site-related chemicals in tissue of fish, crab, and fish prey (benthic invertebrates and other fish) for some COPCs, are modeled from measured sediment concentrations. As discussed below, fish prey items for which tissue modeling is performed include benthic invertebrates, crab, and other fish. As described in Section 2, the COPCs selected for fish and crab were identified through a bioaccumulative screening process. The list of COPCs for crab and fish is provided in Table 4-1.

Data on total PCBs as Aroclors in sediment form the basis for estimating PCB exposures and risks to ROCs at the Lockheed West Site. The LDW ERA demonstrated that risks from exposures to PCBs measured as Aroclors and those estimated as congeners, using the TEQ approach, were not substantially different, and hence risk estimates focus on PCBs as Aroclors for the Lockheed West Site.

Table 4-1. Summary of COPCs for Crab and Fish

COPC	Rationale for Selection
Metals	
Chromium	Above Screening Value
Copper	Above Screening Value
Lead	Above Screening Value
Mercury	Above Screening Value
Selenium	Bioaccumulative chemical, no screening value
Organometals	
Tributyltin	Above Screening Value
PAHs	
Acenaphthene	Bioaccumulative chemical, no screening value
Acenaphthylene	Bioaccumulative chemical, no screening value
Anthracene	Bioaccumulative chemical, no screening value
Benzo(a)anthracene	Bioaccumulative chemical, no screening value
Benzo(a)pyrene	Below Screening Level
Benzo(b)fluoranthene	Bioaccumulative chemical, no screening value
Benzo(g,h,i)perylene	Bioaccumulative chemical, no screening value
Benzo(k)fluoranthene	Bioaccumulative chemical, no screening value
Benzofluoranthenes (total)	Bioaccumulative chemical, no screening value
Chrysene	Bioaccumulative chemical, no screening value
Dibenzo(a,h)anthracene	Bioaccumulative chemical, no screening value
Fluoranthene	Above Screening Value
Fluorene	Bioaccumulative chemical, no screening value
Indeno(1,2,3-cd)pyrene	Bioaccumulative chemical, no screening value
Phenanthrene	Bioaccumulative chemical, no screening value
Pyrene	Above Screening Value

Table 4-1. Summary of COPCs for Crab and Fish (continued)

COPC	Rationale for Selection
Other SVOCs	
Pentachlorophenol	Above Screening Value
PCBs	
PCB-1254	Bioaccumulative chemical, no screening value
PCB-1260	Bioaccumulative chemical, no screening value
PCB-1268	Bioaccumulative chemical, no screening value
PCBs (total)	Above Screening Value
Organochlorine Pesticides	
gamma-Chlordane	Above Screening Value
Methoxychlor	Bioaccumulative chemical, no screening value
Mirex	Bioaccumulative chemical, no screening value
p,p-DDD	Bioaccumulative chemical, no screening value
p,p-DDT	Bioaccumulative chemical, no screening value
Total DDT	Above Screening Value
Total Chlordanes	Above Screening Value

4.1 METHODOLOGY FOR MODELING TISSUE CONCENTRATIONS

Concentrations of COPCs in fish and crab tissue, and tissue of benthic invertebrates as prey for fish, were estimated by modeling from sediment concentrations. The modeling methods consisted of the biota-sediment accumulation factor (BSAF) methodology (see Section 4.1.1.1) and regression models (Section 4.1.1.2).

4.1.1.1 BSAF Modeling

The BSAF method was used to model tissue concentrations of most COPCs at the Lockheed West Site. The BSAF is essentially the ratio of the contaminant concentration in tissue to the contaminant concentration in sediment. In sediment, organic material (i.e., organic carbon derived from decayed plant matter and microorganisms) is a major factor in chemical-sediment sorption, particularly for non-ionic organic chemicals but also some metals. Measures of partition coefficients and BSAF values for the same compound from different sediments have shown that the major source of variability of BSAF values is reduced by normalization to sediment organic carbon (WDOH 1995).

Organic compounds also vary in their affinity for lipids. Chemicals with log K_{ow} values greater than 1.0 partition into lipid to a greater extent than into an aqueous environment. The concentrations of hydrophobic organic chemicals in tissues have been found to correlate with percent lipid content (WDOH 1995). In order to account for differing lipid contents of organisms, organic chemical concentrations in tissue are normalized to the lipid content of the organism. To account for the normalization to organic carbon in sediment and to lipid in tissue in the derivation of the BSAF, concentrations in tissue are normalized to lipid fraction in tissue and concentrations in sediment are normalized to the organic carbon content of sediment.

For ionic or polar organic compounds and metals, bioaccumulation is not controlled by a single common property such as partitioning to organic phases. The BSAFs used to model uptake of metals, which are also called bioaccumulation factors (BAFs), are based on a mix of laboratory and empirical field data (PTI 1995a). The factors that govern the partitioning of metals between sediment and tissues in the field studies are not clear, but are generally not related to the lipid content of tissue and organic carbon content of sediments. As summarized in PTI (1995a), observations of bioaccumulation of metals into fish have been mixed, with some studies finding substantial uptake with certain fish species and metals, and other studies finding no uptake. Bioaccumulation of metals appears to be dependent on the species of organism and chemical properties of the metal, as well as on the experimental or site conditions for studies performed with field data. Although studies on metals uptake with benthic organisms are more available than studies with fish, the relationships between metals in tissues of detritus or deposit feeders has been characterized as weak. Factors that appear to govern metals uptake into aquatic organisms have been identified as temperature, oxygen content, water hardness, pH, physiology, life cycle and history, seasonal variations, species and individual variability, and food content of intestines.

Because of the lack of correlation of uptake with known factors, BSAFs for metals are not based on lipid-normalization or organic carbon normalization, and instead are calculated as the ratio of dry weight concentrations in tissue and sediment. The availability of published BSAFs for metals accumulation in fish and crabs was very limited, and those for bivalves fairly uncertain due to the limitations described above. For those reasons, the resultant modeled tissue concentrations are uncertain.

The sources of BSAF values used in the modeling of tissue concentrations are discussed below. Consistent with partitioning theory and also reflected in the BSAF equation (Equation 4-1), BSAF values are independent of whether wet weight or dry weight values were used in its derivation, as long as the sediment concentration and organic carbon fraction are in the same units, and the tissue concentration and lipid fraction are in the same units.

BSAFs are derived using the following equation:

$$BSAF = \frac{C_T \div F_L}{C_{sed} \div F_{oc}}$$ **Equation 4-1**

where:

C_T = chemical concentration in tissue (mg/kg ww)
C_{sed} = chemical concentration in sediment (mg/kg dw)
F_L = fraction lipid in tissue (kg lipid/kg ww)
F_{oc} = fraction organic carbon in sediment (kg OC/kg dw)

To model tissue concentrations (C_T) of non-polar organic compounds, the BSAFs are used with the sediment concentration (C_{sed}), sediment total organic fraction (F_{oc}), and tissue lipid fraction (F_L) by rearranging Equation 4-1 to solve for C_T, as follows:

$$C_T = \frac{(C_{sed} \times F_L) \times BSAF}{F_{OC}}$$ **Equation 4-2**

In using Equation 4-2 to model tissue concentrations, the sediment concentration (C_{sed}) and organic carbon fraction (F_{oc}) were expressed in dry weight units, and the lipid fraction (F_L) was in wet weight units, to result in a modeled tissue concentration (C_T) in wet weight units. The wet weight tissue concentrations were converted to dry weight concentrations based on moisture content of the organisms (Table 4-2).

The lipid fractions (F_L) for the various organisms identified as ROCs or as prey items for ROCs in this ERA were taken from data collected from the LDW (Windward 2008, Appendix D). Note that although a clam lipid fraction of 0.0095 (0.95 percent) was used in the LDW benthic invertebrate sampling QAPP to develop the RBCs that were used in the screening step for sandpiper described in Section 2 above, which is based on 11 composite tissue samples of Puget Sound clams (Tetra Tech 1994), sufficient data are available from the upstream LDW site on lipid fractions for aquatic organisms that are considered more representative of the Lockheed West Site. Application of the LDW data on lipid fractions to the BSAF modeling of each Lockheed West Site aquatic organism, rather than using values from the literature, helps ensure that tissue concentrations are not underpredicted. The lipid fractions used for modeling tissue concentrations in ROCs and their prey items at the Lockheed West Site are shown in Table 4-2.

The organic carbon fractions (F_{oc}) of 0.0126 (1.26 percent) and 0.003 (0.3 percent) are the mean organic carbon fractions from the full sediment data set (i.e., subtidal plus intertidal sediments) and for the intertidal sediments, respectively, from the 2007 sampling of the Lockheed West Site.

Table 4-2. Lipid and Moisture Contents of ROCs and Their Prey

Parameter	Mean Values	Source
Benthic Invertebrates[1/]		
Lipid content (%)	0.89	LDW Phase 2 data (n = 20).
Moisture (%)	79	Water content range data for bivalves, isopods, amphipods, and cladocerans reported in Sample et al. (1997).
Dungeness Crab[2/]		
Lipid content (%)	2.6	LDW Phase 1 and 2 data (n = 12).
Moisture (%)	82	LDW Phase 1 and 2 data (n = 12).
Pacific Staghorn Sculpin		
Lipid content (%)	2.1	LDW Phase 2 data (n = 28).
Moisture (%)	79	LDW Phase 2 data (n = 28).
English Sole[3/]		
Lipid content (%)	5.5	LDW Phase 2 data (n = 42).
Moisture (%)	75	LDW Phase 2 data (n = 42).

1/ Modeled as prey items for English sole, Pacific staghorn sculpin, and spotted sandpiper
2/ Lipid and moisture content of Dungeness crab were used to model tissue concentrations in the crab ROC
3/ Lipid and moisture content of English sole were used to model tissue concentrations in the fish ROC and fish prey for sculpin.
Source: Table D.4-1, Food web model, Appendix D of the LDW draft RI (Windward 2008). Phase 1 and Phase 2 refer to two phases of data collection in the LDW to support the RI.

BSAFs were not available for uptake of TBT or any other organotin by any species of fish, so empirical data from the LDW site were used to derive a field-based BSAF for fish. The site-wide mean concentrations of TBT in surficial sediment reported in the draft RI for the LDW site (Windward 2008) was 0.09 mg/kg dry wt, and the mean concentration of TBT in side-wide shiner surfperch reported in Attachment 11 of the LDW ERA (Windward 2007) was 0.058 mg/kg wet wt. Shiner surfperch tissue data were used for this comparison because they had the highest TBT tissue concentration of all fish collected from the LDW. The OC fraction (F_{oc}) was used as 0.0165 (1.65 percent), taken from the LDW draft RI (Windward 2008), and the lipid fraction (F_L) of 0.046 (4.6 percent) for shiner surfperch, also taken from the LDW RI, was used because it was the highest of all LDW fish, resulting in a more protective estimate of a field-based BSAF. Using these F_{oc} and F_L values and the site-wide concentrations of sediment TBT and TBT in shiner surf perch, with Equation 4-1, the resultant field-based BSAF for TBT in fish is 0.23.

BSAFs for modeling chemical uptake into tissues are taken from sources specific to fish, crab, and benthic invertebrates as ROCs or prey for ROCs, where available. Values for clams were used as surrogates where values were missing for ROCs or their prey. The sources of BSAFs and notes on their use are provided in Table 4-3. As a protective measure, the 90th percentile BSAFs were used or calculated for use in modeling tissue concentrations, except where indicated in Table 4-3 for Washington Department of Health values (Washington State Department of Health [WDOH] 1995) and EPA (1997c).

Table 4-3. Sources of BSAF Values

BSAF Source	Notes
USACE. 2008. US Army Corps of Engineers Environmental BSAF Database http://el.erdc.usace.army.mil/bsaf/BSAF.html	BSAFs were calculated as the 90th percentile of values identified as dry weight unless unavailable, then values identified as wet weight were used. BSAF values in this database are highly variable, and those identified as dry weight are generally more consistent and higher than other values, and were selected for BSAF estimation as a conservative measure. Specific selections of BSAFs for clams, benthic invertebrates, and crabs are described in footnotes to the tables on estimated tissue concentrations. No marine/estuarine fish BSAFs were available for COPCs from this source.
Tracey GA, Hansen DJ. 1996. Use of biota-sediment accumulation factors to assess similarity of nonionic organic chemical exposure to benthically-coupled organisms of differing trophic mode. Arch Environ Contam Toxicol 30:467-475.	Values were taken from the PAH group for *Macoma nasuta* for clams; from the PCB group for rock crab for crab and *M. nasuta* for clams; and from the pesticides group for *M. nasuta* for clams and for white perch for fish. No other crab or fish species values were available; chemical-specific values are not available.
EPA. 1997c. The incidence and severity of sediment contamination in surface waters of the United States. Volume 1: National Sediment Quality Survey. EPA 823-R-97-006. US Environmental Protection Agency, Office of Science and Technology, Washington, DC.	BSAFs are available for fish and were obtained from the EPA Office of Research and Development (EPA ORD) Environmental Research Laboratories at Duluth, Minnesota, and Narragansett, Rhode Island. The BSAFs developed by EPA ORD-Narragansett are mean values for benthic organisms and demersal (bottom-dwelling) fishes. The BSAFs developed by EPA ORD-Duluth are for benthically coupled pelagic (open-water) fishes. Species of organism is not specified.
Washington State Department of Health. 1995. Tier I report, development of sediment quality criteria for the protection of human health. Washington State Department of Health, Olympia, Washington.	BSAFs were taken from the chemical class groups, which are recommended by WDOH as 75th percentile values developed from multiple databases for various fish species. Values are based on a mix of empirical national data and surrogates using chemical groupings.
PTI. 1995. Bioaccumulation Factor Approach Analysis for Metals and Polar Compounds. Washington Department of Ecology.	BSAFs for metals were used as 90th percentile values for marine/estuarine deposit feeder clams (cadmium, lead, zinc), or filter feeders where deposit feeder data were unavailable. (chromium, copper, mercury). BSAFs for metals are used without normalizing tissues for lipid content or sediment for organic carbon content.
Oak Ridge National Laboratory. 1998. Biota Sediment Accumulation Factors for Invertebrates: Review and Recommendations for the Oak Ridge Reservation. Bechtel Jacobs Co.	BSAFs are available for metals in freshwater clams; the 90th percentile value for nickel was selected for modeling benthic invertebrate tissue because a BSAF was not available in PTI (1995).
Windward. 2007. Ecological Risk Assessment, Lower Duwamish Waterway, Attachment 11.	Regression equations on collocated benthic invertebrates and sediment data were developed for arsenic, PCBs, and TBT using LDW site data and applied to benthic invertebrates.
Windward. 2008. Remedial Investigation, Draft, Lower Duwamish Waterway, Appendix D, Food Web Model.	Regression equations for total PCBs in fish and crab tissues, developed from the food web model, as calibrated with LDW site data.

4.1.1.2 Regression Models

In addition to the numerical BSAFs used in modeling described above, two sets of regression models taken from LDW site documents are available for select chemicals and tissues: 1) regression equations based on relationships between sediment and benthic invertebrate tissue concentrations at the LDW site; and 2) regression equations for total PCBs developed in the LDW RI from a numerical food web model (FWM). Each of these sets of regression equations is described below.

Benthic Invertebrate Regression Model

For modeling arsenic, TBT, and total PCBs into tissue of benthic invertebrates, which serve as prey for fish, regression equations based on relationships between sediment and benthic invertebrate tissue concentrations at the LDW site were used. Significant regressions had been found for arsenic, TBT, and PCBs between co-located sediment and benthic invertebrate tissue data collected from the LDW site (Attachment 11 to the LDW ERA, Windward 2007). Benthic invertebrate tissue samples were collected from 10 intertidal locations and 10 subtidal locations, with co-located sediment collected from each location. The sample locations were selected to represent areas that covered the range of arsenic, TBT, and PCB concentrations measured throughout the LDW, so that a relationship between chemical concentrations in sediment and benthic invertebrate tissue could be established (Windward 2007).

The concentrations of arsenic, TBT, and total PCBs in tissue of benthic invertebrates at the Lockheed West Site were modeled using the regression equations and the 95 UCL concentrations of these chemicals in sediment from the Lockheed West Site. Note that the modeling of TBT into benthic invertebrate tissue was previously described for the exposure assessment of benthic invertebrates in Section 3.1. The LDW regression equations for benthic invertebrates are as follows:

> Arsenic: y = 5.1x^0.47, R^2 = 0.96, exponential model; units in mg/kg dw.
>
> PCBs: y = 75 + 0.37x; R^2 = 0.67; linear model; units in µg/kg dw sediment and µg/kg ww tissue.
>
> TBT: y = 145x^0.18; R^2 = 0.59; exponential model; units in mg/kg dw.

Food Web Model Regression Equations for PCBs

A second set of regression equations was used to model total PCB concentrations in fish and crab tissues, using regression equations developed in the RI report for the LDW site. Regression equations for total PCBs were developed in the LDW RI from the food web model (FWM); the FWM regression equations are taken from Appendix D, Food Web Model, of the draft final RI for the LDW site (Windward 2008). The LDW FWM was used to develop the relationships between PCB concentrations in sediment and various marine tissues at the LDW site. The application of the LDW FWM to model tissue concentrations at the Lockheed West Site was based on the understanding that the aquatic organisms that were modeled at the LDW site are also present in the estuarine environment of the Lockheed West Site, that the subtidal and intertidal habitats of the two sites are similar, and that the range of concentrations of PCBs in Lockheed West Site sediment is similar to that range found in the sediments of the LDW site. Due to the similar habitats and continuity of the Lockheed West site with the LDW site, the food resources and various physiological and chemical parameters used in the modeling of the LDW site would be expected to be present in the aquatic ecosystem of the Lockheed West Site.

The FWM was developed in the LDW RI to estimate the relationship between total PCB concentrations in tissue and sediment in order to estimate risk-based threshold concentrations (RBTCs) in sediment for the RI. The structure of the FWM was based on the Arnot and Gobas model (Arnot and Gobas 2004), a steady-state bioaccumulation model. The FWM provides estimates of total PCB concentrations for nine species or species groups, many of which were ecological receptors, prey for ecological receptors, or seafood organisms evaluated for human consumption in the ERA and HHRA for the LDW site. The species or species groups included English sole, crabs, clams, and pelagic fish species, which are also ROCs or prey items of ROCs for the Lockheed West Site ERA.

Input parameter values and distributions for the model were based on literature-derived and site-specific environmental data. The model was calibrated to identify sets of parameter values that best estimated empirical tissue PCB concentration data. For many model input parameters, distributions of estimates of mean values were developed to reflect uncertainty in their values. Calibration was performed using a probabilistic approach in order to systematically explore all combinations of plausible parameter sets and their corresponding estimated total PCB concentrations in tissue. Through the calibration process, a best-fit parameter set was identified that estimated total PCB concentrations for all modeled fish and crab species within a factor of 2 (1.2 on average) of empirical data. The input parameters that most influenced the model output were dietary absorption for crabs, relative fractions of benthic versus pelagic food items in the diet of fish and crabs, and parameters that characterized prey species (such as lipid content and porewater ventilation rate).

The FWM was calibrated at a LDW-wide spatial scale, and tested at smaller scales within the LDW. Based on these analyses, application of the FWM appeared to be most appropriate at the modeling area scale for shiner surfperch. This modeling area scale is approximately a one-mile length segment of the waterway, which is approximately similar to the total length of the aquatic shoreline of the Lockheed West Site. The FWM was also found to perform well for clams at locations in the LDW with sediment concentrations of total PCBs at 3,300 µg/kg dw or lower. The exposure point concentration of total PCBs in combined subtidal and intertidal sediment at the Lockheed West Site is 498.3 µg/kg dw, which is less than the value identified above for the FWM performance. The FWM was used to model tissue concentrations into crab and fish from the combined subtidal and intertidal sediment total PCB concentrations at the Lockheed West Site, as described below.

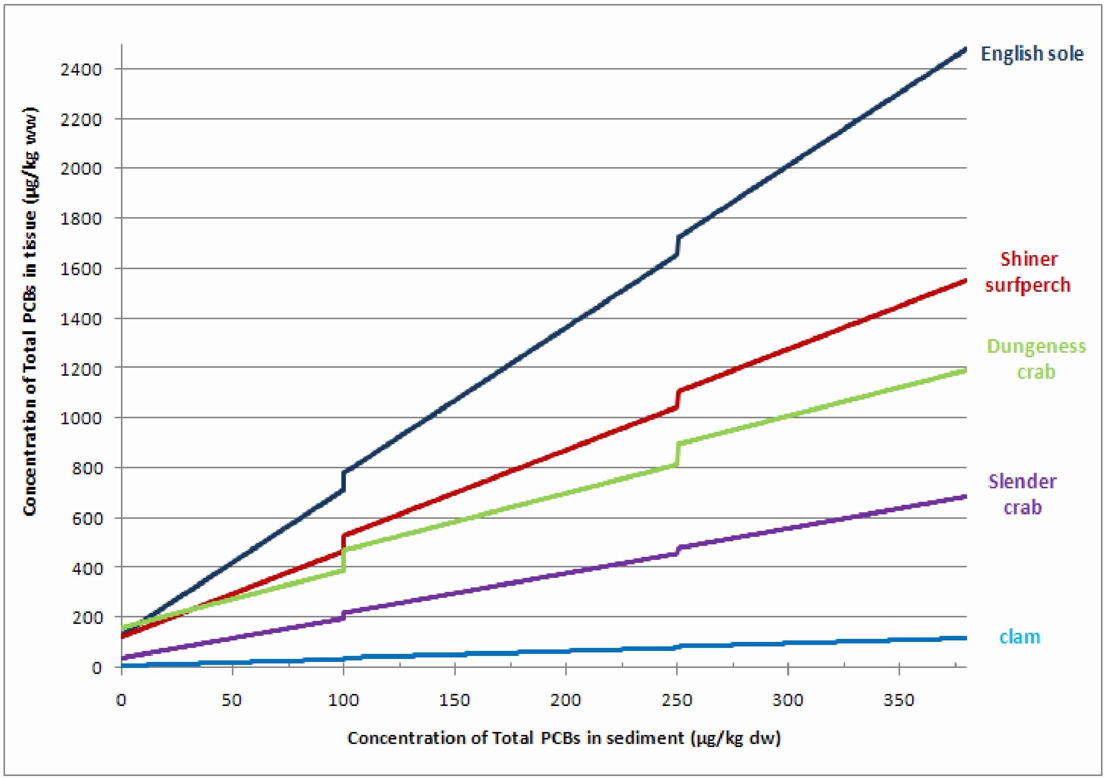
Figure 4-1 below presents a graph from Appendix D of the LDW draft RI that shows an output of the model displaying the best fit relationships between sediment PCBs (total) and tissue PCBs (total) for various organisms. These are modeled outputs, not the actual data from the site. The modeled output data on tissue concentrations are based on best fit modeling of concentrations using empirical data for numerous site-specific parameters related to the LDW. The regression lines of the graph in Figure 4-1 show up as steps due to the incorporation in the model of differing water concentrations of PCBs in intervals. Further details on the development of the FWM and its calibration for the LDW site can be found in Appendix D of the RI report for the LDW site (Windward 2008).

Based on the tabulated data from the FWM for the LDW that are graphed in Figure 4-1, simple regression equations for total PCBs in tissue of fish and crab were developed in Appendix D of the LDW RI report:

English sole whole body: $y = 6.2255x + 118.05$

Dungeness crab whole body: $y = 2.779x + 145.28$

The regression equations are used in place of numerical BSAFs for modeling PCBs in fish (English sole whole body equation) and crab (Dungeness crab whole body equation) tissues for the Lockheed West Site.



Source: LDW Draft Final RI (Windward 2008)

Figure 4-1. LDW Food Web Model Output of Total PCB Concentrations in Whole-body Tissues of Seafood as a Function of Total PCB Concentrations in Sediment

The LDW regression equations for total PCBs were used instead of BSAF values partly because of the limited availability of PCB BSAFs, particularly for fish. In addition, use of the regression equations for modeling was considered to be more specific to the Lockheed West Site than using literature-based BSAFs, given the proximity of the Lockheed West Site to the LDW site from which site data were used to calibrate the FWM, and the likelihood that crab and fish home ranges overlap both sites. Food web modeling was not performed for the Site; instead it was assumed that the food web modeling performed for the upstream LDW site was sufficiently protective for application of the regression equations to the Lockheed West Site ERA, based on the above discussion.

4.2 FISH EXPOSURE ASSESSMENT

The approach to determining exposures of fish to site-related chemicals depends on the specific method for evaluating risks. Potential exposure of fish to sediment-related COPCs was evaluated by two approaches: 1) modeling sediment COPCs into food items for fish and estimating daily dietary intake of COPCs from food and sediment ingestion, and 2) modeling COPCs into fish tissues. Two types of fish are evaluated for exposures to sediment COPCs: demersal and pelagic fish. As described in the Problem Formulation, demersal fish are characterized for potentially high exposures of bottom-feeding flatfish such as the English sole, and pelagic fish are characterized by the Pacific staghorn sculpin.

For those COPCs for which risks are evaluated using tissue concentrations, exposures are estimated using whole-body tissue residues. Examples of these chemicals include PCBs, mercury, DDT, and TBT. For those COPCs for which risks are assessed through dietary exposures, exposures to fish are determined through concentrations of COPCs in dietary items. A dietary approach is used for exposures to PAHs and metals because these chemicals are either metabolized or actively regulated by fish. The selection of tissue residue or dietary method for evaluating fish risks follows the approach described in the ERA for the LDW site (Windward 2007).

As described above, tissue modeling is performed following the BSAF method, supplemented with use of regression relationships using LDW site data. Exposure point concentrations of COPCs from the intertidal and subtidal surficial sediment samples collected from the Site in 2007 (expressed as 95 percent UCLs on the mean concentrations, or maximum concentrations if less then six detections) are used as sediment data in the modeling.

4.2.1 Dietary Exposures

This section presents the approach used to estimate exposure of fish ROCs to COPCs evaluated through dietary exposures. The dietary approach for fish exposures follows the approach used in the LDW ERA. Comparison of chemical concentrations in prey to suitable dietary TRVs is preferable for COPCs that are metabolized by fish, such as PAHs (Varanasi 1989), or that are highly regulated, such as metals, except for butyltins, mercury, and selenium, which are evaluated by the tissue residue approach. Most aquatic organisms have specific mechanisms for uptake, internal transport, sequestration, and depuration of metals (Meyer et al. 2005).

The primary dietary exposure routes for these COPCs were assumed to be ingestion of food and incidental ingestion of sediment. Although direct water contact and water ingestion are complete exposure pathways for fish ROCs, risks associated with water exposure have previously been evaluated for the West Waterway in the King County Water Quality Assessment (King County 1999). The contribution of Lockheed West Site sediment contaminants to water column exposures of fish is considered to be very low compared with sediment contributions to fish tissue loads through the ingestion of benthic prey and ingestion of sediment pathways. For that reason, water quality issues in the West Waterway or Elliott Bay areas of the Site are not further evaluated for ecological risks.

The dietary exposure approach requires an approximation of the COPC concentration in the diet of the receptor. This section presents the dietary exposure assumptions for each fish ROC, the dietary exposure calculation methods, and the results of the exposure calculations. To approximate the dietary concentrations for each fish ROC, the feeding habits of each ROC were considered. ROC-specific exposure assumptions are described below.

4.2.1.1 Sediment Exposure Point Concentrations

Concentrations of COPCs in sediments in the combined subtidal and intertidal areas of the Lockheed West Site were developed from the 2007 sediment sampling results. The method used to develop exposure point concentrations (EPCs) for sediment was to calculate 95 UCLs using ProUCL 4.0 software. ProUCL tests for normality, lognormality, and gamma distributions of the dataset and computes 95 percent UCLs of the unknown population mean for each distribution type (EPA 2007). The ProUCL software then recommends a 95 UCL based on the data distribution.

For each COPC that was detected in at least 6 samples, the UCL recommended by ProUCL was used as the exposure concentration. ProUCL is not recommended for use in determining UCLs for datasets with a percentage of non-detects greater than 15 percent when a simple substitution method for non-detects has been employed (EPA 2007). For chemicals with less than 6 detected values out of the 51 samples in the full sediment dataset, the maximum concentration is used as the sediment EPC. For chemicals with non-detected values, ProUCL uses robust regression on order statistic (ROS) methods to fill-in a set of concentrations for nondetects that results in a better estimate of central tendency than other substitution methods (e.g., use of ½ the detection limit for the non-detected value). ProUCL assumes a distribution for the non-detected values based on the distribution of the detected concentrations, and substitutes values for the non-detected concentrations. The full dataset, including the substituted concentrations, is then used by ProUCL to calculate the 95 UCL. For the Lockheed West Site sediment dataset, none of the sediment UCLs are based on the use of ½ detection limits, and sediment EPCs are either the ProUCL-recommended value for the 95 UCL or the maximum value.

Table 4-4 presents summary statistics (e.g., frequency of detection, minimum concentrations, maximum concentrations, the distribution of the data, the 95 UCL, and the EPC) for each tissue COPC in intertidal plus subtidal sediments of the Lockheed West Site.

Table 4-4. Summary Statistics for COPCs in Intertidal Plus Subtidal Sediment

COPC	Units	Detection Frequency	Mean Conc.	Min. Conc.	Max. Conc.	Distribution	Recommended UCL	Exposure Point Concentration
Metals								
Chromium	mg/kg dw	51/51	73.21	14.4	504	Lognormal	90.0	90
Copper	mg/kg dw	51/51	281.5	28.2	1,900	Nonparametric, 97.5%	618	618
Lead	mg/kg dw	51/51	145.7	15.9	1,420	Lognormal	200	200
Mercury	mg/kg dw	51/51	0.479	0.021	2.94	Gamma	0.61	0.61
Selenium	mg/kg dw	35/51	0.582	0.2	1.2	Nonparametric	0.67	0.67
PAHs								
Acenaphthene	µg/kg dw	48/51	75.69	2.8	450	Gamma	130	130
Acenaphthylene	µg/kg dw	50/51	81.87	3	650	Gamma	146	146
Anthracene	µg/kg dw	50/51	281.5	3.9	2,500	Gamma	519	519
Benzo(a)anthracene	µg/kg dw	51/51	534.7	2.6	2,700	Gamma	709	709
Benzo(a)pyrene	µg/kg dw	51/51	518.4	2.6	2,000	Gamma	680	680
Benzo(b)fluoranthene	µg/kg dw	51/51	838.7	5	3,400	Gamma	1,110	1,110
Benzo(g,h,i)perylene	µg/kg dw	51/51	290.4	4.3	1,300	Gamma	379	379
Benzo(k)fluoranthene	µg/kg dw	50/51	331.9	7.3	1,500	Gamma	549	549
Benzofluoranthenes (total)	µg/kg dw	51/51	1170	5	4,600	Gamma	1,548	1,548
Chrysene	µg/kg dw	51/51	833.3	3.1	5,800	Gamma	1,123	1,123
Dibenzo(a,h)anthracene	µg/kg dw	49/51	83.67	3.6	340	Lognormal	134	134
Fluoranthene	µg/kg dw	51/51	1699	4.5	33,000	Approx. Gamma	2,381	2,381
Fluorene	µg/kg dw	48/51	92.84	2.8	470	Gamma	153	153
Indeno(1,2,3-cd)pyrene	µg/kg dw	51/51	321.8	2.9	1,400	Gamma	422	422
Phenanthrene	µg/kg dw	50/51	579.1	4.5	3,200	Gamma	977	977
Pyrene	µg/kg dw	51/51	1469	3.8	23,000	Approx. Gamma	2,042	2,042
Total PAH	µg/kg dw	51/51	8095	28.8	72,924	Gamma	10,870	10,870
Organometals								
Tributyltin	µg/kg dw	51/51	665.1	0.81	4,500	Lognormal	2,810	2,810
SVOCs								
Pentachlorophenol	µg/kg dw	20/51	82.93	16	570	Nonparametric	123.8	123.8
PCBs								
PCB-1254	µg/kg dw	51/51	210.5	4.2	1,400	Lognormal	368	368
PCB-1260	µg/kg dw	45/51	150.7	7.6	900	Lognormal	269	269
PCB-1268	µg/kg dw	7/51	29.71	23	160	Lognormal	36	36
PCBs (total)	µg/kg dw	51/51	370.2	4.2	2240	Gamma	498.3	498.3

Table 4-4. Summary Statistics for COPCs in Intertidal Plus Subtidal Sediment (continued)

COPC	Units	Detection Frequency	Mean Conc.	Min. Conc.	Max. Conc.	Distribution	Recommended UCL	Exposure Point Concentration
Pesticides								
p,p-DDD	µg/kg dw	12/51	3.798	3.1	14	Normal	4.5	4.5
p,p-DDT	µg/kg dw	41/51	15.11	0.28	97	Gamma	27.28	27.28
Total DDT	µg/kg dw	49/51	16.32	0.28	294	Lognormal	75.5	75.5
gamma-Chlordane	µg/kg dw	29/51	5.465	0.14	46	Gamma	7.5	7.5
Methoxychlor	µg/kg dw	4/51	7.769	11	15	Normal	8.19	15
Mirex	µg/kg dw	5/51	0.454	0.2	3	Normal	0.7	3
Total Chlordane	µg/kg dw	29/51	5.465	0.14	46	Gamma	7.50	7.50

Data distribution and upper confidence limits determined using ProUCL 4.0.
Exposure Point Concentrations are 95 UCL, or maximum values where less than 6 detected values.
All pesticides were qualified JN, estimated and tentatively identified until confirmed.
All non-detects were evaluated by the Kaplan-Meier (KM) Method, with substitution based on distribution of detected values; UCL values were as recommended by ProUCL 4.0.
Duplicate samples (for stations 4, 5, and 6) were first averaged prior to calculation of summary statistics.
NA – ProUCL was unable to calculate a UCL for this compound because there were insufficient detections of the compound in the data subset.
ND – There were no detections of this compound in this data subset, therefore there is no maximum concentration.

4.2.1.2 Prey Tissue Exposure Point Concentrations

Prey items of English sole were assumed to consist of invertebrates that reside in direct contact with contaminated sediments; whereas prey items for Pacific staghorn sculpin are assumed to be small fish, crabs, and benthic invertebrates associated with site sediment. The methods used to model concentrations of PAH and metal COPCs in prey items of fish have been described above in Section 4.1.

The modeled prey tissue EPCs are used as dietary exposure values for comparison with the literature effects values for dietary items. Biota prey concentrations resulting from the modeling are presented as both wet weight and dry weights assuming average moisture contents taken from the moisture contents for organisms collected from the LDW shown above in Table 4-2 (Windward 2008).

Lipid content used to model tissue concentrations in each prey item was taken from Table 4-2 above. The fraction of organic carbon in Lockheed West Site combined subtidal and intertidal sediments was set at 1.26 percent based on the mean of 51 subtidal plus intertidal sediment stations from the 2007 data set. For intertidal sediments, from which intertidal benthic invertebrate tissue concentrations are modeled, the fraction of organic carbon was set at 0.3 percent, which is the mean total organic carbon of the nine intertidal stations.

The BSAFs for PAHs developed by WDOH (1995) are based on empirical studies, where chemical concentrations were measured in fish and shellfish. Values are presented as 75th percentile values for upper trophic fish, and were considered by WDOH to be sufficiently conservative for predicting tissue concentrations in fish. BSAFs presented for metals in fish and shellfish in PTI (1995) are the 90th percentile values, as are the values derived from the USACE (2008) BSAF database and presented in Table 4-3. The conditions of the empirical studies may not be similar to the conditions at the Lockheed West Site; however, to ensure that the uptake of sediment PAHs in the fish tissue is not under-estimated we used the 75th percentile values of the BSAFs for PAHs in fish and 90th percentiles for metals and all other chemicals in fish and dietary prey items.

As summarized in the LDW ERA (Windward 2007), stomach contents analyses of English sole collected from Puget Sound show that English sole ingest almost exclusively benthic invertebrates such as marine worms, amphipods, bivalves, and mollusks (Fresh et al. 1979; Wingert et al. 1979). Based on these stomach contents analyses, all prey of English sole were assumed to be represented by modeled concentrations in benthic invertebrate. In addition, incidental sediment ingestion of 1 percent was assumed based on anecdotal stomach contents observations of English sole and other bottom-feeding fish (Johnson 2006; Lange 2006; as cited in Windward 2007). Although English sole foraging ranges are uncertain, the available information (Day 1976; Stern et al. 2003) suggests that English sole that may be present at the Lockheed West Site would forage in an area much larger than the Site, and probably forage within both Elliott Bay and the LDW. The fraction of foraging that may occur at the Site was not included in the modeling of E. sole tissue levels; i.e., an area use factor of 1 was assumed and dietary exposure was calculated on a site-wide basis.

Stomach contents analyses of Pacific staghorn sculpin collected from Puget Sound show that they ingest small fish and benthic invertebrates such as crabs, shrimp, marine worms, and amphipods (Wingert et al. 1979; Fresh et al. 1979; Miller et al. 1977a,b). Based on the relative proportions of biomass reported in stomach contents analyses of Pacific staghorn sculpin in Puget Sound, the average proportions of dietary components in the exposure estimates was assumed to be 44 percent fish, 32 percent crabs and shrimp, and 23 percent benthic invertebrates (Wingert et al. 1979; Fresh et al. 1979; Miller et al. 1977a,b). Incidental sediment ingestion of 1 percent of the diet was assumed based on the primarily epifaunal diet of Pacific staghorn sculpin (Lange 2006). No data are available to determine Pacific staghorn sculpin foraging area; however, based on discussions presented in the LDW ERA (Windward 2007), Pacific staghorn sculpin may have foraging areas similar to the approximately one mile long areas designated in the LDW ERA, which is as large or larger than the size of the Lockheed West Site. Therefore an area use factor, or foraging factor, of 1 is also used for Pacific staghorn sculpin. The relative proportions of each prey item in each fish ROC diet are summarized in Table 4-5.

Table 4-5. Proportions of Dietary Items in Dietary Exposure Estimates for each Fish ROC

Receptor of Concern	Prey Item	Proportion in Diet (unitless)	Source
English sole	Benthic invertebrates	0.99	Fresh et al. (1979) Wingert et al. (1979)
	Sediment	0.01	Johnson (2006) Lange (2006)
Pacific Staghorn sculpin	Fish	0.44	Fresh et al (1979) Wingert et al (1979) Miller et al (1977a,b)
	Benthic invertebrates	0.23	
	Crabs	0.32	
	Sediment	0.01	Lange (2006)

Using the ROC-specific assumptions described above, COPC concentrations in the diet of each fish ROC were calculated as the weighted average of COPC concentrations in sediment and prey tissue using Equation 4-3.

$$C_{diet} = \sum_{i=1}^{n} X_i C_i \qquad \textbf{Equation 4-3}$$

Where:

C_{diet} = COPC concentration in the diet (mg/kg dw or µg/kg dw)
X_i = proportion of a particular food item (or sediment) in the diet (unitless)
C_i = COPC concentration in the prey item (mg/kg dw or µg/kg dw)
n = number of dietary items

Concentrations of chemicals in each fish prey item were modeled from the sediment EPCs of the full subtidal plus intertidal sediment data set. For benthic invertebrate prey for English sole and Pacific staghorn sculpin, EPCs were calculated using the BSAF method for most COPCs, and the regression equations for arsenic, TBT, and PCBs, as described above.

The estimated chemical concentrations of COPCs in tissues of benthic invertebrate prey items for English sole and Pacific Staghorn sculpin are shown in Table 4-6. Concentrations of COPCs in fish prey items for Pacific staghorn sculpin in Table 4-7, and in crab prey for Pacific staghorn sculpin in Table 4-8.

4.2.2 Whole Body Fish Tissue Exposures

For those COPCs for which risks to fish are evaluated through the tissue residue method, concentrations in fish tissue are estimated through modeling. Tissue modeling is performed following the methods described above in Section 4.1. The EPCs of COPCs from the intertidal and subtidal surficial sediment samples collected from the Site in 2007 are used as sediment data in the modeling.

BSAFs used for the modeling of whole body fish tissue concentrations are described in the database sources as developed from higher trophic fish (WDOH 1995, EPA 1997c), and are therefore considered to be sufficiently conservative for modeling tissue concentrations for English sole and Pacific staghorn sculpin at the Lockheed West Site. Where fish are described as being demersal fish in other sources of BSAFs (e.g., EPA 1997c), it is assumed that the BSAFs are applicable to English sole. English sole is considered to be the highest trophic fish ROC that may be exposed to sediments at the Lockheed West Site, as was determined in the FWM for the LDW site (Windward 2005b,c; 2006b). The FWM calibrations and results of tissue modeling can be found in Appendix D of the RI report (Windward 2008). For a given concentration of total PCBs in sediment, the FWM predicted highest tissue concentrations in English sole whole body compared to tissues of Pacific staghorn sculpin, crabs, and other aquatic organisms at the site.

Table 4-6. Modeled Tissue Concentrations of COPCs in Benthic Invertebrate Prey

COPC	Csed (mg/kg dw)	F_l	F_{oc}	BSAF[1/]	BSAF Reference	BI C_T (mg/kg dw)	BI C_T (mg/kg ww)
Metals							
Chromium	90.0	-	-	0.0043	3	0.39	0.08
Copper	618	-	-	0.452	3	279	59
Lead	200	-	-	2.54	3	508	107
Mercury	0.61	-	-	0.92	3	0.56	0.12
Selenium	0.67	-	-	na	na	na	na
PAHs							
Acenaphthene	0.130	0.0089	0.0126	2.01	2	0.88	0.185
Acenaphthylene	0.146	0.0089	0.0126	2.64	2	1.29	0.271
Anthracene	0.519	0.0089	0.0126	2.07	2	3.60	0.757
Benzo(a)anthracene	0.709	0.0089	0.0126	0.62	2	1.47	0.308
Benzo(a)pyrene	0.680	0.0089	0.0126	0.37	2	0.85	0.178
Benzo(b)fluoranthene	1.11	0.0089	0.0126	0.91	2	3.38	0.710
Benzo(g,h,i)perylene	0.379	0.0089	0.0126	0.02	2	0.02	0.004
Benzo(k)fluoranthene	0.549	0.0089	0.0126	1.08	2	2.00	0.419
Benzofluoranthenes (total)	1.55	0.0089	0.0126	0.72	2	3.72	0.782
Chrysene	1.12	0.0089	0.0126	0.68	2	2.56	0.538
Dibenzo(a,h)anthracene	0.134	0.0089	0.0126	0.54	2	0.25	0.052
Fluoranthene	2.38	0.0089	0.0126	0.79	2	6.30	1.32
Fluorene	0.153	0.0089	0.0126	1.54	2	0.79	0.166
Indeno(1,2,3-cd)pyrene	0.422	0.0089	0.0126	0.26	2	0.37	0.077
Phenanthrene	0.977	0.0089	0.0126	0.09	2	0.29	0.060
Pyrene	2.04	0.0089	0.0126	0.52	2	3.60	0.756
Total PAH	10.9	0.0089	0.0126	0.77	2	28.3	5.94
Organometals							
Tri-n-butyltin	2.81	-	-	-	4	0.608	0.128
Other SVOCs							
Pentachlorophenol	0.124	0.0089	0.0126	0.105	1	0.04	0.009
PCBs							
Aroclor 1254	0.368	0.0089	0.0126	4.01	2	4.96	1.043
Aroclor 1260	0.269	0.0089	0.0126	4.01	2[2/]	3.63	0.763
Aroclor 1268	0.036	0.0089	0.0126	4.01	2[2/]	0.49	0.103
Total PCBs	0.498	0.0089	0.0126	-	4	1.24	0.259

Table 4-6. Modeled Tissue Concentrations of COPCs in Benthic Invertebrate Prey (continued)

COPC	Csed (mg/kg dw)	F_l	F_{oc}	BSAF[1/]	BSAF Reference	BI C_T (mg/kg dw)	BI C_T (mg/kg ww)
Pesticides							
4,4'-DDD	0.004	0.0089	0.0126	4.23	2	0.06	0.013
4,4'-DDT	0.027	0.0089	0.0126	0.76	2	0.07	0.015
Total DDT	0.076	0.0089	0.0126	5.55	2	1.41	0.296
Chlordane (gamma)	0.008	0.0089	0.0126	4.1	2	0.10	0.022
Methoxychlor	0.015	0.0089	0.0126	1.8	2	0.09	0.019
Mirex	0.003	0.0089	0.0126	1.8	2[3/]	0.02	0.004
Total Chlordanes	0.008	0.0089	0.0126	4.1	2	0.10	0.022

[1/] BSAFs for metals are from deposit feeding clams or filter feeding clams (e.g., copper), and for organic chemicals are from benthic invertebrates or based on regression modeling for TBT and PCBs.
[2/] Aroclor 1254 used as surrogate for Aroclor 1260 and 1268
[3/] Methoxychlor used as surrogate for Mirex.
Csed – exposure point concentration in subtidal plus intertidal sediment
BI C_T – Exposure point concentration in benthic invertebrate whole body
Foc – fraction of organic carbon in Lockheed West Site sediment; average organic carbon for 42 subtidal plus 9 intertidal sediment stations is 1.26%, 2007 data set; in dry weight.
Fl – fraction lipid in benthic invertebrates from the LDW RI (Windward 2008); assumed to be wet weight.
na – not available
Moisture content assumed at 79%, based on LDW benthic invertebrate data in the LDW RI.
BSAF references:

1. Washington State Department of Health. 1995. Tier I report, development of sediment quality criteria for the protection of human health. Washington State Department of Health, Olympia, WA. Values are for higher trophic fish.
2. USACE 2008. BSAF Database, http://el.erdc.usace.army.mil/bsaf/BSAF.html; 90th percentile of all marine/estuarine mollusks, crustacea, worms, and echinoderm values. Dry weight values used if n>2, otherwise wet values used.
3. PTI 1995. Bioaccumulation Factor Approach Analysis for Metals and Polar Compounds. Washington Department of Ecology. Based on 90th percentile values for deposit feeder clams, or filter feeders if no deposit feeder data.
4. Based on a regression equation using LDW site data, as reported in Windward (2007), Attachment 11. Equation for arsenic: tissue concentration = 5.1 x (sediment concentration^0.47); units in mg/kg dw. Equation for PCBs: tissue concentration = 75 + 0.37 x sediment concentration; units calculated as µg/kg dw sediment and µg/kg ww tissue. Equation for TBT: tissue concentration = sediment concentration^0.1801 x 145.4; units calculated as µg/kg dw sediment, and µg/kg dw tissue, converted to mg/kg ww.

Table 4-7. Modeled Tissue Concentrations of COPCs in Fish Whole Body

Chemical	C_{sed} (mg/kg dw)	F_l	F_{oc}	BSAF[1/]	BSAF Reference	Fish C_T (mg/kg dw)	Fish C_T (mg/kg ww)
Metals							
Chromium	90.0	-	-	0.043	3	3.87	0.97
Copper	618	-	-	0.452	3	279	69.8
Lead	200	-	-	0.35	3	70	17.5
Mercury	0.61	-	-	0.535	3	0.33	0.08
Selenium	0.67	-	-	na	na	na	na
PAHs							
Acenaphthene	0.130	0.055	0.0126	0.083	2	0.19	0.047
Acenaphthylene	0.146	0.055	0.0126	0.083	2	0.21	0.053
Anthracene	0.519	0.055	0.0126	0.05	2	0.45	0.11
Benzo(a)anthracene	0.709	0.055	0.0126	0.105	2	1.30	0.33
Benzo(a)pyrene	0.680	0.055	0.0126	0.105	2	1.25	0.31
Benzo(b)fluoranthene	1.11	0.055	0.0126	0.105	2	2.04	0.51
Benzo(g,h,i)perylene	0.379	0.055	0.0126	0.105	2	0.69	0.17
Benzo(k)fluoranthene	0.549	0.055	0.0126	0.105	2	1.01	0.25
Benzofluoranthenes (total)	1.55	0.055	0.0126	0.105	2	2.84	0.71
Chrysene	1.12	0.055	0.0126	0.105	2	2.06	0.52
Dibenzo(a,h)anthracene	0.134	0.055	0.0126	0.105	2	0.25	0.062
Fluoranthene	2.38	0.055	0.0126	0.105	2	4.37	1.09
Fluorene	0.153	0.055	0.0126	0.083	2	0.22	0.055
Indeno(1,2,3-cd)pyrene	0.422	0.055	0.0126	0.105	2	0.77	0.19
Phenanthrene	0.977	0.055	0.0126	0.105	2	1.79	0.45
Pyrene	2.04	0.055	0.0126	0.105	2	3.74	0.94
Total PAH	10.87	0.055	0.0126	0.105	2	19.9	4.98
Organometals							
Tri-n-butyltin	2.81	0.055	0.0126	0.23	4	11.34	2.84
Other SVOCs							
Pentachlorophenol	0.124	0.055	0.0126	0.105	2	0.23	0.057
PCBs							
Aroclor 1254	0.368	0.055	0.0126	3.962	2	25.4	5.32
Aroclor 1260	0.269	0.055	0.0126	4.134	2	19.4	4.06
Aroclor 1268	0.036	0.055	0.0126	3.962	2[2/]	2.52	0.53
PCBs (total)	0.498	-	-	-	5	12.9	3.22

Table 4-7. Modeled Tissue Concentrations of COPCs in Fish Whole Body (continued)

Chemical	C_{sed} (mg/kg dw)	F_l	F_{oc}	BSAF[1/]	BSAF Reference	Fish C_T (mg/kg dw)	Fish C_T (mg/kg ww)
Pesticides							
4,4'-DDD	0.004	0.055	0.0126	7.7	1	0.60	0.15
4,4'-DDT	0.027	0.055	0.0126	7.7	1	3.67	0.92
Total DDT	0.076	0.055	0.0126	7.7	1	10.2	2.54
Chlordane (gamma)	0.008	0.055	0.0126	4.77	1	0.62	0.16
Methoxychlor	0.015	0.055	0.0126	1.8	1	0.47	0.12
Mirex	0.003	0.055	0.0126	1.31	1	0.07	0.017
Total Chlordane	0.008	0.055	0.0126	4.77	1	0.62	0.16

[1/] BSAFs presented for fish groupings where available.
[2/] Aroclor 1254 used as surrogate for Aroclor 1268
C_{sed} – Exposure point concentration in sediment, converted to units of mg/kg dry weight for use with Foc.
Fish C_T – Exposure point concentration in fish whole body
Foc – fraction of organic carbon in Lockheed West Site sediment; average organic carbon for 42 subtidal plus 9 intertidal sediment stations is 1.26%, from the 2007 data set; in dry weight.
Fl – fraction lipid in English sole from the LDW RI (Windward 2008), assumed to be wet weight; percent lipids from other fish species were lower and would result in less conservative lower EPCs.
Moisture content assumed at 75%, based on LDW English sole data in the LDW RI.
BSAF references:

1. EPA. 1997. The incidence and severity of sediment contamination in surface waters of the United States. Volume 1: national sediment quality survey. EPA 823-R-97-006. EPA, Office of Science and Technology, Washington, DC.
2. Washington State Department of Health. 1995. Tier I report, development of sediment quality criteria for the protection of human health. Washington State Department of Health, Olympia, WA. BSAFs are developed as 75th percentile values for upper trophic level fish (species not identified), and grouped into chemical classes based on Kow.
3. PTI 1995. Bioaccumulation Factor Approach Analysis for Metals and Polar Compounds. Washington Department of Ecology. Developed 90th percentile values for fish, except a single value for chromium; fish species not identified but stated as high trophic species. Copper based on 90th percentile for filter clams.
4. BSAF derived from mean TBT concentrations in site wide sediment and whole body pelagic fish for the LDW site (Windward 2008).
5. Based on the regression equation for English sole from the LDW food web model, Appendix D, draft final RI (Windward 2007c). Equation PCBs: tissue concentration = 6.2255 x sediment concentration + 118.05; units in µg/kg dw.

Table 4-8. Modeled Tissue Concentrations of COPCs in Crab Whole Body

Chemical	C_{sed} (mg/kg dw)	F_l	F_{oc}	BSAF[1/]	BSAF Reference	Crab C_T (mg/kg dw)	Crab C_T (mg/kg ww)
Metals							
Chromium	90	-	-	0.0043	5	0.39	0.07
Copper	618	-	-	0.14	4	87	14.7
Lead	200	-	-	0.028	4	5.6	0.95
Mercury	0.61	-	-	0.13	4	0.079	0.013
Selenium	0.67	-	-	na	na	na	na
PAHs							
Acenaphthene	0.130	0.026	0.0126	1.55	2	2.45	0.42
Acenaphthylene	0.146	0.026	0.0126	2.64	2	4.66	0.79
Anthracene	0.519	0.026	0.0126	3.10	2	19.5	3.32
Benzo(a)anthracene	0.709	0.026	0.0126	1.74	2	15.0	2.55
Benzo(a)pyrene	0.68	0.026	0.0126	0.14	2	1.19	0.20
Benzo(b)fluoranthene	1.11	0.026	0.0126	1.48	2	19.9	3.38
Benzo(g,h,i)perylene	0.379	0.026	0.0126	0.02	2	0.077	0.013
Benzo(k)fluoranthene	0.549	0.026	0.0126	1.07	2	7.16	1.22
Benzofluoranthenes (total)	1.55	0.026	0.0126	0.72	2	13.4	2.28
Chrysene	1.12	0.026	0.0126	1.17	2	15.9	2.71
Dibenzo(a,h)anthracene	0.134	0.026	0.0126	0.54	2	0.887	0.15
Fluoranthene	2.38	0.026	0.0126	0.77	2	22.4	3.80
Fluorene	0.153	0.026	0.0126	1.29	2	2.40	0.41
Indeno(1,2,3-cd)pyrene	0.422	0.026	0.0126	0.35	2	1.80	0.31
Phenanthrene	0.977	0.026	0.0126	0.09	2	1.03	0.18
Pyrene	2.04	0.026	0.0126	0.51	2	12.5	2.13
Total PAH	10.87	0.026	0.0126	0.77	2	102	17.4
Organometals							
Tri-n-butyltin	2.81	0.026	0.0126	4.181	2	143	24.2
Other SVOCs							
Pentachlorophenol	0.124	0.026	0.0126	0.105	1	0.16	0.027
PCBs							
Aroclor 1254	0.368	0.026	0.0126	1.0	3	4.46	0.76
Aroclor 1260	0.269	0.026	0.0126	1.0	3[2/]	3.27	0.56
Aroclor 1268	0.036	0.026	0.0126	1.0	3[2/]	0.44	0.075
PCBs (total)	0.498	-	-	-	6	9.0	1.53

Table 4-8. Modeled Tissue Concentrations of COPCs in Crab Whole Body (continued)

Chemical	C_{sed} (mg/kg dw)	F_l	F_{oc}	BSAF[1/]	BSAF Reference	Crab C_T (mg/kg dw)	Crab C_T (mg/kg ww)
Pesticides							
4,4'-DDD	0.004	0.026	0.0126	2.9	2	0.16	0.027
4,4'-DDT	0.027	0.026	0.0126	2.14	2	0.71	0.12
Total DDT	0.076	0.026	0.0126	2.852	2	2.62	0.45
Chlordane (gamma)	0.008	0.026	0.0126	2.21	2	0.20	0.034
Methoxychlor	0.015	0.026	0.0126	1.62	3	0.30	0.050
Mirex	0.003	0.026	0.0126	na	na	na	na
Total Chlordane	0.008	0.026	0.0126	2.21	2	0.20	0.034

[1/] BSAFs are for marine/estuarine crustaceans or crab species where available, otherwise values are from marine/estuarine clam. Single values were available for metals and crabs from reference 4.

[2/] Aroclor 1254 used as surrogate for Aroclor 1260, and Aroclor 1268; BSAF for rock crab.

C_{sed} – Exposure point concentration in sediment, converted to units of mg/kg dry weight, for use with Foc

Crab C_T – Exposure point concentration in crab whole body

Foc – fraction of organic carbon in Lockheed West Site sediment; average organic carbon for 42 subtidal plus 9 intertidal sediment stations is 1.26%, from the 2007 data set; in dry weight.

Fl – fraction lipid in Dungeness crab from the LDW RI (Windward 2008), assumed to be wet weight; percent lipids from slender crab were lower.

Moisture content assumed at 83%, based on average of crab ROCs from the LDW RI.

BSAF references:

1. Washington State Department of Health. 1995. Tier I report, development of sediment quality criteria for the protection of human health. Washington State Department of Health, Olympia, WA.
2. Environmental Residue-Effects Database - Averages of marine crustacean if n>1, or of marine crustacean and mollusk marine/estuarine.
3. Tracey GA, Hansen DJ. 1996. Use of biota-sediment accumulation factors to assess similarity of nonionic organic chemical exposure to benthically-coupled organisms of differing trophic mode. Arch Environ Contam Toxicol 30:467-475. Taken as the BSAF for bivalve mollusk.
4. PTI 1995. Bioaccumulation Factor Approach Analysis for Metals and Polar Compounds. Washington Department of Ecology. Single BSAF for crab.
5. Taken from reference 4 for clams, as per the QAPP for sediment sampling at the LDW, Windward (2004b); Table D-1, QAPP, Benthic Invertebrate Sampling of the LDW, Appendices A-E. Final. July 30.
6. Based on the regression equation for Dungeness crab from the LDW food web model, Appendix D, draft final RI (Windward 2007c). Equation PCBs: tissue concentration = 2.779 x sediment concentration + 145.28; units in µg/kg dw.

Data are also available from Puget Sound that suggest English sole as the highest trophic organism of fish ROCs. Tissue concentrations of PCBs were measured in a trophic transfer study of marine organisms in Sinclair Inlet (Johnson et al. 2007). The data collected in Johnson et al. (2007) demonstrates higher bioaccumulation of PCBs by English sole than sculpin or perch from the same sediment source, despite sculpin typically being categorized as the higher trophic level organism. The findings of Johnson et al. (2007) support the modeling results of the FWM developed for the LDW site that demonstrate English sole as the higher bioaccumulator of PCBs of all the fish species selected as ROCs for this ERA.

As mentioned above in Section 4.2.1 on modeling dietary exposures, the fractional area represented by foraging at the Site by English sole was not included in modeling tissue concentrations. Although English sole that may be present at the Lockheed West Site probably forage within both Elliott Bay and the LDW, an area use factor or exposure factor of 1 was assumed and whole body tissue concentrations were calculated on a site-wide basis.

The results of modeled tissue concentrations of COPCs in fish are shown above in Table 4-7. The wet weight tissue concentration data are used with the TRVs for tissue residues that are also expressed in wet weight units.

4.3 CRAB EXPOSURE ASSESSMENT

The method for modeling COPC concentrations in crab tissue uses the sediment EPCs and BSAF values specific to marine/estuarine crab where available, or to marine crustaceans. Modeling of crab tissue was also performed using the FWM regression equation for PCBs in crab from the LDW, as described earlier. The USACE (2008) database of BSAF values was used as the preferential source for crab and other shellfish BSAFs. Metals BSAFs for crab are single values from PTI (1995). Where BSAF values were not available for crabs, values were used for other shellfish species. For example, Tracey and Hansen (1996) reported median BSAFs for organochlorine pesticides for *Macoma nasuta*, which is a clam species present in Lockheed West Site sediments. Clam BSAFs were also used for some PAHs where values for crab or marine crustacean were not available.

Modeled tissue chemical concentrations are for whole body of crab. In the assessment of risk to crabs, exposure point concentrations are crab whole body tissue concentrations that are used with a tissue-based toxicity value. The modeled tissue concentrations for crab are shown above in Table 4-8.

4.4 EVALUATION OF BIOACCUMULATION OF SEDIMENT COPCS

Several of the ROCs described above address exposures to sediment COPCs by bioaccumulation through the food chain. For example, crabs have been selected to represent higher trophic level benthic organisms that may bioaccumulate sediment COPCs. BSAFs were identified specifically for crab where available. Similarly, English sole and Pacific staghorn sculpin were selected to represent upper trophic level fish that may bioaccumulate chemicals from sediment through ingestion of prey items that have taken up sediment chemicals from the site. As mentioned above, various lines of evidence support the identification of English sole as the highest trophic bioaccumulator of ROCs selected for this ERA. The BSAFs used to model tissue concentrations in English sole were preferentially selected from the available sources to represent higher trophic level fish, or English sole specifically. Similarly, the regression equation used to model uptake of PCBs into fish was developed using data from English sole. The use of these approaches was designed to adequately address bioaccumulation of sediment chemicals in the marine aquatic food chain at the Lockheed West Site. Similarly, the selection of spotted sandpiper as the higher trophic wildlife ROC addresses the potential bioaccumulation of COPCs to wildlife receptors that may contact sediment chemicals from the Lockheed West Site.

5. EFFECTS ASSESSMENT: CRAB AND FISH

The Effects Assessment presents toxicity data on potential adverse effects to crab and fish ROCs from exposures to site-related COPCs. (The evaluations of effects data for the benthic invertebrate community ROC and for wildlife are addressed in Sections 3.2 and 6.2, respectively.) The effects data are used to estimate risks associated with exposure estimates in the Risk Characterization. The types of effects data depend on the ROC. For example, fish effects data consist of either tissue concentrations related to toxicity (critical tissue residue approach) or dose related to dietary intake toxicity, whereas crab effects data consist of tissue concentrations in whole body.

5.1 CRABS EFFECTS ASSESSMENT

For crabs, a critical tissue residue approach is used to assess effects from exposure to sediment-associated COPCs. Tissue-based TRVs associated with survival, growth, and reproduction were taken from the compiled TRVs in the LDW ERA (Windward 2007), except for pentachlorophenol and mirex, for which TRVs are identified in the present report following the procedure of the LDW ERA. Windward (2007) searched the scientific literature to identify TRVs for the crab COPCs. The literature search included BIOSIS, the EPA ECOTOX database, aquatic life sciences database, the USACE (2005) Environmental Residue Effects Database (ERED), and Jarvinen and Ankley (1999). Original sources of toxicity data were obtained and reviewed in Windward (2007) to verify effects data summarized in the databases as well as the suitability of the studies. The databases were searched for studies that evaluated effects on survival, growth, and reproduction (including developmental effects).

The types of TRVs selected are based on the risk evaluation method used. For crabs, the TRV search focused on chemical tissue-residue data associated with effects on decapods to support the critical tissue-residue approach. For critical tissue-residue studies to be acceptable, the concentration in tissue had to be analyzed as part of the study. Acceptable toxicological data that met the following criteria were compiled for crabs:

- All selected TRVs were based on laboratory toxicological studies. Studies using field-collected data (i.e., field-collected crabs) were not considered acceptable. Field studies were not used to derive TRVs because adverse effects observed in organisms from field studies may be attributed to the presence of multiple chemicals and/or other uncontrolled environmental factors, rather than to a single test chemical.

- Selected TRVs were based preferentially on dietary, sediment, or water exposure studies.

All acceptable studies for TRV derivation were compiled and presented in the ERA for the LDW site (Windward 2007). For each chemical, a TRV was selected for both the NOAEL and the LOAEL. The NOAEL represents the level below which adverse effects would not be expected. The LOAEL represents the level above which an effect would be expected. Risks are then evaluated using both NOAEL and LOAEL values.

The LOAEL was selected from among the possible TRVs if it was the lowest dose at which an effect was observed for any of the three endpoints evaluated and a clear dose-response relationship was observed. The NOAEL was selected as the highest level below the selected LOAEL with the same endpoint. If no NOAEL with the same endpoint as the selected LOAEL was available, the NOAEL was selected as the highest NOAEL below the selected LOAEL based on another endpoint (survival, growth, or reproduction).

For chemicals without NOAELs lower than the selected LOAEL, the NOAEL was determined using the following uncertainty factors following EPA Region 10 guidance (EPA 1997b):

- Acute or subchronic LOAEL ÷ 10
- Chronic or critical lifestage LOAEL ÷ 5
- LC50 (or similar) ÷ 50

Chronic exposure is defined as >15 percent of an organism's lifespan (Calabrese and Baldwin 1993). A critical lifestage is one that occurs during reproduction, gestation, or development (Sample et al. 1996).

TRVs for seven crab COPCs were identified in Windward (2007), and TRVs for mirex were developed following the procedure described above. COPCs with available TRVs for crab are listed in Table 5-1. No studies with reproductive endpoints were identified; all acceptable studies addressed either growth or survival. TRVs selected from the acceptable studies are presented in Table 5-2. Chemicals with no TRVs are discussed in the uncertainty analysis.

Table 5-1. Availability of TRVs for Crab COPCs

COPCs with TRVs		
Chromium	TBT	Total DDTs[1/]
Copper	Methoxychlor	Total PCBs[2/]
Mercury	Mirex	
COPCs without TRVs		
Lead	Benzo(a)pyrene	Fluoranthene
Selenium	Benzo(b)fluoranthene	Fluorene
Acenaphthene	Benzo(g,h,i)perylene	Indeno(1,2,3-cd)pyrene
Acenaphthylene	Benzo(k)fluoranthene	Phenanthrene
Anthracene	Chrysene	Pyrene
Benzo(a)anthracene	Dibenzo(a,h)anthracene	Total chlordane[3/]
		Pentachlorophenol

[1/] 2,4-DDD, 2,4-DDT, 4,4-DDD, 4,4-DDE, and 4,4-DDT were assessed as total DDTs.
[2/] Aroclor-1248, Aroclor-1254, and Aroclor-1260 were assessed as total PCBs.
[3/] Alpha-chlordane and gamma-chlordane were assessed as total chlordane.
COPC – chemical of potential concern
PCB – polychlorinated biphenyl
TBT – tributyltin
TRV – toxicity reference value

5.2 FISH EFFECTS ASSESSMENT

For fish, toxicity criteria are selected as concentrations in tissue or as doses associated with adverse effects and with no effects on the population-level endpoints of survival, growth, and reproduction. Toxicity criteria for fish are the TRVs that were compiled in the LDW ERA (Windward 2007), which describes a search of the scientific literature to identify TRVs for chemical exposures of fish. Additional searches were performed in the present report for pentachlorophenol and mirex. The literature search included BIOSIS, the EPA ECOTOX database, aquatic life sciences database, the USACE (2005) ERED, and Jarvinen and Ankley (1999). Original sources of toxicity data were obtained and reviewed to verify effects data summarized in the databases as well as the suitability of the studies. The databases were searched for studies that evaluated effects on survival, growth, and reproduction (including developmental effects).

The selection of TRVs was based on the risk evaluation method used for each COPC. For fish, Windward (2007) searched databases for dietary studies for metals and PAHs and for critical tissue-residue data for other chemicals. For critical tissue-residue studies to be acceptable, the concentration in tissue had to be analyzed as part of the study.

Table 5-2. Selected Critical Tissue-residue TRVs for Crab COPCs

COPC	Test Species	Tissue Type	NOAEL	LOAEL	Units	Endpoint	Source
Chromium	juvenile (2nd instar) sand crab (*Portunus pelagicus*)	whole body	1	3.2	mg/kg ww	growth	Mortimer and Miller (1994)
Copper	adult crayfish (*Orconectes rusticus*)	whole body	50[1/]	na	mg/kg ww	survival	Evans (1980)
Mercury	adult Norway lobster (*Nephrops norvegicus*)	hepatopancreas	0.99[1/, 2/]	na	mg/kg ww	survival	Canli and Furness (1995)
	adult male shore crab (*Eriocheir sinensis*)	hepatopancreas	Na	1[4/, 5/]	mg/kg ww	survival	Bianchini and Giles (1996)
TBT	juvenile blue crab (*Callinectes sapidus*)	whole body	120	na	µg/kg dw	growth	Rice et al. (1989)
PCBs (Aroclor 1016)	grass shrimp (*Palaemonetes pugio*)	whole body	110[3/]	1,100[6/]	µg/kg ww	survival	Hansen et al. (1974b)
Total chlordane	pink shrimp (*Penaeus duorarum*)	whole body	710	1,700	µg/kg ww	survival	Parrish et al. (1976)
Total DDTs	pink shrimp (*Penaeus duorarum*)	whole body	na	60	µg/kg ww	survival	Nimmo et al. (1970)
	crayfish (*Orconectes nais*)	whole body	46	na	µg/kg ww	survival	Johnson et al. (1971)
Methoxychlor	juvenile Dungeness crab (*Cancer magister*)	whole body	15[3/]	150	µg/kg ww	survival	Armstrong et al. (1976)
Mirex	immature blue crab (*Callinectes sapidus*)	whole body	0.02	0.03	mg/kg ww	survival	Tagatz et al. (1975)

[1/] Converted from dry weight to wet weight using a moisture content of 80% (Jarvinen and Ankley 1999) (80% was also the average moisture content of two crab samples collected by King County in 1997 [King County 1999]; the mean % moisture in LDW crabs was 82.7% [Windward 2007]).
[2/] Dietary exposure route
[3/] Calculated from LOAEL by dividing by 10.
[4/] Full equilibrium between water and tissue may not have been reached because of a short exposure time (≤ 48 hrs).
[5/] Concentration is lowest of three crab species tested (*Carcinus maenas*, *Eriocheir sinensis*, and *Cancer pagurus*).
[6/] Survival was reduced by 33%.
dw – dry weight
na – not available
PCB – polychlorinated biphenyl
TBT – tributyltin
ww – wet weight
Source: Windward (2007), except mirex developed in this report.

Acceptable toxicological data that met the following criteria (Windward 2007) were compiled for fish.

- All selected TRVs were based on laboratory toxicological studies. Studies using field-collected data (i.e., field-collected fish or fish fed field-collected diets) were not considered acceptable. Field studies were not used to derive TRVs because adverse effects observed in organisms from field studies may be attributed to the presence of multiple chemicals and/or other uncontrolled environmental factors, rather than to a single test chemical.
- Selected TRVs were based preferentially on dietary, sediment, or water exposure studies. Studies conducted using intraperitoneal (IP) or egg injection or oral gavage as exposure routes were not considered representative of the ROC exposure conditions but were used if no other studies were available.
- All selected TRVs were based on whole-body tissue concentrations or egg concentrations that were converted to adult tissue concentrations using egg-to-adult conversion factors from the literature.
- For fish, chronic exposure duration was assumed to be 28 days or greater, to cover a critical lifestage occurring during reproduction, gestation, or development.

COPCs for fish are based on bioaccumulative potential into tissue and are the same COPCs as identified for crabs. TRVs were available for 37 of the fish COPCs, as listed in Table 5-3. Selected TRVs are presented as NOAEL and the LOAEL values in Tables 5-4 and 5-5 for COPCs evaluated using the dietary approach and critical tissue-residue approach, respectively. Note that total PAHs are included in the table though they are not selected as COPCs for fish since they are not on the EPA list of bioaccumulative chemicals in sediment. Chemicals with no TRVs are discussed in the uncertainty analysis.

Table 5-3. Availability of TRVs for Fish COPCs

COPCs with TRVs		
Chromium	Benzo(a)anthracene[1/]	Indeno(1,2,3-cd)pyrene[1/]
Copper	Benzo(a)pyrene[2/]	Phenanthrene[1/]
Lead	Benzo(b)fluoranthene[1/]	Pyrene[1/]
Selenium	Benzo(g,h,i)perylene[1/]	Methoxychlor
Mercury	Benzo(k)fluoranthene[1/]	Mirex
TBT as ion	Chrysene[1/]	Total chlordane
Acenaphthene[1/]	Dibenzo(a,h)anthracene[1/]	Total PCBs
Anthracene[1/]	Fluoranthene[1/]	Total PAHs
	Fluorene[1/]	Pentachlorophenol
COPCs without TRVs		
Acenaphthylene		

[1/] PAHs included in the mixture of PAHs evaluated by Palm et al. (2003) or Meador et al. (2006).
[2/] Benzo(a)pyrene was included in the mixture of PAHs evaluated by Meador et al. (2006). Benzo(a)pyrene was not selected as a COPC for tissues at the Lockheed West Site based on sediment concentrations below bioaccumulation screening criteria, but was included in the risk estimates for completeness (see Section 2).
PAH – polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
TBT – tributyltin
TRV – toxicity reference value

Table 5-4. Selected TRVs for Fish COPCs Evaluated Using a Dietary Approach

COPC	Test Species	NOAEL (mg/kg dw)	LOAEL (mg/kg dw)	Endpoint	Source
Chromium	grey mullet	9.42	na	growth	Walsh et al. (1994)
Copper	rainbow trout	8	16	growth	Murai et al. (1981)
Lead	rainbow trout	7,040	na	growth	Goettl et al. (1976)
Benzo(a)pyrene[1/]	rainbow trout	100	nr	growth	Hart and Heddle (1991)
	English sole	nr	116	growth	Rice et al. (2000)
Total PAHs[2/]	Chinook salmon	324	951	growth	Meador et al. (2006)

[1/] Benzo(a)pyrene is included in the evaluation of risks to fish because of the limited TRV data for other PAHs even though it was not selected as a COPC for fish based on the screening for bioaccumulation.
[2/] Mixture comprises the following 21 PAHs included in Meador et al. (2006) diet: naphthalene, 2-methylnaphthalene, dimethylnaphthalene, dibenzothiophene, acenaphthene, fluorene, 1,8-dimethyl(9H)fluorene, phenanthrene, 9-ethylphenanthrene, 9-ethyl-10-methylphenanthrene, 1-methyl-7-isopropylphenanthrene, anthracene, fluoranthene, pyrene, methyl pyrene, benz(a)anthracene, chrysene, benz[a]pyrene, benzo(k)fluoranthene, benzo(g,h,i)perylene, dibenzanthracene.
COPC – chemical of potential concern
dw – dry weight
LOAEL – lowest-observed-adverse-effect level
na – not available; no LOAELs identified in the literature search; selected NOAEL is the highest unbounded NOAEL in the literature reviewed.
NOAEL – no-observed-adverse-effect level
nr – not relevant; NOAEL and LOAEL TRVs were derived from separate studies reporting the same endpoint.
PAH – polycyclic aromatic hydrocarbon
Source: Windward (2007)

Table 5-5. Selected TRVs for Fish COPCs Evaluated Using the Critical Tissue-residue Approach

COPC	Test Species	NOAEL (µg/kg ww)	LOAEL (µg/kg ww)	Endpoint	Source
Mercury	golden shiner	230	nr	survival	Webber and Haines (2003)
	mummichog	nr	470	survival	Matta et al. (2001)
Selenium	[national criterion]	1,200[1/]	1,600[2/]	adverse effects	EPA (2004a)
TBT	Japanese flounder	18	159	growth	Shimasakai et al. (2003)
Pentachlorophenol	sheepshead minnow	12.3	22.1	growth	Spehar et al. (1985)
PCBs	common barbel	104 – 528[4/]	520 – 2,640[4/]	reproduction	Hugla and Thome (1999)
DDTs (total)	cutthroat trout	1,800[5/]	1,800[5/]	survival	Allison et al. (1964)
Methoxychlor	brook trout	50	300	growth	Oladimeji and Leduc (1975)
Mirex	salmon - coho	1,600	9,600	growth	Leatherland et al. (1979)
Total chlordane	goldfish	710	nr	survival	Moore et al. (1977)
	goldfish	nr	1,360	survival	Feroz and Khan (1979)

1/ National criterion for selenium in summer-collected fish. Dry weight concentration converted to wet weight assuming 80% moisture content.
2/ National criterion for selenium in winter-collected fish. Dry weight concentration converted to wet weight assuming 80% moisture content.
3/ Adult whole-body tissue residue estimated using egg concentration (857 µg/kg ww) and egg:adult conversion factor of 4.69 based on rainbow trout PCB data (Niimi 1983).
4 A LOAEL range was selected from this study for use in the LDW ERA because the specific LOAEL was unclear because of study uncertainties. The NOAEL range was estimated using an uncertainty factor of 5 (chronic LOAEL to NOAEL).
5/ LOAEL is tissue concentration at 111 days (3.7 months) in fish exposed to 0.1 mg/L DDT in water where mortality was significant after approximately 4 months (approximately 120 days), the tissue concentrations at this dose increased to 3.0 mg/kg ww at the next sampling (166 days, 5.5 months) so the actual tissue concentration associated with the LOAEL is likely somewhat higher than 1,800 µg/kg ww. The NOAEL (1,800 µg/kg ww) is the highest tissue concentration (at 466 days) in fish exposed to 0.03 mg/kg DDT in water at which significant mortality was not observed over entire exposure duration of 612 days.
COPC – chemical of potential concern
nr – not relevant; NOAEL and LOAEL TRVs were derived from separate studies reporting the same endpoint.
PCB – polychlorinated biphenyl
TBT – tributyltin
TRV – toxicity reference value
ww – wet weight
Source Windward (2007), except pentachlorophenol and mirex developed in this report.

The LDW ERA provided reviews of the studies from which TRVs were developed. In the study reporting the lowest LOAEL for fish exposed to PCBs, Hugla and Thome (1999) exposed 3- to 5-year-old common barbel from the University of Liege hatchery to 2,500 µg/kg PCBs in food for 50 days or to 12,500 µg/kg PCBs in food for 75 days (nominal concentrations) and analyzed effects on reproduction through two seasons of spawning. A NOAEL was not observed in this study, and no other study provided a NOAEL that is lower than the LOAEL from this study. For that reason, the NOAEL for PCBs in fish tissue was determined by applying an uncertainty factor of 5 to the LOAEL to result in a range of NOAEL for whole body concentrations in fish of 104 to 528 µg/kg ww.

As reviewed in the LDW ERA, the fecundity LOAEL associated with the lower dose is uncertain because fecundity was not dose responsive. Fecundity comparisons are complicated by the fact that the higher-dosed fish did not spawn during the first season and whole-body tissue concentrations were not measured 1 year later when the high-dose fish finally spawned. After the second spawning, average fecundity was similar between the high and low doses, but variance in fecundity was greater at the higher dose. In addition, the study was unclear on the number of fish that were exposed at each treatment level and evaluated for effects. Because of these uncertainties, the range of effects concentrations reported in this paper for the fecundity, spawning, and egg hatchability endpoints was considered to represent the range of exposures over which the lowest adverse effects may occur in fish. Thus, the selected LOAEL for PCBs in fish tissue was set at a range of 520 to 2,640 µg/kg ww.

The laboratory studies that produced effects data for PCBs in fish used unweathered Aroclors. However, PCB residues in fish exposed to PCBs in Site sediments would have undergone physico-chemical weathering and differential accumulation through the food web, which may result in PCB mixtures in fish tissue that are more biologically active than the commercial mixtures (Parkinson and Safe 1987; Smith et al. 1990). The influences of weathering of congeners and their differential accumulation in field tissues present uncertainties in the application of laboratory toxicity data to predicting toxicity or risks related to field exposures. In addition, it is unknown whether PCB congener enrichment in biota at the Lockheed West Site may differ from the enrichment found with biota at the LDW site. Although the same aquatic organisms may be present at both sites, the sources of PCBs to each site may differ, and consequently the weathering and enrichment of PCB congeners may differ between the sites. Differential weathering and enrichment between the two sites would add uncertainties in the application of the LDW food web model results to the Lockheed West Site.

6. EXPOSURE AND EFFECTS ASSESSMENT: WILDLIFE

The wildlife ROC for the Lockheed West Site consists of the spotted sandpiper. The selection of spotted sandpiper as the higher trophic wildlife ROC addresses the potential bioaccumulation of COPCs to wildlife receptors that may contact sediment chemicals from Lockheed West. Key bioaccumulative chemicals such as arsenic, PCBs, and TBT are addressed by using regression relationships from the nearby LDW site to derive tissue concentrations in benthic invertebrate prey of sandpipers

6.1 SANDPIPER EXPOSURE ASSESSMENT

Eight COPCs were identified for sandpiper in the problem formulation step of this ERA. The sandpiper exposure assessment presents the methods and results of estimated daily exposure doses of these COPCs to sandpipers that may be exposed to sediment contaminants at the Lockheed West Site.

6.1.1 Approach

Sandpiper exposures are evaluated through a dietary approach where estimates of the daily doses of each COPC are calculated following the method used in the LDW ERA for two ingested media: food and sediment. Other pathways considered in the conceptual site model in the problem formulation were determined to be insignificant relative to these primary exposure pathways. In the LDW ERA, surface water ingestion was shown to represent an insignificant proportion of the exposure and risk of sandpipers to chemicals in the LDW. Based on that finding, exposures to surface water from ingestion are not evaluated for sandpiper. Direct contact with water was also considered a complete exposure pathway, but also was assumed to be insignificant because feathers on birds limit direct contact of skin with contaminated media, although large portions of their heads, legs, feet, and in some birds seasonal brood spots on their chests, are not feathered. Direct (or dermal) contact with sediment was considered a complete exposure pathway. However, risks to birds from sediment contact are considered to be insignificant relative to those from ingestion (EPA 2000b).

The daily doses for sandpiper were estimated using the following equation:

$$Exposure\ Dose = \frac{\left[\left(FIR \times C_{food}\right) + \left(SIR \times C_{sed}\right)\right] \times AUF}{BW}$$ **Equation 6-1**

where:

Daily Dose	=	COPCs ingested per day via food and sediment (mg COPC/kg body weight/day)
FIR	=	food ingestion rate (kg food dw/day)
C_{food}	=	concentration in prey items (mg COPC/kg food dw)
SIR	=	sediment ingestion rate (kg sediment dw/day)
C_{sed}	=	concentration in sediment (mg COPC/kg dw)
AUF	=	area use factor (unitless); fraction of time that a receptor spends foraging at the site relative to the entire home range (set at 1.0)
BW	=	body weight (kg ww)

Exposures to sandpiper for the Lockheed West Site are based on exposure parameters used for the LDW ERA, including intake parameters such as body weights, and food and sediment ingestion rates, and equations for developing intake. The sediment ingestion rate is calculated as a specified percentage of the FIR.

6.1.2 Exposure Assumptions

This section presents values used in Equation 6-1 to calculate the daily exposure dose for sandpiper, including the dietary fraction of prey items; ingestion rates of food, water, and incidental sediment; and body weight. Table 6-1 summarizes these values and the following sections provide details of exposure factor assumptions and sources of information for sandpiper.

Table 6-1. Exposure Factor Values for Spotted Sandpiper

Gender[1/]	Fraction of Benthic Invertebrates as Dietary Prey	Body Weight (kg ww)	Food Ingestion Rate (kg dw/day)	Incidental Sediment Ingestion Rate (kg dw/day)	Area Use Factor (unitless)[2/]
M	1.0	0.038	0.0060	0.0011	1
F	1.0	0.047	0.0074	0.0013	
average	1.0	0.043	0.0067	0.0012	

[1/] Female values were used for COPCs with a TRV based on a reproductive endpoint and average values were used for COPCs with a TRV based on a growth or survival endpoint. Because of the slight differences in body weights and food ingestion rates, average values were used.
[2/] Area use factor is the fraction of a receptor's total foraging time that is spent at the site (EPA 1997a, 2001, 2005).
dw – dry weight
M – male
F – female
ww – wet weight

6.1.2.1 Body Weight

Representative body weights for adult male and female spotted sandpiper (0.0379 and 0.0471 kg, respectively) were obtained from a study by Maxson and Oring (1980), as cited in EPA (1993).

6.1.2.2 Food Ingestion Rate

The FIR for spotted sandpiper was estimated in the LDW ERA as a function of the metabolic rate and the caloric content of the prey using the following equation:

$$FIR = \frac{FMR}{ME} \times \frac{0.001\text{ kg food}}{\text{g food}}$$ **Equation 6-2**

where:

FIR = food ingestion rate (kg food dw/day)
FMR = free-living metabolic rate (kcal/day)
ME = average metabolizable energy of the total diet (kcal/g food dw).

The body-weight-normalized free-living metabolic rate (FMR) for the common sandpiper (0.676 kcal/g bw/day) was developed from the FMR of 146 kJ/day and body weight of 51.6 g reported in from Nagy et al. (1999). The body-weight normalized FMR was multiplied by male and female spotted sandpiper body weights to derive male and female FMRs used in Equation 6-2 for spotted sandpiper (25.7 and 31.8 kcal/day, respectively). An average metabolizable energy (ME) value of 4.3 kcal/g dw is used in Equation 6-2. This value was derived from Nagy (1987) as the average ME of insects that are ingested by birds. Using these FMR and ME values, the calculated male and female FIRs are 0.0060 and 0.0074 kg dw/day, respectively, with an average of 0.0067 kg dw/day (Table 6-1).

6.1.2.3 Incidental Sediment Ingestion Rate

Data are available from Beyer et al. (1994) regarding incidental sediment ingestion by four sandpiper species that feed on mud-dwelling invertebrates. On a dry-weight basis, the incidental sediment ingestion ranged from 7.3 to 30 percent of the diet, with an average of 18 percent, which is the basis of the values in Table 6-1. Consistent with their feeding behavior, it was assumed that spotted sandpiper would ingest sediment only from intertidal areas.

6.1.2.4 Composition of Diet

Spotted sandpipers feed along the sandy or muddy edges of inlets, creeks, and ponds. Their diet is composed primarily of terrestrial and marine invertebrates (Bent 1929), but they also may feed on crustaceans, leeches, mollusks, small fish, and carrion (Oring et al. 1983). At the Lockheed West Site, it was assumed that spotted sandpipers feed 100 percent on benthic invertebrates, such as amphipods and polychaetes, in the available intertidal mudflats along the West Waterway and Elliott Bay shorelines of the site. Exposure of spotted sandpipers via ingestion of benthic invertebrate prey from intertidal areas was calculated using tissue concentrations that were modeled from intertidal sediment data.

6.1.2.5 Site Use

Spotted sandpiper is a common bird in western Washington, and is known to nest along the lower Duwamish River. They have been previously observed in the LDW from late June through September (Cordell et al. 1996), but have been known to overwinter locally (Paulson 1993). A foraging range for sandpiper has been estimated at about 1 mile from their nest (Norman 2002), and they breed in open habitats along the margins of water bodies (Oring and Lank 1986). Their presence at the Lockheed West Site, either along the West Waterway or Elliott Bay, has not been documented, but limited intertidal habitat is available at the Lockheed West Site.

Because of the possible presence of sandpiper at the Lockheed West Site, it is assumed that sandpiper may be present at the site throughout the year regardless of the size or availability of habitat or foraging area (i.e., exposure frequency = 365 day/yr). An area use factor of 1.0 is used, which means that sandpipers are assumed to nest nearby and forage at the site, with continuous exposure to site contaminants

6.1.3 Prey Tissue and Sediment Data

This section presents the COPC concentrations in prey tissue and sediment that are used in Equation 6-1 to calculate exposure doses for sandpiper.

6.1.3.1 Sediment

Surface sediment data were used to estimate COPC exposure of sandpiper resulting from incidental sediment ingestion. For spotted sandpiper, surface sediment EPCs are based on the intertidal sediment data of the Lockheed West Site. Data on intertidal sediment are available for nine stations from the 2007 sampling. The estimated dietary doses from sediment ingestion for spotted sandpiper using the ingestion rates described above and Equation 6-1 are presented in Table 6-2. The derivation of the intertidal sediment EPCs that are listed in Table 6-2 is presented in Table 6-3.

Table 6-2. Spotted Sandpiper COPC Dose from Sediment Ingestion

COPC	Intertidal Sediment EPC (mg/kg dw)	Sediment Dose (mg/kg BW-day)
Metals		
Chromium	198	5.5
Copper	840	23.6
Lead	660	18.5
Vanadium	51.8	1.5
PAHs		
Benzo(a)pyrene	0.182	0.005
Total PAH	1.68	0.047
Organometals		
Tributyltin	0.036	0.001
PCBs		
PCBs (total)	0.042	0.001

BW – body weight
COPC – chemical of potential concern
dw – dry weight
EPC – exposure point concentration
PCB – polychlorinated biphenyl

6.1.3.2 Prey Tissue

Because prey tissue data are unavailable from the site to quantify sandpiper exposures through dietary ingestion, prey tissue concentrations are modeled. The modeling of prey tissue concentrations follows the methodology described in Section 4.1 for modeling tissue concentrations of COPCs. The BSAFs used in the modeling of sandpiper prey tissue are the benthic invertebrate BSAFs, or the benthic invertebrate regression equations, that were described in Section 4.2.1 for modeling COPCs into benthic invertebrate prey for fish. However, for spotted sandpipers, concentrations of COPCs in the benthic invertebrate fraction of the diet were modeled using only the intertidal data for the site.

The modeled benthic invertebrate tissue concentrations of organic chemicals using the BSAF method were calculated as follows:

$$C_{bi} = \frac{(C_{sed} \times F_L) \times BSAF}{F_{OC}}$$ **Equation 6-3**

where:

C_{bi} = Chemical concentration in benthic invertebrate prey tissue (mg/kg ww)
C_{sed} = Concentration of chemical in sediment (mg/kg dw)
F_L = Fraction of lipid in tissue (wet weight)
BSAF = Biota-sediment accumulation factor (unitless)
F_{oc} = Fraction of organic carbon in bottom sediment (dry weight)

Table 6-3. Summary Statistics for Tissue COPCs in Intertidal Sediment

COPC	Units	Detection Frequency	Mean Conc.	Min. Conc.	Max. Conc.	Distribution	Recommended 95 UCL	Intertidal Sediment Exposure Point Concentration
Metals								
Chromium	mg/kg dw	9/9	138.1	39.2	289	Normal	197.8	198
Copper	mg/kg dw	9/9	533.7	44.6	1310	Normal	840.2	840
Lead	mg/kg dw	9/9	367.2	91.5	1420	Gamma	660.2	660
Vanadium	mg/kg dw	9/9	40.98	22	68.6	Normal	51.83	51.8
PAHs								
Benzo(a)pyrene	µg/kg dw	9/9	77.96	2.6	260	Gamma	181.7	182
Total PAH	µg/kg dw	9/9	1081	28.8	2461	Normal	1681	1681
Organometals								
Tributyltin	µg/kg dw	9/9	22.02	0.81	57	Normal	36.38	36.4
PCBs								
PCBs (total)	µg/kg dw	9/9	27.8	12	77	Normal	41.76	41.8

Data distribution and upper confidence limits determined using ProUCL 4.0
Exposure Point Concentrations are 95 UCL, or maximum values where less than 6 detected values.
Duplicate samples (for intertidal sediment stations 4, 5, and 6) were first averaged prior to calculation of summary statistics.

The modeled benthic invertebrate tissue concentrations of metals were calculated without the normalization to OC or lipid fraction. As described in Section 4.1, for TBT and PCBs, the BSAF approach was not used for modeling tissue concentrations in benthic invertebrates. The LDW ERA developed regression equations for sediment and benthic invertebrate tissue data on TBT and PCBs (Windward 2007, Attachment 11). For the Lockheed West Site, these regression equations for TBT and PCBs were used to replace the BSAF method for modeling tissue concentrations for benthic invertebrate prey of sandpiper. The concentrations of TBT and PCBs in intertidal benthic invertebrate tissues were modeled using the intertidal sediment EPCs shown in Table 6-3.

The results of the modeling of COPC concentrations in benthic invertebrate tissues by both the BSAF approach and the regression models for TBT and total PCBs at the Lockheed West Site are shown in Table 6-4. The estimated dietary doses of COPCs were calculated from the tissue EPCs presented in Table 6-4 and the prey ingestion rates presented in Table 6-1, using Equation 6-1. Resultant estimated dietary doses of COPCs to spotted sandpiper are shown in Table 6-5.

6.2 SANDPIPER EFFECTS ASSESSMENT

For sandpiper, dietary intake-based TRVs from the LDW ERA (Windward 2007) are used in this ERA. Toxicity data for bird species were NOAELs, which are the highest doses at which no adverse effects were observed, and LOAELs, which are the lowest doses at which adverse effects were observed.

In the LDW ERA, the scientific literature was searched to identify TRVs for sandpiper COPCs. The literature search included BIOSIS, EPA's ECOTOX database, the National Library of Medicine's TOXNET database, the US Fish and Wildlife Service's Contaminant Review series, the Oak Ridge National Laboratory database, and the EPA IRIS database. Eisler (2000) and Sample et al. (1996) were reviewed for avian toxicity data. Original sources of toxicity data were obtained and reviewed to verify effects data summarized in the databases as well as the suitability of the studies. The databases were searched for studies that evaluated effects on survival, growth, and reproduction (including developmental effects).

Table 6-4. Spotted Sandpiper COPC Concentrations in Intertidal Benthic Invertebrate Tissues

COPC	C_{sed} (mg/kg dw)	F_l	F_{oc}	BSAF[1/]	BSAF Reference	C_{bi} (mg/kg ww)	C_{bi} (mg/kg dw)
Metals							
Chromium	198	-	-	0.0043	2	0.18	0.85
Copper	840	-	-	0.452	2	80	380
Lead	660	-	-	2.54	2	352	1,677
Vanadium	52	-	-	na	na	na	na
PAHs							
Benzo(a)pyrene	0.182	0.0071	0.003	0.37	1	0.199	0.95
Total PAH	1.68	0.0071	0.003	0.77	1	3.86	18.4
Organometals							
Tri-n-butyltin	0.036	-	-	-	3	0.058	0.28
PCBs							
Total PCBs	0.042	-	-	-	3	0.090	0.43

[1/] BSAFs for metals are from deposit feeding clams or filter feeding clams (e.g., copper), and for organic chemicals are from benthic invertebrates or based on regression modeling for TBT and PCBs.

Csed – exposure point concentration in intertidal sediment, 95 UCL or maximum concentration

Cbi – modeled concentration in intertidal whole body benthic invertebrate tissue

Foc – fraction of organic carbon in Lockheed West Site sediment; average organic carbon for nine intertidal sediment stations is 0.3%, from 2007 data; in dry weight.

Fl – fraction lipid in benthic invertebrates from the LDW RI (Windward 2008); assumed to be wet weight.

Moisture content assumed at 79%, based on LDW benthic invertebrate data in the LDW RI.

BSAF references

1. USACE 2008. BSAF Database, http://el.erdc.usace.army.mil/bsaf/BSAF.html; 90th percentile of all marine/estuarine mollusks, crustacea, worms, and echinoderm values. Dry weight values used if n>2, otherwise wet values used.
2. PTI 1995. Bioaccumulation Factor Approach Analysis for Metals and Polar Compounds. Washington Department of Ecology. Based on 90th percentile values for deposit feeder clams, or filter feeders if no deposit feeder data.
3. Based on a regression equation using LDW site data, as reported in Windward (2007), Attachment 11 to the LDW ERA. Equation for PCBs: tissue concentration = 75 + 0.37 x sediment concentration; units calculated as µg/kg dw sediment and µg/kg ww tissue. Equation for TBT: tissue concentration = sediment concentration^0.1801 x 145.4; units calculated as µg/kg dw sediment and µg/kg dw tissue (data presented in Table A.3-4 of the LDW ERA), converted to mg/kg ww.

Table 6-5. Spotted Sandpiper COPC Doses from Ingestion of Benthic Invertebrates

COPC	Modeled Intertidal Benthic Invertebrate EPC (mg/kg dw)	Dietary Dose (mg/kg BW-day)
Metals		
Chromium	0.85	0.13
Copper	380	59.2
Lead	1,677	261
Vanadium	na	--
PAHs		
Benzo(a)pyrene	0.95	0.148
Total PAH	18.4	2.86
Organometals		
Tributyltin	0.28	0.043
PCBs		
PCBs (total)	0.43	0.067

BW – body weight
COPC – chemical of potential concern
dw – dry weight
EPC – exposure point concentration
PCB – polychlorinated biphenyl

Windward (2007) reviewed the toxicity studies for methods, relevance, and interpretation to ensure that TRVs were derived appropriately. Studies were excluded if there was no control group for comparison to treated groups, or if test species were exposed to more than one chemical. Exceptions were made for certain mixtures of related chemicals such as a mixture of DDT and its metabolites, or a mixture of PCBs as Aroclors. In addition, the PAH TRV for the protection of spotted sandpipers was derived from an aromatic hydrocarbon chemical mixture including individual PAHs, because no other dietary studies were available. These requirements eliminated most field studies from consideration in the development of TRVs, because field studies generally lack suitable controls, and organisms are typically exposed to a mixture of different types of chemicals in the field.

Dietary dose studies were identified. In many cases, the toxicity literature presented data only as a concentration in food, so these values were converted to a daily dose (mg/kg bw/day) using the animal's body weight and ingestion rate (IR). The following guidelines were considered by Windward (2007) in the selection of TRVs for wildlife.

- Studies using field-collected data were not used to develop TRVs, but were considered if no other toxicity data were available.
- Studies conducted using IP injection, intramuscular injection, forced ingestion, or oral gavage as exposure routes were not considered for deriving TRVs unless no other toxicity data are available.

- Studies using drinking water as the exposure medium were not used to develop TRVs because bioavailability from water may be different from that of food. If no other toxicity data were available, then drinking water studies were considered.
- Studies with egg production endpoints for chicken or quail, such as Edens and Garlich (1983) and Edens et al. (1976) studies on lead, are considered highly uncertain and were only considered if data from other more appropriate studies were not available. These data are considered uncertain because chickens and quail have been bred to have high egg-laying rates. Even with a significant reduction in their baseline egg production, these egg production rates may be much higher than those of any wild avian species. These differences in reproductive physiology result in high uncertainty in extrapolating a reproductive effect threshold from egg production rates for chickens or quails.
- Toxicity studies conducted with chemical forms not likely found in West Waterway or the nearshore of Elliott Bay areas of the Site, such as the fungicide methylmercury dicyandiamide, were not used to develop TRVs. Toxicity of these chemical forms is not comparable to the toxicity of forms of chemicals present at the site.
- The exposure duration was not chronic, defined as more than 10 weeks or exposure during a critical lifestage (i.e., reproduction, gestation, or development) (Sample et al. 1996), or was not conducted during a sensitive life stage (i.e., reproduction or early growth stages).
- Exposure was through gavage, oral intubation, or injection rather than through the diet. These routes of exposure are not directly related to environmental exposures of birds.
- Results were not statistically evaluated to identify significant differences from control values.
- Endpoints were not related to growth, reproduction, or survival.

After the literature search was conducted, all acceptable studies for TRV derivation were compiled in Windward (2007). For each COPC, TRVs were selected for both the NOAEL and the LOAEL. TRV selection rules and uncertainty factors discussed above for crab and fish were used for sandpiper as well. The NOAELs and LOAELs derived from the literature are expressed as dietary doses in mg/kg body weight/day. The LOAEL and NOAEL values were chosen in Windward (2007) as follows: 1) the selected LOAEL was the lowest LOAEL from any study using any of the specified endpoints (i.e., growth, reproduction, survival), and 2) the selected NOAEL was the highest NOAEL that was lower than the selected LOAEL, with the same endpoint as the selected LOAEL.

Table 6-6 summarizes spotted sandpiper NOAEL and LOAEL TRVs as compiled in Windward (2007). The table also includes summary information on the endpoint, test species, exposure pathway, and reference for each NOAEL and LOAEL shown.

Table 6-6. TRVs Identified for Spotted Sandpiper COPCs

COPC	Test Species	NOAEL (mg/kg bw/day)	LOAEL (mg/kg bw/day)	Endpoint	Source
Metals					
Chromium	black duck	1.0	5.0	reproduction	Haseltine et al. (unpublished), as cited in Sample et al. (1996)
Copper	chicken	ns	29	growth	Smith (1969)
	chicken	21	ns	growth	Poupoulis and Jensen (1976)
Lead	Japanese quail	ns	20	reproduction	Edens et al. (1976)
	American kestrel	5.82	na	reproduction	Pattee (1984)
Vanadium	chicken	1.2	2.3	growth	Ousterhout and Berg (1981)
Organometals					
TBT	Japanese quail	1.4	3.6	reproduction	Coenen et al. (1992)
PAHs					
Benzo(a)pyrene	pigeon	0.28[1/]	1.4	reproduction	Hough el al. (1993)
Total PAHs	mallard	8.0	40	growth	Patton and Dieter (1980)
PCBs					
PCBs	screech owl	0.49	na	reproduction	McLane and Hughes (1980)
	ringed turtle dove	na	1.4	reproduction	Peakall et al. (1972); Peakall and Peakall (1973)

[1/] NOAEL estimated from a chronic LOAEL using an uncertainty factor of 5.
bw – body weight
COPC – chemical of potential concern
LOAEL – lowest-observed-adverse-effect level
na – not available
NOAEL – no-observed-adverse-effect level
ns – NOAEL or LOAEL not selected from this study
PAH – polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
TBT – tributyltin
Source: Windward (2007)

6.3 SUMMARY OF ECOLOGICAL ROC EXPOSURES

A summary of the exposure assessment data types and sources for each of the ecological ROCs for the Lockheed West Site ERA are shown in Table 6-7.

Table 6-7. Measures of Exposure and Data Types for the Lockheed West Site ERA

Ecological Receptor	Measure of Exposure[1/]	Use in Risk Characterization	Data Type
Benthic			
Benthic invertebrates, including clams	Sediment (intertidal + subtidal)	Comparison with sediment criteria	Sampling Data[2/]
Crabs	Crab tissue	Comparison with toxicity data for crab tissue	Modeled Tissue[3/]
Fish			
English sole	Prey (benthic invertebrates)	Dietary exposure, intake calculation	Modeled Tissue[3/]
	Sediment (intertidal + subtidal)	Dietary exposure, intake calculation	Sampling Data[2/]
	Chemicals in English sole tissue	Comparison with toxicity data for fish tissue	Modeled Tissue[3/, 4/]
Pacific staghorn sculpin	Prey (benthic invertebrates, crab, fish)	Dietary exposure, intake calculation	Modeled Tissue[3/, 4/]
	Sediment (intertidal + subtidal)	Dietary exposure, intake calculation	Sampling Data[2/]
	Chemicals in sculpin tissue	Comparison with toxicity data for fish tissue	Modeled Tissue[3/, 4/]
Wildlife			
Sandpiper	Prey (intertidal benthic invertebrates)	Dietary exposure, intake calculation	Modeled Tissue[3/]
	Sediment (intertidal)	Dietary exposure, intake calculation	Sampling Data[2/]

1/ Measures of chemical exposure include direct contact with sediment or through dietary intake, such as sediment and prey items ingested by fish and crab, or as tissue concentrations in the ROC. Dietary intake measures are evaluated for those COPCs for which TRVs are based on dietary intake (PAHs and metals except butyltins and mercury), whereas chemicals with whole body tissue TRVs are evaluated by comparison with tissue levels modeled to the ROC.
2/ Source of sediment sampling data consists of Lockheed West Site data collected in 2007.
3/ Tissue modeling is based on BSAF methodology or regression equations identified for arsenic, TBT, and PCBs in the LDW ERA and RI documents (Windward 2007,b).
4/ Because of the limited availability of BSAFs for fish, tissue concentrations of COPCs are modeled for non-speciated whole body fish and are equally applicable to whole body English sole, whole body sculpin, and fish as prey for sculpin.
na – not applicable

7. ECOLOGICAL RISK CHARACTERIZATION

This section of the Lockheed West Site baseline ERA estimates risks to the ecological ROCs that may contact COPCs in sediment at the site directly or indirectly through trophic transfer of these contaminants. As stated in the Introduction to this ERA, the approach to evaluating risks to ecological ROCs at the Lockheed West Site was to use ecological receptors and exposure information from the nearby LDW site in combination with sediment concentration data from the Lockheed West Site. This approach to estimating ecological risks at the Lockheed West Site was adopted to expedite implementation of active remedial measures and to maintain consistency in the ERA with the LDW site. This approach does not fully account for the differences between the LDW and Lockheed West site (e.g., site size); however, the approach is sufficiently protective of the health of aquatic organisms and communities to estimate ecological risks at the Lockheed West site and support the RI/FS process.

The typical approach to estimating ecological risks is to compare the effects-based toxicity criteria (e.g., TRVs) with exposure data for each COPC and each receptor group (i.e., benthic invertebrates, fish, crab, and sandpiper). As per EPA guidance, TRVs based on no effects and on low level exposure effects are compared to the tissue EPCs or to doses to calculate hazard quotients (HQs). HQs greater than 1.0 indicate that the exposures of the receptors are estimated to be greater than toxicological benchmarks. Such a finding is generally regarded as indicating a potential for adverse effects, particularly if the benchmark is an effects concentration (or dose) at which adverse effects were observed (i.e., a LOAEL). HQs may also be calculated based on a NOAEL. The potential for adverse effects associated with a NOAEL HQ greater than 1.0 is uncertain unless the LOAEL is also assessed because the true threshold for effects lies at a concentration (or dose) somewhere between the NOAEL and LOAEL. An exposure falling between the NOAEL and LOAEL may not result in any adverse effect. Therefore, both types of HQs are calculated and presented to better describe the potential for adverse effects and to support risk management decisions at the Site.

7.1 BENTHIC INVERTEBRATES

This section characterizes risks to benthic invertebrates closely associated with sediment (i.e., infaunal benthos), such as amphipods, bivalves, and polychaetes, as well as more mobile, higher-trophic-level benthic invertebrates (i.e., epibenthic benthos), such as crabs, that may travel over relatively greater distances than other invertebrates.

Risk characterization for infaunal and epibenthic invertebrates was based on a prediction of effects through the comparison of available surface sediment chemistry data with available sediment chemical criteria and guidelines. Risks to crabs from COPCs were characterized using a critical tissue-residue approach. The critical tissue-residue approach was also used to evaluate risks to infaunal invertebrates from TBT. Risks to meso- and neogastropods were characterized by a critical tissue residue approach and by comparison with results of a LDW gastropod study.

7.1.1 Benthic Community

The potential for adverse effects to benthic invertebrate communities resulting from exposure to sediment-associated COPCs was evaluated through a comparison of COPC concentrations in subtidal and intertidal surface sediments at the site to SMS chemical criteria or to toxicologically based sediment guidelines or TRVs.

7.1.1.1 Risk Estimates

Individual station comparisons of benthic invertebrate COPC concentrations with SMS or other criteria are presented in the attached tables in Appendix B. Table 7-1 presents a summary of the SMS comparison of intertidal surface sediment chemistry data for the benthic invertebrate COPCs. COPCs without SMS are evaluated further below. Table 7-2 presents a summary of the SMS comparison of subtidal surface sediment chemistry data for the benthic invertebrate COPCs. A discussion of chemicals not detected in sediments but with RLs greater than the SMS chemical criteria is presented in the uncertainty analysis. Detected chemical concentrations in intertidal sediment above the SQS or alternative chemical criteria are shown as point locations on the map in Figure 7-1. Detected chemical concentrations above the CSL and alternative chemical criteria are shown as point locations on the map in Figure 7-2.

Table 7-1. Detection Frequencies and Frequencies of Detected Concentrations Greater than SQS and CSL in Intertidal Sediments for Benthic Invertebrate COPCs

COPC	Detection Frequency (n=9)	Frequency of Detected Concentrations > SQS		Frequency of Detected Concentrations > CSL	
		No. of Stations	Percent[1/]	No. of Stations	Percent[2/]
Metals					
Arsenic	100%	5	55.6%	5	55.6%
Chromium	100%	1	11.1%	1	11.1%
Copper	100%	4	44.4%	4	44.4%
Lead	100%	1	11.1%	1	11.1%
Mercury	100%	1	11.1%	0	0.0%
Zinc	100%	7	77.8%	2	22.2%
PAHs					
Acenaphthene	67%	1	11.1%	0	0%
Benzo(a)anthracene	100%	0	0.0%	0	0%
Benzo(a)pyrene	100%	0	0.0%	0	0%
Benzo(g,h,i)perylene	100%	0	0.0%	0	0%
Chrysene	100%	0	0.0%	0	0%
Dibenzo(a,h)anthracene	78%	0	0.0%	0	0%
Fluoranthene	100%	0	0.0%	0	0%
Indeno(1,2,3-cd)pyrene	100%	0	0.0%	0	0%
Phenanthrene	89%	0	0.0%	0	0%
Total HPAH	100%	0	0.0%	0	0%
PCBs					
PCBs (total)	100%	0	0.0%	0	0%
Other SVOCs					
bis(2-ethylhexyl)phthalate	33%	0	0.0%	0	0%
Pentachlorophenol	0%	0	0.0%	0	0%

1/ Number of detected concentrations > SQS / number of intertidal surface sediment samples analyzed for the COPC. For individual samples with OC < 0.5%, that sample was tallied as greater than the SQS if the dry weight concentration was greater than the LAET. The number of detected concentrations > SQS includes the number > CSL (i.e., this is not the number of concentrations between the SQS and the CSL).

2/ Number of detected concentrations > CSL / number of intertidal surface sediment samples analyzed for the COPC. For individual samples with OC < 0.5%, the sample was tallied as greater than the CSL if the dry weight concentration was greater than the 2LAET.

COPC – chemical of potential concern
CSL – cleanup screening level (SMS)
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
LAET – lowest apparent effects threshold
2LAET – second lowest apparent effects threshold
OC – organic carbon
PAH – polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
SMS – Washington State Sediment Management Standards
SQS – sediment quality standards (SMS)
SVOC – semivolatile organic compound

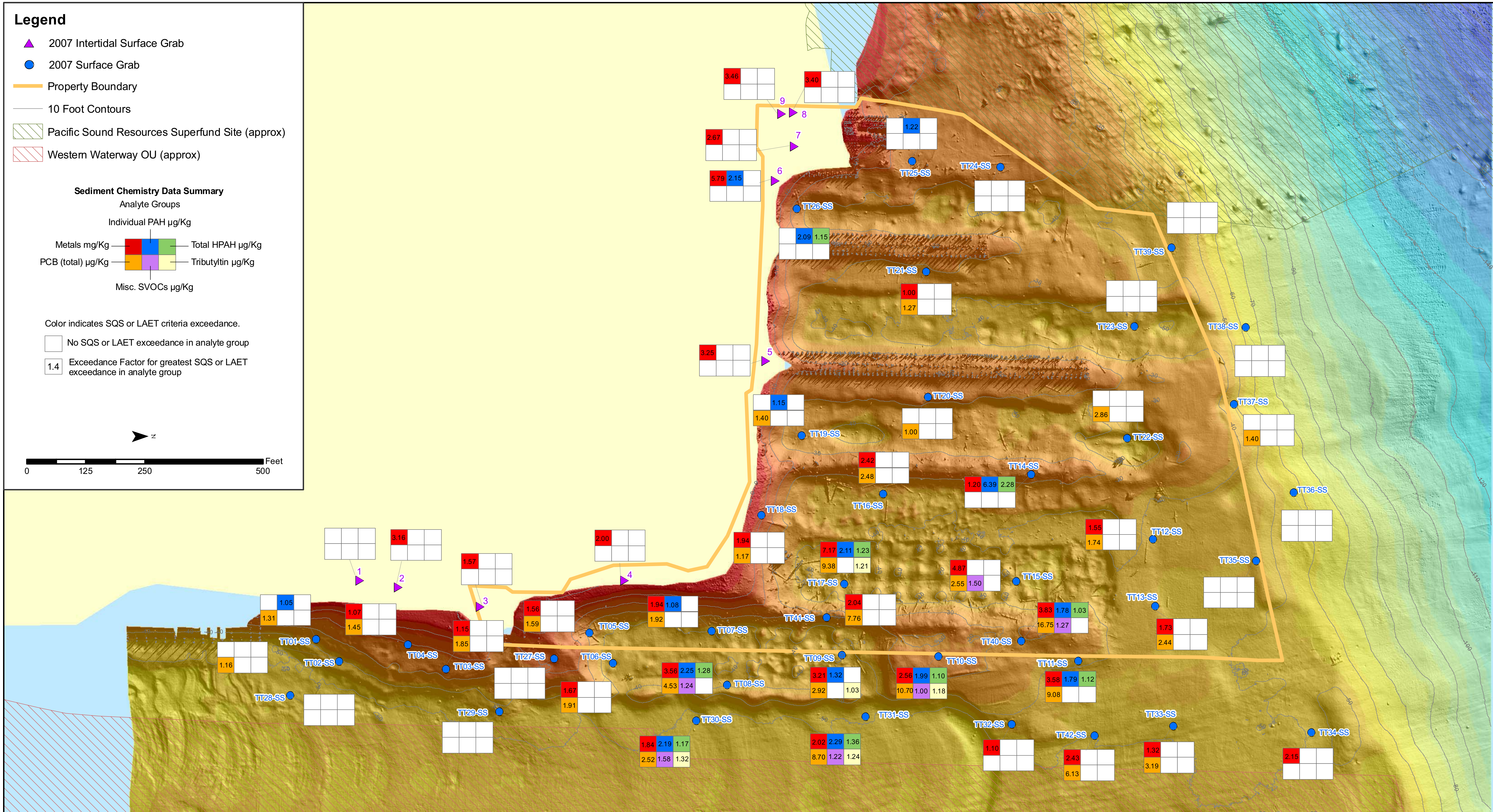
Table 7-2. Detection Frequencies and Frequencies of Detected Concentrations Greater than SQS and CSL in Subtidal Sediments for Benthic Invertebrate COPCs

COPC	Detection Frequency (n=42)	Frequency of Detected Concentrations > SQS		Frequency of Detected Concentrations > CSL	
		No. of Stations	Percent[1/]	No. of Stations	Percent[2/]
Metals					
Arsenic	100%	6	14.3%	4	9.5%
Chromium	100%	1	2.4%	1	2.4%
Copper	100%	8	19.0%	8	19.0%
Lead	100%	1	2.4%	0	0%
Mercury	100%	21	50.0%	17	40.5%
Zinc	100%	6	14.3%	1	2.4%
PAHs					
Acenaphthene	100%	2	4.8%	0	0%
Benzo(a)anthracene	100%	3	7.1%	0	0%
Benzo(a)pyrene	100%	4	9.5%	0	0%
Benzo(g,h,i)perylene	100%	9	21.4%	0	0%
Chrysene	100%	8	19.0%	0	0%
Dibenzo(a,h)anthracene	100%	6	14.3%	0	0%
Fluoranthene	100%	10	23.8%	0	0%
Indeno(1,2,3-cd)pyrene	100%	10	23.8%	0	0%
Phenanthrene	100%	6	14.3%	0	0%
Total HPAH	100%	9	21.4%	0	0%
PCBs					
PCBs (total)	100%	27	64.3%	7	16.7%
Other SVOCs					
bis(2-ethylhexyl)phthalate	95%	3	7.1%	0	0%
Pentachlorophenol	48%	3	7.1%	0	0%

[1/] Number of detected concentrations > SQS / number of subtidal surface sediment samples analyzed for the COPC. For individual samples with OC < 0.5%, that sample was tallied as greater than the SQS if the dry weight concentration was greater than the LAET. The number of detected concentrations > SQS includes the number > CSL (i.e., this is not the number of concentrations between the SQS and the CSL).

[2/] Number of detected concentrations > CSL / number of surface sediment samples analyzed for the COPC. For individual samples with OC < 0.5%, the sample was tallied as greater than the CSL if the dry weight concentration was greater than the 2LAET.

COPC – chemical of potential concern
CSL – cleanup screening level (SMS)
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
LAET – lowest apparent effects threshold
2LAET – second lowest apparent effects threshold
OC – organic carbon
PAH – polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
SMS – Washington State Sediment Management Standards
SQS – sediment quality standards (SMS)
SVOC – semivolatile organic compound

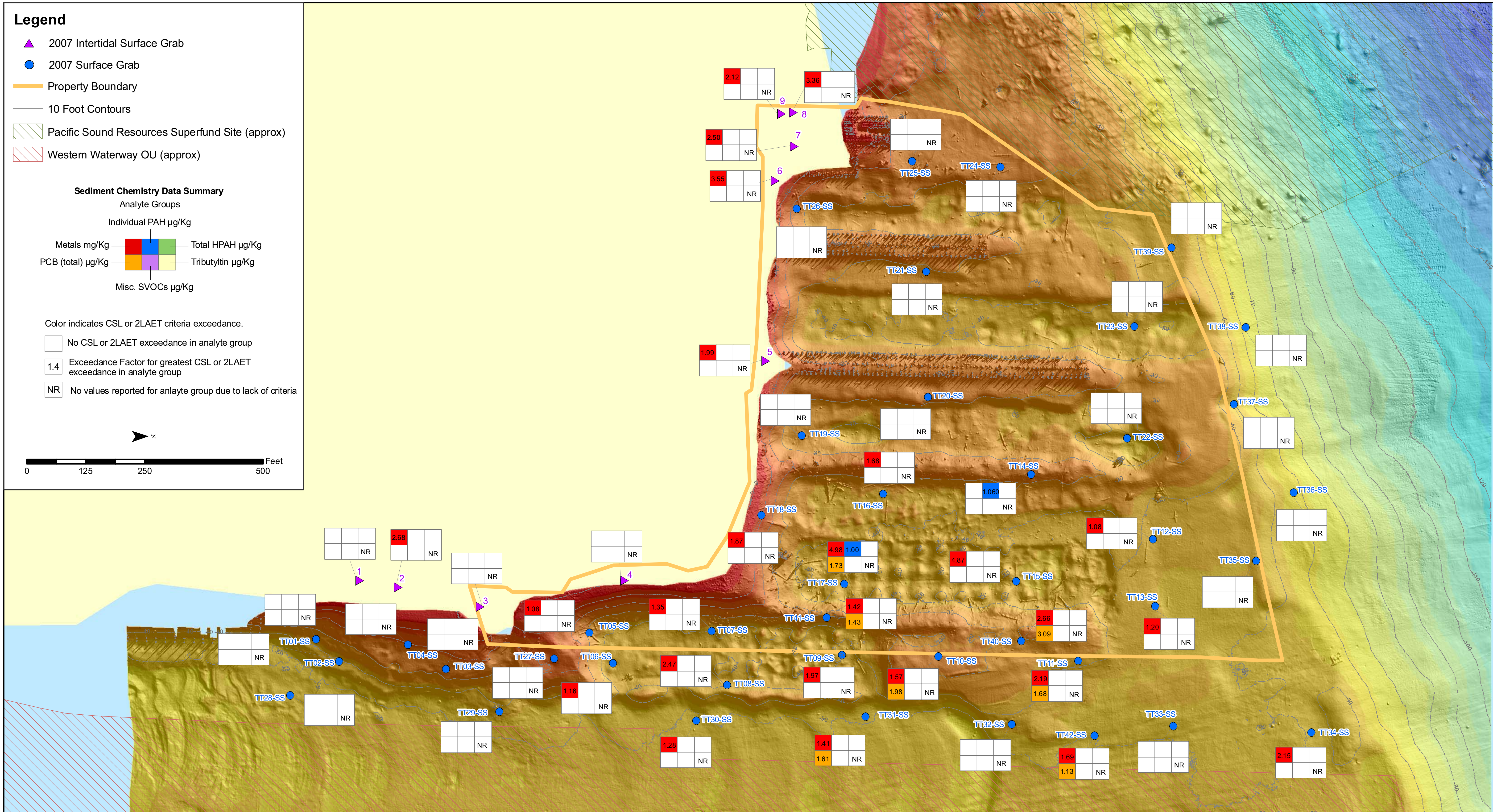


TETRA TECH INC.

Lockheed West Shipyard No. 2 Seattle, WA

Figure 7-1 SQS, SL, LAET Exceedances in Surface Sediment Samples from 2007

Z:\projects_2006\Lockheed\maps\EA_figs_10-22-08\Figure_7-1_SQS_SL_LAET.mxd



TETRA TECH INC.

Lockheed West Shipyard No. 2 Seattle, WA

Figure 7-2 CSL, ML, 2LAET Exceedances in Surface Sediment Samples from 2007

Z:\projects_2006\Lockheed\maps\EA_figs_10-22-08\Figure_7-1_CSL_ML_2LAET.mxd

In intertidal sediment stations, the frequency of COPC concentrations greater than the SQS chemical criteria ranged from 11 to 78 percent for metals and trace elements, and 11 percent for a single PAH (acenaphthene at one station). None of the PCBs or other semivolatile organic compound (SVOCs) exceeded their SQS in intertidal sediments. None of the PAHs, PCBs, or SVOCs exceeded the CSL chemical criteria in intertidal sediments. Metals exceeded the CSL at a frequency of 11 to 56 percent, with highest percentages of exceedances in intertidal sediment found for arsenic and copper, and the highest percentage of exceedance in subtidal sediment found for mercury.

In subtidal sediment stations, the frequency of COPC concentrations greater than the SQS chemical criteria ranged from 2 to 50 percent for metals and trace elements, from 5 to 24 percent for PAHs, and 7 percent for phthalates and pentachlorophenol; whereas the frequency of total PCB concentrations in subtidal sediment greater than the SQS was 64 percent. None of the PAHs, phthalates, or pentachlorophenol concentrations exceeded the CSL chemical criteria in subtidal sediments. Metals exceeded the CSL at a frequency of 2 to 41 percent, except for lead, which did not exceed the CSL. PCBs exceeded the CSL chemical criterion in 7 percent of the subtidal sediment stations.

For chemicals without SMS, sediment concentration comparisons are made with alternative criteria. Tables 7-3 and 7-4 present the intertidal and subtidal sediment chemistry data, respectively, for the benthic COPCs without SMS chemical criteria (antimony, cobalt, nickel, selenium, vanadium, and benzo[b]fluoranthene). Tributyltin is evaluated separately in the following section. DMMP SL, LAET, and NOAEL values are used for lowest criteria in the comparison, similar to the use of SQS; DMMP ML, second LAET (2LAET), and LOAEL values are used for the higher criteria.

In intertidal sediment stations (Table 7-3), nickel, vanadium, and cobalt exceeded their screening level or NOAEL values, at frequencies of 22 to 56 percent. None of the metals exceeded their ML or LOAEL values in intertidal sediment. In subtidal sediment stations (Table 7-4), metals exceeded low criteria values at a frequency of 2 to 24 percent, except nickel, which did not exceed its screening level. Benzo(b)fluoranthene exceeded its LAET value in 17 percent of samples, and its 2LAET value in 5 percent of samples. None of the metals or tributyltin exceeded their ML or LOAEL values in subtidal sediment.

The detected chemical concentrations greater than the DMMP screening level, LAET, and NOAEL values as alternative guidelines are shown as point locations on the map in Figure 7-1. The detected chemical concentrations greater than the DMMP ML, 2LAET, and LOAEL values as alternative guidelines are shown as point locations on the map in Figure 7-2.

Table 7-3. Detection Frequencies and Frequencies of Detected Concentrations in Intertidal Sediment above the SL/NOAEL and ML/LOAEL for COPCs without SMS Chemical Criteria

COPC	Detection Frequency (n=9)	Frequency of Detected Concentrations > SL/NOAEL/LAET		Frequency of Detected Concentrations > ML/LOAEL/2LAET	
		No. of Stations	Percent[1/]	No. of Stations	Percent[2/]
Metals					
Antimony	100%	0	0%	0	0%
Cobalt	100%	5	55.6%	0	0%
Nickel	100%	2	22.2%	0	0%
Selenium	100%	0	0%	0	0%
Vanadium	100%	2	22.2%	0	0%
PAHs					
Benzo(b)fluoranthene	100%	0	0%	0	0%

1/ [Number of detected concentrations > DMMP SL or NOAEL or LAET] / number of surface sediment samples analyzed for the COPC. The number of detected concentrations > SL or NOAEL includes the number > ML or LOAEL (i.e., this is not the number of concentrations between the SL and the ML or between the NOAEL and the LOAEL).
2/ [Number of detected concentrations > DMMP ML or LOAEL or 2LAET] / number of surface sediment samples analyzed for the COPC.
LAET – lowest apparent effects threshold
2LAET – second lowest apparent effects threshold
COPC – chemical of potential concern
DMMP – Dredged Material Management Program
LOAEL – lowest-observed-adverse-effect level
ML –maximum level (DMMP)
NOAEL – no-observed-adverse-effect level
SL –screening level (DMMP)

Table 7-4. Detection Frequencies and Frequencies of Detected Concentrations in Subtidal Sediment above the SL/NOAEL/LAET and ML/LOAEL/2LAET for COPCs without SMS Chemical Criteria

COPC	Detection Frequency (n=42)	Frequency of Detected Concentrations > SL/NOAEL/LAET		Frequency of Detected Concentrations > ML/LOAEL/2LAET	
		No. of Stations	Percent[1/]	No. of Stations	Percent[2/]
Metals					
Antimony	100%	1	2.4%	0	0%
Cobalt	100%	6	14.3%	0	0%
Nickel	100%	0	0%	0	0%
Selenium	38%	8	19.0%	0	0%
Vanadium	100%	10	23.8%	0	0%
PAHs					
Benzo(b)fluoranthene	100%	7	16.7%	2	4.8%

1/ [Number of detected concentrations > DMMP SL or NOAEL or LAET] / number of surface sediment samples analyzed for the COPC. The number of detected concentrations > SL or NOAEL includes the number > ML or LOAEL (i.e., this is not the number of concentrations between the SL and the ML or between the NOAEL and the LOAEL).
2/ [Number of detected concentrations > DMMP ML or LOAEL or 2LAET] / number of surface sediment samples analyzed for the COPC.
LAET – lowest apparent effects threshold
2LAET – second lowest apparent effects threshold
COPC – chemical of potential concern
DMMP – Dredged Material Management Program
LOAEL – lowest-observed-adverse-effect level
ML –maximum level (DMMP)
NOAEL – no-observed-adverse-effect level
SL –screening level (DMMP)

7.1.1.2 Uncertainties Associated with Benthic Invertebrate Risk Estimates

This section presents uncertainties in the sediment-based risk characterization for the benthic invertebrate community. The uncertainties are discussed separately for the problem formulation, exposure assessment, and effects assessment. Uncertainties related to the assessment of exposures of benthic invertebrates to TBT in sediment are discussed in the following section. The following discussion is based on the uncertainties described for the benthic invertebrate risk estimates at the LDW site (Windward 2007). Note that because the Site will be remediated, the uncertainties in the ecological risk estimates will have minimal effect on the site cleanup decision.

Problem Formulation

The benthic community as a whole was selected as an ROC to assess risks to benthic invertebrates because it encompasses all benthic invertebrates (except larger, more mobile species, such as crabs, that were assessed separately). Because the benthic community is so diverse, some uncertainty is associated with the assumption that the risk assessment for the benthic community is protective of all benthic invertebrate species.

AETs, which form the basis for SMS criteria and some of the DMMP guidelines, do not exist for 15 of the chemicals that were detected at a frequency greater than 5 percent in Lockheed West Site sediment stations. Therefore, chemicals without such criteria or guidelines or other relevant toxicity information were not identified as COPCs during the problem formulation. However, it is likely that locations with the highest potential for adverse effects were adequately identified because criteria and guidelines are available for 51 of the chemicals that were detected, which include chemical groups that are generally considered to be toxic to benthic invertebrates. Similar to an evaluation of uncertainty in the LDW ERA, chemicals without criteria that were detected above 5 percent in surface sediment stations were assessed by identifying locations where the maximum concentration of that chemical was greater than 10 times the mean concentration. Only antimony was identified through this process as having a maximum concentration 14 times higher than the mean concentration in subtidal sediment. The maximum concentration of antimony was found at station 11, where 13 other COPCs were found to exceed the SQS.

Exposure Assessment

Uncertainties in the exposure assessment for the benthic invertebrate community were associated with the following factors:

- Depth of biologically active zone
- Relationships among chemistry, toxicity, and actual *in-situ* effects

- Frequency of analyses of chemicals in surface sediment samples
- Elimination of COPCs based on the 5 percent detection frequency screen
- RLs greater than screening criteria

These uncertainties are discussed in detail below.

Depth of Biological Active Zone

Some benthic invertebrate species (e.g., clams) may burrow deeper than 10 cm, which was the surface sediment threshold used in this ERA to define the biologically active zone where the majority of the benthic invertebrate community resides. Estimated risks for these animals could differ from the risks presented for surficial organisms if 1) concentrations in sediment above 10 cm are markedly different than those in sediment between 10 and 40 cm (possible depth of clams, as seen upstream in the LDW), or 2) the chemical sensitivity of animals living below 10 cm is markedly different than the chemical sensitivity of animals living above 10 cm, on which the existing chemical criteria and guidelines are based. Subsurface sediments are not evaluated further for risk.

Prediction of In-situ Effects

The use of chemical criteria to predict *in-situ* effects is uncertain. Because of this uncertainty, adverse effects on the benthic community may occur in areas with chemical concentrations < SQS chemical criteria and may not occur in areas with concentrations > SQS or CSL chemical criteria. Factors such as site-specific bioavailability, mixtures of chemicals with or without criteria, and species-specific sensitivities may contribute to this uncertainty. For example, the SMS provides chemical-specific criteria to assess the risks from individual chemicals. Although these criteria were developed from field data in which mixtures of chemicals are common, the chemical-specific criteria do not assess the cumulative risks to benthic invertebrates from site-specific exposure to multiple chemicals with potentially synergistic or antagonistic effects.

Reporting Limits

Non-detected chemicals were evaluated for whether their RLs in the 2007 data set were above screening criteria. For those chemicals with SQS values based on carbon normalization, the LAET value was used as the screening criterion. The LAET is based on units of µg/kg dw and can be compared directly with the reporting levels in the same units.

The RLs for the chemicals which were not detected or which were detected below the 5 percent detection frequency criterion and were not selected as COPCs are compared in Table 7-5 with their screening criteria. Only three chemicals had RLs in at least one sample above their SQS or SL values. These chemicals are hexachlorobutadiene, alpha-chlordane, and dieldrin. The RL for each of these is less than 2-fold higher than the screening value. Based on an assumption that an undetected chemical might be present in site sediments at one-half the reporting limit, chemical concentrations would likely be below screening criteria for these three chemicals.

Most of the undetected chemicals did not have screening criteria for comparison. Forty-nine chemicals that were not detected or were below the detection frequency criterion do not have screening criteria for benthic effects. The potential risk to benthos due to these RLs
is uncertain.

Elevated RL values for organochlorine pesticides generally reflect the presence of probable analytical interference in the analysis because of the presence of PCB congeners. All of the detected organochlorine pesticides were qualified as JN, because of analytical interference resulting from the presence of PCB congeners. The elevated RLs for undetected organochlorine pesticides are likely due to the interference by PCB congeners, and the risk to benthos is considered to be low.

Table 7-5. Analysis of Reporting Limits for Undetected Compounds

Chemical	Reporting Limit (µg/kg dw)	Detection Status	Screening Criteria (µg/kg dw)
Phthalates			
Diethylphthalate	5.9	BDF	200[1/]
Di-n-octyl phthalate	2.1	BDF	2,100[1/]
Other SVOCs			
1,2,4-Trichlorobenzene	2.6	U	31[1/]
1,2-Dichlorobenzene	2.2	BDF	35[1/]
1,3-Dichlorobenzene	2.7	U	na
2,4,5-Trichlorophenol	5.1	U	na
2,4,6-Trichlorophenol	3.1	U	na
2,4-Dichlorophenol	3.1	U	na
2,4-Dimethylphenol	9.3	U	29
2,4-Dinitrophenol	61	U	na
2,4-Dinitrotoluene	4.8	U	na
2,6-Dinitrotoluene	4.8	U	na
2-Chloronaphthalene	6.1	U	na
2-Chlorophenol	2.9	U	na
2-Methylphenol	5.8	BDF	63
2-Nitroaniline	4.6	U	na
2-Nitrophenol	4.4	U	na
3,3'-Dichlorobenzidine	6.3	U	na
3-Nitroaniline	4.4	U	na

Table 7-5. Analysis of Reporting Limits for Undetected Compounds (continued)

Chemical	Reporting Limit (µg/kg dw)	Detection Status	Screening Criteria (µg/kg dw)
4,6-Dinitro-o-cresol	2.9	U	na
4-Bromophenyl phenyl ether	2.4	U	na
4-Chloro-3-methylphenol	3.6	U	na
4-Chloroaniline	3.6	U	na
4-Chlorophenyl phenyl ether	3.4	U	na
4-Nitroaniline	5.8	BDF	na
4-Nitrophenol	51	U	na
Aniline	2.6	BDF	na
Benzoic acid	170	U	650
bis(2-chloroethoxy)methane	2.2	U	na
bis(2-chloroethyl)ether	4.1	U	na
bis(2-chloroisopropyl)ether	2.1	U	na
Hexachlorobutadiene	**2.4**	U	1.3[1/]
Hexachlorocyclopentadiene	26	U	na
Hexachloroethane	3.8	U	140
Isophorone	2.7	U	na
Nitrobenzene	3.4	U	na
N-Nitrosodimethylamine	11	BDF	na
N-Nitroso-di-n-propylamine	5.4	U	na
N-Nitrosodiphenylamine	3.8	U	28[1/]
PCBs			
PCB-1016	2.9	U	na
PCB-1221	2.9	U	na
PCB-1232	2.9	U	na
PCB-1242	2.9	U	na
PCB-1248	2.9	U	na
PCB-1262	2.9	U	na
Organochlorine Pesticides			
Aldrin	2.6	U	9.5[1/]
alpha-BHC	4.4	U	na
alpha-Chlordane	**3.9**	U	2.8[1/]
delta-BHC	0.93	U	na
beta-BHC	5.1	U	na
Dieldrin	**4.9**	U	3.5[1/]
Endosulfan I	2.9	BDF	na
Endosulfan II	3.2	U	na
Endosulfan sulfate	1.4	U	na
Endrin	3.4	U	na
gamma-BHC	2.6	BDF	na
Heptachlor	1.4	U	1.5[1/]
Heptachlor epoxide	2.2	U	na
Nonachlor (cis)	1.4	BDF	na
Nonachlor (trans)	1.5	BDF	na
o,p'-DDE	3.9	U	na
Oxychlordane	6.3	U	na
p,p'-DDE	1.7	BDF	9[1/]
Toxaphene	160	U	na

[1/] Comparison is based on LAET.
Screening criteria are SQS or LAET
BDF – Detected but below detection frequency of 5% and not selected as a COPC for benthic invertebrates.
LAET – lowest apparent effects threshold
U – Undetected at Reporting Limit
Values in **Bold** exceed the associated screening criterion

Effects Assessment

The primary uncertainty in the effects assessment for the benthic invertebrate community was associated with the use of SMS chemical criteria, DMMP guidelines, or TRVs to predict a biological affect.

Use of SMS, DMMP, and TRVs to Predict Biological Effects

The chemical criteria, guidelines, and TRVs used to predict biological effects were based on test species that represent a small portion of the diverse benthic invertebrate community likely present at the Lockheed West Site, although the test species included crustaceans, which are considered to represent one of the taxonomic groups most sensitive to chemical exposure (Hyland et al. 1999). In addition, the benthic community AETs, which were the basis for several SQS or CSL chemical criteria, incorporated many different species with different feeding strategies and utilization of habitats, and therefore, represent COPC concentrations likely to be protective of the benthic invertebrate community as a whole. However, some uncertainty is associated with the benthic community AETs because they are based on abundance alone and therefore do not include adverse effects to the community, such as loss of species. In addition, some effects, such as endocrine disruption, are not explicitly addressed by the SMS endpoints. In summary, potential effects to some benthic species at the site may not be addressed by these criteria and guidelines; consequently, there is some uncertainty associated with the risk estimates.

The use of chemical criteria and guidelines predicts effects based on a comparison to detected chemical concentrations. SMS chemical criteria and some of the DMMP guidelines were developed using the AET approach. An AET is the highest "no effect" chemical-specific sediment concentration above which a significant adverse biological effect always occurred among the several hundred samples used for its derivation. The SMS criteria as presented in WAC 173-204 were developed for application to Puget Sound sediments. The Lockheed West Site aquatic environment is an estuarine system with possibly some spatial and temporal variation in the salinity between the Elliott Bay side and the West Waterway side. Although the West Waterway area of the site sediments lay within the mouth of the Duwamish River, salinity in West Waterway sediments at the Lockheed West Site would reflect the salinity of the salt wedge intrusion from Elliott Bay, and SMS criteria are considered applicable to those sediments.

Note that SMS chemical criteria were developed for specific chemicals based on AETs empirically derived from a dataset of field-collected sediment samples that contained diverse chemical mixtures and that were analyzed for both chemistry and toxicity. Therefore, the AETs do not develop a cause-and-effect relationship for specific chemicals.

Risk Conclusions

The potential for adverse effects on benthic invertebrate communities was evaluated based on comparisons of chemical concentrations in surface sediment to SQS/CSL chemical criteria, toxicologically based DMMP guidelines, and TRVs. The potential adverse effects included in the existing criteria are mortality, abnormal development, and growth at the individual level, and altered ecological function at the community level.

According to SMS, locations with all chemical concentrations less than or equal to the SQS chemical criteria are defined as having no acute or chronic adverse effects on biological resources; locations with any chemical concentrations greater than CSL chemical criteria are defined as having adverse effects; and locations with any chemical concentrations between the SQS and CSL chemical criteria have adverse effects between these two definitions. In the absence of site-specific toxicity testing, the prediction of adverse effects at locations with chemical concentrations greater than SQS or CSL chemical criteria and other guidelines is uncertain.

The potential for adverse effects is more uncertain at locations where no detected chemicals exceeded the SQS/CSL chemical criteria or DMMP guidelines but RLs were greater than criteria and guidelines. However, based on an analysis of these elevated RLs, the likelihood of risks from non-detected chemicals with RLs that exceeded their respective SQS chemical criteria is low.

7.1.1.3 Benthic Invertebrate Risks from Transition Zone Water

Infaunal benthic invertebrates, i.e., organisms that live within the biologically active zone of sediment, defined as the top 10 cm in Puget Sound (PSWQAT 1997), can be exposed to chemicals in transition zone water, which is defined as the location of groundwater interface with surficial sediment at the point of groundwater discharge to surface water. For the Lockheed West Site, data on transition zone water contamination related to the former Yard 2 upland area are not available for use in assessing risks to benthos from contaminated groundwater discharge to the surface water. The following is an evaluation of potential risks to benthos at the Lockheed West Site associated with this pathway and related uncertainties.

Surrogate data for an evaluation of transition zone water risks to benthos would typically come from groundwater samples collected near or at the area of contaminated groundwater discharge to surface water. However, knowledge is lacking about the present extent of contaminated groundwater in the former shipyard uplands and whether it may move and discharge to the aquatic areas of the site. Data on present conditions of contaminated groundwater in the upland area that could be used to represent groundwater discharge to the surface waters of the Lockheed West Site are not currently available.

The lack of recent data for evaluating whether transition zone water is contaminated and any related risks to sediment infaunal benthos presents an uncertainty in the benthic invertebrate risk assessment. To further evaluate this uncertainty, an analysis is presented of historical groundwater contaminant data collected in the upland areas of the former shipyard uplands. As described below, because the data were collected in upland groundwater samples over 17 years ago prior to remediation of upland soils, they are assumed to over-estimate potential concentrations in transition zone water under present conditions. Data sources and summaries related to the upland areas of the former shipyard uplands have been compiled in a review of existing data for source control activities required under CERCLA for the Lockheed West Site (Tetra Tech 2009). Groundwater data are summarized in Appendix G-2 of the source control existing data report (Tetra Tech 2009), which presents a map showing groundwater contaminant source areas and monitoring wells for which historical data are available. The most recent groundwater data compiled and presented in the source control existing data report were collected in 1992 (Enviros 1993). The analyte list is limited and consists of metals and several volatile organic and semi-volatile organic chemicals; most PAHs are not reported and PCBs were reported as not detected (McLaren-Hart 1992).

The evaluation of potential risks from transition zone water consists of comparison of the maximum concentrations of chemicals compiled from the 1992 groundwater sampling with EPA-recommended water quality criteria for the protection of marine aquatic organisms (saltwater criteria continuous concentration, CCC) (http://www.epa.gov/waterscience/criteria/wqctable/index.html). For this evaluation, only the wells along the perimeter of the water sides of the former shipyard uplands are used (Table 7-6). These wells were identified through review of the map of wells reproduced in Appendix G-2 of the source control existing data report. The comparison of maximum contaminant concentrations with water quality criteria is presented in Table 7-6. Results of the comparison indicate that the maximum concentrations of several metals (copper, lead, nickel, zinc) and cyanide from one well (MW-38A) and nickel in well MW-5 in the 1992 data set exceeded the marine water quality criteria for the protection of aquatic organisms. MW-38A and MW-5 represent shallow aquifer wells located along the north perimeter of the former shipyard uplands, along the Elliott Bay side. None of the concentrations of volatile organic compounds or semi-volatile organic compounds were found to exceed water quality criteria, partly because of the lack of water quality criteria for most of these chemicals. Only one well (MW-38A) showed criteria exceedances by more than one chemical.

The representativeness of the historical groundwater data used for screening potential risks to sediment benthos is highly uncertain. Uncertainties with this comparison are summarized as follows:

- The water samples were reported as total metals and the data report indicates that compiled data were from unfiltered samples (Enviros 1993), whereas the water quality criteria are intended to be compared with the dissolved fraction for metals. The use of unfiltered water samples likely overestimates the concentrations of dissolved metals in the MW-38A and MW-5 samples.
- The cyanide water quality criterion is for free cyanide whereas the measured cyanide is total cyanide, which may overestimate the free cyanide concentration in MW-38A.
- Low-flow sampling was not conducted, and most of the samples were collected with a bailer. Use of this technique may overestimate concentrations for metals.
- The data collected in 1992 were collected 17 years ago and do not represent present conditions of the groundwater in the upland areas. The soils of the upland area of former Yard 2 were also cleaned up in 1993-1994, with removal of hot spot soils and slag, and cleanout of storm water catch basins.
- A previous risk assessment for the upland area of former Yard 2 had demonstrated through modeling that groundwater contamination did not pose risks to aquatic receptors in the nearby surface waters (ChemRisk 1991). Most of the wells that were sampled and reported in 1992 were subsequently abandoned, with MW-5 and MW-26 remaining as part of the long term monitoring of groundwater being performed by the Port of Seattle for the former Yard 2 upland area.

Because of the finding of multiple exceedances in only a single well, and the numerous uncertainties in the representativeness of the data for present conditions of the upland groundwater, this comparison suggests that transition zone water, as represented by the 1992 upland well data, would not present significant risks to benthic infaunal organisms at the Lockheed West Site. The present conditions of the former shipyard uplands groundwater could differ substantially from the 1992 data. Recent upland groundwater data were collected by the Port in spring 2009 under the long-term monitoring program for the outhwest Harbor project; the data will be evaluated by comparison with AWQC in an upcoming source control evaluation report for the Lockheed West Site.

Table 7-6. Maximum Concentrations of Chemicals in Perimeter Shallow Aquifer Wells, Lockheed West Upland, in 1992

Location of Perimeter Wells:		**Northwest, Elliott Bay**		**North Side, Elliott Bay**		**Northeast, Elliott Bay**	**East Side, West Waterway**			**Southeast, West Waterway**
Chemical	**Criterion Continuous Concentration (CCC)**	**MW-15**	**MW-16**	**MW-38A**	**MW-5**	**MW-33**	**MW-25**	**MW-26**	**MW-27**	**MW-31**
Metals (µg/L)										
Arsenic	36	**34**	5	**9**	5	5	5	5	5	5
Cadmium	8.8	5	5	1	5	5	5	5	5	5
Copper	3.1	10	10	***61***	10	10	10	10	10	10
Cyanide	1	NA	5	***299***	5	NA	5	NA	NA	NA
Lead	8.1	1.5	1.5	***37***	1.5	1.5	1.5	1.5	1.5	1.5
Mercury	0.94	0.25	0.25	**0.2**	0.25	0.25	0.25	0.25	0.25	0.25
Nickel	8.2	10	10	***30***	***23***	10	10	10	10	10
Selenium	71	2.5	2.5	2.5	**5**	2.5	2.5	2.5	2.5	2.5
Thallium	NA	5	5	5	5	5	5	5	5	5
Zinc	81	10	10	***150***	10	10	10	10	10	**29**
Volatile Organic Compounds (µg/L)										
1,1-Dichloroethane	NA	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
1,2-Dichloroethene	NA	0.5	0.5	0.5	0.5	0.5	0.5	0.5	**0.55**	0.5
Methylene Chloride	NA	10	10	10	10	10	10	10	10	10
Toluene	NA	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Tetrachloroethylene	NA	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	**2**
Trichloroethylene	NA	0.25	0.25	0.25	0.25	0.25	0.25	0.25	**0.86**	**0.7**
Xylenes	NA	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75

Table 7-6. Maximum Concentrations of Chemicals in Perimeter Shallow Aquifer Wells, Lockheed West Upland, in 1992 (continued)

Location of Perimeter Wells:		Northwest, Elliott Bay		North Side, Elliott Bay		Northeast, Elliott Bay	East Side, West Waterway			Southeast, West Waterway
Chemical	**Criterion Continuous Concentration (CCC)**	**MW-15**	**MW-16**	**MW-38A**	**MW-5**	**MW-33**	**MW-25**	**MW-26**	**MW-27**	**MW-31**
Semivolatile Organic Compounds (µg/L)										
Acenaphthalene	NA	0.1	0.1	0.1	0.1	0.1	**0.28**	NA	NA	NA
Benzoic Acid	NA	25	25.0	25	25.0	25	25	NA	NA	NA
Bis(2-ethylhexyl)phthalate	NA	5	5.0	5	5.0	5	5	NA	NA	NA
Fluorene	NA	0.05	0.05	**1.5**	0.05	0.05	0.05	NA	NA	NA
Naphthalene	NA	**0.96**	0.05	**8**	0.05	0.05	0.05	NA	NA	NA

Notes

Results represent total (unfiltered) samples collected from the shallow aquifer during 1992.

CCC = EPA National Recommended Water Quality Criteria; values for metals are expressed as dissolved metals

Non-bold values are undetected, value is one-half reporting limit.

Bold values represent detected compounds above reporting limits.

Bold and italics indicate exceedance of water quality criterion.

NA = Not Available, Not Applicable, or Not Analyzed

Data Source: Distillation Report, Volume II, Appendix A to Feasibility Study (Enviros 1993).

7.1.1.4 Benthic Invertebrate Risks from TBT

This section presents an evaluation of risks to benthic invertebrates from exposure to TBT at the Lockheed West Site, including uncertainties and risk conclusions. Risks from exposure to TBT were assessed separately for benthic invertebrates and gastropods; both are assessed using a critical tissue-residue approach. TBT exposures are based on TBT concentrations in sediment samples and modeling to tissue concentrations.

Critical Tissue-Residue Approach

The potential adverse effects of TBT exposure were assessed for benthic invertebrates other than gastropods using a critical tissue-residue approach. TBT concentrations in tissue were calculated from the non-linear regression relationship observed between the TBT concentrations in co-located benthic invertebrate tissue and sediment samples presented in the LDW ERA and described in Section 3. The concentration of TBT in tissue of benthic invertebrates at the Lockheed West Site was modeled at 0.61 mg/kg dw. This concentration is less than the NOAEL TRV of 0.97 mg/kg dw for benthic invertebrates, which suggests a low risk to benthic invertebrates from TBT at the Lockheed West Site.

The largest source of uncertainty associated with the critical tissue-residue evaluation of risk to benthic invertebrates is the TRV value. The selected TRV from the LDW ERA was based on the response of a single species, the polychaete *Armandia brevis,* in a spiked sediment bioassay. This polychaete is found in marine intertidal mud flats and would not be expected to be present in substantial numbers in the predominantly subtidal Lockheed West Site sediments. This species has been shown to bioaccumulate TBT with relatively little ability to metabolize TBT (Meador 1997; Meador et al. 1997).

Another source of uncertainty is the modeling of benthic invertebrate tissue concentrations. The use of a regression equation from the LDW site reduces uncertainty compared to using a BSAF from the literature. Although the 95 UCL concentration of TBT in sediment at the Lockheed West Site fell just above the range of values used in the regression, the upper end of the Lockheed West Site concentrations was well above the range. Extrapolation of the regression to a concentration outside the regression range increases the uncertainty in the modeled tissue concentration.

Porewater Approach

Comparison of the range of sediment porewater concentrations of TBT at the Lockheed West Site with the porewater screening trigger value suggests a potential for low to moderate risk. Sediment porewater concentrations from six stations at Lockheed West ranged from 0.02 to 1.9 µg/L, with the maximum level substantially above the EPA

Interagency TBT work group threshold concentration of 0.05 µg/L. Only one of the six stations had a concentration of TBT in porewater below the threshold.

Imposex Assessment in Gastropods

The potential adverse effects from TBT exposure were assessed for meso- and neogastropods through two approaches: comparison of a modeled tissue concentration in benthic invertebrates with a tissue body residue associated with imposex effects on gastropods, and a comparison of the sediment concentrations of TBT with those in the upstream LDW site where direct measurement of imposex in field-collected gastropods was performed.

Critical Tissue-Residue Approach

The potential adverse effect of TBT concentrations in Lockheed West Site sediments on sensitive neogastropod and mesogastropod species was evaluated by a tissue residue approach. Concentrations of TBT in neogastropod and mesogastropod species that have been associated with reproductive effects due to imposex were compared with modeled concentrations of TBT in benthic invertebrate tissue based on Lockheed West Site sediment data. Data are not available on the relationship between TBT concentrations in sediment and those in tissue of TBT-sensitive gastropods. Therefore, the modeled TBT concentrations in benthic invertebrates at the Lockheed West Site (see Table 4-6) were used as surrogates for tissue concentrations of TBT in gastropods at the Lockheed West Site.

Modeled tissue concentrations of TBT in benthic invertebrates at Lockheed West were compared with the lowest tissue-based LOEC of 0.72 mg/kg dw that was reported to result in 40 percent sterilization of periwinkle (Oehlmann et al. 1998). Using the LDW regression relationship, the tissue concentration in benthic invertebrates at Lockheed West was modeled at 0.61 mg/kg dw based on the 95 UCL sediment concentration of 2,810 µg/kg dw. This value is less than the critical tissue residue LOEC of 0.72 mg/kg dw, resulting in an HQ of 0.86. The evaluation suggests a low risk of imposex to gastropods from TBT in sediment at the Lockheed West Site.

The sources of uncertainty in the assessment of TBT risks to sensitive gastropods are both the modeled tissue residue concentration and the critical residue LOEC. Uncertainties related to the modeled tissue concentration are the same as described above for the benthic invertebrate assessment. The critical residue TRV that was used in the evaluation was the lowest of compiled values from the LDW site. The test species that the TRV is based on do not occur in the West Waterway, based on surveys described in an earlier West Waterway risk assessment (ESG 1999). The finding that the modeled tissue concentration of TBT is less than the tissue-based TRV, although not based on the same species as the TRV, suggests a low risk from TBT to sensitive benthic invertebrates at Lockheed West.

Comparison with Field-Based Study in LDW

Results of a field study of gastropod exposures to TBT in LDW sediment are reported in the ERA for the LDW site (Windward 2007) and in related technical memoranda. Imposex was not observed in two of the three neogastropod species examined, or in two mature female mesogastropods collected in the LDW (Windward 2006a). Imposex was not observed in the abundant neogastropods *Astyris gausapata* or *Olivella baetica*, including specimens collected from areas within the LDW that historically have had high TBT concentrations in surface sediment.

The sediment concentrations of TBT at the Lockheed West Site were compared with those that were associated with the field collected gastropods from the LDW site. The sediment concentrations of TBT in the areas from which gastropods were collected at the LDW site ranged from 34 to 358 µg/kg dw, with the highest imposex indices found in the neogastropod *Nassarius mendicus* females associated with concentrations at 320 and 350 µg/kg dw. In comparison, the range of concentrations of TBT in sediments at the Lockheed West Site was 0.81 µg/kg dw to 4,500 µg/kg dw, with a 95 UCL of 2,829 µg/kg dw. Most of the concentrations of TBT in the Lockheed West Site sediments exceed the upper end of the range of concentrations in the LDW sediments where gastropods were studied, and the results and conclusions of the LDW gastropod imposex assessment cannot be extrapolated to the Lockheed West Site.

7.1.2 Crabs

This section presents the risk estimates, uncertainties, and risk conclusions for crabs.

7.1.2.1 Risk Estimates

In this section, risks to crabs from exposures to bioaccumulative COPCs are assessed using a critical tissue-residue approach. Risks were assessed separately for crabs as benthic invertebrates using a critical tissue-residue approach because crabs are more mobile than infaunal organisms, are not specifically covered by SMS criteria, and have a greater potential for exposure through bioaccumulation because of their higher trophic position. HQs were calculated by comparing the tissue EPCs of the bioaccumulative COPCs modeled in whole-body crab tissue with tissue-based NOAEL and LOAEL TRVs. Results of the risk estimates are shown in Table 7-7.

Of the bioaccumulative COPCs for crab, TBT was found to present a substantial risk. For TBT, the NOAEL-based HQ at 202 was substantially greater than 1.0. There is no LOAEL-based TRV for TBT exposure of crab for developing a LOAEL-based HQ for comparison. For PCBs, the NOAEL-based HQ is 9.3, although the LOAEL-based HQ is much lower and slightly less than 1.0, at 0.9. HQs for the remaining COPCs other than pesticides were below 1.0. For many COPCs, particularly PAHs, TRVs were unavailable for crabs and HQs are not estimated. For organochlorine pesticides, HQs above 1.0 were found for total DDTs and methoxychlor, but because all organochlorine pesticides were JN-qualified, the HQs are associated with very high uncertainty.

Table 7-7. HQs for Crabs Using Whole-body Exposure and Effects Data

COPC	Sediment EPC (mg/kg dw)	Modeled Tissue Concentration (mg/kg ww)	TRV NOAEL (mg/kg ww)	TRV LOAEL (mg/kg ww)	HQ NOAEL	HQ LOAEL
Metals						
Chromium	90.0	0.07	1	3.2	0.1	0.02
Copper	618	14.7	50	na	0.3	--
Lead	200	1.0	Na	na	--	--
Mercury	0.61	0.013	0.99	1	0.01	0.01
Selenium	0.67	na	na	na	--	--
PAHs						
Acenaphthene	0.13	0.071	na	na	--	--
Acenaphthylene	0.15	0.135	na	na	--	--
Anthracene	0.52	0.56	na	na	--	--
Benzo(a)anthracene	0.71	0.43	na	na	--	--
Benzo(a)pyrene	0.68	0.03	na	na	--	--
Benzo(b)fluoranthene	1.11	0.57	na	na	--	--
Benzo(g,h,i)perylene	0.38	0.002	na	na	--	--
Benzo(k)fluoranthene	0.55	0.21	na	na	--	--
Benzofluoranthenes (total)	1.55	0.39	na	na	--	--
Chrysene	1.12	0.46	na	na	--	--
Dibenzo(a,h)anthracene	0.13	0.03	na	na	--	--
Fluoranthene	2.38	0.65	na	na	--	--
Fluorene	0.15	0.07	na	na	--	--
Indeno(1,2,3-cd)pyrene	0.42	0.05	na	na	--	--
Phenanthrene	0.98	0.05	na	na	--	--
Pyrene	2.04	0.36	na	na	--	--
Organometals						
Tri-n-butyltin	2.81	25.2	0.12	na	**202**	--
Other SVOCs						
Pentachlorophenol	0.12	0.027	na	na	--	--
PCBs						
Aroclor 1254	0.37	0.76	na	na	--	--
Aroclor 1260	0.27	0.56	na	na	--	--
Aroclor 1268	0.04	0.075	na	na	--	--
Total PCBs	0.50	1.03	0.11	1	**9**	0.9
Organochlorine Pesticides						
Chlordane (gamma)	0.008	0.034	0.71	2	0.05	0.02

Table 7-7. HQs for Crabs Using Whole-body Exposure and Effects Data (continued)

COPC	Sediment EPC (mg/kg dw)	Modeled Tissue Concentration (mg/kg ww)	TRV NOAEL (mg/kg ww)	TRV LOAEL (mg/kg ww)	HQ NOAEL	HQ LOAEL
4,4'-DDD	0.004	0.027	na	na	--	--
4,4'-DDT	0.027	0.120	na	na	--	--
Total DDT	0.076	0.45	0.046	0.06	**10**	**7**
Methoxychlor	0.015	0.050	0.015	0.15	**3**	0.33
Mirex	0.003	na	0.02	0.03	--	--
Total Chlordanes	0.008	0.034	0.71	2	0.05	0.02

EPC – exposure point concentration
HQ – hazard quotient
LOAEL – lowest-observed-adverse-effect level
NOAEL – no-observed-adverse-effect level
PCB – polychlorinated biphenyl
TRV – toxicity reference value
Bold identifies HQs greater than 1.

7.1.2.2 Uncertainty Associated with Crab Tissue Risk Estimates

This section presents specific areas of uncertainty in the crab risk estimates related to the problem formulation, exposure assessment, effects assessment, and risk characterization. Note that because the entire Site will be remediated, the uncertainties in the ecological risk estimates will have minimal effect on the site cleanup decision.

Problem Formulation

Crabs were selected as an ROC to represent higher-trophic-level benthic invertebrates not addressed by the SMS. There is uncertainty associated with the assumption that COPC concentrations in crab tissue would represent those of other mobile, higher-trophic-level benthic invertebrates at the site, which would include sea stars and shrimp. Dungeness crabs are scavengers; their diet includes shrimp, mussels, small crabs, clams, and sea urchins. Thus, crabs are likely to be similarly exposed through their diet as sea stars and shrimp, which have comparable diets. Thus, there is relatively little uncertainty in using crabs as representatives of larger, more mobile benthic invertebrates.

Exposure Assessment

The use of modeled tissue data based on crab or clam BSAFs to estimate crab exposure rather than basing exposures on dietary intake was intended to integrate all potential exposure pathways to crabs. The BSAFs were taken as crab values where available, or were based on deposit feeder clam values. Many of the BSAF values were listed for marine or estuarine crustaceans without species or location identification. For example, the BSAF for TBT in crabs was taken as the 90th percentile of two values for infaunal benthic crustaceans because values were not available for crabs. This BSAF of 4.2 resulted in a crab NOAEL HQ of 202 for TBT. How applicable this BSAF may be to crabs that might be present at the Lockheed West Site is highly uncertain. For the other COPCs, in addition to the uncertainty associated with the use of BSAFs from uncertain species and location, the number of crab BSAFs were limited to single values or a small range of values. Most of the BSAFs for PAHs were the 90th percentile values for estuarine mollusks in the USACE (2008) BSAF database. The low number of BSAFs also entails high uncertainty. Because of the high uncertainty, the degree of potential overestimation or underestimation of risks to crab is not known.

All exposures and hence the modeled tissue concentrations were assumed to occur to sediment located on the Lockheed West Site. However, because the home range of crabs extends further than the size of the sediment site boundaries from which data were collected, their concentrations could differ from those estimated in this ERA.

Effects Assessment

The primary uncertainty in the crab effects assessment is the limited number of tissue-based TRVs available in the literature. The TRVs used in this ERA were taken directly from the LDW ERA (Windward 2007), with development of TRVs for mirex. Windward (2007) reported effects data for decapods for only 8 of the 34 COPCs identified herein for crab tissue at Lockheed West. These toxicity studies investigated only survival or growth endpoints, although it is possible that reproductive endpoints are more sensitive. In some of the studies, tests were conducted only with adults, although juveniles or early life stages may be more sensitive than adults. Additional uncertainties with these studies were associated with exposure durations, exposure pathways (water exposure vs. dietary exposure), and test organism used (decapods other than crabs).

For COPCs that are evaluated as a group, such as DDTs and Aroclors, the toxicities of all individual COPCs are captured within the TRV for the total. In other words, the toxicities of the individual Aroclors that are missing TRVs are captured in the TRV for total PCBs, and the toxicities of the individual DDT isomers that are missing TRVs are captured in the TRV for total DDTs. The uncertainties of these COPCs missing TRVs are thus minimized by accounting for their toxicity within a chemical group.

Risk Characterization

Organochlorine pesticides such as total DDT were identified as COPCs for crabs as well as other ROC tissues at the Lockheed West Site based on their potential for bioaccumulation. The highest HQ for a chlorinated pesticide in crab tissue was 9.7 for total DDT. Risks to crabs from chlorinated pesticides are highly uncertain because of the JN-qualified sediment data from which tissue data were modeled. As described earlier, the JN qualifiers indicate suspected false identifications of the presence of organochlorine pesticides as well as overestimates in their concentrations. Therefore, risk to crabs from total DDT is considered to be low and uncertain.

7.1.3 Summary of Risk Conclusions for Benthic Invertebrate Community

In summary, results of the benthic invertebrate community risk estimates and evaluation of associated uncertainties are as follows. Risks to crab are assessed separately from the benthic invertebrate community.

Benthic invertebrate community. Of the 42 subtidal sediment stations, 33 of them, or 79 percent, had at least one chemical that exceeded its SQS. Twenty-one percent of the intertidal stations (9 stations) did not have SQS or CSL exceedances and are predicted to present no to very low risk to benthic invertebrates. Twenty subtidal stations were found to have CSL exceedances for at least one chemical, meaning that 48 percent, or almost half, of the subtidal stations present a likelihood of adverse effects to benthic invertebrates.

Intertidal sediments presented more of a risk to benthic invertebrates through metals exposure rather than organic compounds. Of the nine intertidal stations, eight stations, or 89 percent of the stations, had at least one metal that exceeded its SQS. Six of the nine stations, or 67 percent, had at least one metal that exceeded its CSL. Based on these results, most (i.e., 67 percent) of the intertidal sediment stations of the Lockheed West Site poses a risk of adverse effects to benthic invertebrates.

Risks to gastropods from TBT based on the tissue residue approach using modeled data were low, with a NOAEL-based HQ less than 1. However, using the porewater criterion approach, risks to gastropods from porewater TBT are considerably higher, with HQs for five of six stations greater than 1 and as high as 38.

Crabs. Risks to crabs at the site were very high for TBT based on the critical-residue approach and a tissue concentration modeled from sediment using the BSAF method. For TBT, there is high uncertainty with the BSAF, and because of the lack of a LOAEL-based TRV, no LOAEL-HQ was calculated. For PCBs, the LOAEL-HQ was less than 1, indicating a low risk for adverse effects to crabs due to PCBs.

7.2 RISK CHARACTERIZATION FOR FISH

This section presents a risk characterization and uncertainty analysis for each of the fish ROCs. Risks are estimated for each ROC by comparison of modeled exposures with TRVs. Following the risk estimates, a detailed evaluation of uncertainty associated with these calculations is presented. Risk conclusions are then presented for each ROC synthesizing risk estimates and uncertainties.

7.2.1 English Sole

This section presents risk estimates, uncertainties, and risk conclusions for English sole.

7.2.1.1 Risk Estimates

COPCs evaluated for English sole consisted of the tissue COPCs that were identified based on potential to bioaccumulate from site sediments. Of these COPCs, mercury, selenium, TBT, total PCBs, and organochlorine pesticides were evaluated using a critical tissue-residue approach; and chromium, copper, lead, and PAHs were evaluated using a dietary approach.

Whole Body Residue Approach

The HQs for English sole based on the whole body tissue residue approach are presented in Table 7-8. Modeled tissue concentrations of TBT for English sole were greater than both LOAEL and NOAEL TRVs, with a LOAEL-based HQ of 18. Modeled tissue concentrations of PCBs for English sole were greater than both LOAEL and NOAEL TRVs, with LOAEL-based HQs ranging from 6 to 31 and NOAEL-based HQs ranging from 1 to 6. No other LOAEL-based HQs exceeded 1 for the fish tissue residue approach, except for total DDTs, which are highly uncertain because of the JN-qualifiers on the sediment concentrations of all pesticides.

Dietary Approach

The HQs for English sole based on dietary approach, assuming a diet of benthic invertebrates as 100 percent prey items and ingestion of sediment, are presented in Table 7-9.

Estimated exposures based on dietary concentrations of COPCs for English sole prey were greater than both LOAEL and NOAEL TRVs only for copper, with a LOAEL-based HQ of 18.

These results suggest a risk to English sole for TBT based on modeled whole body concentrations, and for copper based on concentrations modeled in English sole prey and concentrations in sediment.

Table 7-8. HQ Calculations for English Sole Based on Tissue Residue

COPC	Sediment EPC (mg/kg dw)	Modeled Tissue Concentration (mg/kg ww)	TRV NOAEL (mg/kg ww)	TRV LOAEL (mg/kg ww)	HQ NOAEL	HQ LOAEL
Metals						
Mercury	0.61	0.08	0.23	0.47	0.3	0.2
Selenium	0.67	na	1	2	--	--
Organometals						
Tri-n-butyltin	2.81	2.84	0.018	0.159	**158**	**18**
SVOCs						
Pentachlorophenol	0.12	0.06	12.3	22.1	0.005	0.003
PCBs						
Total PCBs	0.50	3.22	0.20 – 0.53	0.52 – 2.6	**6 - 31**	**1 - 6**
Organochlorine Pesticides						
Total DDT	0.08	2.54	1.8	1.8	**1**	**1**
Chlordane (gamma)	0.01	0.16	0.71	1.36	0.2	0.1
Methoxychlor	0.02	0.12	0.05	0.3	**2**	0.4
Mirex	0.003	0.017	1.6	9.6	0.01	0.002
Total Chlordanes	0.01	0.16	0.71	1.36	0.2	0.11

dw – dry weight
EPC – exposure point concentration
HQ – hazard quotient
LOAEL – lowest-observed-adverse-effect level
NOAEL – no-observed-adverse-effect level
PCB – polychlorinated biphenyl
TRV – toxicity reference value
ww – wet weight
Bold identifies HQs greater than 1.

Table 7-9. HQ Calculations for English Sole Based on Dietary Exposures

COPC	Sediment EPC (mg/kg dw)	Modeled Tissue Conc. in Benthic Invertebrate Prey (mg/kg dw)	Total Dietary Exposure (mg/kg dw)	TRV NOAEL (mg/kg dw)	TRV LOAEL (mg/kg dw)	HQ NOAEL	HQ LOAEL
Metals							
Chromium	90	0.39	1.3	9.42	na	0.1	--
Copper	618	279	286	8	16	**36**	**18**
Lead	200	508	510	7,040	na	0.07	--
PAHs							
Benzo(a)pyrene	0.68	0.85	0.85	100	116	0.009	0.007
Total PAHs	10.9	28.3	28.4	324	951	0.09	0.03

Dietary proportions of each prey item and sediment are described in Section 4
COPC – chemical of potential concern
dw – dry weight
EPC – exposure point concentration
HQ – hazard quotient
LOAEL – lowest-observed-adverse-effect level
NOAEL – no-observed-adverse-effect level
PAHs – polycyclic aromatic hydrocarbons
TRV – toxicity reference value
ww – wet weight
Bold identifies HQs greater than 1.

7.2.1.2 Uncertainty Analysis for English Sole

This section presents a discussion of the uncertainty associated with the problem formulation, the exposure and effects assessments, and the risk characterization for English sole. Because some of the uncertainties associated with risk estimates for fish at the Lockheed West Site are similar to those with the upstream LDW site, the following discussion of the uncertainties is taken partly from the ERA for the LDW site. Note that because the entire Site will be remediated, the uncertainties in the ecological risk estimates will have minimal effect on the site cleanup decision.

Problem Formulation

Primary uncertainties in the problem formulation for English sole include ROC selection, assessment endpoints, and the COPC screen. Uncertainties associated with ROC selection and the COPC screen are presented below.

ROC Selection

English sole are benthic fish that live in close contact with sediments and thus have a high likelihood of exposure to sediment-associated chemicals through direct contact and through their diet. Other fish represented by English sole as an ROC have either similar exposure pathways (e.g., sculpin), or less direct contact with sediments (e.g., shiner surfperch). As part of the ERA for the nearby LDW site, shiner surfperch were collected and PCB concentrations evaluated in an assessment of the suitability of English sole as a representative species (Windward 2007). That analysis demonstrated that shiner surfperch tissue data and related HQs did not change the status of English sole as the higher trophic level fish and the most suitable representative fish benthivore ROC for the LDW ERA. The selection of English sole as the ROC for the Lockheed West Site is deemed similarly appropriate.

COPC Screen

Uncertainties associated with the COPC screen are largely related to the lack of tissue data for the Lockheed West Site. In lieu of tissue data, COPCs for fish were selected based on their presence in sediment at the site and their potential to bioaccumulate into fish tissue. Because of the substantial number of potentially bioaccumulative chemicals in Lockheed West Site sediment and the lack of tissue data to corroborate their bioaccumulation into site tissue, the number of COPCs for fish tissue at the Lockheed West Site was greater than the number of COPCs that were screened for the upstream LDW site, which were based on actual tissue data. Because of the high number of COPCs selected for tissues, there is low uncertainty that COPCs may have been omitted.

Exposure Assessment

Key uncertainties in the exposure assessment for English sole were associated with the following factors:

- Foraging range
- Modeling of tissue concentrations
- Incidental sediment ingestion
- Benthic invertebrate prey tissue data

Due to the lack of site-specific exposure data on fish for the Lockheed West Site, including lack of tissue data and lack of known foraging area and exposure durations, substantial uncertainties exist regarding their potential exposures to site chemicals and the application of exposure assumptions to the Lockheed West Site that were taken from the LDW ERA.

Foraging Range

English sole are known to migrate seasonally from the lower Duwamish River to spawn in Puget Sound. Their foraging area is not known precisely, but is expected to be on the order of miles in distance. Studies summarized in the LDW ERA document their foraging ranges to include Elliott Bay and upstream into the West Waterway and the LDW (see Figure 1-2 for locations). Exposures of English sole were assumed in this ERA to occur solely to the Lockheed West Site sediments and to prey items that acquire all their body burden of chemicals from Lockheed West Site sediments. The ERA from the nearby LDW site evaluated site-specific tissue and sediment data and did not detect a relationship between English sole tissue concentrations of chemicals and those in sediment that were collected at co-located subareas throughout the site. In other words, the English sole that were collected at the LDW site did not show site fidelity to subareas of the waterway that were approximately a mile in length, nor to larger areas of the site. From this finding, the LDW ERA concluded that English sole likely forage over an area greater than the six miles of the LDW site. Based on that conclusion, English sole foraging area is highly likely to exceed the limited size of the Lockheed West Site, and their exposure to chemicals from sediment would extend far beyond the boundaries of the Lockheed West Site.

Nonetheless, the streamlined approach to this ERA is based on an assumed area use factor of 1 for English sole. Since this streamlined ERA uses the exposure assumptions directly from the LDW ERA, adjustments to the exposure area for English sole was not accounted for. Uncertainties with this assumption in the context of using modeling to determine tissue concentrations are discussed in the following section. The modeling of tissue concentrations of English sole assumes that the fish spend all or a substantial portion of time at the site, which clearly would not occur for fish species with a larger foraging area. Estimation of exposures of English sole only to chemicals in the sediment of the Lockheed West Site is highly uncertain, and the method used likely overestimates the exposures based on their likely foraging area.

Modeling of Tissue Concentrations

One of the major uncertainties in the risk assessment for all fish at the Lockheed West Site is due to the use of modeling to estimate exposures rather than use of field-collected tissue data. The modeling was based on BSAFs and site-specific sediment data, and was performed for those COPCs selected based on their potential to bioaccumulate from site sediments. The BSAFs were selected to be reasonably conservative, and were largely 75th and 90th percentile values, depending on the source of the BSAFs. BSAFs were taken from established sources, including regression equations from the LDW site that were calibrated with field data.

The BSAFs that were used in the modeling were taken from sources that had compiled the values from nationwide sources. Sources that provided BSAFs specifically for fish were preferred over those provided for other aquatic organisms. The WDOH (1995) source of BSAFs recommended for use in Puget Sound were compiled from numerous sources on empirical studies with fish, and were listed at the 75th percentile values of the ranges of BSAFs. The conservativeness of the BSAFs in the modeling, and the lack of incorporating foraging areas or area use factors into the modeling, ensures that the fish tissue concentrations and resultant risks would not be underestimated.

EPA guidance on quantifying exposures in risk assessments includes a term to make adjustments to the exposures of ecological organisms based on the differences between their foraging area and the size of the site (EPA 1997c, 1998b, 2000a, 2001, 2003c, 2005c). The area use factor (AUF) is defined as the ratio of an organism's home range, breeding range, or feeding/foraging range to the area of contamination, and accounts for the fraction of the exposures that are expected to occur at the site (EPA 1997c, 2001, 2005c). This term is also commonly referred to as the site use factor (SUF). EPA guidance documents specifically addressing accumulation of chemicals from sediment refer to this term as the exposure fraction (EF), defined as a measure of the proportion of study area relative to the entire home range of aquatic or terrestrial organisms for modeling tissue concentrations of sediment chemicals (EPA 2000a). EPA also refers to this term as FR_k, which is the fraction of intake of the k_{th} food type that is from the contaminated area (EPA 1998b, 2003c). The AUF or EF is used to indicate the portion of an animal's home range or foraging range that would be represented by the site. If the home range or foraging range is larger than the site, the AUF or

EF equals the site area divided by the home or foraging range area. If the site area is greater than or equal to the home range or foraging range, the AUF or EF is equal to 1.

For the Lockheed West Site, English sole and crabs are ROCs that have foraging ranges much larger than the area of the Lockheed West Site. Studies summarized in the LDW ERA document their foraging ranges to include Elliott Bay and upstream into the West Waterway and the LDW (see Figure 1-2 for locations). With foraging ranges larger than the Lockheed West Site, their body burden of chemicals would be influenced by the contaminant loads in food sources and sediment and surface waters of those areas outside the Site. Thus, the assumption that their entire body burden of chemicals comes from the Lockheed West Site (i.e., the AUF or EF is set to 1) is highly uncertain and overestimates the chemical load from the Site.

Although the amount of foraging at the Lockheed West Site by organisms with large home ranges is expected to be less than in the LDW site because of the large differences in site sizes, the difference in foraging rates of these receptors at each of the two sites is unknown. Foraging rates and success at the Lockheed West Site for marine species could be higher because of the relatively more saline environment compared to the LDW site (i.e., the Lockheed West Site's role to the local ecosystem could provide more foraging success per acre than the LDW site for marine species). However, due to the large differences in site sizes, it remains probable that the contribution of Lockheed West Site chemicals to total body load of organisms with large home ranges is less than the contribution from the LDW site or other nearby areas.

Because of the use of modeling to determine fish tissue concentrations, fish exposures are highly uncertain but are biased high. The protectiveness of the fish tissue modeling was intended to streamline the ERA process rather than attempt to achieve site specificity with regards to fish tissue concentrations. Modeling of metals concentrations in fish whole tissue were based on 90^{th} percentile values of pooled BSAFs, except for chromium, which was a single value. The estimated tissue concentrations of metals are not expected to be underestimated. For English sole risks based on diet, the concentration of copper in benthic invertebrate prey was the driver of the risks. The BSAF for copper in benthic invertebrates was developed as the 90^{th} percentile of values for filter feeder clams, as provided in the WDOH document (PTI 1995), and its use in modeling fish tissue concentrations entails uncertainty.

A BSAF for TBT for fish was not available, so an apparent BSAF was developed from field data collected in the LDW, as described in Section 4.1. The BSAF of 0.23 resulted in a modeled tissue concentration of TBT in fish whole body of 2.84 mg/kg wet weight. The derivation of this field-based BSAF entails uncertainty since it was based on site wide data for shiner surf perch and sediments, as taken from summary tables in the LDW ERA. Whether the locations of the sediment TBT data and the perch tissue data are related is highly uncertain, and whether the approach can be extrapolated to the much smaller Lockheed West Site is uncertain. Nonetheless, the approach in using the LDW data was useful in developing potential exposures of fish to sediment TBT at the Lockheed West Site, and suggests that exposures could be high enough to present a risk to fish.

Incidental Sediment Ingestion

The exposure assessment for chemicals evaluated by a dietary approach for English sole assumed 1 percent of the diet was incidental sediment ingestion. This value is taken from the LDW ERA, which states that the value is based on subjective observations by experienced fish biologists and not based on empirical data. Estimates ranged from 1 percent to as high as 10 percent. The LDW ERA demonstrated that there was a very slight effect to the overall dose to English sole by increasing the sediment ingestion to 10 percent, and this uncertainty appears to be low.

Benthic Invertebrate Tissue Data

The uncertainties associated with modeling benthic invertebrate tissue data are similar to those discussed above for English sole whole body tissue modeling.

Effects Assessment

The effects assessment data were taken from the LDW ERA (Windward 2007), and the uncertainties in the effects assessment are the same. PAHs were not selected as COPCs for the LDW site due to the low detections in fish tissue; however PAHs were selected as COPCs for the present Lockheed West Site ERA based on their potential to bioaccumulate from sediment. Because of the low risks to fish that were modeled in the present ERA, the following discussion focuses on the risk driver chemicals that were also discussed in the LDW ERA.

Uncertainties in the effects assessment for English sole were associated with the following factors:

- Effects from chemical mixtures
- Chemicals missing TRVs
- Copper TRV
- PCB TRV

- COPCs without LOAEL TRVs
- Egg-to-adult conversion factors used to derive PCBs and TBT NOAELs or LOAELs
- Regional field studies
- Critical tissue residue approach

Effects from Chemical Mixtures

Effects from exposure to multiple chemicals that share the same mode of toxic action that could result in additive, synergistic, or antagonistic effects are typically not factored into laboratory studies. However, for fish COPCs that are evaluated as a group, such as PAHs, DDTs, and Aroclors, the toxicities of the individual COPCs are captured within the TRV for the total. In other words, the toxicities of the individual PAHs that are missing TRVs are captured in the TRV for total PAHs, except for acenaphthylene; the toxicities of the individual Aroclors that are missing TRVs should be captured in the TRV for total PCBs, and the toxicities of the individual DDT isomers that are missing TRVs should be captured in the TRV for total DDTs. Although there is uncertainty with the additivity of the effects from the individuals within each chemical group, the uncertainties of these COPCs missing TRVs are minimized by accounting for their toxicity within the group.

Chemicals Missing TRVs

Fish tissue COPCs that are missing TRVs consisted primarily of those chemicals contained within a chemical group, such as PAHs, PCBs, and DDTs. The potential for risks from these chemicals on fish that may be exposed to them at the Lockheed West Site is unknown.

Copper TRV

Copper presented the highest risks to English sole based on the dietary approach. The lowest copper LOAEL and NOAEL TRVs were identified as 8 and 16 mg/kg dw, respectively, based on markedly lower growth of channel catfish. In addition, data from a study not published in manuscript form (Erickson et al. 2003) showed lower sensitivity of channel catfish to dietary copper toxicity than the selected TRVs suggest, with a reported growth NOAEL of 246 mg/kg dw in diet. The next lowest growth LOAEL was 100 mg/kg dw, with a corresponding NOAEL of 50 mg/kg dw diet from the same study (Kang et al. 2005).

HQs calculated using the dietary exposures to English sole at the Lockheed West Site and the alternative LOAEL and its associated NOAEL TRVs (Kang et al. 2005) would have been 3 and 6, respectively, for English sole. These alternative HQs still exceed 1 and indicated a potential risk for adverse effects to English sole based on modeled concentrations of copper in benthic invertebrate tissue.

PCB TRV

Windward (2007) provides a detailed review of the TRV selected for PCBs by the tissue residue approach. The TRV is based on fecundity effects in barbel (Hugla and Thome 1999). Numerous uncertainties were identified in the study in the statistical analysis, in the effects of elevated fish holding and exposure temperatures, and in the exposure-response relationship for fecundity. Because of these uncertainties, the fecundity LOAEL from the low dose for PCBs is highly uncertain. Given these uncertainties and the lack of confirming studies using the same species (barbel), the range of LOAEL TRVs provided by Hugla and Thome (1999) are considered to provide a conservative assessment of PCB risks to fish.

Windward (2007) identifies numerous toxicity values that would span a wide range of TRVs. If the next higher LOAEL of 9,300 μg/kg ww for sheepshead minnow egg and larval survival (Hansen et al. 1974a) had been selected as the LOAEL TRV, the LOAEL-based HQ for English sole would have been 0.35. The highest NOAEL below this LOAEL was 1,900 μg/kg ww from the same study. If this NOAEL had been selected as the NOAEL TRV, the NOAEL-based HQ would have been 1.7.

Egg-to-Adult Conversion Factors

The critical TRVs for PCBs were converted in the LDW ERA from concentrations in eggs to concentrations in whole-body tissues (Windward 2007). There is uncertainty associated with the use of these conversion factors because of the variability in egg-to-adult ratios compounded by variability among populations and in response to environmental conditions. The uncertainty associated with the use of conversion factors may result in overestimates or underestimates of risk.

Regional Field Studies

Several regional studies have been conducted with field-collected English sole from the LDW; however, none have focused on the West Waterway portion of the Lockheed West Site. In the LDW site, English sole were found to more likely to have lesions than English sole collected from less-contaminated locations (Johnson and Landahl 1994; Rhodes et al. 1987), and to exhibit inhibited gonadal development (Johnson et al. 1988), depressed plasma estradiol and reduced ovarian production *in vitro* (Johnson et al. 1988; 1993), and reduced spawning success (Casillas et al. 1991). The reports reviewed in Windward (2007) suggest that these effects are a result of elevated concentrations of aromatic and chlorinated hydrocarbons present in LDW sediments.

The above field studies are supported by laboratory experiments showing that pretreatment of gravid female English sole with extracts of contaminated sediment or crude oil (containing high levels of PAHs) decreased levels of endogenous estradiol (Johnson et al.

1995; Stein et al. 1991). Related experiments suggest that exposure to benzo(a)pyrene or PAH-contaminated sediment may suppress estradiol-induced vitellogenin production in fish, including English sole (Anulacion et al. 1997; Nicolas 1999).

Chemicals implicated as causal factors include PAHs and PCBs; however, linking the results of field studies to risks from specific chemicals is difficult considering, among other factors, the complex mixtures of chemicals in the field and the uncertainties in English sole home range. In addition, interpreting cause and effect of the adverse effects reported in field studies is complicated because of genetic variation, health, and seasonal variation in the spawning cycle. Therefore, although regional studies indicate an increased risk of adverse effects on English sole reproduction in the LDW, the LDW ERA concluded that chemical-specific NOAELs and LOAELs cannot be determined from these studies because the fish were exposed to chemical mixtures under uncontrolled conditions. In addition, risks to English sole from benzo(a)pyrene or total PAHs via dietary exposures were evaluated to be extremely low, with NOAEL and LOAEL-based HQs all less than 0.1. These results suggest that PAH-related effects that may occur in the LDW would not be apparent in fish exposed to dietary benthic invertebrates from the Lockheed West Site.

Risk Characterization

Uncertainties in the risk characterization for English sole are associated primarily with the organochlorine pesticides data. Although the sediment data for organochlorine pesticides were evaluated as tentatively identified due to analytical inferences, their HQs to English sole are presented above. Risks to fish from organochlorine pesticides were very low, despite the potentially elevated concentrations due to analytical inferences.

7.2.1.3 Risk Conclusions

The English sole ROC was evaluated to represent benthivorous fish at the Lockheed West Site. English sole are more highly exposed to sediment-associated chemicals than are pelagic fish based on their close sediment proximity and diet of benthic invertebrates.

Both the NOAEL- and LOAEL-based HQs were substantially greater than 1.0 for copper. There is uncertainty in the copper TRV because the lowest LOAEL and NOAEL TRVs that were reported for channel catfish are markedly lower than those presented for the four other species for which data were available. In addition, data from an unpublished study shows an order-of-magnitude lower sensitivity of channel catfish to dietary copper toxicity than do the selected TRVs based on a study with channel catfish. All copper NOAELs and LOAELs evaluated were for the growth endpoint, except the highest NOAEL, which examined effects on survival. Of the 13 papers reviewed in Windward (2007), the two lowest LOAELs were 16 and 100 mg/kg dw, and the next lowest LOAEL was seven times higher. Of the 13 NOAELs for growth, 11 were higher than 200 mg/kg dw.

Based on the results of the dietary exposure pathway analysis, risks are estimated to English sole from exposure to modeled concentrations of copper in the benthic invertebrate prey from the Lockheed West Site. However, the level of risk is highly uncertain because of uncertainties in the modeling of the tissue concentration of copper in benthic invertebrate prey, the foraging area of English sole relative to the contaminated sediment area of the Lockheed West Site, and in the dietary TRV for copper.

PAH risks to English sole are extremely low based on dietary pathways. However, no effects data were available to evaluate PAH effects on reproduction, and the selected dietary TRVs were based on growth endpoints. Effects data evaluated for PCBs included reproduction endpoints. Nonetheless, the NOAEL HQs for PAHs were substantially below 0.01; alternative TRVs would need to be 100-fold lower than the present ones used in this assessment for risks to increase to a level of concern for English sole.

7.2.2 Pacific Staghorn Sculpin

This section presents risk estimates, uncertainties, and risk conclusions for Pacific staghorn sculpin.

7.2.2.1 Risk Estimates

This section presents the HQ calculations for Pacific staghorn sculpin. The bioaccumulative COPCs detected in sediment were evaluated for risks to Pacific staghorn sculpin. Risks to fish are evaluated through whole body tissue residues and through dietary exposures. The whole body tissue residue approach is based on modeling tissue concentrations from sediment concentrations using the BSAF methodology. Modeling of fish tissue concentrations uses BSAFs identified specifically for fish. However, BSAFs for fish are not available for a variety of fish species; mostly the available sources developed fish BSAFs based on English sole data or on data from a higher trophic level fish that is not identified. BSAFs specific to Pacific staghorn sculpin whole body tissues are not available. Hence, the BSAFs used to model fish tissue concentrations in this ERA are considered to be the same for all fish ROCs regardless of species, and since the combined subtidal and intertidal sediment data set is the same exposure medium for predicting concentrations in all fish ROC tissues, the fish tissue concentrations modeled for English sole above would be the same as those modeled for Pacific staghorn sculpin. Consequently, risks to Pacific staghorn sculpin based on whole body concentrations are not evaluated, but instead are referred to the risk estimates developed above for English sole.

Chromium, copper, lead, and PAHs were evaluated for Pacific staghorn sculpin using a dietary approach, as described in the Fish Exposure Assessment above. The dietary approach for Pacific staghorn sculpin assumes exposures based on combined diet of fish, benthic invertebrates, and crabs as prey items, and sediment. Results of the HQ calculations for dietary exposures of Pacific staghorn sculpin are presented in Table 7-10. Estimated total dietary exposure concentration for Pacific staghorn sculpin was greater than both the NOAEL and LOAEL TRVs only for copper, with a LOAEL-based HQ of 14.

7.2.2.2 Uncertainty Analysis

This section presents a discussion of the uncertainty associated with the problem formulation, the exposure and effects assessments, and the risk characterization for Pacific staghorn sculpin. Note that because the entire Site will be remediated, the uncertainties in the ecological risk estimates will have minimal effect on the site cleanup decision.

Problem Formulation

The primary uncertainty in the problem formulation is with the COPC screen. The COPC screen for Pacific staghorn sculpin was based on the identification of bioaccumulative chemicals in Lockheed West Site sediment. The COPCs for the tissues of all ROCs are same. Hence, uncertainties associated with the COPC screen for Pacific staghorn sculpin are the same as for English sole, which are presented above.

Table 7-10. HQ Calculations for Pacific Staghorn Sculpin Based on Dietary Exposures

COPC	Sediment EPC (mg/kg dw)	Modeled Tissue Concentration in Benthic Invertebrate Prey (mg/kg dw)	Modeled Tissue Concentration in Fish Prey (mg/kg dw)	Modeled Tissue Concentration in Crab Prey (mg/kg dw)	Total Dietary Exposure (mg/kg dw)	TRV NOAEL (mg/kg dw)	TRV LOAEL (mg/kg dw)	HQ NOAEL	HQ LOAEL
Metals									
Chromium	90	0.39	3.9	0.39	2.8	9.42	na	0.3	--
Copper	618	279	279	87	221	8	16	**28**	**14**
Lead	200	508	70	5.6	151	7,040	na	0.02	--
PAHs									
Benzo(a)pyrene	0.68	0.85	1.2	1.1	1.1	100	116	0.01	0.009
Total PAHs	10.9	28.3	19.9	96	156	324	951	0.5	0.2

dw – dry weight
EPC – exposure point concentration
HQ – hazard quotient
LOAEL – lowest-observed-adverse-effect level
NOAEL – no-observed-adverse-effect level
PAHs – polycyclic aromatic hydrocarbons
TRV – toxicity reference value
Bold identifies HQs greater than or equal to 1.

Exposure Assessment

Key uncertainties in the exposure assessment for Pacific staghorn sculpin were associated with the following factors:

- Modeling of tissue concentrations in prey items
- Foraging range
- Dietary composition

Due to the lack of exposure data on any fish species for the Lockheed West Site, including lack of tissue data and lack of known foraging area and exposure durations, substantial uncertainties exist regarding their potential exposures to site chemicals. The use of conservative assumptions in the modeling of tissue concentrations, particularly for fish ROCs with foraging ranges larger than the Site, is a protective measure in the exposure assessment for fish.

Modeling of Tissue Concentrations

The uncertainties associated with modeling of tissue concentrations in prey of Pacific staghorn sculpin are the same as those discussed above for modeling tissue concentrations in benthic invertebrate prey of English sole. Modeling was performed using the same BSAF approach as used for the whole body fish tissue concentration modeling. The selection of BSAFs for the fish tissue residue modeling was based on fish-specific BSAFs wherever available, whereas the BSAFs for prey items were specific to clams, benthic invertebrates, and crabs. Uncertainties in predicted tissue concentrations are high due to the uncertainties in modeling using literature BSAFs rather than site-specific BSAFs, and lack of site-specific data other than sediment data. The selection of BSAFs was deliberately biased high by the choice of 75^{th} and 90^{th} percentile values from the pools of BSAF values for fish tissue, and the use of 90^{th} percentile values for all other prey items. The modeling with this approach is considered to be sufficiently conservative, but with uncertainty regarding specificity to the ROCs that may be exposed to sediment contaminants at the Lockheed West Site.

Foraging Range

As described above for English sole, exposures of Pacific staghorn sculpin were assumed in this ERA to occur solely to the Lockheed West Site sediments and to prey items that acquire all their body burden of chemicals from Lockheed West Site sediments. As per the streamlined approach to this ERA, the exposure assessment does not account for the possibility that sculpin may forage over an area larger than the contaminated sediment area of the site. Exposures related to this assumption are considered conservative and uncertain due to the lack of tissue data and the lack of data on the presence of sculpin at the site.

Dietary Composition

Concentrations of COPCs in the diet of Pacific staghorn sculpin are based on modeling from sediment concentrations. Pacific staghorn sculpin were assumed to ingest fish, crabs, and benthic invertebrates. The approach used in the LDW ERA for the dietary component of sculpin, which assumed that crabs were not a component of the diet, was not used in this ERA. According to regional studies, crabs and shrimp constitute 25 to 32 percent of Pacific staghorn sculpin diets in Puget Sound (Fresh et al. 1979; Miller et al. 1977b; Wingert et al. 1979). Pacific staghorn sculpin at the site are likely to prey on crabs and shrimp when the desirable sizes are available, and crabs were included in the dietary composition.

Prey Tissue Data

The uncertainties associated with modeling benthic invertebrate tissue data are the same as those discussed above for English sole, with the inclusion of crab and fish as prey items. Conservative modeling of tissue concentrations in prey items compounds the uncertainty with the exposure doses estimated for Pacific staghorn sculpin. The BSAFs used in the modeling were specific for the prey type when available, or they were based on clam BSAFs when prey-specific BSAFs were unavailable as a conservative measure.

Effects Assessment

Uncertainties in the effects assessment for Pacific staghorn sculpin were associated with the following factors:

- Effects from chemical mixtures and estimation of NOAELs from LOAELs
- Exclusion of field studies from TRV selection
- Estimation of NOAELs from LOAELs
- Copper TRV
- COPCs without LOAEL TRVs
- Egg-to adult conversion factors

All of the above uncertainties associated with the effects assessment for Pacific staghorn sculpin are evaluated above for English sole, except that COPCs without LOAEL TRVs are assessed below.

COPCs without LOAEL TRVs

Two chemicals had modeled exposures for Pacific staghorn sculpin dietary components exceeding NOAEL TRVs but LOAEL TRVs were not available. Because no LOAEL toxicity data were available for these chemicals, the low NOAEL-based HQs calculated using NOAEL TRVs are assumed to indicate very low risks.

7.2.2.3 Risk Conclusions

Pacific staghorn sculpin, a benthic omnivorous fish, was selected to represent upper-trophic-level fish at the Lockheed West Site. Upper-trophic-level fish are expected to have higher body burdens of biomagnifying chemicals than lower trophic fish that feed only on benthic invertebrates, such as English sole or perch.

Both the NOAEL- and LOAEL-based HQs for Pacific staghorn sculpin were substantially greater than 1.0 for copper (LOAEL and NOAEL HQs of 28 and 14, respectively). There is uncertainty in the copper TRV because a wide range of NOAEL and LOAEL toxicity data has been reported and a lower LOAEL exists for the species and endpoint that the TRV is based on. The uncertainty with the TRV suggests a possibly lower risk estimate. The results of the dietary exposure pathway analysis using modeled tissue concentrations suggest that there is a risk to Pacific staghorn sculpin from copper in sediment at the Lockheed West Site. Because of uncertainty in the modeling of copper into dietary components and the dietary TRV for copper, the level of risk is uncertain.

7.2.3 Summary of Risk Conclusions for Fish

In summary, results of the risk estimates and evaluation of associated uncertainties for fish are as follows:

- Exposure concentrations of copper modeled in the diet of English sole and Pacific staghorn sculpin were greater than those associated with adverse effects, suggesting moderate risk from exposure to copper. Based on the variability in copper TRVs, these risks are somewhat uncertain.
- Risks from exposures to PCBs were low for English sole.
- Risks to English sole related to modeled TBT concentrations in whole body tissue were moderate, with a LOAEL-based HQ of 18.
- Risks from exposure to remaining COPCs with TRVs were low to very low, including organochlorine pesticides. Risks related to COPCs without TRVs are uncertain.

7.3 RISK CHARACTERIZATION FOR SPOTTED SANDPIPER

This section presents the risk characterization and uncertainty analysis for sandpiper, the wildlife ROC selected for the Lockheed West Site. The risk characterization estimates risk by calculating HQs using estimated ingested doses of COPCs and TRVs associated with the ingestion route. Uncertainties in the exposure and effects data that may result in overestimates or underestimates of risk for each of the COPCs are discussed. Risk conclusions are presented that integrate risk estimates with associated uncertainties.

7.3.1 Risk Estimates

This section presents the HQ calculations for spotted sandpiper. Ingested doses, NOAEL and LOAEL TRVs, and HQs for sandpiper are presented in Table 7-11.

Eight COPCs were evaluated for spotted sandpiper: four metals, two PAHs, TBT, and PCBs. All four metals (i.e., chromium, copper, lead, and vanadium) had NOAEL-based HQs that were greater than 1.0; three metals had LOAEL-based HQs greater than 1.0 (chromium, copper, lead). The HQ based on the LOAEL for vanadium was <1.0. As shown in Table 7-11, the highest LOAEL-based HQs (14 for lead and 2.9 for copper) were based primarily on elevated concentrations that were modeled in prey (benthic invertebrates).

Table 7-11. HQ Calculations for Spotted Sandpiper

COPC	Total Ingested Dose (mg/kg bw/day)	TRV NOAEL (mg/kg-day)	TRV LOAEL (mg/kg-day)	HQ NOAEL	HQ LOAEL	Percent Contribution by Dietary Component	
						Sediment	Prey
Metals							
Chromium	5.7	1	5	**6**	**1**	98%	2%
Copper	83	21	29	**4**	**3**	28%	72%
Lead	280	5.82	20	**48**	**14**	7%	93%
Vanadium[1/]	1.45	1.2	2.3	**1**	0.6	100%	--
PAHs							
Benzo(a)pyrene	0.15	0.28	1.4	0.6	0.1	3%	97%
Total PAH	2.91	8	40	0.4	0.07	2%	98%
Organometal							
Tributyltin	0.04	1.4	3.6	0.03	0.01	2%	98%
PCBs							
PCBs (total)	0.07	0.49	1.4	0.1	0.05	2%	98%

[1/] No prey component was calculated due to the lack of a BSAF.
HQ – hazard quotient
LOAEL – lowest-observed-adverse-effect level
NOAEL – no-observed-adverse-effect level
PCB – polychlorinated biphenyl
TRV – toxicity reference value
Bold identifies HQs greater than or equal to 1.

The remaining COPCs (PAHs, PCBs, and TBT) had both NOAEL and LOAEL-based HQs less than 1.0 for spotted sandpiper. The HQ for lead at 14 based on the LOAEL suggests the possibility of risk to spotted sandpiper that consumes benthic invertebrates with lead concentrations modeled from the intertidal sediment at the Lockheed West Site.

7.3.2 Uncertainty Analysis

This section presents a discussion of uncertainties associated with the problem formulation, the exposure and effects assessments, and the risk characterization for spotted sandpiper.

Problem Formulation

The primary uncertainties in the problem formulation for spotted sandpiper are associated with ROC selection and the COPC screen.

ROC Selection

Uncertainties related to how well spotted sandpiper represents other benthivorous birds at the Lockheed West Site were evaluated in the LDW ERA (Windward 2007), which concluded that spotted sandpiper is expected to have an exposure that is similar or higher than those of other benthivorous bird species because its diet consists primarily of benthic invertebrates, and it has a high sediment ingestion rate and a high body-weight-normalized FIR. Its home range could occur within the boundaries of the Lockheed West Site during the nesting season, although present conditions of the intertidal and upland habitat greatly reduce this potential. Based on these analyses, risk estimates for spotted sandpiper should be higher than would be calculated for other species that may have different diets, lower sediment and FIRs, or less frequent site use.

COPC Screen

Eight chemicals detected in sediment at the Lockheed West Site were identified as COPCs for birds based on the screen against risk-based analytical concentration goals established for the LDW site. Effects data for birds were not available for many chemicals detected in Lockheed West Site sediments, including 15 individual PAHs. Risks to birds from exposures to PAHs in sediment and prey were evaluated using TRVs for total PAHs and benzo(a)pyrene. Since the selection of COPCs was based on screening values developed from TRVs, TRVs were available for all COPCs.

Exposure Assessment

Uncertainties in the exposure assessment for spotted sandpiper were associated with the following factors:

- Modeling of prey tissue concentrations
- Direct sediment contact
- Incidental sediment ingestion rate
- COPC bioavailability
- Dietary composition
- Site use

These uncertainties are discussed in detail below.

Modeling of Prey Tissue Concentrations

The major contribution of risk to sandpiper was through the ingestion of prey. Prey tissue concentrations of COPCs were based on modeling from intertidal sediment concentrations. Uncertainties in modeling of tissue are discussed above for fish prey tissue, and many of the same uncertainties apply to modeling benthic invertebrate prey tissue for sandpiper. Modeling was performed rather than collection of site data on tissue concentrations in order to streamline the ERA process. The use of modeling instead of collecting site-specific data entails substantial uncertainties in representativeness of the exposures of sandpiper at the Site, but is considered to be a sufficiently protective approach.

The uncertainty in using modeling to determine tissue concentrations in benthic invertebrate prey was reduced for PCBs by the use of a significant linear relationship between sediment and benthic invertebrate tissue concentrations that was observed at the LDW site (Windward 2007). This relationship was used to estimate tissue UCL concentrations for PCBs from the intertidal sediment dataset for spotted sandpiper. For the remaining COPCs, there is high uncertainty with the use of BSAFs for the modeling of tissue concentrations.

Although LDW site data were used for the PCB BSAF regression equation, many chemicals at the LDW site for which co-located sediment and benthic invertebrate tissue data were collected did not show significant sediment/tissue relationships. It is uncertain whether these chemicals would show a significant relationship at the Lockheed West Site. At the LDW site, it is possible that significant sediment/tissue relationships were not found for many chemicals because the range of sediment concentrations was not large enough to capture a relationship, if one existed.

Direct Sediment Contact

Risk to birds from direct contact with sediment is considered insignificant relative to that from sediment ingestion (EPA 2000b), which was included as one of the exposure pathways for spotted sandpiper.

Incidental Sediment Ingestion Rate

Increasing the incidental sediment ingestion rate to 30 percent of the FIR was found to increase the spotted sandpiper HQs by an average of less than 0.1 at the LDW site (Windward 2007). This illustrates the low contribution of sediment ingestion to total risks for the spotted sandpiper. Despite the low risk, the inclusion of sediment ingestion as an exposure pathway for the Lockheed West Site ERA reduces the uncertainty for the spotted sandpiper exposures.

COPC Bioavailability

Metals may be less bioavailable in ingested sediment than in ingested prey. In calculating the ingested doses, it was assumed that metals were 100 percent bioavailable, which may overestimate risk for those sources consisting of sediment. Table 7-11, above, shows the relative contributions of sediment and prey to the total ingested doses. Up to 98 percent of the ingested dose may be associated with sediment exposure for chromium, whereas 93 percent of the lead exposure is due to modeled concentrations in tissue. This difference is mostly due to the much higher BSAF for lead than for chromium for modeling tissue concentrations. The exposure estimate for chromium has uncertainty in that it does not account for any limited bioavailability of chromium from ingested sediment, resulting in a potential overestimation of risk. On the other hand, the limited BSAF data available for chromium and the low BSAF that was identified for invertebrates may result in underestimation of risk from chromium. For the remaining COPCs for which risks are primarily related to ingestion of prey, the assumption of 100 percent bioavailability from prey tissue may overestimate exposures and risks.

Dietary Composition

The use of alternative diets to estimate exposures of spotted sandpiper to sediment and prey was evaluated in the LDW ERA. The consumption of different amounts of fish, crabs, or mussels in their diet was evaluated using the highest UCL concentration in the prey. This analysis found slight changes in HQs, but the use of alternative dietary components did not cause a change in risk conclusions, and would unlikely change the outcomes of the present risk estimates for the Lockheed West Site ERA.

Site Use

Habitat for spotted sandpiper was not surveyed at the Lockheed West Site. However, most of the intertidal sediment area of the site is armored with some open sandy area, and provides little habitat for spotted sandpiper. In keeping with the streamlined approach to this ERA, the availability or quality of sandpiper habitat and their site use were not considered in the exposure assessment; i.e., the area use factor was assumed to be 1. Instead, all exposure assumptions in the LDW ERA for sandpiper were retained for the evaluation of sandpiper exposures at the Lockheed West Site.

Effects Assessment

Uncertainty associated with available toxicity benchmarks for birds may affect risk estimates. These uncertainties were discussed in detail in the LDW ERA (Windward 2007). The primary uncertainties include:

- None of the laboratory toxicological studies used to derive TRVs were conducted using sandpiper.
- The laboratory studies on which TRVs are based were conducted in controlled settings using single-contaminant exposures. Effects associated with multiple-chemical exposure and other environmental stressors present at the site (e.g., habitat loss) were not factored into these studies. It is unknown if these factors would result in additive, synergistic, antagonistic, or neutral effects on overall risk conclusions.
- NOAELs were not available for some COPCs, so they were estimated from LOAELs.

In addition, TRVs are considered less certain when developed from a small number of studies, if endpoints were subchronic, or if data quality was questionable. The relative uncertainties in the TRVs for birds for the COPCs with HQ > 1, and the potential effect on the risk estimates, are summarized in Table 7-12.

In summary, uncertainty associated with the chromium TRV is high because only one study that reported effects was available; this study is unpublished and could not be reviewed. Risk for copper could be under- or overestimated because the endpoint was based on subchronic growth effects and no reproductive endpoint was available. The effect of uncertainties in toxicity data for chromium and lead on the risk estimates for these COPCs is unknown. The toxicity study for lead, which presents the highest risks to sandpiper, was based on a chronic reproductive endpoint, with less uncertainty than others.

Table 7-12. Level of Uncertainty Associated with TRVs for Birds

COPC	Number of TRV Studies	Uncertainty in TRV[1/]	Potential Effect on Risk Estimate
Chromium	3	high; only one study reported effects, but this study was unpublished and could not be obtained for review of data quality	unknown
Copper	7	medium; selected TRVs were based on a subchronic growth endpoint	risk could be under- or overestimated
Lead	4	medium; selected TRVs were based on a chronic reproductive endpoint	Unknown

[1/] Level of uncertainty key:
Low = large dataset including chronic studies
Medium = moderately sized dataset including chronic studies
High = small dataset with only subchronic studies, unbounded NOAELs/LOAELs, or data with questionable data quality
COPC – chemical of potential concern
TRV – toxicity reference value
Source: Windward (2007)

Risk Characterization

Risks to spotted sandpiper from total DDTs were not included in the risk estimates, although total DDTs were identified as a COPC, because of high uncertainty in the sediment pesticide data. As indicated by the JN qualifier, probable analytical interference from PCBs in the sediment samples collected and analyzed in 2007 likely resulted in false identifications of presence of some organochlorine pesticides as well as overestimates in their concentrations. The analysis performed on JN-qualified organochlorine pesticide concentrations in tissues at the LDW site demonstrated that more realistic concentrations determined by alternative methods were substantially lower or non detectable compared with the original JN-qualified concentrations. Because of the presence of high concentrations of PCBs in sediments at the Lockheed West Site, the results from the LDW site suggest that the JN-qualified concentrations of organochlorine pesticides at the Lockheed West Site would similarly be lower or non-detectable with alternative analytical methods.

Total DDTs, o,p-DDT, and p,p-DDT were selected as COPCs for spotted sandpiper based on the exceedance of a NOAEL screening criteria by the maximum concentration. However, none of those maximum concentrations exceeded the LOAEL-based screening values. Together with the understanding that the concentrations were JN-qualified as tentatively identified with interference from PCB congeners, the risks from the DDTs in Lockheed West Site sediment to spotted sandpiper are expected to be very low.

7.3.3 Risk Conclusions for Spotted Sandpiper

Spotted sandpiper was selected to represent benthivorous birds such as dunlin, dowitcher, western sandpiper, and dabbling ducks. Spotted sandpiper was also selected as a ROC for the nearby LDW site. The risk characterization for sandpiper should be protective of other benthivorous birds because of the spotted sandpiper's high exposure to COPCs through the ingestion of benthic invertebrates and the incidental ingestion of sediment from the intertidal area of the Lockheed West Site.

Results of the risk characterization for spotted sandpiper are summarized in Table 7-13.

Table 7-13. Summary of Risk Characterization for Spotted Sandpiper

COPC	NOAEL HQ	LOAEL HQ	LOAEL Endpoint	Primary Uncertainty[1/]
Chromium	**6**	**1**	mortality	high uncertainty in TRV because study was unpublished; risk could be overestimated because of high sediment contribution to ingested dose and 100% bioavailability assumption
Copper	**4**	**3**	subchronic growth	medium uncertainty in TRV; risk could be under- or overestimated because of endpoint
Lead	**48**	**14**	chronic reproduction	medium uncertainty in TRV; risk could be overestimated because of high sediment contribution to ingested dose and 100% bioavailability assumption
Vanadium	**1**	0.6	subchronic growth	high uncertainty in TRV; risk could be under- or overestimated because of endpoint
Total PCBs	0.1	0.05	reproduction	medium uncertainty in TRV

[1/] Level of uncertainty key:
Low = large dataset including chronic studies with species taxonomically similar to the ROC
Medium = moderately sized dataset including chronic studies
High = small dataset with only subchronic studies, unbounded NOAELs/LOAELs, or data with questionable data quality
COPC – chemical of potential concern
HQ – hazard quotient
LOAEL – lowest-observed-adverse-effect level
NOAEL – no-observed-adverse-effect level
PCB – polychlorinated biphenyl
Bold identifies HQs greater than or equal to 1.
Adapted from Windward (2007)

The following COPCs had LOAEL-based HQs greater than or equal to 1 for spotted sandpiper: chromium, copper, and lead. LOAEL-based HQs ranged from 1 to 14 for these COPCs. LOAEL-based HQ was highest for lead at 14. Risks to spotted sandpiper from copper and vanadium may be under- or overestimated because the selected TRVs were based on subchronic growth endpoints. The ingested dose is primarily from sediment for chromium, but from concentrations in intertidal invertebrate prey for all other COPCs, based on modeling. The modeled concentrations of copper and lead in benthic invertebrate prey were based on the 90th percentiles of available BSAF values. The BSAFs are considered to be conservative for both copper and lead, with uncertainty as to whether uptake of copper or lead would occur to that extent from the intertidal sediments of the Lockheed West Site. Bioavailability of metals in sediment is not likely 100 percent, so the LOAEL-based HQs for copper and lead are likely biased high. Overall, these findings indicate risk for spotted sandpiper from exposure to copper and lead to be moderate to high, with uncertainty about the extent of uptake of copper and lead by the benthic invertebrate prey of spotted sandpiper.

For total PCBs, the NOAEL-based and LOAEL-based HQs were much less than 1, indicating low to very low risk. Overall, risks to spotted sandpiper from PCBs are low to very low.

For total DDT, all sediment data were qualified as JN, with the reported values overestimated due to the influence by the presence of PCB congeners. Although the initial screen for total DDT for sandpiper showed an exceedance of the NOAEL-based screening criterion, the maximum concentration of total DDT in intertidal sediment was below the LOAEL-based screening criterion. Because the actual maximum concentration of total DDT would be far lower than the reported JN-qualified maximum concentration, the exceedance of the NOAEL-based screening criterion in sediment is highly uncertain. The risks to sandpiper from total DDT in intertidal sediment at the Lockheed West Site are considered to be very low, due to the high uncertainty regarding the JN-qualifiers.

7.4 RISK CONCLUSIONS FOR ECOLOGICAL RECEPTORS AT LOCKHEED WEST

Risks were estimated for benthic invertebrates, crabs, fish, and sandpipers that may be exposed to chemicals in subtidal and intertidal sediments at the Lockheed West Site. Exposures were based on site-specific surface sediment data and use of exposure parameters from the upstream LDW site. Table 7-14 lists the COPCs for benthic invertebrates that exceeded SMS criteria, DMMP guidelines, or TRVs. Table 7-15 provides a summary of COPCs for crabs, fish or sandpiper for which the HQs were greater than or equal to 1.

In summary, baseline ecological risk estimates for the Lockheed West Site were found to exceed regulatory thresholds for a number of chemicals:

> For benthic invertebrates, sediment concentrations exceeded CSL or similar effects-based sediment guidelines for arsenic and copper in 67 percent of intertidal sediment stations, and copper and mercury in 48 percent of subtidal sediment stations.
>
> For crab, TBT presented the highest potential for risk, with a NOAEL-based HQ of 202, although the risk related to an effects-based HQ could not be estimated.
>
> For fish, the highest risks were found for PCBs, copper, and TBT to English sole, with LOAEL-based HQs ranging from 1 to 6 for PCBs, and HQs of 18 for both copper and TBT. The PCB risks are highly uncertain because of high uncertainties in the TRV coupled with uncertainty in the modeling of tissue concentrations using the LDW food

web model. PCBs present moderate to low risks to crab, with uncertain risk estimates because exposures were less than levels associated with effects.

For sandpiper, the highest risks were found for intertidal lead, with a LOAEL-based HQ of 14, with lesser but significant risks from copper and chromium. PCBs were not found to present a risk to sandpiper.

PAHs and other organic chemicals in intertidal and subtidal sediment were found to present low risks to benthic invertebrate organisms and no risks to crab, fish, or sandpiper.

Table 7-14. Summary of Benthic Invertebrate Community COPCs with Exceedances of Sediment Quality Guidelines

COPC	Number of Detected Concentrations > CSL (No. Stations = 51)	Number of Detected Concentrations > SQS and ≤ CSL (No. Stations = 51)
Mercury	17	5
Copper	12	0
Arsenic	9	2
Total PCBs	7	20
Total benzofluoranthenes	2	7
Chromium	2	0
Zinc	1	12
Lead	1	1
Vanadium	0	12
Cobalt	0	11
Fluoranthene	0	10
Indeno(1,2,3-cd)pyrene	0	10
Benzo(g,h,i)perylene	0	9
Total HPAH	0	9
Chrysene	0	8
Selenium	0	8
Dibenzo(a,h)anthracene	0	6
Phenanthrene	0	6
Benzo(a)pyrene	0	4
Bis(2-ethylhexyl) phthalate	0	3
Acenaphthene	0	3
Benzo(a)anthracene	0	3
Pentachlorophenol	0	3
Nickel	0	2
Antimony	0	1

COPCs are ranked by number of sediment stations with concentrations > CSL.
COPC – chemical of potential concern
CSL – cleanup screening level
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
SQS – sediment quality standards

Table 7-15. Summary of Hazard Quotients for Fish, Crabs, and Birds

COPC	ROC	NOAEL HQ	LOAEL HQ
COPCs with LOAEL HQs ≥ 1.0			
Chromium	spotted sandpiper	**6**	**1**
Copper	English sole	**36**	**18**
	Pacific staghorn sculpin	**28**	**14**
	spotted sandpiper	**4**	**3**
Lead	spotted sandpiper	**48**	**14**
Tributyltin (TBT)	English sole	**158**	**18**
PCBs	English sole	**6 - 31**	**1 - 6**
COPCs with NOAEL HQs ≥ 1.0 and LOAEL HQs < 1.0			
Total PCBs	crab	**9**	0.9
TBT	crab	**202**	not available
	spotted sandpiper	**1**	0.6
Organochlorine pesticides (a)			

[1/] Organochlorine pesticide HQs are considered highly uncertain because of analytical interferences from PCB Aroclors in the pesticide analyses of sediments, resulting in a high bias in concentrations. The LOAEL-based HQs for total DDT were 7 for crab, and 1 for English sole. The NOAEL-based HQs were ≥1 for the following COPC/ROC pairs based on risk calculations conducted in the uncertainty sections: 1) total DDT and crab (10); methoxychlor and crab (3); total DDT and English sole (1); methoxychlor and English sole (2).

COPC – chemical of potential concern
HQ – hazard quotient
LOAEL – low-observed-adverse-effect level
NOAEL – no-observed-adverse-effect level
PCB – polychlorinated biphenyl
ROC – receptor of concern
TBT – tributyltin
Bold identifies HQs greater than or equal to 1.

8. REFERENCES

Note: Many of the references are taken directly from the ERA for the LDW site (Windward 2007).

Allison, D.T., B.J. Kollman, O.B. Cope, and C. Van Valin. 1964. Some chronic effects of DDT on cutthroat trout. Research report 64. Bureau of Sport Fisheries and Wildlife, US Fish and Wildlife Service, Washington, DC.

Anderson, M.E. 1994. Systematics and osteology of the Zoarcidae (Teleostei: *Perciformes*). *Ichthyol. Bull. J.L.B. Smith Inst. Ichthyol.* 60:120.

Anulacion, B.F., D.P. Lomax, B.D. Bill, L.L. Johnson, and T.K. Collier. 1997. Assessment of antiestrogenic activity and CYP1A induction in English sole exposed to environmental contaminants. Poster presented at SETAC 18th Annual Meeting, San Francisco, CA, November 16-20, 1997.

Arkoosh, M.R., E. Casillas, E. Clemons, B. McCain, and U. Varanasi. 1991. Suppression of immunological memory in juvenile chinook salmon (*Oncorhynchus tshawytscha*) from an urban estuary. *Fish Shellfish Immunol* 1:261-277.

Armstrong, R.H. 1996. Alaska's fish. A guide to selected species. Alaska Northwest Books, Portland, OR.

Armstrong, D.A., D.V. Buchanan, M.H. Mallon, R.S. Caldwell, and R.E. Millemann. 1976. Toxicity of the insecticide methoxychlor to the Dungeness crab *Cancer magister*. *Mar Biol* 38:239-252.

Arnot JA, Gobas FAPC. 2004. A food web bioaccumulation model for organic chemicals in aquatic ecosystems. *Environ Toxicol Chem* 23:2343-2355.

ATSDR. 2002. Toxicological Profile for Creosote. Agency for Toxic Substances and Disease Registry, Atlanta, GA.

Bailey, S.K., and I.M. Davies. 1991. Continuing impact of TBT, previously used in mariculture, on dog whelk (*Nucella lapillus* L.) populations in a Scottish sea loch. *Mar Environ Res* 32:187-199.

Barrick, R., S. Becker, L. Brown, H. Beller, and R. Pastorok. 1988. Sediment quality values refinement: Volume I. 1988 update and evaluation of Puget Sound AET. Prepared for Puget Sound Estuary Program, US Environmental Protection Agency, Region 10. PTI Environmental Services, Inc., Bellevue, WA.

Bauer, B., P. Fioroni, U. Schulte-Oehlmann, J. Oehlmann, and W. Kalbfus. 1997. The use of *Littorina littorea* for tributyltin (TBT) effect monitoring—results from the German TBT study 1994/1995 and laboratory experiments. *Env Poll* 96(3):299.

Bent, A.C. 1929. Life histories of North American shore birds: order Limicolae. US National Museum. Bulletin, US Government Printing Office, Washington, DC. Republished, 1963, Dover Press, New York, NY.

Berlin, W.H., R.J. Hesselberg, and M.J. Mac. 1981. Growth and mortality of fry of Lake Michigan lake trout during chronic exposure to PCBs and DDE. In: Chlorinated hydrocarbons as a factor in the reproduction and survival of lake trout (*Salvelinus namaycush*) in Lake Michigan. Technical Paper 105. US Fish and Wildlife Service, Washington, DC.

Beyer, W.N., E.E. Connor, and S. Gerould. 1994. Estimates of soil ingestion by wildlife. *J Wildl Manage* 58:375-382.

Bianchini, A., and R. Gilles. 1996. Toxicity and accumulation of mercury in three species of crabs with different osmoregulatory capacities. *Bull Environ Contam Toxicol* 57:91-98.

Borgmann, U., Y.K. Chau, P.T.S. Wong, M. Brown, and J. Yaromich. 1996. The relationship between tributyltin (TBT) accumulation and toxicity in *Hyalella azteca* for use in identifying TBT toxicity in the field. *J Aquat Ecosys Health* 5:199-206.

Bryan, G.W., P.E. Gibbs, G.R. Burt, and L.G. Hummerstone. 1987. The effects of tributyltin (TBT) accumulation on adult dogwhelks, *Nucella lapillus*: long-term field and laboratory experiments. *J Mar Biol Assoc UK* 67:525-544.

Bury, N.R., P.A. Walker, and C.N. Glover. 2003. Nutritive metal uptake in teleost fish. J Exp Biol 206:11-23.

Calabrese, E.J., and L.A. Baldwin. 1993. Performing ecological risk assessments. Lewis Publishers, Chelsea, MI.

Canli, M., and R.W. Furness. 1995. Mercury and cadmium uptake from seawater and from food by the Norway lobster *Nephrops norvegicus*. *Environ Toxicol Chem* 14(5):819-828.

Casillas, E., D. Misitano, L.L. Johnson, L.D. Rhodes, T.K. Collier, J.E. Stein, B.B. McCain, and U. Varanasi. 1991. Inducibility of spawning and reproductive success of female English sole (*Paraphrys vetulus*) from urban and nonurban areas of Puget Sound, Washington. *Mar Environ Res* 31:99-122.

CCME. 2002. Canadian sediment quality guidelines for the protection of aquatic life: summary tables. Canadian Environmental Quality Guidelines, 1999, updated 2001, updated 2002 [online]. Canadian Council of Ministers of the Environment, Winnipeg, MB. Updated 2002. Available from: http://www.ccme.ca/assets/pdf/e7_002.pdf.

Chapman, P.M. 1996. A test of sediment effects concentrations: DDT and PCB in the Southern California Bight. *Environ Toxicol Chem* 15(7):1197-1198.

ChemRisk. 1991. An evaluation of potential human health and aquatic impacts associated with current conditions and proposed future construction activities at the Lockheed Shipyard II site. Volume I, Risk Assessment. ChemRisk, Portland, ME.

Clemens, W.A., and G.V. Wilby. 1961. Fishes of the Pacific coast of Canada. 2nd ed. *Bull Fish Res Bd Can* 68:443.

Coenen, T.M.M., A. Brouwer, I.C. Enninga, and J.H. Koeman. 1992. Subchronic toxicity and reproduction effects of tri-*n*-butyltin oxide in Japanese quail. *Arch Environ Contam Toxicol* 23:457-463.

Cohen, D.M. (ed.). 1989. Papers on the systematics of Gadiform Fishes. Sci. Ser. Nat. Hist. Mus. L.A. County, 32, pp. 204-236

Cooper, J.A., and F. Chapleau. 1998. Monophyly and intrarelationships of the family Pleuronectidae (*Pleuronectiformes*), with a revised classification. *Fish Bull* 96(4):686-726.

Cordell, J.R., L.M. Tear, C.A. Simenstad, and W.G. Hood. 1996. Duwamish river coastal America restoration and reference sites: Results from 1995 monitoring studies. Fish Research Institute, University of Washington, Seattle, WA.

Cordell, J.R., L.M. Tear, and K. Jensen. 2001. Biological monitoring at Duwamish River coastal America restoration and reference sites: A seven-year retrospective. SAFS-UW-0108. Wetlands Ecosystem Team, School of Aquatic and Fisheries Sciences, University of Washington, Seattle, WA.

Cox, G., and M. Francis. 1997. Sharks and rays of New Zealand. Canterbury University Press, Christchurch, New Zealand.

Dawson, C.E. 1985. Indo-Pacific pipefishes (Red Sea to the Americas). The Gulf Coast Research Laboratory, Ocean Springs, MS.

Day, D.E. 1976. Homing behavior and population stratification in central Puget Sound English sole (*Parophrys vetulus*). J Fish Res Board Can 33:287-282.

Demetropoulos, C.L., L.F. Braithwaite, B.A. Maurer, and D. Whiting. 1990. Foraging and dietary strategies of two sublittoral cottids, *Jordania zonope* and *Artedius harringtoni*. *J Fish Biol* 37(1):19-32.

Ecology. 2001. Model Toxics Control Act Cleanup Regulation, Chapter 173-340 WAC. Publication No. 94-06. Toxics Cleanup Program, Washington State Department of Ecology, Olympia, WA.

Edens, F.W., E. Benton, S.J. Bursian, and G.W. Morgan. 1976. Effect of dietary lead on reproductive performance in Japanese quail, *Coturnix coturnix japonica*. *Toxicol Appl Pharmacol* 38:307-314.

Edens, F.W., and J.D. Garlich. 1983. Lead-induced egg production decrease in leghorn and Japanese quail hens. *Poult Sci* 62:1757-1763.

Eisler, R. 2000. Handbook of Chemical Risk Assessment: Health Hazards to Humans, Plants, and Animals. Vol. 3. Lewis Publishers. Boca Raton, Florida.

Enviros. 1993. Volume II, Appendix A to Feasibility Study, Distillation Report Summarizing McLaren/Hart and Enviros Remedial Investigation Work at the Former Lockheed Shipyard (Yard II) in West Seattle, Washington. Prepared for Port of Seattle by Enviros, Inc. March 19.

Eschmeyer, W.N., E.S. Herald, and H. Hammann. 1983. Pacific coast fishes. Peterson Field Guide Series. Houghton Mifflin, Boston, MA.

ESG. 1999. Waterway Sediment Operable Unit, Harbor Island Superfund Site. Assessing Human Health Risks from the Consumption of Seafood: Human Health Risk Assessment Report. Prepared for Port of Seattle, Lockheed Martin, Todd Pacific Shipyards. Environmental Solutions Group, Seattle, WA. September.

EPA. 1991. Role of the baseline risk assessment in Superfund remedy selection decisions. Office of Solid Waste and Emergency Response Directive 9355.0-30. Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, DC.

EPA. 1992. Framework for ecological risk assessment. EPA/630/R-92/001. Risk Assessment Forum, U.S. Environmental Protection Agency, Washington, DC.

EPA. 1993. Wildlife exposure factors handbook. EPA/600/R-93/187a. Office of Research and Development, U.S. Environmental Protection Agency, Washington, DC.

EPA. 1997a. Ecological risk assessment guidance for Superfund: Process for designing and conducting ecological risk assessments. EPA/540/R-97/006. Interim final. Environmental Response Team, U.S. Environmental Protection Agency, Edison, NJ.

EPA. 1997b. EPA Region 10 supplemental ecological risk assessment guidance for Superfund. EPA/910/R-97/005. Region 10 Office of Environmental Assessment Risk Evaluation Unit, U.S. Environmental Protection Agency, Seattle, WA.

EPA. 1997c. The incidence and severity of sediment contamination in surface waters of the United States. Volume 1: National Sediment Quality Survey. EPA 823-R-97-006. U.S. Environmental Protection Agency, Office of Science and Technology, Washington, DC.

EPA. 1997d. Recommended Guidelines for Sampling Marine Sediment, Water Column, and Tissue in Puget Sound. U.S. Environmental Protection Agency Region 10, Seattle, WA. April.

EPA. 1998. Guidelines for ecological risk assessment. EPA/630/R-95/002 F. Risk Assessment Forum, U.S. Environmental Protection Agency, Washington, DC.

EPA. 1999a. Development of a tissue trigger level for bioaccumulated tributyltin in marine benthic organisms: West Waterway Harbor Island Superfund Site, Seattle, WA. U.S. Environmental Protection Agency Region 10, Seattle, WA.

EPA. 1999b. USEPA contract laboratory program national functional guidelines for organic data review. EPA-540/R-99/008. Office of Emergency and Remedial Response, U.S. Environmental Protection Agency, Washington, DC.

EPA. 2000a. Bioaccumulation testing and interpretation for the purpose of sediment quality assessment: status and needs. EPA-823-R-00-001. Bioaccumulation Analysis Workgroup, U.S. Environmental Protection Agency, Washington, DC.

EPA. 2000b. Evaluation of dermal contact and inhalation exposure pathways for the purpose of setting Eco-SSLs. Draft ecological soil screening level guidance, Exhibit 1-3. U.S. Environmental Protection Agency, Washington, DC.

EPA. 2001. Risk Assessment Guidance for Superfund: Volume III - Part A, Process for Conducting Probabilistic Risk Assessment. OSWER 9285.7-45. www.epa.gov/superfund/RAGS3A/index.htm. Office of Emergency and Remedial Response, U.S. Environmental Protection Agency Washington, DC. December.

EPA. 2002. Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites. EPA 540-R-01-003. U.S. Environmental Protection Agency, Washington, DC. September.

EPA. 2003a. Record of Decision. Harbor Island Superfund Site, West Waterway Operable Unit, Seattle, Washington. U.S. Environmental Protection Agency, Seattle, WA. September 11.

EPA. 2003b. Wildlife Exposure Factors Handbook. EPA/600/R-93/187a. Office of Research and Development, US Environmental Protection Agency, Washington, DC. December.

EPA. 2004. USEPA Region 9 preliminary remediation goals: 2004 PRG table [online]. U.S. Environmental Protection Agency Region IX, San Francisco, CA. Updated December 2004. Available from: http://www.epa.gov/region09/waste/sfund/prg/index.html.

EPA. 2005. Guidance for Developing Ecological Soil Screening Levels. OSWER Directive 9285.7-55. US Environmental Protection Agency, Office of Solid Waste and Emergency Response. Washington, DC. November 2003, Revised February 2005.

EPA. 2007. ProUCL Version 4.0. User Guide. Statistical software to compute Upper Confidence Limits of the unknown population mean [online]. EPA/600/R-07/038. Technical Support Center for Monitoring and Site Characterization U.S. Environmental Protection Agency. Updated 5/6/2004. Available from: http://www.epa.gov/nerlesd1/tsc/download.htm.

EPA. 2008. BSAF User Guide, Biota-Sediment Accumulation Factor Data Set, Version 1.0. Prepared by Computer Sciences Corporation, Duluth, Minnesota. U.S. Environmental Protection Agency, Office of Research and Development, Duluth, Minnesota. January.

Erickson, R.J., T.L. Highland, J.R. Hocket, E.N. Leonard, V.R. Mattson, and D.R. Mount. 2003. Effects of dietary copper, zinc, lead, cadmium, and arsenic on growth and survival of juvenile fish using live food organisms. Platform presentation at SETAC 24th annual meeting, Austin TX, 9-13 November 2003. Manuscript in prep.

ESG. 1999. Waterway sediment operable unit, Harbor Island Superfund site. Assessing human health risks from the consumption of seafood: human health risk assessment report. Prepared for Port of Seattle, Todd Shipyards, and Lockheed-Martin for submittal to US Environmental Protection Agency, Region 10,Seattle, WA. Environmental Solutions Group, Inc., Seattle, WA.

EVS. 1999. Waterway Sediment Operable Unit, Harbor Island Superfund Site. Tributyltin in Marine Sediments and the Bioaccumulation of Tributyltin: Combined Data Report. Prepared for Port of Seattle, Lockheed Martin, Todd Pacific Shipyards. EVS Solutions, Seattle, WA. May.

Evans, M.L. 1980. Copper accumulation in the crayfish (*Orconectes rusticus*). Bull *Environ Contam Toxicol* 24:916-920.

Feroz, M., and M.A.Q. Khan. 1979. Fate of 14C-cis-chlordane in goldfish, *Carassius auratus (L.). Bull Environ Contam Toxicol* 23:64-69.

Fisher, J.P., J.M. Spitsbergen, B. Bush, and B. Jahan-Parwar. 1994. Effect of embryonic PCB exposure on hatching success, survival, growth and developmental behavior in landlocked Atlantic salmon, *Salmo salar*. In: Gorsuch JW, Dwyer FJ, Ingersoll CG, La Point TW, eds, Environmental Toxicology and Risk Assessment. Vol 2. ASTM STP 1216. American Society for Testing and Materials, Philadelphia, PA, pp 298-314.

Fitch, J.E., and R.J. Lavenberg. 1975. Tidepool and nearshore fishes of California. California Natural History Guides: 38. University of California Press, Berkeley and Los Angeles, CA.

Florida Museum of Natural History. 2005. Biological profiles: longnose skate. Ichthyology at the Florida Museum of Natural History: Education-Biological Profiles [online]. Florida Museum of Natural History, University of Florida, Gainesville, FL. [Cited 26 August 2005]. Available from: www.flmnh.ufl.edu/fish/Gallery/Descript/LongnoseSkate/LongnoseSkate.html.

Freeman, H.C., and D.R. Idler. 1975. The effect of PCB on steroidogenesis and reproduction in the brook trout (*Salvelinus fontinalis*). *Can J Biochem* 53:666-670.

Fresh, K.L., D. Rabin, C.A. Simenstad, E.O. Salo, K. Garrison, and L. Matheson. 1979. Fish ecology studies in the Nisqually Reach area of southern Puget Sound, Washington. FRI-UW-7904. Prepared for Weyerhaeuser Company. Fisheries Research Institute, University of Washington, Seattle, WA.

Gall, G.A.E., and P.A. Crandell. 1992. The rainbow trout. *Aquaculture* 100:1-10.

Gibbs, P.E., P.L. Pascoe, and G.R. Burt. 1988. Sex change in the female dog whelk, *Nucella lapillus*, induced by tributyltin from antifouling paints. *J Mar Biol Assoc* UK 68:715-731.

Gibbs, P.E., and G.W. Bryan. 1996. Reproductive failure in the gastropod *Nucella lapillus* associated with imposex caused by tributyltin pollution: a review. In: Champ MA, Seligman PF, eds, Organotin: environmental fate and effects. Chapman & Hill, London, pp 259-280.

Gilbert, C.R., and J.D. Williams. 2002. National Audobon Society field guide to fishes. Alfred A. Knopf, Inc., New York, NY.

Goettl, J.P., P.H. Davies, and J.R. Sinley. 1976. Water pollution studies. Colorado Fisheries Research Review 1972-1975. *CO Div Wildlife Rev* 8:68-75.

Gries, T.H., and K.H. Waldow. 1996. Progress re-evaluating Puget Sound apparent effects thresholds (AETs). Volume I: 1994 amphipod and echinoderm larval AETs. Draft report. Prepared for Puget Sound Dredged Disposal Analysis agencies. Washington Department of Ecology, Olympia, WA.

Groot, C., and L. Margolis. 1998. Pacific salmon life histories. UBC Press, Vancouver, BC.

Grossman, G.D. 1979. Demographic characteristics of an intertidal bay goby (*Lepidogobius lepidus*). *Environ Biol Fish* 4(3):207-218.

Hansen, D., S.C. Schimmel, and J. Forester. 1974a. Aroclor 1254 in eggs of sheepshead minnows: effect on fertilization success and survival of embryos and fry. Proceedings of 27th Annual Conference, Southeastern Association of Game and Fish Commissioners, Hot Springs, AR, pp 420-426.

Hansen, D.J., S.C. Schimmel, and J. Forester. 1974b. Aroclor 1016: Toxicity to and uptake by estuarine animals. *Environ Res* 7:363-373.

Hart, D.R., and J.A. Heddle. 1991. Micronucleus assays in peripheral blood of rainbow trout: Timing of response and chemical mutagen sensitivity. In: Chapman P, Bishay F, Power E, Hall K, Harding L, McLeay D, Nassichuk M, and Knapp K, eds, Proceedings of the 17th Annual Aquatic Toxicity Workshop, Nov.5-7, 1990, Vancouver, BC. *Can Tech Rep Fish Aquat Sci* 1774(2):993-1010.

Hart, J.L. 1973. Pacific fishes of Canada. Bull. 180. Fisheries Research Board of Canada, Ottawa, ON.

Haseltine, S.D., L. Sileo, D.J. Hoffman, and B.D. Mulhern. Unpublished. Effects of chromium on reproduction and growth in black ducks. As cited in Sample BE, Opresko DM, and Suter GW. 1996. Toxicological benchmarks for wildlife. 1996 revision. ES/ERM-86/R3. Office of Environmental Management, US Department of Energy, Washington, DC.

Hendricks, J.D., W.T. Scott, T.P. Putnam, and R.O. Sinnhuber. 1981. Enhancement of aflatoxin B1 hepatocarcinogenesis in rainbow trout (*Salmo gairdneri*) embryos by prior exposure of gravid females to dietary Aroclor 1254. In: Branson DR, Dickson KL, eds, Aquat Toxicol and Hazard Assessment. Fourth Conference. ASTM STP 737. American Society for Testing and Materials, Philadelphia, PA, pp 203-214.

Hobson, E.S. 2000. Interannual variation in predation on first-year Sebastes spp. by three northern California predators. *Fish Bull* 99(2):292-302.

Hopkins, C.L., S.R.B. Solly, and A.R. Ritchie. 1969. DDT in trout and its possible effect on reproductive potential. *NZ J Mar Freshw Res* 3:220-229.

Hough, J.L., M.B. Baird, G.T. Sfeir, C.S. Pacini, D. Darrow, and C. Wheelock. 1993. Benzo(a)pyrene enhances atherosclerosis in white carneau and show racer pigeons. *Arterioscler Thromb* 13:1721-1727.

Hyland, J.L., R.F. Van Dolah, and T.R. Snoots. 1999. Predicting stress in benthic communities of southeastern U.S. estuaries in relation to chemical contamination of sediments. *Environ Toxicol Chem* 18(11):2557-2564.

Ingersoll, C.G., N. Wang, J.M.R. Hayward, J.R. Jones, S.B. Jones, and D.S. Ireland. 2005. A field assessment of long-term laboratory sediment toxicity tests with the amphipod *Hyalella azteca*. *Environ Toxicol Chem* 24(11):2853-2870.

Jarvinen, A.W., and G.T. Ankley. 1999. Linkage of effects to tissue residues: Development of a comprehensive database for aquatic organisms exposed to inorganic and organic chemicals. SEATAC Press, Pensacola, FL.

Johnson, L. 2001. An analysis in support of sediment quality thresholds for polycyclic aromatic hydrocarbons to protect estuarine fish. US Department of Commerce, NOAA, Seattle. Tech. Memo. NMFS-NWFSC-47, 30p.

Johnson, L. 2006. Personal communication (telephone conversation with Matt Luxon, Windward Environmental LLC, regarding incidental sediment ingestion by English sole and Pacific staghorn sculpin). Zoologist, Ecotoxicology and Environmental Fish Health Program, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Seattle, WA. May 17, 2006

Johnson, R.K., D.E. Leslie, J.M. Brandenberger, S.A. Steinert, M.H. Salazar, and S.M. Salazar. 2007. Contaminant residues in demersal fish, invertebrates, and deployed mussels in selected areas of Puget Sound, WA. Georgia Basin – Puget Sound Research Conference, March 26-29, Vancouver, BC.

Johnson, L.L., and J.T. Landahl. 1994. Chemical contaminants, liver disease, and mortality rates in English sole (*Pleuronectes vetulus*). *Ecol Applic* 4:59-68.

Johnson, B.T., C.R. Saunders, and H.O. Sanders. 1971. Biological magnification and degradation of DDT and aldrin by freshwater invertebrates. *J Fish Res Board Can* 28:705-709.

Johnson, L.L., E. Casillas, T.K. Collier, B.B. McCain, and U. Varanasi. 1988. Contaminant effects on ovarian development in English sole (*Pleuronectes vetulus*) from Puget Sound, Washington. *Can J Fish Aquat Sci* 45:2133-2146.

Johnson, L.L., E. Casillas, S.Y. Sol, T.K. Collier, J.E. Stein, and U. Varanasi. 1993. Contaminant effects on reproductive success in selected benthic fish species. *Mar Environ Res* 35:165-170.

Johnson, L.L., J.E. Stein, T. Hom, S. Sol, T.K. Collier, and U Varanasi. 1995. Effects of exposure to Prudhoe Bay crude oil on reproductive function in gravid female flatfish. *Environ Sci* 3:67-81.

Kang, J-C, S-G Kim, and S-W Jang. 2005. Growth and hematological changes of rockfish, *Sebastes schlegeli* (Hilgendorf) exposed to dietary Cu and Cd. *J World Aquacult Soc* 36(2):188-195.

Kerwin, J., and T.S. Nelson, eds. 2000. Habitat limiting factors and reconnaissance assessment report, Green/Duwamish and Central Puget Sound watersheds (WRIA 9 and Vashon Island) [online]. Washington Conservation Commission, Lacey, WA, and King County Department of Natural Resources, Seattle, WA. Available from: http://dnr.metrokc.gov/WRIAS/9/Recon.htm.

King County. 1999. King County combined sewer overflow water quality assessment for the Duwamish River and Elliott Bay. Vol 1, Appendix B2, B3, & B4: human health, wildlife, and aquatic life risk assessments. King County Department of Natural Resources, Seattle, WA.

Kolok, A.S., J.N. Huckins, J.D. Petty, and J.T. Oris. 1996. The role of water ventilation and sediment ingestion in the uptake of benzo(a)pyrene in gizzard shad (*Dorosoma cepedianum*). *Environ Toxicol Chem* 15(10):1752-1759.

Kubin, L.A. 1997. Growth of juvenile English sole exposed to sediments amended with aromatic compounds. Master's thesis. Western Washington State University, Bellingham, WA. 99 pp.

Lamb, A., and P. Edgell. 1986. Coastal fishes of the Pacific Northwest. Harbour Publishing Co. Ltd., Madeira Park, BC.

Lange, J. 2006. Personal communication (telephone conversation with Matt Luxon, Windward Environmental LLC, regarding incidental sediment ingestion by English sole and Pacific staghorn sculpin, as cited in Windward 2007). Zoologist, Ecotoxicology and Environmental Fish Health Program, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Seattle, WA. May 18, 2006.

Leatherland, J.F., B.A. Sonstegard, and N.V. Holdrient. 1979. *Comp Biochem Physiol* 063c:243-246.

Lotufo, G.R., J.D. Farrar, and T.S. Bridges. 2000. Effects of exposure source, worm density, and sex on DDT bioaccumulation and toxicity in the marine polychaete *Neanthes arenaceodentata*. *Environ Toxicol Chem* 19(2):472-484.

Lotufo, G.R., J.D. Farrar, B.M. Duke, and T.S. Bridges. 2001a. DDT toxicity and critical body residue in the amphipod *Leptocheirus plumulosus* in exposures to spiked sediment. *Arch Environ Contam Toxicol* 41:142-150.

Lotufo, G.R., P.F. Landrum, and M.L. Gedeon. 2001b. Toxicity and bioaccumulation of DDT in freshwater amphipods in exposures to spiked sediments. *Environ Toxicol Chem* 20(4):810-825.

Lu, P-Y, and R.L. Metcalf. 1975. Environmental fate and biodegradability of benzene derivatives as studied in a model aquatic ecosystem. *Environ Health Persp* 10:268-284.

Mac, MJ, C.C. Edsall, and J.G. Seelye. 1985. Survival of lake trout eggs and fry reared in water from the upper Great Lakes. *J Great Lakes Res* 11(4):520-529.

Malins, D.C., B.B. McCain, D.W. Brown, A.K. Sparks, and H.O. Hodgins. 1980. Chemical contaminants and biological abnormalities in central and southern Puget Sound. NOAA Technical Memorandum OMPA-2. Environmental Conservation Division, National Marine Fisheries Service, Seattle, WA.

Matsuda, R.I., G.W. Isaac, and R.D. Dalseg. 1968. Fishes of the Green-Duwamish River. Water Quality Series No. 4. Municipality of Metropolitan Seattle, Seattle, WA.

Matta, M.B., J. Linse, C. Cairncross, L. Francendese, and R.M. Kocan. 2001. Reproductive and transgenerational effects of methylmercury or Aroclor 1268 on *Fundulus heteroclitus*. *Environ Toxicol Chem* 20(2):327-335.

Maxson, S.J., and L.W. Oring. 1980. Breeding season time and energy budgets of the polyandrous spotted sandpiper. *Behaviour* 74:200-263.

McCarthy, I.D., L.A. Fuiman, and M.C. Alvarez. 2003. Aroclor 1254 affects growth and survival skills of Atlantic croaker *Micropogonias undulatus* larvae. *Mar Ecol Prog Ser* 252:295-301.

McEachran, J.D., and K.A. Dunn. 1998. Phylogenetic analysis of skates, a morphologically conservative clade of elasmobranchs (Chondrichthyes: Rajidae). *Copeia* 1998(2):271-290.

McLane, M.A.R., and D.L. Hughes. 1980. Reproductive success of screech owls fed Aroclor 1248. *Arch Environ Contam Toxicol* 9:661-665.

McLaren-Hart. 1992. Remedial Investigation Report Lockheed Shipbuilding Company Seattle, Yard II Facility. Volumes 1-12. Casabases, California

Meador, J.P. 1997. Comparative toxicokinetics of tributyltin in five marine species and its utility in predicting bioaccumulation and acute toxicity. *Aquat Toxicol* 37:307-326.

Meador, J.P. 2000. An analysis in support of tissue and sediment based threshold concentrations of polychlorinated biphenyls (PCBs) to protect juvenile salmonids listed by the Endangered Species Act. Northwest Fisheries Science Center, National Oceanic and Atmospheric Administration, Seattle, WA.

Meador, J.P., and C.A. Rice. 2001. Impaired growth in the polychaete *Armandia brevis* exposed to tributyltin in sediment. *Mar Environ Res* 51:113-129.

Meador, J.P., C.A. Krone, D.W. Dyer, and U. Varanasi. 1997. Toxicity of sediment-associated tributyltin to infaunal invertebrates: species comparison and the role of organic carbon. *Mar Environ Res* (43):219-241.

Meador, J.P., T.K. Collier, and J.E. Stein. 2002. Determination of a tissue and sediment threshold for tributyltin to protect prey species of juvenile salmonids listed under the US Endangered Species Act. *Aquat Conserv: Mar Freshw Ecosys* 12:539-551.

Meador, J.P., F.C. Sommers, G.M. Ylitalo, and C.A. Sloan. 2006. Altered growth and related physiological responses in juvenile chinook salmon (*Oncorhynchus* *tshawytscha*) from dietary exposure to polycyclic aromatic hydrocarbons (PAHs). *Can J Fish Aquat Sci* 63:2364-2376.

Meyer, J.S., W.J. Adams, K.V. Brix, S.N. Luoma, D.R. Mount, W.A. Stubblefield, and C.M. Wood, eds. 2005. Toxicity of dietborne metals to aquatic organisms. Chapter 1, introduction, pp. 1-11. Society of Environmental Toxicology and Chemistry (SETAC), Pensacola, FL.

Michelsen, T.C., and K. Bragdon-Cook. 1993. Technical information memorandum: Organic carbon normalization of sediment data. Washington Department of Ecology, Olympia, WA.

Michelsen, T., T.C. Shaw, and S. Stirling. 1996. *Testing, Reporting, and Evaluation of Tributyltin Data in PSDDA and SMS Programs*. PSDDA Issue Paper/SMS Technical Information Memorandum.

Miller, B.S., R.C. Wingert, and S.F. Borton. 1975. Ecological survey of demersal fishes in the Duwamish River and at West Point 1974. Prepared for Municipality of Metropolitan Seattle. Report no. FRI-UW-7509. Fisheries Research Institute, University of Washington, Seattle, WA.

Miller, B.S., R.C. Wingert, S.F. Borton, and D.T. Griggs. 1977a. Ecological survey of demersal fishes in the Duwamish River and at West Point, 1975. Prepared for Municipality of Metropolitan Seattle. Fisheries Research Institute, University of Washington, Seattle, WA.

Miller, B.S., C.A. Simenstad, L.L. Moulton, K.L. Fresh, F.C. Funk, W.A. Karp, and S.F. Borton. 1977b. Puget Sound baseline program nearshore fish survey. Final report, July 1974-June 1977. Prepared for Washington Department of Ecology. Fisheries Research Institute, University of Washington, Seattle, WA.

Moore, D.W., T.M. Dillon, and B.C. Suedel. 1991. Chronic toxicity of tributyltin to the marine polychaete worm, *Neanthes arenaceodentata*. *Aquat Toxicol* 21:181-198.

Moore, R., E. Toro, M. Stanton, and M.A.Q. Khan. 1977. Absorption and elimination of 14C-alpha- and gamma-chlordane by a freshwater alga, daphnid, and goldfish. Arch *Environ Contam Toxicol* 6:411-420.

Morrow, J.E. 1980. The freshwater fishes of Alaska. Animal Resources Ecology Library, University of British Columbia, Vancouver, BC.

Mortimer, M.R., and G.J. Miller. 1994. Susceptibility of larval and juvenile instars of the sand crab, *Portunus pelagicus* (L.) to sea water contaminated by chromium, nickel or copper. *Aust J Mar Freshwater Res* 45:1107-1121.

Murai, T., J.W. Andrews, and R.G. Smith, Jr. 1981. Effects of dietary copper on channel catfish. *Aquaculture* 22:353-357.

Murdoch, M.H., P.M. Chapman, D.M. Norman, and V.M. Quintino. 1997. Spiking sediment with organochlorines for toxicity testing. *Environ Toxicol Chem* 16(7):1504-1509.

Mulsow, S.G., and P. Landrum. 1995. Bioaccumulation of DDT in a marine polychaete, the conveyor-belt deposit feeder *Heteromastus filiformis* (Claparede). *Chemosphere* 31(4):3141-3152.

Nagy, K.A., I.A. Girard, and T.K. Brown. 1999. Energetics of free-ranging mammals, reptiles, and birds. *Annu Rev Nutr* 247-277.

Nagy, K.A. 1987. Field metabolic rate and food requirement scaling in mammals and birds. *Ecol Monogr* 57(2):111-128.

Nebeker, A.V., G.S. Schuytema, W.L. Griffis, J.A. Barbitta, and L.A. Carey. 1989. Effect of sediment organic carbon on survival of *Hyalella azteca* exposed to DDT and endrin. *Environ Toxicol Chem* 8:705-18.

Nicolas, J.M. 1999. Vitellogenesis in fish and the effects of polycyclic aromatic hydrocarbon contaminants. *Aquat Toxicol* 45:77-90.

Niimi, A.J. 1983. Biological and toxicological effects of environmental contaminants in fish and their eggs. *Can J Fish Aquat Sci* 40:306-312.

Nimmo, D.R., A.J. Wilson, Jr., and R.R. Blackman. 1970. Localization of DDT in the body organs of pink and white shrimp. *Bull Environ Contam Toxicol* 5(4):333-341.

NOAA (National Oceanic and Atmospheric Administration). 2008. NOAA Screening Quick Reference Tables, NOAA OR&R Report 08-1, Seattle, WA, Office of Response and Restoration Division. http://response.restoration.noaa.gov/book_shelf/122_NEW-SQuiRTs.pdf

Norman, D. 1999. Observation. In: King County combined sewer overflow water quality assessment for the Duwamish River and Elliott Bay. Appendix C: Issue Papers. King County Department of Natural Resources, Seattle, WA.

Norman, D. 2002. Personal communication (email on 4/5/02 to Berit Bergquist, Windward Environmental LLC, regarding great blue herons in the LDW). Norman Wildlife Consulting, Shoreline, WA. April 5.

ODEQ (Oregon Department of Environmental Quality). 2001. Guidance for Ecological Risk Assessment: Level II Screening. Final. Oregon Department of Environmental Quality, Waste Management and Cleanup Division, Portland, OR. December.

ODEQ. 2007. Guidance for Assessing Bioaccumulative Chemicals of Concern in Sediment. Final. Oregon Department of Environmental Quality, Environmental Cleanup Program, Portland, OR. Updated April 3.

Oehlmann, J., E. Stroben, and P. Fioroni. 1991. The morphological expression of imposex in *Nucella lapillus* (Linnaeus) (Gastropoda: Muricidae). *J Moll Stud* 57:375-390.

Oehlmann, J., B. Bauer, D. Minchin, U. Schulte-Oehlmann, P. Fioroni, and B. Markert. 1998. Imposex in *Nucella lapillus* and intersex in *Littorina littorea*: interspecific comparison of two TBT-induced effects and their geographical uniformity. *Hydrobiologia* 318:199-213.

Oladimeji, A.A., and G. Leduc. 1975. Effects of dietary methoxychlor on the food maintenance requirements of brook trout. *Prog Wat Tech* 7(3/4):587-598.

Oring, L.W., and D.B. Lank. 1986. Polyandry in spotted sandpipers: the impact of environment and experience. In: Rubenstein DO, Wrangham RW, eds, Ecological aspects of social evolution - birds and mammals. pp 21-42.

Oring, L.W., D.B. Lank, and S.J. Maxson. 1983. Population studies of polyandrous sandpiper. *Auk* 100:272-285.

Oring, L.W., E.M. Gray, and J.M. Reed. 1997. Spotted sandpiper (*Actitis macularia*). In: Poole A, Gill F, eds, The birds of North America, No. 289. Academy of Natural Sciences, Philadelphia, PA, and American Ornithologists' Union, Washington, DC.

Ousterhout, L.E., and L.R. Berg. 1981. Effects of diet composition on vanadium toxicity in laying hens. *Poult Sci* 60:1152-1159.

Page, L.M., and B.M. Burr. 1991. A field guide to freshwater fishes of North America north of Mexico. Houghton Mifflin, Boston, MA. 432 pp.

Palm, R.C., Jr, D.G. Powell, A. Skillman, and K. Godtfredsen. 2003. Immunocompetence of juvenile chinook salmon against *Listonella anquillarum* following dietary exposure to polycyclic aromatic hydrocarbons. *Environ Toxicol Chem* 22(12):2986-2994.

Parkinson, A., and S. Safe. 1987. Mammalian biologic and toxic effects of PCBs. Pages 49-75 in S. Safe (ed.). Polychlorinated Biohenyls (PCBs): Mammalian and Environmental Toxicology. Environ. Toxin. Ser. 1. Springer-Verlag, NY.

Parrish, P.R., S.C. Schimmel, D.J. Hansen, J.M. Patrick, Jr., and J. Forester. 1976. Chlordane: Effects on several estuarine organisms. *J Toxicol Environ Health* 1:485-494.

Pattee, O.H. 1984. Eggshell thickness and reproduction in American kestrels exposed to chronic dietary lead. *Arch Environ Contam Toxicol* 13:29-34.

Patton, J.F., and M.P. Dieter. 1980. Effects of petroleum hydrocarbons on hepatic function in the duck. *Comp Biochem Physiol* 65C:33-36.

Paulson, D. 1993. Shorebirds of the Pacific Northwest. University of Washington Press, Seattle, WA.

Peakall, D.B., J.L. Lincer, and S.E. Bloom. 1972. Embryonic mortality and chromosomal alterations caused by Aroclor 1254 in ring doves. *Environ Health Perspect* 1:103-104.

Peakall, D.B., and M.L. Peakall. 1973. Effect of a polychlorinated biphenyl on the reproduction of artificially and naturally incubated dove eggs. *J Appl Ecol* 10:863-868.

Pearcy, W.G., and D. Hancock. 1978. Feeding habits of Dover sole, *Microstomus pacificus*; rex sole, *Glyptocephalus zachirus*; slender sole, *Lyopsetta exilis*; and pacific sanddab, *Citharichthys sordidus*, in a region of diverse sediments and bathymetry off Oregon. *Fish Bull* 76(3):641-651.

Poupoulis, C., and L.S. Jensen. 1976. Effect of high dietary copper on gizzard integrity of the chick. *Poult Sci* 55:113-121.

PSDDA (Puget Sound Dredge Disposal Analysis). 1988. PSDDA Reports - Management plan report: Unconfined open-water disposal of dredged material, phase I (Central Puget Sound). Prepared for Puget Sound Dredged Disposal Authority. US Army Corps of Engineers, Seattle District; US Environmental Protection Agency, Region 10, Seattle, WA; Washington Department of Ecology; and Washington Department of Natural Resources.

PSWQAT. 1997. Recommended guidelines for sampling marine sediment, water column, and tissue in Puget Sound. Puget Sound Water Quality Action Team. U.S. EPA Region 10. Seattle, WA. April.

PTI. 1995. Bioaccumulation Factor Approach Analysis for Metals and Polar Organic Compounds. Prepared for WA Dept Ecology, Environmental Review and Sediment Section. PTI, Bellevue, WA. October.

Rhodes, L.D., M.S. Myers, W.D. Gronlund, and B.B. McCain. 1987. Epizootic characteristics of hepatic and renal lesions in English sole, *Parophrys vetulus*, from Puget Sound. *J Fish Biol* 31:395-407.

Rice, C.A., M.S. Myers, M.L. Willis, B.L. French, and E. Casillas. 2000. From sediment bioassay to fish biomarker – connecting the dots using simple trophic relationships. *Mar Environ Res* 50:527-533.

Rice, S.D., J.W. Short, and W.B. Stickle. 1989. Uptake and catabolism of tributyltin by blue crabs fed TBT contaminated prey. *Mar Environ Res* 27:137-145.

Rieman, B.E., and J.D. McIntyre. 1993. Demographic and habitat requirements for conservation of bull trout. USFS Publication IN-GTR-302:1-38. US Fish and Wildlife Service, Washington, DC.

Roberts, M.H., W.J. Hargis, C.J. Strobel, and P.F. DeLisle. 1989. Acute toxicology of PAH contaminated sediments to the estuarine fish, *Leiostomus xanthurus*. Bull *Environ Contam Toxicol* 42:142-149.

Sample, B.E., D.M. Opresko, and G.W. Suter. 1996. *Toxicological benchmarks for wildlife. 1996 revision.* ES/ERM-86/R3. US Department of Energy Office of Environmental Management, Washington, DC.

Sample, B.E., M.S. Aplin, R.A. Efroymson, G.W. Suter II, and C.J.E. Welsh. 1997. Methods and tools for estimation of the exposure of terrestrial wildlife to contaminants. Publ. no. 4650. Oak Ridge National Laboratory, Oak Ridge, TN.

Santos, J.F., and J.D. Stoner. 1972. Physical, Chemical, and Biological Aspects of the Duwamish River Estuary, King County, Washington, 1963 – 1967. Geological Survey Water Supply Paper 1873-C. Stock No. 2401-1207. U.S. Government Printing Office, Washington, D.C.

Scott, W.B., and E.J. Crossman. 1973. Freshwater fishes of Canada. (Reprinted 1990). Bull. Fish Res Board Can (184). 966 pp.

Shannon, J. 2006. Personal communication (e-mails to Matt Luxon, Windward Environmental, regarding Duwamish-Elliott beach seine data collected by Taylor Associates in 1998, 2000, and 2002-2003. Biologist, Taylor Associates, Seattle, WA. March 30, 2006.

Shimasaki, Y., T. Kitano, Y. Oshima, S. Inoue, N. Imada, and T. Honjo. 2003. Tributyltin causes masculinization in fish. *Environ Toxicol Chem* 22(1):141-144.

Smith L.M., T.R. Schwartz, and K. Feltz. 1990. Determination and occurrence of AHH-active polychlorinated biphenyls, 2,3,7,8-tetrachloro-p-dioxin and 2,3,7,8-tetrachlorodibenzofuran in Lake Michigan sediment and biota. The question of their relative toxicological significance. *Chemosphere* 21:1062–1085

Smith, M.S. 1969. Responses of chicks to dietary supplements of copper sulphate. *Brit Poult Sci* 10:97-108.

Spehar, R.L., H.P. Nelson, M.J. Swanson, and J.W. Renoos. 1985. *Environ Tox Chem* 04:389-397.

Spence, S.K., G.W. Bryan, P.E. Gibbs, D. Masters, L. Morris, and S.J. Hawkins. 1990. Effects of TBT contamination on Nucella populations. *Func Ecol* 4:425-432.

Stein, J.E., T. Hom, H.R. Sanborn, and U. Varanasi. 1991. Effects of exposure to a contaminated-sediment extract on the metabolism and disposition of 17B-estradiol in English sole (*Parophrys vetulus*). *Comp Biochem Physiol* 99C(1/2):231-240.

Stern, J.H., D.P. Hennessy, and C.R. Patmont. 2003. Improving estimates of contaminant exposure for mobile organisms: an assessment of area-weighted home range exposure estimates applied to the relationship between sediment chemistry and liver lesions in English sole. Puget Sound Research Conference 2003, Vancouver, BC.

Stoner, J.D., W.L. Haushild, and J.B. McConnel. 1975. Numerical model of material transport in salt-wedge estuaries. U.S. Geological Survey Professional Paper 917.

Tagatz, M.E., P.W. Borthwick, and J. Forester. 1975. *Arch Environ Contam Toxicol* 03:371-383.

Taylor, W.J., D.K. Shreffler, and J.R. Cordell. 1999. Duwamish East Waterway channel deepening project: alternative dredge disposal sites juvenile salmonid and epibenthic prey assessment. Technical report. Preliminary draft. Prepared for Port of Seattle. Taylor Associates, Seattle, WA.

Tetra Tech. 1994. Sediment and shellfish investigation at Defense Fuel Support Point (DFSP), Mukilteo, Washington. Prepared for Groundwater Technology Government Services, Inc., Kent, WA. Tetra Tech, Inc., Redmond, WA.

Tetra Tech. 2008a. Remedial Investigation/Feasibility Study Work Plan for Lockheed West Seattle Superfund Site. Final. Revision 3. Prepared for Lockheed-Martin Corporation. Bothell, WA. June.

Tetra Tech. 2008b. Lockheed West Seattle Superfund Site. Remedial Investigation. Data Report. Prepared for Lockheed-Martin Corporation. Bothell, WA.

Tetra Tech. 2009. Existing Information and Data Gap Summary Report. Potential Sources for Remedy Recontamination. Lockheed West Seattle Superfund Site. Final. Prepared for Lockheed Martin Corporation. Tetra Tech, Inc., Bothell, WA. January.

Tracey, G.A., and D.J. Hansen. 1996. Use of biota-sediment accumulation factors to assess similarity of nonionic organic chemical exposure to benthically-coupled organisms of differing trophic mode. *Arch Environ Contam Toxicol* 30:467-475.

USACE, EPA, WDNR (Washington Department of Natural Resources), and Ecology. 2000. Dredged material evaluation and disposal procedures. A user's manual for the Puget Sound Dredged Disposal Analysis Program. U.S. Army Corps of Engineers, Seattle District, Seattle, WA; U.S. Environmental Protection Agency, Region 10, Seattle, WA; Washington Department of Natural Resources; and Washington Department of Ecology, Olympia, WA.

USACE. 2005. Environmental Residue-Effects Database (ERED). US Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS. On-line database, updated October 2005 - http://el.erdc.usace.army.mil/ered/. Database accessed November 2003 (Windward 2007) and October 2008.

USACE. 2008. BSAF Database. US Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS. On-line database, updated January 2008 - http://el.erdc.usace.army.mil/bsaf/BSAF.html. Database accessed September 2008.

Varanasi, U. 1989. Metabolism of polycyclic aromatic hydrocarbons in the aquatic environment. CRC Press, Boca Raton, FL.

Walsh, A.R., J. O'Halloran, and A.M. Gower. 1994. Some effects of elevated levels of chromium (III) in sediments to the mullet *Chelon labrosus* (R). *Ecotoxicol Environ Saf* 27:168-176.

Warner, E.J., and R.L. Fritz. 1995. The distribution and growth of Green River chinook salmon (*Oncorhynchus tshawytscha*) and chum salmon (*Oncorhynchus keta*) outmigrants in the Duwamish estuary as a function of water quality and substrate. Water Resources Division, Muckleshoot Indian Tribe, Auburn, WA.

WDOH. 1995. Development of Sediment Quality Criteria for the Protection of Human Health. Tier I Report. Washington State Department of Health, Office of Toxic Substances. June 1995.

Webber, H.M., and T.A. Haines. 2003. Mercury effects on predator avoidance behavior of a forage fish, golden shiner (*Notemigonus crysoleucas*). *Environ Toxicol Chem* 22(7):1556-1561.

Weitkamp, D.E., and R.F. Campbell. 1980. Port of Seattle Terminal 107 fisheries study. Parametrix, Inc., Bellevue, WA.

West, J.E., S.M. O'Neill, G. Lippert, and S. Quinnell. 2001. Toxic contaminants in marine and anadromous fishes from Puget Sound, Washington. Results of the Puget Sound ambient monitoring program fish component 1989-1999. Washington Department of Fish and Wildlife, Olympia, WA.

Weston. 1994. Remedial Investigation Report, Harbor Island (Part 2 – Sediment). Volume I. Prepared for USEPA Region 10, Seattle, WA. Roy F. Weston, Inc., Seattle, WA.

Weston. 1998a. Remedial investigation report, Pacific Sound Resources, Marine Sediments Unit, Seattle, Washington. Volume I. Prepared for the U.S. Environmental Protection Agency, Region 10, Seattle, WA. Roy F. Weston, Seattle, WA.

Weston. 1998b. Appendix K. Technical Memorandum. Ecological and human health risk assessments. Pacific Sound Resources. Marine Sediments Unit. Vol. II. Prepared for USEPA Region 10, Seattle, WA. Roy F. Weston, Inc., Seattle, WA. April.

Whitehead, P.J.P. 1985. Clupeoid fishes of the world (suborder Clupeioidei). An annotated and illustrated catalogue of the herrings, sardines, pilchards, sprats, shads, anchovies and wolf-herrings. Part 1 - Chirocentridae, Clupeidae and Pristigasteridae. FAO species catalogue. FAO Fish Synopses 125, vol 7. Food and Agriculture Organization of the United Nations, Rome, Italy.

Widdows, J., and D.S. Page. 1993. Effects of tributyltin and dibutyltin on the physiological energetics of the mussel, *Mytilus edulis*. *Marine Environ Res* 35:233-249.

Windward. 2003. Lower Duwamish Waterway remedial investigation. Phase 1 remedial investigation report. Appendix A: Ecological risk assessment. Prepared for Lower Duwamish Waterway Group. Windward Environmental LLC, Seattle, WA.

Windward. 2004a. Lower Duwamish Waterway remedial investigation. Quality assurance project plan: Benthic invertebrate sampling of the Lower Duwamish Waterway. Prepared for Lower Duwamish Waterway Group. Windward Environmental LLC, Seattle, WA.

Windward. 2004b. Quality Assurance Project Plan: Fish and crab tissue collection and chemical analyses: Appendix D. Final. Prepared for Lower Duwamish Waterway Group. Windward Environmental LLC, Seattle, WA. August 27.

Windward. 2004c. Lower Duwamish Waterway remedial investigation. Technical memorandum: LDW sandpiper presence and habitat survey results. Prepared for Lower Duwamish Waterway Group. Windward Environmental LLC, Seattle, WA.

Windward. 2005a. Quality Assurance Project Plan: Surface sediment chemical analyses and toxicity testing of the Lower Duwamish Waterway. Appendix C. Final. Prepared for Lower Duwamish Waterway Group. Windward Environmental LLC, Seattle, WA. January 14.

Windward. 2005b. Lower Duwamish Waterway Remedial Investigation. Food web model memorandum 1: Objectives, conceptual model, and selection of food web model. Draft. Prepared for Lower Duwamish Waterway Group. Windward Environmental LLC, Seattle, WA.

Windward. 2005c. Lower Duwamish Waterway Remedial Investigation. Food web model memorandum 2: Modeling approach. Draft. Prepared for Lower Duwamish Waterway Group. Windward Environmental LLC, Seattle, WA.

Windward. 2006a. Lower Duwamish Waterway remedial investigation. Technical memorandum: 2005 gastropod imposex study results. Prepared for Lower Duwamish Waterway Group. Windward Environmental LLC, Seattle, WA.

Windward. 2006b. Lower Duwamish Waterway Remedial Investigation. Food web model memorandum 3: Preliminary model results. Draft. Prepared For Lower Duwamish Waterway Group. Windward Environmental LLC, Seattle, WA. April 7.

Windward. 2007. Lower Duwamish Waterway Remedial Investigation. Baseline Ecological Risk Assessment. Final. Prepared for Lower Duwamish Waterway Group. Windward Environmental LLC, Seattle, WA. July 31.

Windward. 2008. Lower Duwamish Waterway Remedial Investigation. Draft Final. Remedial Investigation Report. Prepared for Lower Duwamish Waterway Group. Windward Environmental LLC, Seattle, WA. October.

Wingert, R.C., C.B. Terry, and B.S. Miller. 1979. Food and feeding habits of ecologically important nearshore and demersal fishes in central Puget Sound. FRI-UW-7903. Prepared for Washington Department of Ecology. Fisheries Research Institute, University of Washington, Seattle, WA.

APPENDIX A

FISH SPECIES FOUND IN THE LOWER DUWAMISH WATERWAY

Table A. Fish Species Found in the Lower Duwamish Waterway

Common Name	Scientific Name	Family	Abundance[1/]	Abundance Citation	Environment	Habitat	E/H Citation	Diet	Diet Citation
American shad	*Alosa sapidissima*	Engraulidae	rare	9, 10, 11, 12	anadromous	bays, estuaries, freshwater	32	plankton, copepods, mysids, small fish	33
Bay goby	*Lepidogobius lepidus*	Gobiidae	rare	2, 3, 6	marine (estuary)	benthic (mud bottom)	13	benthic organisms	28
Bay pipefish	*Syngnathus grisiolineatum*	Syngnathidae	common rare	11 6, 10	marine	demersal (associated with eel grass in the intertidal areas)	15	isopods, amphipods	14
Big skate	*Raja binoculata*	Rajidae	rare	7, 11	marine	benthic (sandy and gravelly bottoms)	16	crustaceans, fish	14
Blackbelly eelpout	*Lycodopsis pacifica*	Zoarcidae	rare	11	marine	over soft bottoms	32	worms, crustaceans, small bivalves, brittle stars	34
Brown rockfish	*Sebastes auriculatus*	Scorpaenidae	rare	11, 12	marine	shallow, low-profile, rocky reefs	32	finfish, benthic crustaceans, fish eggs, larvae	35
Buffalo sculpin	*Enophrys bison*	Cottidae	rare	1, 2, 3, 4, 7, 11, 12	marine (estuary)	benthic (inshore rocky and sandy areas)	13	mainly algae, also amphipods, small fishes, crabs, polychaetes, nudibranchs, isopods	13, 29
Bull trout	*Salvelinus confluentes*	Salmonidae	rare	6, 9	anadromous	benthopelagic (near shore)	21	mainly fish, plus zooplankton	31
Butter sole	*Isopsetta isolepis*	Pleuronectidae	common rare	6 7	marine (estuary)	benthic (sandy bottom)	13	worms, fish, shrimps	14
Chinook salmon[2/]	*Oncorhynchus tshawytscha*	Salmonidae	abundant rare	1, 4, 5, 6, 9, 10 2	anadromous	benthopelagic	27	juveniles: insects, epibenthic crustaceans, pelagic organisms	30
Chum salmon	*Oncorhynchus keta*	Salmonidae	abundant common rare	5, 6, 9 10 1, 4	anadromous	benthopelagic	27	juveniles: copepods, amphipods, cumaceans, euphausiids	29

Table A. Fish Species Found in the Lower Duwamish Waterway (continued)

Common Name	Scientific Name	Family	Abundance[1/]	Abundance Citation	Environment	Habitat	E/H Citation	Diet	Diet Citation
C-O sole	*Pleuronichthys coenosus*	Pleuronectidae	rare	7, 11	marine	benthic (flat bottoms, rocky areas)	13	isopods, fish, polychaetes, amphipods, turbellarians, bivalves	29
Coho salmon[b]	*Oncorhynchus kisutch*	Salmonidae	abundant	6, 9, 10	anadromous	benthopelagic	27	juveniles: insects, epibenthic crustaceans, pelagic organisms, small fish	29
			common	4, 10					
			rare	1, 2					
Crescent gunnel	*Pholis laeta*	Pholidae	rare	6, 9, 11	marine (estuary)	demersal (intertidal areas, under rocks)	13	gammarid amphipods, copepods, tanaids, isopods	29
Cutthroat trout	*Oncorhynchus clarki*	Salmonidae	rare	1, 4, 5, 6, 9, 10	anadromous	benthopelagic	22	fish, epibenthic crustaceans, pelagic organisms, insects	18
Dolly Varden	*Salvelinus malma*	Salmonidae	rare	1, 4	freshwater	benthopelagic	21	fish, epibenthic crustaceans, pelagic organisms, insects	14
Dover sole	*Microstomus pacificus*	Pleuronectidae	common	2, 11	marine	benthic (mud bottom)	13	benthic invertebrates, echinoderms, mollusks, polychaetes	24
			rare	3					
English sole	*Parophrys vetulus*	Pleuronectidae	abundant	2, 3, 4, 7, 11, 12	marine (estuary)	benthic (sand and mud bottoms)	18	cumaceans, gammarid amphipods, polychaetes, tanaids, crabs, bivalves	29
			rare	1, 6					
Eulachon	*Thaleichthys pacificus*	Osmeridae	rare	3	anadromous	pelagic	13	plankton (feeds only while at sea)	20
Flathead sole	*Hippoglossoides elassodon*	Pleuronectidae	rare	2, 11, 12	marine	benthic (soft mud bottom, adults below 180 m)	13	polychaetes, cumaceans, gammarid amphipods, isopods, bivalves	29
Gunnel sp.	*Apodichthys sp.*	Pholidae	rare	10	marine	intertidal zone among rocks and shallow eelgrass beds	32	small crustaceans, mollusks	13

Table A. Fish Species Found in the Lower Duwamish Waterway (continued)

Common Name	Scientific Name	Family	Abundance[1/]	Abundance Citation	Environment	Habitat	E/H Citation	Diet	Diet Citation
Great sculpin	*Myoxocephalus polyacanthocephalus*	Cottidae	rare	11	marine	intertidal areas, sand and mud bottoms	13	small fish	13
Hybrid sole	*Inopsetta Isopsetta ischyra*	Pleuronectidae	rare	1, 12	marine (estuary)	benthic	13	benthic organisms	14
Kelp perch	*Brachyistius frenatus*	Embiotocidae	rare	9	marine	among fronds in kelp beds from near surface to depths of about 30 m	32	small crustaceans, parasites	13
Largescale sucker	*Catostomus macrocheilus*	Catostomidae	rare	1, 2, 4, 6	freshwater	demersal	21	algae, diatoms, insects, amphipods, and mollusks	20
Longfin sculpin	*Jordania zonope*	Cottidae	rare	11	marine	demersal, intertidal areas, rocky areas and kelp	13	amphipods, benthic copepods, crabs, shrimp, gastropods, polychaetes	38
Longfin smelt	*Spirinchus thaleichthys*	Osmeridae	abundant	1, 2, 11	anadromous	benthopelagic (close to shore, in bays and estuaries)	21	crab larvae, copepods, mysid shrimp	29
			common	12					
			rare	7, 9					
Longnose dace	*Rhinichthys cataractae*	Cyprinidae	rare	6	freshwater	demersal	21	mayflies, blackflies, and midges	20
Longnose skate	*Raja rhina*	Rajidae	rare	11	marine	partially or entirely buried in sand or silt bottoms	36	small fish, crustaceans, worms, mollusks	36
Mountain whitefish	*Prosopium williamsoni*	Salmonidae	rare	1, 6, 9	freshwater	benthopelagic	14	insects, invertebrates, eggs, small fish	14
Northern pikeminnow	*Ptychocheilus oregonensus*	Cyprinidae	rare	1, 6	freshwater	benthopelagic	20	insects, fish	20
Northern ronquil	*Ronquilus jordani*	Bathymasteridae	rare	11	marine	demersal	13	polychaetes, plankton, invertebrates, cladocerans, copepods	14
Northern sculpin	*Icelinus borealis*	Cottidae	rare	6	marine	demersal	13	benthic crustaceans, shrimps/prawns	14, 29

Table A. Fish Species Found in the Lower Duwamish Waterway (continued)

Common Name	Scientific Name	Family	Abundance[1/]	Abundance Citation	Environment	Habitat	E/H Citation	Diet	Diet Citation
Pacific cod	*Gadus macrocephalus*	Gadidae	rare	2, 3, 4	marine	(demersal, continental shelf and upper slopes)	23	fish, octopi, large crustaceans, worms, amphipods	26, 29
Pacific herring	*Clupea pallasi*	Clupeidae	abundant	4, 9, 11	marine	benthopelagic (coastal, first year in bays)	14	planktonic crustaceans, fish larvae	14, 29
			common	1, 2, 7, 12					
			rare	6, 10					
Pacific sand dab	*Citharichthys sordidus*	Paralichthyidae	common	11	marine	over soft sand bottoms	13	benthic crustaceans, worms	24
			rare	12					
Pacific sandlance	*Ammodytes hexapterus*	Ammodytidae	abundant	6, 9	marine (brackish)	benthopelagic (surface or burrowed in sand)	13	zooplankton	17, 29
			common	4					
			rare	1, 10, 11					
Pacific staghorn sculpin	*Leptocottus armatus*	Cottidae	abundant	1, 2, 3, 4, 6, 9, 10, 11, 12	marine (lower estuary, offshore)	benthic (sandy bottom)	13	isopods, bivalve siphons, polychaetes, crabs, fish, tanaids, shrimp	19
			common	7					
Pacific tomcod	*Microgadus proximus*	Gadidae	abundant (juveniles)	7, 11	marine (brackish)	benthic (over sand)	23	shrimp, amphipods, isopods, gastropods, mussels, fishes	24
			common	2, 3, 12					
			rare	1, 4					
Padded sculpin	*Artedius fennestralis*	Cottidae	common	2, 3	marine	benthic	13	gammarid amphipods, isopods, tanaids, shrimp, copepods, small fish	18, 29
			rare	7, 12					
Peamouth chub	*Mylocheilus caurinus*	Cyprinidae	rare	9	freshwater	demersal (brackish)	21	aquatic insects, larvae, terrestrial insects, crustaceans, mollusks, small fish	21
Penpoint gunnel	*Apodichthys flavidus*	Pholidae	rare	5, 6, 9	marine (estuary)	demersal (intertidal tide pools)	13	isopods, amphipods, shrimp, gastropods, other epibenthic crustaceans	29

Table A. Fish Species Found in the Lower Duwamish Waterway (continued)

Common Name	Scientific Name	Family	Abundance[1/]	Abundance Citation	Environment	Habitat	E/H Citation	Diet	Diet Citation
Pile perch	*Rhacochilus vacca*	Embiotocidae	abundant	12	marine	demersal (rocky shores; near kelp, pilings, underwater structures)	13	isopods, bivalves, crabs, amphipods	29
			common	4, 7, 11					
			rare	1, 2, 3, 6, 9					
Pink salmon[b]	*Oncorhynchus gorbuscha*	Salmonidae	rare	6	anadromous	benthopelagic	27	juveniles: copepods, amphipods, barnacle larvae, cumaceans	27, 28
Plainfin midshipman	*Porichthys notatus*	Batrachoididae	common	11	marine	benthic (nearshore shelf, sand/mud bottom)	18	crustaceans, fish	14
			rare	2					
Prickly sculpin	*Cottus asper*	Cottidae	common	12	marine	benthic	13	benthic organisms	20
			rare	1, 2, 3, 4, 6, 9, 11					
Pygmy poacher	*Odontopyxis trispinosa*	Agonidae	rare	2, 3, 7, 11	marine	demersal (soft bottoms)	13	epibenthic invertebrates	14
Ratfish	*Hydrolagus colliei*	Chimeridae	rare	2, 7, 11	marine	demersal (sandy bottom)	13	worms, bivalves, crustaceans, fishes	17, 29
Redsided shiner	*Richardsonius balteatus*	Cyprinidae	common	6	freshwater	demersal	20	zooplankton, algae, insects	20
Rex sole	*Errex zachirus*	Pleuronectidae	rare	11	marine	demersal	37	worms, benthic crustaceans, mollusks	24
River lamprey	*Lampetra ayresi*	Petromyzontidae	rare	1, 4, 6, 9	anadromous	demersal	14	adult: fish juveniles: detritus, algae	20
Rock sole	*Lepidopsetta bilineata*	Pleuronectidae	abundant	7,11	marine (estuary)	benthic (more pebbly bottom than most other flatfish)	13	isopods, gammarid amphipods, polychaetes, cumaceans, bivalves, crabs, fish	29
			common	2, 3, 12					
Rockfish	*Sebastes* spp.	Scorpaenidae	rare	1, 8	marine	demersal (near structure)	25	crabs, gammarid amphipods, mysids, shrimp, fish	26
Roughback sculpin	*Chitonotus pugeteneis*	Cottidae	common	11,12	marine	benthic (sand/mud bottom)	13	shrimps and other crustaceans	18
			rare	2, 3, 7					

Table A. Fish Species Found in the Lower Duwamish Waterway (continued)

Common Name	Scientific Name	Family	Abundance[1/]	Abundance Citation	Environment	Habitat	E/H Citation	Diet	Diet Citation
Saddleback gunnel	*Pholis ornata*	Pholidae	rare	3, 5, 6, 9, 11, 12	marine (estuary)	demersal (sandy bottom)	13	amphipods, isopods, polychaetes, copepods, cumaceans	29
Sand sole	*Psettichthys melanostictus*	Pleuronectidae	common	1, 2, 3, 7, 11, 12	marine, estuary	benthic (sandy bottom)	14	fishes, worms, crustaceans, and mollusks	14, 29
			rare	1					
Sailfin sculpin	*Nautichthys oculofasciatus*	Hemitripteridae	rare	11	marine	over rocks from inshore to depths of 110 m, often with algae	32	finfish, benthic crustaceans	19
Sharpnose sculpin	*Clinocottus acuticeps*	Cottidae	rare	6	marine	benthic (sand/vegetation)	13	benthic organisms	22
Shiner surfperch	*Cymatogaster aggregata*	Embiotocidae	abundant	1, 4, 5, 6, 7, 9, 10, 11, 12	marine (estuary)	demersal (in shallow water, around eelgrass beds, piers and pilings commonly in bays and quiet back waters)	13	amphipods, cumaceans, polychaetes, copepods, isopods, algae	22, 29
			common	2, 3					
Slender sole	*Lyopsetta exilis*	Pleuronectidae	rare	3, 11	marine	benthic (> 200 m depth)	13	carnivore	24
Snake prickleback	*Lumpenus saggita*	Stichaeidae	abundant	1, 2, 3, 4, 6	marine	benthopelagic (shallow bays and offshore waters)	13	bivalves, marine worms, amphipods	29
			common	9, 10, 11, 12					
			rare	7					
Sockeye salmon[b]	*Oncorhynchus nerka*	Salmonidae	rare	40	anadromous	benthopelagic	27	juveniles: insects, epibenthic crustaceans, pelagic organisms	28
Soft sculpin	*Gilbertidia sigalutes*	Cottidae	rare	4	marine	demersal	13	epibenthic crustaceans, phytoplankton, fish eggs/larvae	14
Speckled sanddab	*Citharichthys stigmaeus*	Bothidae	rare	7, 9, 11	marine	benthic (sandy bottom)	13	crustaceans, fish	19

Table A. Fish Species Found in the Lower Duwamish Waterway (continued)

Common Name	Scientific Name	Family	Abundance[1/]	Abundance Citation	Environment	Habitat	E/H Citation	Diet	Diet Citation
Spiny dogfish	*Squalus acanthias*	Squalidae	rare	2, 11	marine	benthopelagic	26	primarily fish	27
Starry flounder	*Platichthys stellatus*	Pleuronectidae	abundant common	1, 2, 3, 4, 6, 7, 9, 10, 11, 12 5	marine (estuary, brackish)	benthic	22	isopods, fish, gammarid amphipods, polychaetes, gastropods, worms	14
Steelhead[b]	*Oncorhynchus mykiss*	Salmonidae	common rare	9, 10 1, 4, 5, 6, 11	anadromous	benthopelagic	39	juveniles: insects, epibenthic crustaceans, pelagic organisms	29
Striped seaperch	*Embiotoca lateralis*	Embiotocidae	common rare	1, 4, 12 2, 3, 5, 6, 7, 9, 10	marine	demersal	13	amphipods, isopods, crabs, shrimp	29
Sturgeon poacher	*Podothecus acipenserinus*	Agonidae	rare	3, 11	marine	demersal (soft bottom)	13	cumaceans, gammarid amphipods, shrimp, copepods, polychaetes, tanaids	29
Surf smelt	*Hypomesus pretiosus*	Osmeridae	abundant common rare	9 1, 4, 6, 7 11	marine (brackish)	benthopelagic	22	isopods, cumaceans, larvaceans, copepods, amphipods	29
Three-spine stickleback	*Gasterosteus aculeatus*	Gasterosteidae	common rare	1, 5, 6,10, 11 4, 12	marine, anadromous	benthopelagic (in/near vegetation)	21	worms, crustaceans, insects/larvae, small fish	20, 29
Torrent sculpin	*Cottus rhotheus*	Cottidae	rare	11	freshwater	demersal	21	crustaceans, midges and mayflies larvae, minnows	21
Tubesnout poacher	*Pallasina barbata*	Agonidae	rare	3, 11	marine	demersal (eelgrass & seaweeds)	13	amphipods, polychaetes, copepods, mysids	29
Walleye pollock	*Theragra chalcogramma*	Gadidae	rare	1, 2, 4	freshwater	benthopelagic	23	insects, midge larvae, fish	14
Whitespotted greenling	*Hexagrammos stelleri*	Hexagrammidae	common rare	7 2, 11	marine (intertidal)	demersal (nearshore, near rocks, pilings and eelgrass beds)	23	gammarid amphipods, shrimp, crabs, fish, polychaetes	29

Table A. Fish Species Found in the Lower Duwamish Waterway (continued)

Source: Windward (2007)

1/ Abundance: abundant (numerically dominant); common (occurs in most samples); rare (occurs in few samples). Abundance characterizations reflect LDW data collected by authors in the cited study. These data may reflect sampling gear bias for the species identified.

2/ Adults are found in the LDW only as they migrate to spawning ground upstream of the LDW and include wild and hatchery species.

E/H – environment/habitat

Citations

1. Matsuda et al. (1968)
2. Miller et al. (1975)
3. Miller et al. (1977a)
4. Weitkamp and Campbell (1980)
5. Taylor et al. (1999)
6. Warner and Fritz (1995)
7. West et al. (2001)
8. Malins et al. (1980)
9. Shannon (2006)
10. Windward (2004b)
11. Windward (2005c)
12. Windward (2006b)
13. Eschmeyer et al. (1983)
14. Hart (1973)
15. Dawson (1985)
16. McEachran and Dunn (1998)
17. Armstrong (1996)
18. Clemens and Wilbey (1961)
19. Fitch and Lavenberg (1975)
20. Scott and Crossman (1973)
21. Page and Burr (1991)
22. Morrow (1980)
23. Cohen (1989)
24. Pearcy and Hancock (1978)
25. Lamb and Edgel (1986)
26. Cox and Francis (1997)
27. Groot and Margolis (1998)
28. Grossman (1979)
29. Miller et al. (1977b)
30. Cordell et al. (2001)
31. Rieman and McIntyre (1993)
32. Gilbert and Williams (2002)
33. Whitehead (1985)
34. Anderson (1994)
35. Hobson (2000)
36. Florida Museum of Natural History (2005)
37. Cooper and Chapleau (1998)
38. Demetropoulos et al. (1990)
39. Gall and Crandell (1992)
40. Kerwin and Nelson (2000)

APPENDIX B

COMPARISON OF BENTHIC COPC DATA WITH SEDIMENT QUALITY GUIDELINES

Table B1. Benthic Community Evaluation with Intertidal Sediment

Intertidal Sediment Station:		IT-01				IT-02				IT-03				IT-04			
COPC	**Units**		**Comparison Units**	**SQS, SL EF**	**CSL, ML EF**		**Comparison Units**	**SQS, SL EF**	**CSL, ML EF**		**Comparison Units**	**SQS, SL EF**	**CSL, ML EF**		**Comparison Units**	**SQS, SL EF**	**CSL, ML EF**
Metals																	
Antimony	mg/Kg	25.4 J	25.4 mg/Kg	0.17	0.13	14.9 J	14.9 mg/Kg	0.10	0.07	15.2 J	15.2 mg/Kg	0.10	0.08	5.1 J	5.1 mg/Kg	0.03	0.03
Arsenic	mg/Kg	45.4	45.4 mg/Kg	0.80	0.49	20.7	20.7 mg/Kg	0.36	0.22	44.6	44.6 mg/Kg	0.78	0.48	5.86	5.86 mg/Kg	0.10	0.06
Chromium	mg/Kg	49.6 J	49.6 mg/Kg	0.19	0.18	39.2 J	39.2 mg/Kg	0.15	0.15	139 J	139 mg/Kg	0.53	0.51	40.6 J	40.6 mg/Kg	0.16	0.15
Cobalt	mg/Kg	5.63	5.63 mg/Kg	0.56	-	3.91	3.91 mg/Kg	0.39	-	8.72	8.72 mg/Kg	0.87	-	4.15	4.15 mg/Kg	0.42	-
Copper	mg/Kg	73.5	73.5 mg/Kg	0.19	0.19	44.6	44.6 mg/Kg	0.11	0.11	207	207 mg/Kg	0.53	0.53	93.6	93.6 mg/Kg	0.24	0.24
Lead	mg/Kg	91.5	91.5 mg/Kg	0.20	0.17	1420	1420 mg/Kg	**3.16**	**2.68**	152	152 mg/Kg	0.34	0.29	164	164 mg/Kg	0.36	0.31
Mercury	mg/Kg	0.032	0.032 mg/Kg	0.08	0.05	0.046	0.046 mg/Kg	0.11	0.08	0.16 J	0.16 mg/Kg	0.39	0.27	0.266	0.266 mg/Kg	0.65	0.45
Nickel	mg/Kg	37.6	37.6 mg/Kg	0.27	0.10	13.6	13.6 mg/Kg	0.10	0.04	51	51 mg/Kg	0.36	0.14	9.37	9.37 mg/Kg	0.07	0.03
Selenium	mg/Kg	0.2	0.2 mg/Kg	0.20	-	0.2	0.2 mg/Kg	0.20	-	0.3	0.3 mg/Kg	0.30	-	0.3	0.3 mg/Kg	0.30	-
Vanadium	mg/Kg	23.1	23.1 mg/Kg	0.41	-	23.7	23.7 mg/Kg	0.42	-	33.2	33.2 mg/Kg	0.58	-	22	22 mg/Kg	0.39	-
Zinc	mg/Kg	272	272 mg/Kg	0.66	0.28	174	174 mg/Kg	0.42	0.18	645	645 mg/Kg	**1.57**	0.67	818	818 mg/Kg	**2.00**	0.85
PAHs																	
Acenaphthene	µg/Kg	1.3 U	1.3 µg/Kg	0.010	0.003	1.4 U	1.4 µg/Kg	0.01	0.003	1.2 U	1.2 µg/Kg	0.01	0.002	2.8 J	2.8 µg/Kg	0.02	0.006
Benzo(a)anthracene	µg/Kg	2.6 J	2.6 µg/Kg	0.003	0.002	17	17.0 µg/Kg	0.02	0.01	14	14.0 µg/Kg	0.01	0.01	24	24.0 µg/Kg	0.03	0.02
Benzo(a)pyrene	µg/Kg	2.6 J	2.6 µg/Kg	0.002	0.002	16	16.0 µg/Kg	0.01	0.01	15	15.0 µg/Kg	0.01	0.01	20	20.0 µg/Kg	0.02	0.01
Benzo(b)fluoranthene	µg/Kg	5	5.0 µg/Kg	0.00	0.00	19	19.0 µg/Kg	0.01	0.01	21	21.0 µg/Kg	0.01	0.01	31	31.0 µg/Kg	0.02	0.01
Benzo(g,h,i)perylene	µg/Kg	4.3 J	4.3 µg/Kg	0.006	0.006	11	11.0 µg/Kg	0.02	0.02	17	17.0 µg/Kg	0.03	0.02	15	15.0 µg/Kg	0.02	0.02
Chrysene	µg/Kg	3.1 J	3.1 µg/Kg	0.003	0.002	21	21.0 µg/Kg	0.02	0.02	17	17.0 µg/Kg	0.02	0.01	28	28.0 µg/Kg	0.03	0.02
Dibenzo(a,h)anthracene	µg/Kg	2.8 U	2.8 µg/Kg	0.012	0.012	3 U	3.0 µg/Kg	0.01	0.01	3.6 J	3.6 µg/Kg	0.02	0.02	4.2 J	4.2 µg/Kg	0.02	0.02
Fluoranthene	µg/Kg	4.5 J	4.5 µg/Kg	0.003	0.003	30	30.0 µg/Kg	0.02	0.02	31	31.0 µg/Kg	0.02	0.02	80	80.0 µg/Kg	0.06	0.05
Indeno(1,2,3-cd)pyrene	µg/Kg	2.9 J	2.9 µg/Kg	0.005	0.004	11	11.0 µg/Kg	0.02	0.02	14	14.0 µg/Kg	0.02	0.02	15	15.0 µg/Kg	0.03	0.02
Phenanthrene	µg/Kg	1.7 U	1.7 µg/Kg	0.003	0.001	4.5 J	4.5 µg/Kg	0.01	0.00	6 J	6.0 µg/Kg	0.01	0.004	32	32.0 µg/Kg	0.05	0.021
Total HPAH	µg/Kg	28.8	28.8 µg/Kg	0.004	0.002	166.3	166.3 µg/Kg	0.02	0.01	159.9	159.9 µg/Kg	0.02	0.01	276.2	276.2 µg/Kg	0.03	0.02
Organometals																	
Tributyltin	µg/Kg	0.81 J	0.8 ug/Kg	0.0002	-	13	13.0 µg/Kg	0.004	-	3.8	3.8 µg/Kg	0.001	-	1 J	1.0 µg/Kg	0.0003	-
PCBs																	
PCBs (total)	µg/Kg	17	17.0 µg/Kg	0.13	0.04	77	77.0 µg/Kg	0.59	0.17	47	47.0 µg/Kg	0.36	0.10	28	28.0 µg/Kg	0.22	0.06
Other SVOCs																	
bis(2-ethylhexyl)phthalate	µg/Kg	3.3 U	3.3 µg/Kg	0.003	0.002	60 J	60.0 µg/Kg	0.05	0.04	7.4 U	7.4 µg/Kg	0.01	0.004	3.2 U	3.2 µg/Kg	0.002	0.002
Pentachlorophenol	µg/Kg	11 U	11.0 ug/Kg	0.031	0.016	12 U	12.0 µg/Kg	0.03	0.02	9.8 U	9.8 µg/Kg	0.03	0.01	12 U	12.0 µg/Kg	0.03	0.02
Total Organic Carbon	Percent	0.1				0.41				0.24				0.34			
		Number of COPCs > SQS, SL, LAET		0				1				1				1	
		Number of COPCs > CSL, ML, 2LAET			0				1				0				0

Notes:
IT – Intertidal sediment sample
EF - Exceedance factor; concentration divided by appropriate criterion.
Values in **Bold** are an exceedance of the criterion.
mg/kg – milligrams per kilogram
µg/kg – micrograms per kilogram
Data Validation Qualifiers:
U – Result should be considered not-detected at the quantitation limit shown.
J – Result is an estimated concentration.
SQS & CSL values from Ecology Sediment Mangement Standards (SMS)
AET values: Ecology (1996); NOAA SQuiRT (1999), used for cobalt, selenium, vanadium; and organic chemicals at stations with total organic carbon < 0.5%.
LAET = lowest apparent effects threshold
2LAET = second lowest apparent effects threshold
SL, ML = DMMP criteria, used for antimony and nickel

Table B1. Benthic Community Evaluation with Intertidal Sediment

Intertidal Sediment Station:		**IT-05**				**IT-06**				**IT-07**				**IT-08**			
COPC	**Units**		**Comparison Units**	**SQS, SL EF**	**CSL, ML EF**		**Comparison Units**	**SQS, SL EF**	**CSL, ML EF**		**Comparison Units**	**SQS, SL EF**	**CSL, ML EF**		**Comparison Units**	**SQS, SL EF**	**CSL, ML EF**
Metals																	
Antimony	mg/Kg	126 J	126 mg/Kg	0.84	0.63	112 J	112 mg/Kg	0.75	0.56	62.1 J	62.1 mg/Kg	0.41	0.31	61.5 J	61.5 mg/Kg	0.41	0.31
Arsenic	mg/Kg	185	185 mg/Kg	**3.25**	**1.99**	330	330 mg/Kg	**5.79**	**3.55**	152	152 mg/Kg	**2.67**	**1.63**	158	158 mg/Kg	**2.77**	**1.70**
Chromium	mg/Kg	78.1 J	78.1 mg/Kg	0.30	0.29	129 J	129 mg/Kg	0.50	0.48	289 J	289 mg/Kg	**1.11**	**1.07**	253 J	253 mg/Kg	0.97	0.94
Cobalt	mg/Kg	17	17 mg/Kg	**1.70**	-	38.6	38.6 mg/Kg	**3.86**	-	28.1	28.1 mg/Kg	**2.81**	-	34	34 mg/Kg	**3.40**	-
Copper	mg/Kg	266	266 mg/Kg	0.68	0.68	1060	1060 mg/Kg	**2.72**	**2.72**	975	975 mg/Kg	**2.50**	**2.50**	1310	1310 mg/Kg	**3.36**	**3.36**
Lead	mg/Kg	346	346 mg/Kg	0.77	0.65	399	399 mg/Kg	0.89	0.75	213	213 mg/Kg	0.47	0.40	251	251 mg/Kg	0.56	0.47
Mercury	mg/Kg	0.423	0.423 mg/Kg	**1.03**	0.72	0.021	0.021 mg/Kg	0.05	0.04	0.049 J	0.049 mg/Kg	0.12	0.08	0.05	0.05 mg/Kg	0.12	0.08
Nickel	mg/Kg	32.9	32.9 mg/Kg	0.24	0.09	142	142 mg/Kg	**1.01**	0.38	101	101 mg/Kg	0.72	0.27	151	151 mg/Kg	**1.08**	0.41
Selenium	mg/Kg	0.4	0.4 mg/Kg	0.40	-	0.7	0.7 mg/Kg	0.70	-	0.4	0.4 mg/Kg	0.40	-	0.5	0.5 mg/Kg	0.50	-
Vanadium	mg/Kg	41.7	41.7 mg/Kg	0.73	-	65.6	65.6 mg/Kg	**1.15**	-	47.1	47.1 mg/Kg	0.83	-	68.6	68.6 mg/Kg	**1.20**	-
Zinc	mg/Kg	1140	1140 mg/Kg	**2.78**	**1.19**	1360	1360 mg/Kg	**3.32**	**1.42**	768	768 mg/Kg	**1.87**	0.80	894	894 mg/Kg	**2.18**	0.93
PAHs																	
Acenaphthene	µg/Kg	5.1 J	5.1 µg/Kg	0.04	0.010	280	280.0 µg/Kg	**2.15**	0.56	18	18.0 µg/Kg	0.14	0.04	22	22.0 µg/Kg	0.17	0.04
Benzo(a)anthracene	µg/Kg	62	62.0 µg/Kg	0.06	0.05	120	120.0 µg/Kg	0.13	0.09	170	170.0 µg/Kg	0.18	0.13	150	150.0 µg/Kg	0.16	0.12
Benzo(a)pyrene	µg/Kg	48	48.0 µg/Kg	0.04	0.03	260	260.0 µg/Kg	0.24	0.16	110	110.0 µg/Kg	0.10	0.07	110	110.0 µg/Kg	0.10	0.07
Benzo(b)fluoranthene	µg/Kg	110	110.0 µg/Kg	0.06	0.03	340	340.0 µg/Kg	0.19	0.11	230	230.0 µg/Kg	0.13	0.07	180	180.0 µg/Kg	0.10	0.06
Benzo(g,h,i)perylene	µg/Kg	29	29.0 µg/Kg	0.04	0.04	110	110.0 µg/Kg	0.16	0.15	42	42.0 µg/Kg	0.06	0.06	53	53.0 µg/Kg	0.08	0.07
Chrysene	µg/Kg	92	92.0 µg/Kg	0.10	0.07	62	62.0 µg/Kg	0.07	0.04	190	190.0 µg/Kg	0.20	0.14	150	150.0 µg/Kg	0.16	0.11
Dibenzo(a,h)anthracene	µg/Kg	8.4 J	8.4 µg/Kg	0.04	0.04	28	28.0 µg/Kg	0.12	0.12	14	14.0 µg/Kg	0.06	0.06	13	13.0 µg/Kg	0.06	0.05
Fluoranthene	µg/Kg	240	240.0 µg/Kg	0.18	0.14	350	350.0 µg/Kg	0.27	0.21	610	610.0 µg/Kg	0.47	0.36	460	460.0 µg/Kg	0.35	0.27
Indeno(1,2,3-cd)pyrene	µg/Kg	30	30.0 µg/Kg	0.05	0.04	140	140.0 µg/Kg	0.23	0.20	54	54.0 µg/Kg	0.09	0.08	62	62.0 µg/Kg	0.10	0.09
Phenanthrene	µg/Kg	39	39.0 µg/Kg	0.06	0.026	240	240.0 µg/Kg	0.36	0.160	190	190.0 µg/Kg	0.29	0.127	170	170.0 µg/Kg	0.26	0.113
Total HPAH	µg/Kg	792.4	792.4 µg/Kg	0.10	0.07	1710	1710.0 µg/Kg	0.22	0.14	2008	2008.0 µg/Kg	0.25	0.17	1537	1537.0 µg/Kg	0.19	0.13
Organometals																	
Tributyltin	µg/Kg	2.6	2.6 µg/Kg	0.0008	-	28	28.0 µg/Kg	0.0082	-	57	57.0 µg/Kg	0.017	-	56	56.0 µg/Kg	0.016	-
PCBs																	
PCBs (total)	µg/Kg	34	34.0 µg/Kg	0.26	0.08	4.2	4.2 µg/Kg	0.03	0.01	17	17.0 µg/Kg	0.13	0.04	12	12.0 µg/Kg	0.09	0.03
Other SVOCs																	
bis(2-ethylhexyl)phthalate	µg/Kg	9.6 U	9.6 µg/Kg	0.007	0.006	16 U	16.0 µg/Kg	0.012	0.009	14 U	14.0 µg/Kg	0.011	0.008	670	670.0 µg/Kg	0.52	0.39
Pentachlorophenol	µg/Kg	10 U	10.0 µg/Kg	0.03	0.01	10 U	10.0 µg/Kg	0.03	0.01	11 U	11.0 µg/Kg	0.03	0.02	12 U	12.0 µg/Kg	0.03	0.02
Total Organic Carbon	Percent	0.29				0.49				0.34				0.32			
		Number of COPCs > SQS, SL, LAET		4				7				5				6	
		Number of COPCs > CSL, ML, 2LAET			2				3				3				2

Notes:
IT – Intertidal sediment sample
EF - Exceedance factor; concentration divided by appropriate criterion.
Values in **Bold** are an exceedance of the criterion.
mg/kg – milligrams per kilogram
µg/kg – micrograms per kilogram
Data Validation Qualifiers:
U – Result should be considered not-detected at the quantitation limit shown.
J – Result is an estimated concentration.
SQS & CSL values from Ecology Sediment Mangement Standards (SMS)
AET values: Ecology (1996); NOAA SQuiRT (1999), used for cobalt, selenium, vanadium; and organic chemicals at stations with total organic carbon < 0.5%.
LAET = lowest apparent effects threshold
2LAET = second lowest apparent effects threshold
SL, ML = DMMP criteria, used for antimony and nickel

Table B1. Benthic Community Evaluation with Intertidal Sediment

Intertidal Sediment Station:		IT-09				Comparison Criteria						Intertidal Sediment Detection Frequency	Intertidal Sediment Frequency of Detected Concentrations > SQS, SL, LAET		Intertidal Sediment Frequency of Detected Concentrations > CSL, ML, 2LAET	
COPC	Units		Comparison Units	SQS, SL EF	CSL, ML EF	SQS	CSL	Units	LAET/SL	2LAET/ML	Units		No. of Stations	Percent of Stations	No. of Stations	Percent of Stations
Metals																
Antimony	mg/Kg	70.3 J	70.3 mg/Kg	0.47	0.35	na	na	-	150	200	mg/Kg dw	100%	0	0.0%	0	0.0%
Arsenic	mg/Kg	197	197 mg/Kg	**3.46**	**2.12**	57	93	mg/Kg dw	-	-	-	100%	5	55.6%	5	55.6%
Chromium	mg/Kg	225 J	225 mg/Kg	0.87	0.83	260	270	mg/Kg dw	-	-	-	100%	1	11.1%	1	11.1%
Cobalt	mg/Kg	21.8	21.8 mg/Kg	**2.18**	-	na	na	-	10	-	mg/Kg dw	100%	5	55.6%	0	0.0%
Copper	mg/Kg	774	774 mg/Kg	**1.98**	**1.98**	390	390	mg/Kg dw	-	-	-	100%	4	44.4%	4	44.4%
Lead	mg/Kg	268	268 mg/Kg	0.60	0.51	450	530	mg/Kg dw	-	-	-	100%	1	11.1%	1	11.1%
Mercury	mg/Kg	0.022	0.022 mg/Kg	0.05	0.04	0.41	0.59	mg/Kg dw	-	-	-	100%	1	11.1%	0	0.0%
Nickel	mg/Kg	111	111 mg/Kg	0.79	0.30	na	na	-	140	370	mg/Kg dw	100%	2	22.2%	0	0.0%
Selenium	mg/Kg	0.5	0.5 mg/Kg	0.50	-	na	na	-	1	-	mg/Kg dw	100%	0	0.0%	0	0.0%
Vanadium	mg/Kg	43.8	43.8 mg/Kg	0.77	-	na	na	-	57	-	mg/Kg dw	100%	2	22.2%	0	0.0%
Zinc	mg/Kg	851	851 mg/Kg	**2.08**	0.89	410	960	mg/Kg dw	-	-	-	100%	7	77.8%	2	22.2%
PAHs																
Acenaphthene	µg/Kg	10	10.0 µg/Kg	0.08	0.02	16	57	mg/Kg OC	130	500	µg/Kg dw	67%	1	11.1%	0	0.0%
Benzo(a)anthracene	µg/Kg	160	160.0 µg/Kg	0.17	0.12	110	270	mg/Kg OC	960	1300	µg/Kg dw	100%	0	0.0%	0	0.0%
Benzo(a)pyrene	µg/Kg	120	120.0 µg/Kg	0.11	0.08	99	210	mg/Kg OC	1100	1600	µg/Kg dw	100%	0	0.0%	0	0.0%
Benzo(b)fluoranthene	µg/Kg	250	250.0 µg/Kg	0.14	0.08	na	na	-	1800	3200	µg/Kg dw	100%	0	0.0%	0	0.0%
Benzo(g,h,i)perylene	µg/Kg	46	46.0 µg/Kg	0.07	0.06	31	78	mg/Kg OC	670	720	µg/Kg dw	100%	0	0.0%	0	0.0%
Chrysene	µg/Kg	200	200.0 µg/Kg	0.21	0.14	110	460	mg/Kg OC	950	1400	µg/Kg dw	100%	0	0.0%	0	0.0%
Dibenzo(a,h)anthracene	µg/Kg	17	17.0 µg/Kg	0.07	0.07	12	33	mg/Kg OC	230	240	µg/Kg dw	78%	0	0.0%	0	0.0%
Fluoranthene	µg/Kg	290	290.0 µg/Kg	0.22	0.17	160	1200	mg/Kg OC	1300	1700	µg/Kg dw	100%	0	0.0%	0	0.0%
Indeno(1,2,3-cd)pyrene	µg/Kg	59	59.0 µg/Kg	0.10	0.09	34	88	mg/Kg OC	600	690	µg/Kg dw	100%	0	0.0%	0	0.0%
Phenanthrene	µg/Kg	84	84.0 µg/Kg	0.13	0.056	100	480	mg/Kg OC	660	1500	µg/Kg dw	89%	0	0.0%	0	0.0%
Total HPAH	µg/Kg	1412	1412.0 µg/Kg	0.18	0.12	960	5300	mg/Kg OC	7900	12000	µg/Kg dw	100%	0	0.0%	0	0.0%
Organometals																
Tributyltin	µg/Kg	36	36.0 µg/Kg	0.011	-	na	na	-	3400	-	µg/Kg dw	100%	0	0.0%	0	0.0%
PCBs																
PCBs (total)	µg/Kg	14	14.0 µg/Kg	0.11	0.03	12	65	mg/Kg OC	130	450	µg/Kg dw	100%	0	0.0%	0	0.0%
Other SVOCs																
bis(2-ethylhexyl)phthalate	µg/Kg	35 J	35.0 µg/Kg	0.03	0.02	47	78	mg/Kg OC	1300	1700	µg/Kg dw	33%	0	0.0%	0	0.0%
Pentachlorophenol	µg/Kg	12 U	12.0 µg/Kg	0.03	0.02	360	690	µg/Kg dw	-	-	-	0%	0	0.0%	0	0.0%
Total Organic Carbon	Percent	0.19											**Total No. of Stations**	**Total Percent**	**Total No. of Stations**	**Total Percent**
		Number of COPCs > SQS, SL, LAET		4									8	89%	6	67%
		Number of COPCs > CSL, ML, 2LAET			2											

Notes:
IT – Intertidal sediment sample
EF - Exceedance factor; concentration divided by appropriate criterion.
Values in **Bold** are an exceedance of the criterion.
mg/kg – milligrams per kilogram
µg/kg – micrograms per kilogram
Data Validation Qualifiers:
U – Result should be considered not-detected at the quantitation limit shown.
J – Result is an estimated concentration.
SQS & CSL values from Ecology Sediment Mangement Standards (SMS)
AET values: Ecology (1996); NOAA SQuiRT (1999), used for cobalt, selenium, vanadium; and organic chemicals at stations with total organic carbon < 0.5%.
LAET = lowest apparent effects threshold
2LAET = second lowest apparent effects threshold
SL, ML = DMMP criteria, used for antimony and nickel

Table B2. Benthic Community Evaluation with Subtidal Sediment

Subtidal Sediment Station:		1				2				3				4			
COPC	Units		Comparison Units	SQS, SL EF	CSL, ML EF		Comparison Units	SQS, SL EF	CSL, ML EF		Comparison Units	SQS, SL EF	CSL, ML EF		Comparison Units	SQS, SL EF	CSL, ML EF
Metals																	
Antimony	mg/Kg	2.01 J	2.01 mg/Kg	0.01	0.01	1.45 J	1.45 mg/Kg	0.01	0.01	2.17 J	2.17 mg/Kg	0.01	0.01	2.03 J	2.03 mg/Kg	0.01	0.01
Arsenic	mg/Kg	7.88 J	7.88 mg/Kg	0.14	0.08	9.05 J	9.05 mg/Kg	0.16	0.10	10.6 J	10.6 mg/Kg	0.19	0.11	9.74 J	9.74 mg/Kg	0.17	0.10
Chromium	mg/Kg	26.7	26.7 mg/Kg	0.10	0.10	26.5	26.5 mg/Kg	0.10	0.10	34.6	34.6 mg/Kg	0.13	0.13	30.9	30.9 mg/Kg	0.12	0.11
Cobalt	mg/Kg	5.69 J	5.69 mg/Kg	0.57	-	5.88 J	5.88 mg/Kg	0.59	-	5.69 J	5.69 mg/Kg	0.57	-	5.81 J	5.81 mg/Kg	0.58	-
Copper	mg/Kg	64	64 mg/Kg	0.16	0.16	71.4	71.4 mg/Kg	0.18	0.18	97.1	97.1 mg/Kg	0.25	0.25	78.8	78.8 mg/Kg	0.20	0.20
Lead	mg/Kg	39.8 J	39.8 mg/Kg	0.09	0.08	51 J	51 mg/Kg	0.11	0.10	59.2	59.2 mg/Kg	0.13	0.11	52.5	52.5 mg/Kg	0.12	0.10
Mercury	mg/Kg	0.299	0.299 mg/Kg	0.73	0.51	0.374	0.374 mg/Kg	0.91	0.63	0.471	0.471 mg/Kg	**1.15**	0.80	0.44	0.44 mg/Kg	**1.07**	0.75
Nickel	mg/Kg	12.4 J	12.4 mg/Kg	0.09	0.03	12.4 J	12.4 mg/Kg	0.09	0.03	13.5 J	13.5 mg/Kg	0.10	0.04	13.8 J	13.8 mg/Kg	0.10	0.04
Selenium	mg/Kg	0.4 UJ	0.4 mg/Kg	0.40	-	0.4 UJ	0.4 mg/Kg	0.40	-	0.4 U	0.4 mg/Kg	0.40	-	0.50 U	0.50 mg/Kg	0.50	-
Vanadium	mg/Kg	53.6	53.6 mg/Kg	0.94	-	52	52 mg/Kg	0.91	-	55.4	55.4 mg/Kg	0.97	-	48.7	48.7 mg/Kg	0.85	-
Zinc	mg/Kg	90.1	90.1 mg/Kg	0.22	0.09	95.5	95.5 mg/Kg	0.23	0.10	130	130 mg/Kg	0.32	0.14	121	121 mg/Kg	0.30	0.13
PAHs																	
Acenaphthene	µg/Kg	40	4.21 mg/kg OC	0.26	0.07	39	3.61 mg/kg OC	0.23	0.06	55	55 µg/Kg	0.42	0.11	54	4.21 mg/kg OC	0.26	0.07
Benzo(a)anthracene	µg/Kg	570	60.0 mg/kg OC	0.55	0.22	220	20.4 mg/kg OC	0.19	0.08	370	370 µg/Kg	0.39	0.28	350	27.6 mg/kg OC	0.25	0.10
Benzo(a)pyrene	µg/Kg	420	44.2 mg/kg OC	0.45	0.21	270	25.0 mg/kg OC	0.25	0.12	470	470 µg/Kg	0.43	0.29	445	35.0 mg/kg OC	0.35	0.17
Benzo(b)fluoranthene	µg/Kg	660	660 µg/Kg	0.37	0.21	450	450 µg/Kg	0.25	0.14	790	790 µg/Kg	0.44	0.25	615	615 µg/Kg	0.34	0.19
Benzo(g,h,i)perylene	µg/Kg	190	20.0 mg/kg OC	0.65	0.26	140	13.0 mg/kg OC	0.42	0.17	310	310 µg/Kg	0.46	0.43	255	20.1 mg/kg OC	0.65	0.26
Chrysene	µg/Kg	690	72.6 mg/kg OC	0.66	0.16	390	36.1 mg/kg OC	0.33	0.08	540	540 µg/Kg	0.57	0.39	605	47.6 mg/kg OC	0.43	0.10
Dibenzo(a,h)anthracene	µg/Kg	70	7.37 mg/kg OC	0.61	0.22	47	4.35 mg/kg OC	0.36	0.13	82	82 µg/Kg	0.36	0.34	65 J	5.08 mg/kg OC	0.42	0.15
Fluoranthene	µg/Kg	1600	168 mg/kg OC	**1.05**	0.14	550	51 mg/kg OC	0.32	0.04	700	700 µg/Kg	0.54	0.41	715	56 mg/kg OC	0.35	0.05
Indeno(1,2,3-cd)pyrene	µg/Kg	210	22.1 mg/kg OC	0.65	0.25	160	14.8 mg/kg OC	0.44	0.17	310	310 µg/Kg	0.52	0.45	285	22.4 mg/kg OC	0.66	0.26
Phenanthrene	µg/Kg	610	64.2 mg/kg OC	0.64	0.13	300	27.8 mg/kg OC	0.28	0.06	410	410 µg/Kg	0.62	0.27	455	35.8 mg/kg OC	0.36	0.07
Total HPAH	µg/Kg	5730	603 mg/kg OC	0.63	0.11	2857	265 mg/kg OC	0.28	0.05	4712	4712 µg/Kg	0.60	0.39	4185	329 mg/kg OC	0.34	0.06
Organometals																	
Tributyltin	µg/Kg	160	160 µg/Kg	0.05	-	230	230 µg/Kg	0.07	-	380	380 µg/Kg	0.11	-	295	295 µg/Kg	0.09	-
PCBs																	
PCBs (total)	µg/Kg	149	15.68 mg/kg OC	**1.31**	0.24	150	13.89 mg/kg OC	**1.16**	0.21	240	240 µg/Kg	**1.85**	0.53	222	17.44 mg/kg OC	**1.45**	0.27
Other SVOCs																	
Bis(2-ethylhexyl)phthalate	µg/Kg	180	18.9 mg/kg OC	0.40	0.24	160	14.8 mg/kg OC	0.32	0.19	230 J	230 µg/Kg	0.18	0.14	200	15.7 mg/kg OC	0.34	0.20
Pentachlorophenol	µg/Kg	20 J	20 µg/Kg	0.06	0.03	18 J	18 µg/Kg	0.05	0.03	43 J	43 µg/Kg	0.12	0.06	33 J	33 µg/Kg	0.09	0.05
Total Organic Carbon	Percent	0.95				1.08				0.10				1.27			
		Number of COPCs > SQS, SL, LAET		2				1				2				2	
		Number of COPCs > CSL, ML, 2LAET			0				0				0				0

Notes:
EF - Exceedance factor; concentration divided by appropriate criterion.
Values in **Bold** are an exceedance of the criterion.
mg/kg – milligrams per kilogram
µg/kg – micrograms per kilogram
Data Validation Qualifiers:
U – Result should be considered not-detected at the quantitation limit shown.
J – Result is an estimated concentration.
SQS & CSL values from Ecology Sediment Mangement Standards (SMS)
AET values: Ecology (1996); NOAA SQuiRT (1999), used for cobalt, selenium, vanadium; and organic chemicals at stations with total organic carbon < 0.5%.
LAET = lowest apparent effects threshold
2LAET = second lowest apparent effects threshold
SL, ML = DMMP criteria, used for antimony and nickel

Table B2. Benthic Community Evaluation with Subtidal Sediment

Subtidal Sediment Station:		5				6				7				8			
COPC	Units		Comparison Units	SQS, SL EF	CSL, ML EF		Comparison Units	SQS, SL EF	CSL, ML EF		Comparison Units	SQS, SL EF	CSL, ML EF		Comparison Units	SQS, SL EF	CSL, ML EF
Metals																	
Antimony	mg/Kg	2.21 J	2.21 mg/Kg	0.01	0.01	3.74 J	3.735 mg/Kg	0.02	0.02	2.59 J	2.59 mg/Kg	0.02	0.01	15.3 J	15.3 mg/Kg	0.10	0.08
Arsenic	mg/Kg	12.25 J	12.25 mg/Kg	0.21	0.13	15.75 J	15.75 mg/Kg	0.28	0.17	14 J	14 mg/Kg	0.25	0.15	40.5 J	40.5 mg/Kg	0.71	0.44
Chromium	mg/Kg	40.3	40.25 mg/Kg	0.15	0.15	47.3	47.3 mg/Kg	0.18	0.18	44.4	44.4 mg/Kg	0.17	0.16	50.5	50.5 mg/Kg	0.19	0.19
Cobalt	mg/Kg	6.01 J	6.01 mg/Kg	0.60	-	6.67 J	6.665 mg/Kg	0.67	-	6.89 J	6.89 mg/Kg	0.69	-	8.29 J	8.29 mg/Kg	0.83	-
Copper	mg/Kg	116.0	116 mg/Kg	0.30	0.30	146.0	146 mg/Kg	0.37	0.37	143	143 mg/Kg	0.37	0.37	230	230 mg/Kg	0.59	0.59
Lead	mg/Kg	70.4	70.4 mg/Kg	0.16	0.13	88.7	88.7 mg/Kg	0.20	0.17	77.1	77.1 mg/Kg	0.17	0.15	123	123 mg/Kg	0.27	0.23
Mercury	mg/Kg	0.64	0.6395 mg/Kg	**1.56**	**1.08**	0.68	0.6835 mg/Kg	**1.67**	**1.16**	0.796	0.796 mg/Kg	**1.94**	**1.35**	1.46	1.46 mg/Kg	**3.56**	**2.47**
Nickel	mg/Kg	16.1 J	16.05 mg/Kg	0.11	0.04	16.7 J	16.65 mg/Kg	0.12	0.05	16.6 J	16.6 mg/Kg	0.12	0.04	15.9 J	15.9 mg/Kg	0.11	0.04
Selenium	mg/Kg	0.40 U	0.4 mg/Kg	0.40	-	0.40 U	0.4 mg/Kg	0.40	-	0.4 U	0.4 mg/Kg	0.40	-	0.5 U	0.5 mg/Kg	0.50	-
Vanadium	mg/Kg	51.7	51.65 mg/Kg	0.91	-	56.7	56.65 mg/Kg	0.99	-	64	64 mg/Kg	**1.12**	-	48.5	48.5 mg/Kg	0.85	-
Zinc	mg/Kg	152	151.5 mg/Kg	0.37	0.16	186	186 mg/Kg	0.45	0.19	168	168 mg/Kg	0.41	0.18	235	235 mg/Kg	0.57	0.24
PAHs																	
Acenaphthene	µg/Kg	81	4.24 mg/kg OC	0.27	0.07	94	5.30 mg/kg OC	0.33	0.09	170	8.81 mg/kg OC	0.55	0.15	160	12.60 mg/kg OC	0.79	0.22
Benzo(a)anthracene	µg/Kg	750	39.3 mg/kg OC	0.36	0.15	665	37.7 mg/kg OC	0.34	0.14	910	47.2 mg/kg OC	0.43	0.17	1300	102.4 mg/kg OC	0.93	0.38
Benzo(a)pyrene	µg/Kg	800	41.9 mg/kg OC	0.42	0.20	770	43.6 mg/kg OC	0.44	0.21	990	51.3 mg/kg OC	0.52	0.24	1300	102.4 mg/kg OC	**1.03**	0.49
Benzo(b)fluoranthene	µg/Kg	1350	1350 µg/Kg	0.75	0.42	1250	1250 µg/Kg	0.69	0.39	1600	1600 µg/Kg	0.89	0.50	2100	2100 µg/Kg	**1.17**	0.66
Benzo(g,h,i)perylene	µg/Kg	465	24.3 mg/kg OC	0.79	0.31	495	28.0 mg/kg OC	0.90	0.36	640	33.2 mg/kg OC	**1.07**	0.43	860	67.7 mg/kg OC	**2.18**	0.87
Chrysene	µg/Kg	1200	62.8 mg/kg OC	0.57	0.14	950	53.8 mg/kg OC	0.49	0.12	1500	77.7 mg/kg OC	0.71	0.17	1800	141.7 mg/kg OC	**1.29**	0.31
Dibenzo(a,h)anthracene	µg/Kg	135	7.07 mg/kg OC	0.59	0.21	135	7.65 mg/kg OC	0.64	0.23	170	8.81 mg/kg OC	0.73	0.27	250	19.69 mg/kg OC	**1.64**	0.60
Fluoranthene	µg/Kg	1250	65 mg/kg OC	0.41	0.05	1300	74 mg/kg OC	0.46	0.06	2000	104 mg/kg OC	0.65	0.09	3000	236 mg/kg OC	**1.48**	0.20
Indeno(1,2,3-cd)pyrene	µg/Kg	515	27.0 mg/kg OC	0.79	0.31	515	29.2 mg/kg OC	0.86	0.33	710	36.8 mg/kg OC	**1.08**	0.42	970	76.4 mg/kg OC	**2.25**	0.87
Phenanthrene	µg/Kg	655	34.3 mg/kg OC	0.34	0.07	740	41.9 mg/kg OC	0.42	0.09	1100	57.0 mg/kg OC	0.57	0.12	1600	126.0 mg/kg OC	**1.26**	0.26
Total HPAH	µg/Kg	8505	445 mg/kg OC	0.46	0.08	7995	453 mg/kg OC	0.47	0.09	11180	579 mg/kg OC	0.60	0.11	15590	1228 mg/kg OC	**1.28**	0.23
Organometals																	
Tributyltin	µg/Kg	435	435 µg/Kg	0.13	-	835	835 µg/Kg	0.25	-	810	810 µg/Kg	0.24	-	690	690 µg/Kg	0.20	-
PCBs																	
PCBs (total)	µg/Kg	365	19.11 mg/kg OC	**1.59**	0.29	405	22.95 mg/kg OC	**1.91**	0.35	445	23.06 mg/kg OC	**1.92**	0.35	690	54.33 mg/kg OC	**4.53**	0.84
Other SVOCs																	
Bis(2-ethylhexyl)phthalate	µg/Kg	305 J	16.0 mg/kg OC	0.34	0.20	305 J	17.3 mg/kg OC	0.37	0.22	350 J	18.1 mg/kg OC	0.39	0.23	740	58.3 mg/kg OC	**1.24**	0.75
Pentachlorophenol	µg/Kg	77 U	77 µg/Kg	0.21	0.11	85 J	85 µg/Kg	0.24	0.12	78 U	78 µg/Kg	0.22	0.11	310 J	310 µg/Kg	0.86	0.45
Total Organic Carbon	Percent	1.91				1.77				1.93				1.27			
		Number of COPCs > SQS, SL, LAET		2				2				5				12	
		Number of COPCs > CSL, ML, 2LAET			1				1				1				1

Notes:

EF - Exceedance factor; concentration divided by appropriate criterion.

Values in **Bold** are an exceedance of the criterion.

mg/kg – milligrams per kilogram
µg/kg – micrograms per kilogram
Data Validation Qualifiers:
U – Result should be considered not-detected at the quantitation limit shown.
J – Result is an estimated concentration.
SQS & CSL values from Ecology Sediment Mangement Standards (SMS)

AET values: Ecology (1996); NOAA SQuiRT (1999), used for cobalt, selenium, vanadium; and organic chemicals at stations with total organic carbon < 0.5%.

LAET = lowest apparent effects threshold
2LAET = second lowest apparent effects threshold

SL, ML = DMMP criteria, used for antimony and nickel

Table B2. Benthic Community Evaluation with Subtidal Sediment

Subtidal Sediment Station:		9				10				11				12			
COPC	**Units**		**Comparison Units**	**SQS, SL EF**	**CSL, ML EF**		**Comparison Units**	**SQS, SL EF**	**CSL, ML EF**		**Comparison Units**	**SQS, SL EF**	**CSL, ML EF**		**Comparison Units**	**SQS, SL EF**	**CSL, ML EF**
Metals																	
Antimony	mg/Kg	41.3 J	41.3 mg/Kg	0.28	0.21	56.4 J	56.4 mg/Kg	0.38	0.28	194 J	194 mg/Kg	**1.29**	0.97	9.21 J	9.21 mg/Kg	0.06	0.05
Arsenic	mg/Kg	183	183 mg/Kg	**3.21**	**1.97**	146	146 mg/Kg	**2.56**	**1.57**	204	204 mg/Kg	**3.58**	**2.19**	18.3	18.3 mg/Kg	0.32	0.20
Chromium	mg/Kg	60.6	60.6 mg/Kg	0.23	0.22	169	169 mg/Kg	0.65	0.63	94.5	94.5 mg/Kg	0.36	0.35	66.9	66.9 mg/Kg	0.26	0.25
Cobalt	mg/Kg	21	21 mg/Kg	**2.10**	-	23	23 mg/Kg	**2.30**	-	16.3	16.3 mg/Kg	**1.63**	-	5.71	5.71 mg/Kg	0.57	-
Copper	mg/Kg	483	483 mg/Kg	**1.24**	**1.24**	894	894 mg/Kg	**2.29**	**2.29**	514	514 mg/Kg	**1.32**	**1.32**	111	111 mg/Kg	0.28	0.28
Lead	mg/Kg	258	258 mg/Kg	0.57	0.49	395	395 mg/Kg	0.88	0.75	483	483 mg/Kg	**1.07**	0.91	80.9	80.9 mg/Kg	0.18	0.15
Mercury	mg/Kg	0.525	0.525 mg/Kg	**1.28**	0.89	0.631	0.631 mg/Kg	**1.54**	**1.07**	1.04	1.04 mg/Kg	**2.54**	**1.76**	0.636	0.636 mg/Kg	**1.55**	**1.08**
Nickel	mg/Kg	22.9	22.9 mg/Kg	0.16	0.06	58.1	58.1 mg/Kg	0.42	0.16	29.9	29.9 mg/Kg	0.21	0.08	16.6	16.6 mg/Kg	0.12	0.04
Selenium	mg/Kg	1.1	1.1 mg/Kg	**1.10**	-	1	1 mg/Kg	1.00	-	1.2	1.2 mg/Kg	**1.20**	-	0.9	0.9 mg/Kg	0.90	-
Vanadium	mg/Kg	61	61 mg/Kg	**1.07**	-	69	69 mg/Kg	**1.21**	-	58.2	58.2 mg/Kg	**1.02**	-	42.4	42.4 mg/Kg	0.74	-
Zinc	mg/Kg	880	880 mg/Kg	**2.15**	0.92	954	954 mg/Kg	**2.33**	0.99	1430	1430 mg/Kg	**3.49**	**1.49**	163	163 mg/Kg	0.40	0.17
PAHs																	
Acenaphthene	µg/Kg	150	10.95 mg/kg OC	0.68	0.19	130	12.75 mg/kg OC	0.80	0.22	54	4.82 mg/kg OC	0.30	0.08	51	4.15 mg/kg OC	0.26	0.07
Benzo(a)anthracene	µg/Kg	910	66.4 mg/kg OC	0.60	0.25	840	82.4 mg/kg OC	0.75	0.31	1900	169.6 mg/kg OC	**1.54**	0.63	360	29.3 mg/kg OC	0.27	0.11
Benzo(a)pyrene	µg/Kg	930	67.9 mg/kg OC	0.69	0.32	1000	98.0 mg/kg OC	0.99	0.47	860	76.8 mg/kg OC	0.78	0.37	420	34.1 mg/kg OC	0.34	0.16
Benzo(b)fluoranthene	µg/Kg	1400	1400 µg/Kg	0.78	0.44	1500	1500 µg/Kg	0.83	0.47	1200	1200 µg/Kg	0.67	0.38	550	550 µg/Kg	0.31	0.17
Benzo(g,h,i)perylene	µg/Kg	560	40.9 mg/kg OC	**1.32**	0.52	630	61.8 mg/kg OC	**1.99**	0.79	320	28.6 mg/kg OC	0.92	0.37	220	17.9 mg/kg OC	0.58	0.23
Chrysene	µg/Kg	1200	87.6 mg/kg OC	0.80	0.19	1200	117.6 mg/kg OC	**1.07**	0.26	2200	196.4 mg/kg OC	**1.79**	0.43	530	43.1 mg/kg OC	0.39	0.09
Dibenzo(a,h)anthracene	µg/Kg	160	11.68 mg/kg OC	0.97	0.35	170	16.67 mg/kg OC	**1.39**	0.51	90	8.04 mg/kg OC	0.67	0.24	100	8.13 mg/kg OC	0.68	0.25
Fluoranthene	µg/Kg	1800	131 mg/kg OC	0.82	0.11	1700	167 mg/kg OC	**1.04**	0.14	2900 J	259 mg/kg OC	**1.62**	0.22	670 J	54 mg/kg OC	0.34	0.05
Indeno(1,2,3-cd)pyrene	µg/Kg	610	44.5 mg/kg OC	**1.31**	0.51	660	64.7 mg/kg OC	**1.90**	0.74	370	33.0 mg/kg OC	0.97	0.38	240	19.5 mg/kg OC	0.57	0.22
Phenanthrene	µg/Kg	1200	87.6 mg/kg OC	0.88	0.18	1100	107.8 mg/kg OC	**1.08**	0.22	610	54.5 mg/kg OC	0.54	0.11	400	32.5 mg/kg OC	0.33	0.07
Total HPAH	µg/Kg	10080	736 mg/kg OC	0.77	0.14	10770	1056 mg/kg OC	**1.10**	0.20	12060	1077 mg/kg OC	**1.12**	0.20	3900	317 mg/kg OC	0.33	0.06
Organometals																	
Tributyltin	µg/Kg	3500	3500 ug/Kg	**1.03**	-	4000	4000 µg/Kg	**1.18**	-	290	290 µg/Kg	0.09	-	190	190 µg/Kg	0.06	-
PCBs																	
PCBs (total)	µg/Kg	480	35.04 mg/kg OC	**2.92**	0.54	1310	128.43 mg/kg OC	**10.70**	**1.98**	1220	108.93 mg/kg OC	**9.08**	**1.68**	257	20.89 mg/kg OC	**1.74**	0.32
Other SVOCs																	
Bis(2-ethylhexyl)phthalate	µg/Kg	230 J	16.8 mg/kg OC	0.36	0.22	450 J	44.1 mg/kg OC	0.94	0.57	180 J	16.1 mg/kg OC	0.34	0.21	190	15.4 mg/kg OC	0.33	0.20
Pentachlorophenol	µg/Kg	220 J	220 ug/Kg	0.61	0.32	360 J	360 µg/Kg	1.00	0.52	62 U	62 µg/Kg	0.17	0.09	43 J	43 µg/Kg	0.12	0.06
Total Organic Carbon	Percent	1.37				1.02				1.12				1.23			
		Number of COPCs > SQS, SL, LAET		11				15				14				2	
		Number of COPCs > CSL, ML, 2LAET			2				4				5				1

Notes:

EF - Exceedance factor; concentration divided by appropriate criterion.

Values in **Bold** are an exceedance of the criterion.

mg/kg – milligrams per kilogram

µg/kg – micrograms per kilogram

Data Validation Qualifiers:

U – Result should be considered not-detected at the quantitation limit shown.

J – Result is an estimated concentration.

SQS & CSL values from Ecology Sediment Mangement Standards (SMS)

AET values: Ecology (1996); NOAA SQuiRT (1999), used for cobalt, selenium, vanadium; and organic chemicals at stations with total organic carbon < 0.5%.

LAET = lowest apparent effects threshold

2LAET = second lowest apparent effects threshold

SL, ML = DMMP criteria, used for antimony and nickel

Table B2. Benthic Community Evaluation with Subtidal Sediment

Subtidal Sediment Station:		13				14				15				16			
COPC	Units		Comparison Units	SQS, SL EF	CSL, ML EF		Comparison Units	SQS, SL EF	CSL, ML EF		Comparison Units	SQS, SL EF	CSL, ML EF		Comparison Units	SQS, SL EF	CSL, ML EF
Metals																	
Antimony	mg/Kg	7.76 J	7.76 mg/Kg	0.05	0.04	4.86 J	4.86 mg/Kg	0.03	0.02	18.9 J	18.9 mg/Kg	0.13	0.09	5.35 J	5.35 mg/Kg	0.04	0.03
Arsenic	mg/Kg	14.7	14.7 mg/Kg	0.26	0.16	12.4	12.4 mg/Kg	0.22	0.13	74.1	74.1 mg/Kg	**1.30**	0.80	21.4	21.4 mg/Kg	0.38	0.23
Chromium	mg/Kg	34.6	34.6 mg/Kg	0.13	0.13	20.2	20.2 mg/Kg	0.08	0.07	59.1	59.1 mg/Kg	0.23	0.22	57.3	57.3 mg/Kg	0.22	0.21
Cobalt	mg/Kg	5.53	5.53 mg/Kg	0.55	-	5.16	5.16 mg/Kg	0.52	-	17.9	17.9 mg/Kg	**1.79**	-	8.91	8.91 mg/Kg	0.89	-
Copper	mg/Kg	107	107 mg/Kg	0.27	0.27	73.2	73.2 mg/Kg	0.19	0.19	1900	1900 mg/Kg	**4.87**	**4.87**	222	222 mg/Kg	0.57	0.57
Lead	mg/Kg	83.9	83.9 mg/Kg	0.19	0.16	46.5	46.5 mg/Kg	0.10	0.09	132	132 mg/Kg	0.29	0.25	128	128 mg/Kg	0.28	0.24
Mercury	mg/Kg	0.71	0.71 mg/Kg	**1.73**	**1.20**	0.14	0.14 mg/Kg	0.34	0.24	0.675	0.675 mg/Kg	**1.65**	**1.14**	0.993	0.993 mg/Kg	**2.42**	**1.68**
Nickel	mg/Kg	12.9	12.9 mg/Kg	0.09	0.03	20	20 mg/Kg	0.14	0.05	24.8	24.8 mg/Kg	0.18	0.07	21.6	21.6 mg/Kg	0.15	0.06
Selenium	mg/Kg	0.9	0.9 mg/Kg	0.90	-	1.2	1.2 mg/Kg	**1.20**	-	1.2	1.2 mg/Kg	**1.20**	-	1.1	1.1 mg/Kg	**1.10**	-
Vanadium	mg/Kg	47.2	47.2 mg/Kg	0.83	-	28.4	28.4 mg/Kg	0.50	-	72.4	72.4 mg/Kg	**1.27**	-	67.5	67.5 mg/Kg	**1.18**	-
Zinc	mg/Kg	165	165 mg/Kg	0.40	0.17	111	111 mg/Kg	0.27	0.12	721	721 mg/Kg	**1.76**	0.75	255	255 mg/Kg	0.62	0.27
PAHs																	
Acenaphthene	µg/Kg	44	4.15 mg/kg OC	0.26	0.07	74 J	2.29 mg/kg OC	0.14	0.04	110	6.47 mg/kg OC	0.40	0.11	79	5.00 mg/kg OC	0.31	0.09
Benzo(a)anthracene	µg/Kg	390	36.8 mg/kg OC	0.33	0.14	1900	58.8 mg/kg OC	0.53	0.22	830	48.8 mg/kg OC	0.44	0.18	680	43.0 mg/kg OC	0.39	0.16
Benzo(a)pyrene	µg/Kg	450	42.5 mg/kg OC	0.43	0.20	1100	34.1 mg/kg OC	0.34	0.16	810	47.6 mg/kg OC	0.48	0.23	700	44.3 mg/kg OC	0.45	0.21
Benzo(b)fluoranthene	µg/Kg	570	570 µg/Kg	0.32	0.18	3400	3400 µg/Kg	**1.89**	**1.06**	1400	1400 µg/Kg	0.78	0.44	1200	1200 µg/Kg	0.67	0.38
Benzo(g,h,i)perylene	µg/Kg	240	22.6 mg/kg OC	0.73	0.29	530	16.4 mg/kg OC	0.53	0.21	460	27.1 mg/kg OC	0.87	0.35	430	27.2 mg/kg OC	0.88	0.35
Chrysene	µg/Kg	540	50.9 mg/kg OC	0.46	0.11	5800	179.6 mg/kg OC	**1.63**	0.39	1200	70.6 mg/kg OC	0.64	0.15	1100	69.6 mg/kg OC	0.63	0.15
Dibenzo(a,h)anthracene	µg/Kg	84	7.92 mg/kg OC	0.66	0.24	130 J	4.02 mg/kg OC	0.34	0.12	110	6.47 mg/kg OC	0.54	0.20	120	7.59 mg/kg OC	0.63	0.23
Fluoranthene	µg/Kg	820 J	77 mg/kg OC	0.48	0.06	33000	1022 mg/kg OC	**6.39**	0.85	1600	94 mg/kg OC	0.59	0.08	1200	76 mg/kg OC	0.47	0.06
Indeno(1,2,3-cd)pyrene	µg/Kg	260	24.5 mg/kg OC	0.72	0.28	680	21.1 mg/kg OC	0.62	0.24	560	32.9 mg/kg OC	0.97	0.37	460	29.1 mg/kg OC	0.86	0.33
Phenanthrene	µg/Kg	420	39.6 mg/kg OC	0.40	0.08	450	13.9 mg/kg OC	0.14	0.03	810	47.6 mg/kg OC	0.48	0.10	710	44.9 mg/kg OC	0.45	0.09
Total HPAH	µg/Kg	4214	398 mg/kg OC	0.41	0.08	70740	2190 mg/kg OC	**2.28**	0.41	9180	540 mg/kg OC	0.56	0.10	7620	482 mg/kg OC	0.50	0.09
Organometals																	
Tributyltin	µg/Kg	110	110 µg/Kg	0.03	-	100	100 µg/Kg	0.03	-	2800	2800 µg/Kg	0.82	-	1900	1900 µg/Kg	0.56	-
PCBs																	
PCBs (total)	µg/Kg	311	29.34 mg/kg OC	**2.44**	0.45	134	4.15 mg/kg OC	0.35	0.06	520	30.59 mg/kg OC	**2.55**	0.47	470	29.75 mg/kg OC	**2.48**	0.46
Other SVOCs																	
Bis(2-ethylhexyl)phthalate	µg/Kg	170	16.0 mg/kg OC	0.34	0.21	230 U	7.1 mg/kg OC	0.15	0.09	430	25.3 mg/kg OC	0.54	0.32	280	17.7 mg/kg OC	0.38	0.23
Pentachlorophenol	µg/Kg	35 J	35 µg/Kg	0.10	0.05	340 J	340 µg/Kg	0.94	0.49	540	540 µg/Kg	**1.50**	0.78	80 J	80 µg/Kg	0.22	0.12
Total Organic Carbon	Percent	1.06				3.23				1.70				1.58			
		Number of COPCs > SQS, SL, LAET		2				5				9				4	
		Number of COPCs > CSL, ML, 2LAET			1				1				2				1

Notes:

EF - Exceedance factor; concentration divided by appropriate criterion.

Values in **Bold** are an exceedance of the criterion.

mg/kg – milligrams per kilogram

µg/kg – micrograms per kilogram

Data Validation Qualifiers:

U – Result should be considered not-detected at the quantitation limit shown.

J – Result is an estimated concentration.

SQS & CSL values from Ecology Sediment Mangement Standards (SMS)

AET values: Ecology (1996); NOAA SQuiRT (1999), used for cobalt, selenium, vanadium; and organic chemicals at stations with total organic carbon < 0.5%.

LAET = lowest apparent effects threshold

2LAET = second lowest apparent effects threshold

SL, ML = DMMP criteria, used for antimony and nickel

Table B2. Benthic Community Evaluation with Subtidal Sediment

Subtidal Sediment Station:		17				18				19			
COPC	**Units**		**Comparison Units**	**SQS, SL EF**	**CSL, ML EF**		**Comparison Units**	**SQS, SL EF**	**CSL, ML EF**		**Comparison Units**	**SQS, SL EF**	**CSL, ML EF**
Metals													
Antimony	mg/Kg	17.2 J	17.2 mg/Kg	0.11	0.09	3.72 J	3.72 mg/Kg	0.02	0.02	5.75 J	5.75 mg/Kg	0.04	0.03
Arsenic	mg/Kg	71.5	71.5 mg/Kg	**1.25**	0.77	4.87 J	4.87 mg/Kg	0.09	0.05	12.8 J	12.8 mg/Kg	0.22	0.14
Chromium	mg/Kg	129	129 mg/Kg	0.50	0.48	504	504 mg/Kg	**1.94**	**1.87**	45.7	45.7 mg/Kg	0.18	0.17
Cobalt	mg/Kg	13.8	13.8 mg/Kg	**1.38**	-	4.13 J	4.13 mg/Kg	0.41	-	6.87 J	6.87 mg/Kg	0.69	-
Copper	mg/Kg	661	661 mg/Kg	**1.69**	**1.69**	66.6	66.6 mg/Kg	0.17	0.17	115	115 mg/Kg	0.29	0.29
Lead	mg/Kg	248	248 mg/Kg	0.55	0.47	20.3	20.3 mg/Kg	0.05	0.04	73.5	73.5 mg/Kg	0.16	0.14
Mercury	mg/Kg	2.94	2.94 mg/Kg	**7.17**	**4.98**	0.117	0.117 mg/Kg	0.29	0.20	0.306	0.306 mg/Kg	0.75	0.52
Nickel	mg/Kg	32.8	32.8 mg/Kg	0.23	0.09	13.7 J	13.7 mg/Kg	0.10	0.04	16.8 J	16.8 mg/Kg	0.12	0.05
Selenium	mg/Kg	1.1	1.1 mg/Kg	**1.10**	-	0.5 U	0.5 mg/Kg	0.50	-	0.5 U	0.5 mg/Kg	0.50	-
Vanadium	mg/Kg	66.4	66.4 mg/Kg	**1.16**	-	95.6	95.6 mg/Kg	**1.68**	-	52.4	52.4 mg/Kg	0.92	-
Zinc	mg/Kg	617	617 mg/Kg	**1.50**	0.64	128	128 mg/Kg	0.31	0.13	177	177 mg/Kg	0.43	0.18
PAHs													
Acenaphthene	µg/Kg	270	13.57 mg/kg OC	0.85	0.24	25	3.09 mg/kg OC	0.19	0.05	100	7.63 mg/kg OC	0.48	0.13
Benzo(a)anthracene	µg/Kg	1800	90.5 mg/kg OC	0.82	0.34	270	33.3 mg/kg OC	0.30	0.12	690	52.7 mg/kg OC	0.48	0.20
Benzo(a)pyrene	µg/Kg	2000	100.5 mg/kg OC	**1.02**	0.48	220	27.2 mg/kg OC	0.27	0.13	810	61.8 mg/kg OC	0.62	0.29
Benzo(b)fluoranthene	µg/Kg	3200	3200 µg/Kg	**1.78**	**1.00**	340	340 µg/Kg	0.19	0.11	1400	1400 µg/Kg	0.78	0.44
Benzo(g,h,i)perylene	µg/Kg	1300	65.3 mg/kg OC	**2.11**	0.84	110	13.6 mg/kg OC	0.44	0.17	500	38.2 mg/kg OC	**1.23**	0.49
Chrysene	µg/Kg	2500	125.6 mg/kg OC	**1.14**	0.27	520	64.2 mg/kg OC	0.58	0.14	1100	84.0 mg/kg OC	0.76	0.18
Dibenzo(a,h)anthracene	µg/Kg	340	17.09 mg/kg OC	**1.42**	0.52	40	4.94 mg/kg OC	0.41	0.15	140	10.69 mg/kg OC	0.89	0.32
Fluoranthene	µg/Kg	4500	226 mg/kg OC	**1.41**	0.19	760	94 mg/kg OC	0.59	0.08	1500	115 mg/kg OC	0.72	0.10
Indeno(1,2,3-cd)pyrene	µg/Kg	1400	70.4 mg/kg OC	**2.07**	0.80	120	14.8 mg/kg OC	0.44	0.17	510	38.9 mg/kg OC	**1.15**	0.44
Phenanthrene	µg/Kg	3200	160.8 mg/kg OC	**1.61**	0.34	300	37.0 mg/kg OC	0.37	0.08	720	55.0 mg/kg OC	0.55	0.11
Total HPAH	µg/Kg	23440	1178 mg/kg OC	**1.23**	0.22	2910	359 mg/kg OC	0.37	0.07	8730	666 mg/kg OC	0.69	0.13
Organometals													
Tributyltin	µg/Kg	4100	4100 µg/Kg	**1.21**	-	28	28 µg/Kg	0.01	-	250	250 µg/Kg	0.07	-
PCBs													
PCBs (total)	µg/Kg	2240	112.56 mg/kg OC	**9.38**	**1.73**	114	14.07 mg/kg OC	**1.17**	0.22	220	16.79 mg/kg OC	**1.40**	0.26
Other SVOCs													
Bis(2-ethylhexyl)phthalate	µg/Kg	700 J	35.2 mg/kg OC	0.75	0.45	80 J	9.9 mg/kg OC	0.21	0.13	230 J	17.6 mg/kg OC	0.37	0.23
Pentachlorophenol	µg/Kg	330 J	330 µg/Kg	0.92	0.48	12 U	12 µg/Kg	0.03	0.02	68 U	68 µg/Kg	0.19	0.10
Total Organic Carbon	Percent	1.99				0.81				1.31			
		Number of COPCs > SQS, SL, LAET		18				3				3	
		Number of COPCs > CSL, ML, 2LAET			3				1				0

Notes:

EF - Exceedance factor; concentration divided by appropriate criterion.

Values in **Bold** are an exceedance of the criterion.

mg/kg – milligrams per kilogram
µg/kg – micrograms per kilogram
Data Validation Qualifiers:
U – Result should be considered not-detected at the quantitation limit shown.
J – Result is an estimated concentration.
SQS & CSL values from Ecology Sediment Mangement Standards (SMS)

AET values: Ecology (1996); NOAA SQuiRT (1999), used for cobalt, selenium, vanadium; and organic chemicals at stations with total organic carbon < 0.5%.
LAET = lowest apparent effects threshold
2LAET = second lowest apparent effects threshold
SL, ML = DMMP criteria, used for antimony and nickel

Table B2. Benthic Community Evaluation with Subtidal Sediment

Subtidal Sediment Station:		20				21				22			
COPC	Units		Comparison Units	SQS, SL EF	CSL, ML EF		Comparison Units	SQS, SL EF	CSL, ML EF		Comparison Units	SQS, SL EF	CSL, ML EF
Metals													
Antimony	mg/Kg	12.7 J	12.7 mg/Kg	0.08	0.06	10.5 J	10.5 mg/Kg	0.07	0.05	0.98 J	0.98 mg/Kg	0.01	0.00
Arsenic	mg/Kg	30.4	30.4 mg/Kg	0.53	0.33	23.6	23.6 mg/Kg	0.41	0.25	7.23	7.23 mg/Kg	0.13	0.08
Chromium	mg/Kg	81.1	81.1 mg/Kg	0.31	0.30	87.3	87.3 mg/Kg	0.34	0.32	26.1	26.1 mg/Kg	0.10	0.10
Cobalt	mg/Kg	9.87	9.87 mg/Kg	0.99	-	7.38	7.38 mg/Kg	0.74	-	5.63	5.63 mg/Kg	0.56	-
Copper	mg/Kg	173	173 mg/Kg	0.44	0.44	127	127 mg/Kg	0.33	0.33	64.7	64.7 mg/Kg	0.17	0.17
Lead	mg/Kg	106	106 mg/Kg	0.24	0.20	76.8	76.8 mg/Kg	0.17	0.14	32.7	32.7 mg/Kg	0.07	0.06
Mercury	mg/Kg	0.325	0.325 mg/Kg	0.79	0.55	0.215	0.215 mg/Kg	0.52	0.36	0.308	0.308 mg/Kg	0.75	0.52
Nickel	mg/Kg	27.1	27.1 mg/Kg	0.19	0.07	22.7	22.7 mg/Kg	0.16	0.06	14.1	14.1 mg/Kg	0.10	0.04
Selenium	mg/Kg	0.8	0.8 mg/Kg	0.80	-	1	1 mg/Kg	1.00	-	0.7	0.7 mg/Kg	0.70	-
Vanadium	mg/Kg	53.3	53.3 mg/Kg	0.94	-	56.7	56.7 mg/Kg	0.99	-	50.3	50.3 mg/Kg	0.88	-
Zinc	mg/Kg	244	244 mg/Kg	0.60	0.25	257	257 mg/Kg	0.63	0.27	80.1	80.1 mg/Kg	0.20	0.08
PAHs													
Acenaphthene	µg/Kg	55	3.04 mg/kg OC	0.19	0.05	71	5.26 mg/kg OC	0.33	0.09	41	3.06 mg/kg OC	0.19	0.05
Benzo(a)anthracene	µg/Kg	460	25.4 mg/kg OC	0.23	0.09	520	38.5 mg/kg OC	0.35	0.14	300	22.4 mg/kg OC	0.20	0.08
Benzo(a)pyrene	µg/Kg	390	21.5 mg/kg OC	0.22	0.10	440	32.6 mg/kg OC	0.33	0.16	280	20.9 mg/kg OC	0.21	0.10
Benzo(b)fluoranthene	µg/Kg	680	680 µg/Kg	0.38	0.21	860	860 µg/Kg	0.48	0.27	500	500 µg/Kg	0.28	0.16
Benzo(g,h,i)perylene	µg/Kg	230	12.7 mg/kg OC	0.41	0.16	240	17.8 mg/kg OC	0.57	0.23	160	11.9 mg/kg OC	0.39	0.15
Chrysene	µg/Kg	700	38.7 mg/kg OC	0.35	0.08	1000	74.1 mg/kg OC	0.67	0.16	520	38.8 mg/kg OC	0.35	0.08
Dibenzo(a,h)anthracene	µg/Kg	66	3.65 mg/kg OC	0.30	0.11	72	5.33 mg/kg OC	0.44	0.16	45	3.36 mg/kg OC	0.28	0.10
Fluoranthene	µg/Kg	950	52 mg/kg OC	0.33	0.04	990	73 mg/kg OC	0.46	0.06	480	36 mg/kg OC	0.22	0.03
Indeno(1,2,3-cd)pyrene	µg/Kg	250	13.8 mg/kg OC	0.41	0.16	280	20.7 mg/kg OC	0.61	0.24	170	12.7 mg/kg OC	0.37	0.14
Phenanthrene	µg/Kg	550	30.4 mg/kg OC	0.30	0.06	720	53.3 mg/kg OC	0.53	0.11	320	23.9 mg/kg OC	0.24	0.05
Total HPAH	µg/Kg	4896	270 mg/kg OC	0.28	0.05	5612	416 mg/kg OC	0.43	0.08	3215	240 mg/kg OC	0.25	0.05
Organometals													
Tributyltin	µg/Kg	160	160 µg/Kg	0.05	-	180	180 µg/Kg	0.05	-	200	200 µg/Kg	0.06	-
PCBs													
PCBs (total)	µg/Kg	217	11.99 mg/kg OC	1.00	0.18	205	15.19 mg/kg OC	**1.27**	0.23	460	34.33 mg/kg OC	**2.86**	0.53
Other SVOCs													
Bis(2-ethylhexyl)phthalate	µg/Kg	70 J	3.9 mg/kg OC	0.08	0.05	190	14.1 mg/kg OC	0.30	0.18	66 J	4.9 mg/kg OC	0.10	0.06
Pentachlorophenol	µg/Kg	16 J	16 µg/Kg	0.04	0.02	15 U	15 µg/Kg	0.04	0.02	14 U	14 µg/Kg	0.04	0.02
Total Organic Carbon	Percent	1.81				1.35				1.34			
		Number of COPCs > SQS, SL, LAET		0				1				1	
		Number of COPCs > CSL, ML, 2LAET			0				0				0

Notes:
EF - Exceedance factor; concentration divided by appropriate criterion.
Values in **Bold** are an exceedance of the criterion.
mg/kg – milligrams per kilogram
µg/kg – micrograms per kilogram
Data Validation Qualifiers:
U – Result should be considered not-detected at the quantitation limit shown.
J – Result is an estimated concentration.
SQS & CSL values from Ecology Sediment Mangement Standards (SMS)
AET values: Ecology (1996); NOAA SQuiRT (1999), used for cobalt, selenium, vanadium; and organic chemicals at stations with total organic carbon < 0.5%.
LAET = lowest apparent effects threshold
2LAET = second lowest apparent effects threshold
SL, ML = DMMP criteria, used for antimony and nickel

Table B2. Benthic Community Evaluation with Subtidal Sediment

Subtidal Sediment Station:		23				24				25				26			
COPC	**Units**		**Comparison Units**	**SQS, SL EF**	**CSL, ML EF**		**Comparison Units**	**SQS, SL EF**	**CSL, ML EF**		**Comparison Units**	**SQS, SL EF**	**CSL, ML EF**		**Comparison Units**	**SQS, SL EF**	**CSL, ML EF**
Metals																	
Antimony	mg/Kg	0.45 J	0.45 mg/Kg	0.003	0.002	0.43 J	0.43 mg/Kg	0.00	0.00	1.73 J	1.73 mg/Kg	0.01	0.01	3.11 J	3.11 mg/Kg	0.02	0.02
Arsenic	mg/Kg	4.66	4.66 mg/Kg	0.08	0.05	5.58 J	5.58 mg/Kg	0.10	0.06	11.1 J	11.1 mg/Kg	0.19	0.12	13 J	13 mg/Kg	0.23	0.14
Chromium	mg/Kg	17	17 mg/Kg	0.07	0.06	23.8	23.8 mg/Kg	0.09	0.09	70	70 mg/Kg	0.27	0.26	48.6	48.6 mg/Kg	0.19	0.18
Cobalt	mg/Kg	4.03	4.03 mg/Kg	0.40	-	6.07 J	6.07 mg/Kg	0.61	-	6.47 J	6.47 mg/Kg	0.65	-	3.9 J	3.9 mg/Kg	0.39	-
Copper	mg/Kg	33.4	33.4 mg/Kg	0.09	0.09	33.5	33.5 mg/Kg	0.09	0.09	90.1	90.1 mg/Kg	0.23	0.23	114	114 mg/Kg	0.29	0.29
Lead	mg/Kg	15.9	15.9 mg/Kg	0.04	0.03	17	17 mg/Kg	0.04	0.03	50.7	50.7 mg/Kg	0.11	0.10	61.3	61.3 mg/Kg	0.14	0.12
Mercury	mg/Kg	0.138	0.138 mg/Kg	0.34	0.23	0.22	0.22 mg/Kg	0.54	0.37	0.094	0.094 mg/Kg	0.23	0.16	0.094	0.094 mg/Kg	0.23	0.16
Nickel	mg/Kg	10.6	10.6 mg/Kg	0.08	0.03	18.7 J	18.7 mg/Kg	0.13	0.05	20.7 J	20.7 mg/Kg	0.15	0.06	14.7 J	14.7 mg/Kg	0.11	0.04
Selenium	mg/Kg	0.6	0.6 mg/Kg	0.60	-	0.5 U	0.5 mg/Kg	0.50	-	0.4 U	0.4 mg/Kg	0.40	-	0.5	0.5 mg/Kg	0.50	-
Vanadium	mg/Kg	38.5	38.5 mg/Kg	0.68	-	46.2	46.2 mg/Kg	0.81	-	53.5	53.5 mg/Kg	0.94	-	33.1	33.1 mg/Kg	0.58	-
Zinc	mg/Kg	48.5	48.5 mg/Kg	0.12	0.05	71.4	71.4 mg/Kg	0.17	0.07	171	171 mg/Kg	0.42	0.18	117	117 mg/Kg	0.29	0.12
PAHs																	
Acenaphthene	µg/Kg	22	2.53 mg/kg OC	0.16	0.04	73	4.01 mg/kg OC	0.25	0.07	450	16.67 mg/kg OC	**1.04**	0.29	100	5.10 mg/kg OC	0.32	0.09
Benzo(a)anthracene	µg/Kg	120	13.8 mg/kg OC	0.13	0.05	190	10.4 mg/kg OC	0.09	0.04	1000	37.0 mg/kg OC	0.34	0.14	2700	137.8 mg/kg OC	**1.25**	0.51
Benzo(a)pyrene	µg/Kg	130	14.9 mg/kg OC	0.15	0.07	270	14.8 mg/kg OC	0.15	0.07	1200	44.4 mg/kg OC	0.45	0.21	1700	86.7 mg/kg OC	0.88	0.41
Benzo(b)fluoranthene	µg/Kg	170	170 µg/Kg dw	0.09	0.05	430	430 µg/Kg dw	0.24	0.13	2200	2200 µg/Kg dw	**1.22**	0.69	3100	3100 µg/Kg dw	**1.72**	0.97
Benzo(g,h,i)perylene	µg/Kg	63	7.2 mg/kg OC	0.23	0.09	130	7.1 mg/kg OC	0.23	0.09	590	21.9 mg/kg OC	0.70	0.28	610	31.1 mg/kg OC	1.00	0.40
Chrysene	µg/Kg	230	26.4 mg/kg OC	0.24	0.06	350	19.2 mg/kg OC	0.17	0.04	1600	59.3 mg/kg OC	0.54	0.13	4500	229.6 mg/kg OC	**2.09**	0.50
Dibenzo(a,h)anthracene	µg/Kg	19	2.18 mg/kg OC	0.18	0.07	48	2.64 mg/kg OC	0.22	0.08	180	6.67 mg/kg OC	0.56	0.20	210	10.71 mg/kg OC	0.89	0.32
Fluoranthene	µg/Kg	310 J	36 mg/kg OC	0.22	0.03	190	10 mg/kg OC	0.07	0.01	2100	78 mg/kg OC	0.49	0.06	4300	219 mg/kg OC	**1.37**	0.18
Indeno(1,2,3-cd)pyrene	µg/Kg	72	8.3 mg/kg OC	0.24	0.09	140	7.7 mg/kg OC	0.23	0.09	690	25.6 mg/kg OC	0.75	0.29	810	41.3 mg/kg OC	**1.22**	0.47
Phenanthrene	µg/Kg	140	16.1 mg/kg OC	0.16	0.03	290	15.9 mg/kg OC	0.16	0.03	1700	63.0 mg/kg OC	0.63	0.13	1100	56.1 mg/kg OC	0.56	0.12
Total HPAH	µg/Kg	1444	166 mg/kg OC	0.17	0.03	2418	133 mg/kg OC	0.14	0.03	13320	493 mg/kg OC	0.51	0.09	21630	1104 mg/kg OC	**1.15**	0.21
Organometals																	
Tributyltin	µg/Kg	42	42 µg/Kg dw	0.01	-	8.9	8.9 µg/Kg dw	0.00	-	140	140 µg/Kg dw	0.04	-	52	52 µg/Kg dw	0.02	-
PCBs																	
PCBs (total)	µg/Kg	54	6.21 mg/kg OC	0.52	0.10	48	2.64 mg/kg OC	0.22	0.04	202	7.48 mg/kg OC	0.62	0.12	71	3.62 mg/kg OC	0.30	0.06
Other SVOCs																	
bis(2-ethylhexyl)phthalate	µg/Kg	43 J	4.9 mg/kg OC	0.11	0.06	110	6.0 mg/kg OC	0.13	0.08	220 J	8.1 mg/kg OC	0.17	0.10	110 J	5.6 mg/kg OC	0.12	0.07
Pentachlorophenol	µg/Kg	13 U	13 µg/Kg dw	0.04	0.02	13 U	13 µg/Kg dw	0.04	0.02	75 U	75 µg/Kg dw	0.21	0.11	64 U	64 µg/Kg dw	0.18	0.09
Total Organic Carbon	Percent	0.87				1.82				2.70				1.96			
		Number of COPCs > SQS, SL, LAET		0				0				2				7	
		Number of COPCs > CSL, ML, 2LAET			0				0				0				0

Notes:
EF - Exceedance factor; concentration divided by appropriate criterion.
Values in **Bold** are an exceedance of the criterion.
mg/kg – milligrams per kilogram
µg/kg – micrograms per kilogram
Data Validation Qualifiers:
U – Result should be considered not-detected at the quantitation limit shown.
J – Result is an estimated concentration.
SQS & CSL values from Ecology Sediment Mangement Standards (SMS)
AET values: Ecology (1996); NOAA SQuiRT (1999), used for cobalt, selenium, vanadium; and organic chemicals at stations with total organic carbon < 0.5%.
LAET = lowest apparent effects threshold
2LAET = second lowest apparent effects threshold
SL, ML = DMMP criteria, used for antimony and nickel

Table B2. Benthic Community Evaluation with Subtidal Sediment

Subtidal Sediment Station:		**27**				**28**				**29**				**30**			
COPC	**Units**		**Comparison Units**	**SQS, SL EF**	**CSL, ML EF**		**Comparison Units**	**SQS, SL EF**	**CSL, ML EF**		**Comparison Units**	**SQS, SL EF**	**CSL, ML EF**		**Comparison Units**	**SQS, SL EF**	**CSL, ML EF**
Metals																	
Antimony	mg/Kg	3.54 J	3.54 mg/Kg	0.02	0.02	3.85 J	3.85 mg/Kg	0.03	0.02	1.14 J	1.14 mg/Kg	0.01	0.01	9.02 J	9.02 mg/Kg	0.06	0.05
Arsenic	mg/Kg	9.45 J	9.45 mg/Kg	0.17	0.10	8.58 J	8.58 mg/Kg	0.15	0.09	6.08 J	6.08 mg/Kg	0.11	0.07	30.1 J	30.1 mg/Kg	0.53	0.32
Chromium	mg/Kg	26.2	26.2 mg/Kg	0.10	0.10	16.6	16.6 mg/Kg	0.06	0.06	17.7	17.7 mg/Kg	0.07	0.07	49.2	49.2 mg/Kg	0.19	0.18
Cobalt	mg/Kg	4.98 J	4.98 mg/Kg	0.50	-	4.67 J	4.67 mg/Kg	0.47	-	3.18 J	3.18 mg/Kg	0.32	-	8.82 J	8.82 mg/Kg	0.88	-
Copper	mg/Kg	75.1	75.1 mg/Kg	0.19	0.19	34.5	34.5 mg/Kg	0.09	0.09	28.2	28.2 mg/Kg	0.07	0.07	388	388 mg/Kg	0.99	0.99
Lead	mg/Kg	45.9	45.9 mg/Kg	0.10	0.09	22.5	22.5 mg/Kg	0.05	0.04	19.8	19.8 mg/Kg	0.04	0.04	154	154 mg/Kg	0.34	0.29
Mercury	mg/Kg	0.343	0.343 mg/Kg	0.84	0.58	0.178	0.178 mg/Kg	0.43	0.30	0.376	0.376 mg/Kg	0.92	0.64	0.754	0.754 mg/Kg	**1.84**	**1.28**
Nickel	mg/Kg	12.2 J	12.2 mg/Kg	0.09	0.03	9.69 J	9.69 mg/Kg	0.07	0.03	7.29 J	7.29 mg/Kg	0.05	0.02	18.2 J	18.2 mg/Kg	0.13	0.05
Selenium	mg/Kg	0.4 U	0.4 mg/Kg	0.40	-	0.5 UJ	0.5 mg/Kg	0.50	-	0.5 U	0.5 mg/Kg	0.50	-	0.5 U	0.5 mg/Kg	0.50	-
Vanadium	mg/Kg	47.6	47.6 mg/Kg	0.84	-	44.3	44.3 mg/Kg	0.78	-	45	45 mg/Kg	0.79	-	54.7	54.7 mg/Kg	0.96	-
Zinc	mg/Kg	104	104 mg/Kg	0.25	0.11	66.6	66.6 mg/Kg	0.16	0.07	48.1	48.1 mg/Kg	0.12	0.05	298	298 mg/Kg	0.73	0.31
PAHs																	
Acenaphthene	µg/Kg	26 J	1.26 mg/kg OC	0.08	0.02	14	1.97 mg/kg OC	0.12	0.03	14	14 µg/Kg dw	0.11	0.03	210	12.96 mg/kg OC	0.81	0.23
Benzo(a)anthracene	µg/Kg	210	10.2 mg/kg OC	0.09	0.04	86	12.1 mg/kg OC	0.11	0.04	75	75 µg/Kg dw	0.08	0.06	1400	86.4 mg/kg OC	0.79	0.32
Benzo(a)pyrene	µg/Kg	250	12.1 mg/kg OC	0.12	0.06	100	14.1 mg/kg OC	0.14	0.07	100	100 µg/Kg dw	0.09	0.06	1700	104.9 mg/kg OC	**1.06**	0.50
Benzo(b)fluoranthene	µg/Kg	420	420 µg/Kg dw	0.23	0.13	120	120 µg/Kg dw	0.07	0.04	120	120 µg/Kg dw	0.07	0.04	2700	2700 µg/Kg dw	**1.50**	0.84
Benzo(g,h,i)perylene	µg/Kg	170	8.3 mg/kg OC	0.27	0.11	62	8.7 mg/kg OC	0.28	0.11	61	61 µg/Kg dw	0.09	0.08	1100	67.9 mg/kg OC	**2.19**	0.87
Chrysene	µg/Kg	310	15.0 mg/kg OC	0.14	0.03	130	18.3 mg/kg OC	0.17	0.04	97	97 µg/Kg dw	0.10	0.07	1800	111.1 mg/kg OC	**1.01**	0.24
Dibenzo(a,h)anthracene	µg/Kg	45	2.18 mg/kg OC	0.18	0.07	19	2.68 mg/kg OC	0.22	0.08	18	18 µg/Kg dw	0.08	0.08	300	18.52 mg/kg OC	**1.54**	0.56
Fluoranthene	µg/Kg	440	21 mg/kg OC	0.13	0.02	190	27 mg/kg OC	0.17	0.02	170	170 µg/Kg dw	0.13	0.10	3100	191 mg/kg OC	**1.20**	0.16
Indeno(1,2,3-cd)pyrene	µg/Kg	170	8.3 mg/kg OC	0.24	0.09	64	9.0 mg/kg OC	0.27	0.10	64	64 µg/Kg dw	0.11	0.09	1200	74.1 mg/kg OC	**2.18**	0.84
Phenanthrene	µg/Kg	210	10.2 mg/kg OC	0.10	0.02	97	13.7 mg/kg OC	0.14	0.03	110	110 µg/Kg dw	0.17	0.07	2000	123.5 mg/kg OC	**1.23**	0.26
Total HPAH	µg/Kg	2695	131 mg/kg OC	0.14	0.02	1046	147 mg/kg OC	0.15	0.03	921	921 µg/Kg dw	0.12	0.08	18250	1127 mg/kg OC	**1.17**	0.21
Organometals																	
Tributyltin	µg/Kg	240	240 µg/Kg dw	0.07	-	52	52 µg/Kg dw	0.02	-	130	130 µg/Kg dw	0.04	-	4500	4500 µg/Kg dw	**1.32**	-
PCBs																	
PCBs (total)	µg/Kg	217	10.53 mg/kg OC	0.88	0.16	72	10.14 mg/kg OC	0.85	0.16	104	104 µg/Kg dw	0.80	0.23	490	30.25 mg/kg OC	**2.52**	0.47
Other SVOCs																	
bis(2-ethylhexyl)phthalate	µg/Kg	140 J	6.8 mg/kg OC	0.14	0.09	55 J	7.7 mg/kg OC	0.16	0.10	56 J	56 µg/Kg dw	0.04	0.03	700 J	43.2 mg/kg OC	0.92	0.55
Pentachlorophenol	µg/Kg	39 U	39 µg/Kg dw	0.11	0.06	12 U	12 µg/Kg dw	0.03	0.02	12 U	12 µg/Kg dw	0.03	0.02	570 J	570 µg/Kg dw	**1.58**	0.83
Total Organic Carbon	Percent	2.06				0.71				0.22				1.62			
		Number of COPCs > SQS, SL, LAET		0				0				0				13	
		Number of COPCs > CSL, ML, 2LAET			0				0				0				1

Notes:
EF - Exceedance factor; concentration divided by appropriate criterion.
Values in **Bold** are an exceedance of the criterion.
mg/kg – milligrams per kilogram
µg/kg – micrograms per kilogram
Data Validation Qualifiers:
U – Result should be considered not-detected at the quantitation limit shown.
J – Result is an estimated concentration.
SQS & CSL values from Ecology Sediment Mangement Standards (SMS)
AET values: Ecology (1996); NOAA SQuiRT (1999), used for cobalt, selenium, vanadium; and organic chemicals at stations with total organic carbon < 0.5%.
LAET = lowest apparent effects threshold
2LAET = second lowest apparent effects threshold
SL, ML = DMMP criteria, used for antimony and nickel

Table B2. Benthic Community Evaluation with Subtidal Sediment

COPC	Units	Subtidal Sediment Station: 31	Comparison Units	SQS, SL EF	CSL, ML EF	32	Comparison Units	SQS, SL EF	CSL, ML EF	33	Comparison Units	SQS, SL EF	CSL, ML EF	34	Comparison Units	SQS, SL EF	CSL, ML EF
Metals																	
Antimony	mg/Kg	7.46 J	7.46 mg/Kg	0.05	0.04	3.5 J	3.5 mg/Kg	0.02	0.02	2.73 J	2.73 mg/Kg	0.02	0.01	1.17 J	1.17 mg/Kg	0.01	0.01
Arsenic	mg/Kg	32	32 mg/Kg	0.56	0.34	8.58	8.58 mg/Kg	0.15	0.09	13.8	13.8 mg/Kg	0.24	0.15	6.38	6.38 mg/Kg	0.11	0.07
Chromium	mg/Kg	57.3	57.3 mg/Kg	0.22	0.21	24.5	24.5 mg/Kg	0.09	0.09	31.6	31.6 mg/Kg	0.12	0.12	16.2	16.2 mg/Kg	0.06	0.06
Cobalt	mg/Kg	9.78	9.78 mg/Kg	0.98	-	6.37	6.37 mg/Kg	0.64	-	6.86	6.86 mg/Kg	0.69	-	4.93	4.93 mg/Kg	0.49	-
Copper	mg/Kg	409	409 mg/Kg	**1.05**	**1.05**	54.5	54.5 mg/Kg	0.14	0.14	101	101 mg/Kg	0.26	0.26	840	840 mg/Kg	**2.15**	**2.15**
Lead	mg/Kg	192	192 mg/Kg	0.43	0.36	26.5	26.5 mg/Kg	0.06	0.05	80.9	80.9 mg/Kg	0.18	0.15	31.1	31.1 mg/Kg	0.07	0.06
Mercury	mg/Kg	0.83	0.83 mg/Kg	**2.02**	**1.41**	0.253	0.253 mg/Kg	0.62	0.43	0.54	0.54 mg/Kg	**1.32**	0.92	0.758	0.758 mg/Kg	**1.85**	**1.28**
Nickel	mg/Kg	19.4	19.4 mg/Kg	0.14	0.05	14.6	14.6 mg/Kg	0.10	0.04	15.9	15.9 mg/Kg	0.11	0.04	10.5	10.5 mg/Kg	0.08	0.03
Selenium	mg/Kg	1.1	1.1 mg/Kg	**1.10**	-	1.1	1.1 mg/Kg	**1.10**	-	0.8	0.8 mg/Kg	0.80	-	0.6	0.6 mg/Kg	0.60	-
Vanadium	mg/Kg	61	61 mg/Kg	**1.07**	-	55.3	55.3 mg/Kg	0.97	-	48.9	48.9 mg/Kg	0.86	-	43	43 mg/Kg	0.75	-
Zinc	mg/Kg	304	304 mg/Kg	0.74	0.32	68.3	68.3 mg/Kg	0.17	0.07	128	128 mg/Kg	0.31	0.13	167	167 mg/Kg	0.41	0.17
PAHs																	
Acenaphthene	µg/Kg	270	20.00 mg/kg OC	**1.25**	0.35	23	1.25 mg/kg OC	0.08	0.02	37 J	2.89 mg/kg OC	0.18	0.05	31	3.30 mg/kg OC	0.21	0.06
Benzo(a)anthracene	µg/Kg	1500	111.1 mg/kg OC	**1.01**	0.41	90	4.9 mg/kg OC	0.04	0.02	320	25.0 mg/kg OC	0.23	0.09	200	21.3 mg/kg OC	0.19	0.08
Benzo(a)pyrene	µg/Kg	1800	133.3 mg/kg OC	**1.35**	0.63	110	6.0 mg/kg OC	0.06	0.03	360	28.1 mg/kg OC	0.28	0.13	180	19.1 mg/kg OC	0.19	0.09
Benzo(b)fluoranthene	µg/Kg	2100	2100 µg/Kg dw	**1.17**	0.66	130	130 µg/Kg dw	0.07	0.04	430	430 µg/Kg dw	0.24	0.13	170	170 µg/Kg dw	0.09	0.05
Benzo(g,h,i)perylene	µg/Kg	960	71.1 mg/kg OC	**2.29**	0.91	63	3.4 mg/kg OC	0.11	0.04	190	14.8 mg/kg OC	0.48	0.19	85	9.0 mg/kg OC	0.29	0.12
Chrysene	µg/Kg	1900	140.7 mg/kg OC	**1.28**	0.31	120	6.5 mg/kg OC	0.06	0.01	340	26.6 mg/kg OC	0.24	0.06	280	29.8 mg/kg OC	0.27	0.06
Dibenzo(a,h)anthracene	µg/Kg	280	20.74 mg/kg OC	**1.73**	0.63	18	0.98 mg/kg OC	0.08	0.03	59	4.61 mg/kg OC	0.38	0.14	27	2.87 mg/kg OC	0.24	0.09
Fluoranthene	µg/Kg	3800 J	281 mg/kg OC	**1.76**	0.23	250 J	14 mg/kg OC	0.08	0.01	670 J	52 mg/kg OC	0.33	0.04	430 J	46 mg/kg OC	0.29	0.04
Indeno(1,2,3-cd)pyrene	µg/Kg	1000	74.1 mg/kg OC	**2.18**	0.84	69	3.8 mg/kg OC	0.11	0.04	210	16.4 mg/kg OC	0.48	0.19	85	9.0 mg/kg OC	0.27	0.10
Phenanthrene	µg/Kg	2300	170.4 mg/kg OC	**1.70**	0.35	150	8.2 mg/kg OC	0.08	0.02	330	25.8 mg/kg OC	0.26	0.05	480	51.1 mg/kg OC	0.51	0.11
Total HPAH	µg/Kg	17640	1307 mg/kg OC	**1.36**	0.25	1128	61 mg/kg OC	0.06	0.01	3269	255 mg/kg OC	0.27	0.05	1947	207 mg/kg OC	0.22	0.04
Organometals																	
Tributyltin	µg/Kg	4200	4200 µg/Kg dw	**1.24**	-	71	71 µg/Kg dw	0.02	-	160	160 µg/Kg dw	0.05	-	22	22 µg/Kg dw	0.01	-
PCBs																	
PCBs (total)	µg/Kg	1410	104.44 mg/kg OC	**8.70**	**1.61**	139	7.55 mg/kg OC	0.63	0.12	490	38.28 mg/kg OC	**3.19**	0.59	62	6.60 mg/kg OC	0.55	0.10
Other SVOCs																	
bis(2-ethylhexyl)phthalate	µg/Kg	650	48.1 mg/kg OC	**1.02**	0.62	66 J	3.6 mg/kg OC	0.08	0.05	99 U	7.7 mg/kg OC	0.16	0.10	140	14.9 mg/kg OC	0.32	0.19
Pentachlorophenol	µg/Kg	440 J	440 µg/Kg dw	**1.22**	0.64	14 U	14 µg/Kg dw	0.04	0.02	65 U	65 µg/Kg dw	0.18	0.09	13 U	13 µg/Kg dw	0.04	0.02
Total Organic Carbon	Percent	1.35				1.84				1.28				0.94			
		Number of COPCs > SQS, SL, LAET		19				1				2				2	
		Number of COPCs > CSL, ML, 2LAET			3				0				0				2

Notes:
EF - Exceedance factor; concentration divided by appropriate criterion.
Values in **Bold** are an exceedance of the criterion.
mg/kg – milligrams per kilogram
µg/kg – micrograms per kilogram
Data Validation Qualifiers:
U – Result should be considered not-detected at the quantitation limit shown.
J – Result is an estimated concentration.
SQS & CSL values from Ecology Sediment Mangement Standards (SMS)
AET values: Ecology (1996); NOAA SQuiRT (1999), used for cobalt, selenium, vanadium; and organic chemicals at stations with total organic carbon < 0.5%.
LAET = lowest apparent effects threshold
2LAET = second lowest apparent effects threshold
SL, ML = DMMP criteria, used for antimony and nickel

Table B2. Benthic Community Evaluation with Subtidal Sediment

COPC	Units	Station 35	Comparison Units	SQS, SL EF	CSL, ML EF	Station 36	Comparison Units	SQS, SL EF	CSL, ML EF
Metals									
Antimony	mg/Kg	1.08 J	1.08 mg/Kg	0.01	0.01	1.09 J	1.09 mg/Kg	0.01	0.01
Arsenic	mg/Kg	4.56	4.56 mg/Kg	0.08	0.05	5.08	5.08 mg/Kg	0.09	0.05
Chromium	mg/Kg	19	19 mg/Kg	0.07	0.07	14.9	14.9 mg/Kg	0.06	0.06
Cobalt	mg/Kg	4.85	4.85 mg/Kg	0.49	-	3.66	3.66 mg/Kg	0.37	-
Copper	mg/Kg	39.3	39.3 mg/Kg	0.10	0.10	28.3	28.3 mg/Kg	0.07	0.07
Lead	mg/Kg	20.5	20.5 mg/Kg	0.05	0.04	18.5	18.5 mg/Kg	0.04	0.03
Mercury	mg/Kg	0.176	0.176 mg/Kg	0.43	0.30	0.084	0.084 mg/Kg	0.20	0.14
Nickel	mg/Kg	10.8	10.8 mg/Kg	0.08	0.03	7.98	7.98 mg/Kg	0.06	0.02
Selenium	mg/Kg	0.6	0.6 mg/Kg	0.60	-	0.3	0.3 mg/Kg	0.30	-
Vanadium	mg/Kg	45.7	45.7 mg/Kg	0.80	-	36.9	36.9 mg/Kg	0.65	-
Zinc	mg/Kg	64.4	64.4 mg/Kg	0.16	0.07	47.5	47.5 mg/Kg	0.12	0.05
PAHs									
Acenaphthene	µg/Kg	9.5 J	1.20 mg/kg OC	0.08	0.02	6.5 J	6.5 µg/Kg dw	0.05	0.01
Benzo(a)anthracene	µg/Kg	50	6.3 mg/kg OC	0.06	0.02	37	37 µg/Kg dw	0.04	0.03
Benzo(a)pyrene	µg/Kg	60	7.6 mg/kg OC	0.08	0.04	40	40 µg/Kg dw	0.04	0.03
Benzo(b)fluoranthene	µg/Kg	92	92 µg/Kg dw	0.05	0.03	58	58 µg/Kg dw	0.03	0.02
Benzo(g,h,i)perylene	µg/Kg	39	4.9 mg/kg OC	0.16	0.06	27	27 µg/Kg dw	0.04	0.04
Chrysene	µg/Kg	70	8.9 mg/kg OC	0.08	0.02	56	56 µg/Kg dw	0.06	0.04
Dibenzo(a,h)anthracene	µg/Kg	11	1.39 mg/kg OC	0.12	0.04	6.5 J	6.5 µg/Kg dw	0.03	0.03
Fluoranthene	µg/Kg	88	11 mg/kg OC	0.07	0.01	90	90 µg/Kg dw	0.07	0.05
Indeno(1,2,3-cd)pyrene	µg/Kg	43	5.4 mg/kg OC	0.16	0.06	28	28 µg/Kg dw	0.05	0.04
Phenanthrene	µg/Kg	57	7.2 mg/kg OC	0.07	0.02	46	46 µg/Kg dw	0.07	0.03
Total HPAH	µg/Kg	585	74 mg/kg OC	0.08	0.01	448.5	448.5 µg/Kg dw	0.06	0.04
Organometals									
Tributyltin	µg/Kg	520	520 µg/Kg dw	0.15	-	30	30 µg/Kg dw	0.01	-
PCBs									
PCBs (total)	µg/Kg	60	7.59 mg/kg OC	0.63	0.12	47	47 µg/Kg dw	0.36	0.10
Other SVOCs									
bis(2-ethylhexyl)phthalate	µg/Kg	29 J	3.7 mg/kg OC	0.08	0.05	28 J	28.00 µg/Kg dw	0.02	0.02
Pentachlorophenol	µg/Kg	23 J	23 µg/Kg dw	0.06	0.03	12 U	12 µg/Kg dw	0.03	0.02
Total Organic Carbon	Percent	0.79				0.20			
Number of COPCs > SQS, SL, LAET				0				0	
Number of COPCs > CSL, ML, 2LAET					0				0

COPC	Units	Station 37	Comparison Units	SQS, SL EF	CSL, ML EF	Station 38	Comparison Units	SQS, SL EF	CSL, ML EF
Metals									
Antimony	mg/Kg	1.54 J	1.54 mg/Kg	0.01	0.01	2.68 J	2.68 mg/Kg	0.02	0.01
Arsenic	mg/Kg	7.37	7.37 mg/Kg	0.13	0.08	8.76	8.76 mg/Kg	0.15	0.09
Chromium	mg/Kg	17.1	17.1 mg/Kg	0.07	0.06	14.4	14.4 mg/Kg	0.06	0.05
Cobalt	mg/Kg	4.47	4.47 mg/Kg	0.45	-	4.33	4.33 mg/Kg	0.43	-
Copper	mg/Kg	39.8	39.8 mg/Kg	0.10	0.10	31.2	31.2 mg/Kg	0.08	0.08
Lead	mg/Kg	22.4	22.4 mg/Kg	0.05	0.04	25.4	25.4 mg/Kg	0.06	0.05
Mercury	mg/Kg	0.121	0.121 mg/Kg	0.30	0.21	0.122	0.122 mg/Kg	0.30	0.21
Nickel	mg/Kg	9.65	9.65 mg/Kg	0.07	0.03	15.1	15.1 mg/Kg	0.11	0.04
Selenium	mg/Kg	0.5	0.5 mg/Kg	0.50	-	0.5	0.5 mg/Kg	0.50	-
Vanadium	mg/Kg	38.2	38.2 mg/Kg	0.67	-	32.5	32.5 mg/Kg	0.57	-
Zinc	mg/Kg	56.6	56.6 mg/Kg	0.14	0.06	66	66 mg/Kg	0.16	0.07
PAHs									
Acenaphthene	µg/Kg	14	1.94 mg/kg OC	0.12	0.03	11	0.39 mg/kg OC	0.02	0.01
Benzo(a)anthracene	µg/Kg	86	11.9 mg/kg OC	0.11	0.04	56	2.0 mg/kg OC	0.02	0.01
Benzo(a)pyrene	µg/Kg	77	10.7 mg/kg OC	0.11	0.05	63	2.2 mg/kg OC	0.02	0.01
Benzo(b)fluoranthene	µg/Kg	130	130 µg/Kg dw	0.07	0.04	92	92 µg/Kg dw	0.05	0.03
Benzo(g,h,i)perylene	µg/Kg	48	6.7 mg/kg OC	0.22	0.09	42	1.5 mg/kg OC	0.05	0.02
Chrysene	µg/Kg	130	18.1 mg/kg OC	0.16	0.04	88	3.1 mg/kg OC	0.03	0.01
Dibenzo(a,h)anthracene	µg/Kg	14	1.94 mg/kg OC	0.16	0.06	11	0.39 mg/kg OC	0.03	0.01
Fluoranthene	µg/Kg	170	24 mg/kg OC	0.15	0.02	130	5 mg/kg OC	0.03	0.00
Indeno(1,2,3-cd)pyrene	µg/Kg	54	7.5 mg/kg OC	0.22	0.09	42	1.5 mg/kg OC	0.04	0.02
Phenanthrene	µg/Kg	120	16.7 mg/kg OC	0.17	0.03	82	2.9 mg/kg OC	0.03	0.01
Total HPAH	µg/Kg	926	129 mg/kg OC	0.13	0.02	729	26 mg/kg OC	0.03	0.00
Organometals									
Tributyltin	µg/Kg	33	33 µg/Kg dw	0.01	-	18	18 µg/Kg dw	0.01	-
PCBs									
PCBs (total)	µg/Kg	121	16.81 mg/kg OC	**1.40**	0.26	106	3.75 mg/kg OC	0.31	0.06
Other SVOCs									
bis(2-ethylhexyl)phthalate	µg/Kg	31 J	4.3 mg/kg OC	0.09	0.06	33 J	1.2 mg/kg OC	0.02	0.01
Pentachlorophenol	µg/Kg	13 U	13 µg/Kg dw	0.04	0.02	13 U	13 µg/Kg dw	0.04	0.02
Total Organic Carbon	Percent	0.72				2.83			
Number of COPCs > SQS, SL, LAET				1				0	
Number of COPCs > CSL, ML, 2LAET					0				0

Notes:
EF - Exceedance factor; concentration divided by appropriate criterion.
Values in **Bold** are an exceedance of the criterion.
mg/kg – milligrams per kilogram
µg/kg – micrograms per kilogram
Data Validation Qualifiers:
U – Result should be considered not-detected at the quantitation limit shown.
J – Result is an estimated concentration.
SQS & CSL values from Ecology Sediment Mangement Standards (SMS)
AET values: Ecology (1996); NOAA SQuiRT (1999), used for cobalt, selenium, vanadium; and organic chemicals at stations with total organic carbon < 0.5%.
LAET = lowest apparent effects threshold
2LAET = second lowest apparent effects threshold
SL, ML = DMMP criteria, used for antimony and nickel

Table B2. Benthic Community Evaluation with Subtidal Sediment

Subtidal Sediment Station:		39				40				41				42			
COPC	Units		Comparison Units	SQS, SL EF	CSL, ML EF		Comparison Units	SQS, SL EF	CSL, ML EF		Comparison Units	SQS, SL EF	CSL, ML EF		Comparison Units	SQS, SL EF	CSL, ML EF
Metals																	
Antimony	mg/Kg	1.02 J	1.02 mg/Kg	0.01	0.01	58.1 J	58.1 mg/Kg	0.39	0.29	8.51 J	8.51 mg/Kg	0.06	0.04	9.19 J	9.19 mg/Kg	0.06	0.05
Arsenic	mg/Kg	6.41	6.41 mg/Kg	0.11	0.07	114	114 mg/Kg	**2.00**	**1.23**	21.1	21.1 mg/Kg	0.37	0.23	23.3	23.3 mg/Kg	0.41	0.25
Chromium	mg/Kg	16.1	16.1 mg/Kg	0.06	0.06	202	202 mg/Kg	0.78	0.75	32.6	32.6 mg/Kg	0.13	0.12	39.9	39.9 mg/Kg	0.15	0.15
Cobalt	mg/Kg	4.26	4.26 mg/Kg	0.43	-	15.6	15.6 mg/Kg	**1.56**	-	6.72	6.72 mg/Kg	0.67	-	6.96	6.96 mg/Kg	0.70	-
Copper	mg/Kg	34.6	34.6 mg/Kg	0.09	0.09	442	442 mg/Kg	**1.13**	**1.13**	148	148 mg/Kg	0.38	0.38	132	132 mg/Kg	0.34	0.34
Lead	mg/Kg	20.5	20.5 mg/Kg	0.05	0.04	350	350 mg/Kg	0.78	0.66	80.5	80.5 mg/Kg	0.18	0.15	142	142 mg/Kg	0.32	0.27
Mercury	mg/Kg	0.158	0.158 mg/Kg	0.39	0.27	1.57	1.57 mg/Kg	**3.83**	**2.66**	0.837	0.837 mg/Kg	**2.04**	**1.42**	0.998	0.998 mg/Kg	**2.43**	**1.69**
Nickel	mg/Kg	21	21 mg/Kg	0.15	0.06	84.9	84.9 mg/Kg	0.61	0.23	14.6	14.6 mg/Kg	0.10	0.04	16.6	16.6 mg/Kg	0.12	0.04
Selenium	mg/Kg	0.4	0.4 mg/Kg	0.40	-	1	1 mg/Kg	1.00	-	0.6	0.6 mg/Kg	0.60	-	1	1 mg/Kg	1.00	-
Vanadium	mg/Kg	27.9	27.9 mg/Kg	0.49	-	59.2	59.2 mg/Kg	**1.04**	-	44.1	44.1 mg/Kg	0.77	-	50.1	50.1 mg/Kg	0.88	-
Zinc	mg/Kg	53.1	53.1 mg/Kg	0.13	0.06	795	795 mg/Kg	**1.94**	0.83	310	310 mg/Kg	0.76	0.32	210	210 mg/Kg	0.51	0.22
PAHs																	
Acenaphthene	µg/Kg	30	0.56 mg/kg OC	0.04	0.01	150	14.71 mg/kg OC	0.92	0.26	30	3.23 mg/kg OC	0.20	0.06	47 J	3.11 mg/kg OC	0.19	0.05
Benzo(a)anthracene	µg/Kg	95	1.8 mg/kg OC	0.02	0.01	820	80.4 mg/kg OC	0.73	0.30	230	24.7 mg/kg OC	0.22	0.09	300	19.9 mg/kg OC	0.18	0.07
Benzo(a)pyrene	µg/Kg	100	1.9 mg/kg OC	0.02	0.01	800	78.4 mg/kg OC	0.79	0.37	360	38.7 mg/kg OC	0.39	0.18	460	30.5 mg/kg OC	0.31	0.15
Benzo(b)fluoranthene	µg/Kg	160	160 µg/Kg dw	0.09	0.05	940	940 µg/Kg dw	0.52	0.29	530	530 µg/Kg dw	0.29	0.17	480	480 µg/Kg dw	0.27	0.15
Benzo(g,h,i)perylene	µg/Kg	66	1.2 mg/kg OC	0.04	0.02	390	38.2 mg/kg OC	**1.23**	0.49	230	24.7 mg/kg OC	0.80	0.32	270	17.9 mg/kg OC	0.58	0.23
Chrysene	µg/Kg	140	2.6 mg/kg OC	0.02	0.01	1100	107.8 mg/kg OC	0.98	0.23	310	33.3 mg/kg OC	0.30	0.07	400	26.5 mg/kg OC	0.24	0.06
Dibenzo(a,h)anthracene	µg/Kg	18	0.34 mg/kg OC	0.03	0.01	130	12.75 mg/kg OC	**1.06**	0.39	60	6.45 mg/kg OC	0.54	0.20	78	5.17 mg/kg OC	0.43	0.16
Fluoranthene	µg/Kg	220	4 mg/kg OC	0.03	0.00	2900 J	284 mg/kg OC	**1.78**	0.24	400	43 mg/kg OC	0.27	0.04	610 J	40 mg/kg OC	0.25	0.03
Indeno(1,2,3-cd)pyrene	µg/Kg	69	1.3 mg/kg OC	0.04	0.01	440	43.1 mg/kg OC	**1.27**	0.49	250	26.9 mg/kg OC	0.79	0.31	280	18.5 mg/kg OC	0.55	0.21
Phenanthrene	µg/Kg	160	3.0 mg/kg OC	0.03	0.01	1400	137.3 mg/kg OC	**1.37**	0.29	240	25.8 mg/kg OC	0.26	0.05	370	24.5 mg/kg OC	0.25	0.05
Total HPAH	µg/Kg	1172	22 mg/kg OC	0.02	0.00	10100	990 mg/kg OC	**1.03**	0.19	3120	335 mg/kg OC	0.35	0.06	3958	262 mg/kg OC	0.27	0.05
Organometals																	
Tributyltin	µg/Kg	61	61 µg/Kg dw	0.02	-	1200	1200 µg/Kg dw	0.35	-	470	470 µg/Kg dw	0.14	-	130	130 µg/Kg dw	0.04	-
PCBs																	
PCBs (total)	µg/Kg	85	1.59 mg/kg OC	0.13	0.02	2050	200.98 mg/kg OC	**16.75**	**3.09**	866	93.12 mg/kg OC	**7.76**	**1.43**	1110	73.51 mg/kg OC	**6.13**	**1.13**
Other SVOCs																	
bis(2-ethylhexyl)phthalate	µg/Kg	44 J	0.8 mg/kg OC	0.02	0.01	610	59.8 mg/kg OC	**1.27**	0.77	120	12.9 mg/kg OC	0.27	0.17	160 J	10.6 mg/kg OC	0.23	0.14
Pentachlorophenol	µg/Kg	13 U	13 µg/Kg dw	0.04	0.02	90 J	90 µg/Kg dw	0.25	0.13	44 J	44 µg/Kg dw	0.12	0.06	67 U	67 µg/Kg dw	0.19	0.10
Total Organic Carbon	Percent	5.33				1.02				0.93				1.51			
		Number of COPCs > SQS, SL, LAET		0				14				2				2	
		Number of COPCs > CSL, ML, 2LAET			0				4				2				2

Notes:
EF - Exceedance factor; concentration divided by appropriate criterion.
Values in **Bold** are an exceedance of the criterion.
mg/kg – milligrams per kilogram
µg/kg – micrograms per kilogram
Data Validation Qualifiers:
U – Result should be considered not-detected at the quantitation limit shown.
J – Result is an estimated concentration.
SQS & CSL values from Ecology Sediment Mangement Standards (SMS)
AET values: Ecology (1996); NOAA SQuiRT (1999), used for cobalt, selenium, vanadium; and organic chemicals at stations with total organic carbon < 0.5%.
LAET = lowest apparent effects threshold
2LAET = second lowest apparent effects threshold
SL, ML = DMMP criteria, used for antimony and nickel

Table B2. Benthic Community Evaluation with Subtidal Sediment

Subtidal Sediment Station:		Comparison Criteria						Subtidal Sediment Detection Frequency	Subtidal Sediment Frequency of Detected Concentrations > SQS, SL, LAET		Subtidal Sediment Frequency of Detected Concentrations > CSL, ML, 2LAET		Intertidal + Subtidal Sediment Detection Frequency	Intertidal + Subtidal Sediment Frequency of Detected Concentrations > SQS, SL, LAET		Intertidal + Subtidal Sediment Frequency of Detected Concentrations > CSL, ML, 2LAET	
COPC	Units	SQS	CSL	Units	LAET/SL	2LAET/ML	Units		No. of Stations	Percent of Stations	No. of Stations	Percent of Stations		No. of Stations	Percent of Stations	No. of Stations	Percent of Stations
Metals																	
Antimony	mg/Kg	na	na	-	150	200	mg/Kg dw	100%	1	2.4%	0	0.0%	100%	1	2%	0	0%
Arsenic	mg/Kg	57	93	mg/Kg dw	-	-	-	100%	6	14.3%	4	9.5%	100%	11	22%	9	18%
Chromium	mg/Kg	260	270	mg/Kg dw	-	-	-	100%	1	2.4%	1	2.4%	100%	2	4%	2	4%
Cobalt	mg/Kg	na	na	-	10	-	mg/Kg dw	100%	6	14.3%	0	0.0%	100%	11	22%	0	0%
Copper	mg/Kg	390	390	mg/Kg dw	-	-	-	100%	8	19.0%	8	19.0%	100%	12	24%	12	24%
Lead	mg/Kg	450	530	mg/Kg dw	-	-	-	100%	1	2.4%	0	0.0%	100%	2	4%	1	2%
Mercury	mg/Kg	0.41	0.59	mg/Kg dw	-	-	-	100%	21	50.0%	17	40.5%	100%	22	43%	17	33%
Nickel	mg/Kg	na	na	-	140	370	mg/Kg dw	100%	0	0.0%	0	0.0%	100%	2	4%	0	0%
Selenium	mg/Kg	na	na	-	1	-	mg/Kg dw	38%	8	19.0%	0	0.0%	49%	8	16%	0	0%
Vanadium	mg/Kg	na	na	-	57	-	mg/Kg dw	100%	10	23.8%	0	0.0%	100%	12	24%	0	0%
Zinc	mg/Kg	410	960	mg/Kg dw	-	-	-	100%	6	14.3%	1	2.4%	100%	13	25%	3	6%
PAHs																	
Acenaphthene	µg/Kg	16	57	mg/Kg OC	130	500	µg/Kg dw	100%	2	4.8%	0	0.0%	94%	3	6%	0	0%
Benzo(a)anthracene	µg/Kg	110	270	mg/Kg OC	960	1300	µg/Kg dw	100%	3	7.1%	0	0.0%	100%	3	6%	0	0%
Benzo(a)pyrene	µg/Kg	99	210	mg/Kg OC	1100	1600	µg/Kg dw	100%	4	9.5%	0	0.0%	100%	4	8%	0	0%
Benzo(b)fluoranthene	µg/Kg	na	na	-	1800	3200	µg/Kg dw	100%	7	16.7%	2	4.8%	100%	7	14%	2	4%
Benzo(g,h,i)perylene	µg/Kg	31	78	mg/Kg OC	670	720	µg/Kg dw	100%	9	21.4%	0	0.0%	100%	9	18%	0	0%
Chrysene	µg/Kg	110	460	mg/Kg OC	950	1400	µg/Kg dw	100%	8	19.0%	0	0.0%	100%	8	16%	0	0%
Dibenzo(a,h)anthracene	µg/Kg	12	33	mg/Kg OC	230	240	µg/Kg dw	100%	6	14.3%	0	0.0%	96%	6	12%	0	0%
Fluoranthene	µg/Kg	160	1200	mg/Kg OC	1300	1700	µg/Kg dw	100%	10	23.8%	0	0.0%	100%	10	20%	0	0%
Indeno(1,2,3-cd)pyrene	µg/Kg	34	88	mg/Kg OC	600	690	µg/Kg dw	100%	10	23.8%	0	0.0%	100%	10	20%	0	0%
Phenanthrene	µg/Kg	100	480	mg/Kg OC	660	1500	µg/Kg dw	100%	6	14.3%	0	0.0%	98%	6	12%	0	0%
Total HPAH	µg/Kg	960	5300	mg/Kg OC	7900	12000	µg/Kg dw	100%	9	21.4%	0	0.0%	100%	9	18%	0	0%
Organometals																	
Tributyltin	µg/Kg	na	na	-	3400	-	µg/Kg dw	100%	5	11.9%	0	0.0%	100%	5	10%	0	0%
PCBs																	
PCBs (total)	µg/Kg	12	65	mg/Kg OC	130	450	µg/Kg dw	100%	27	64.3%	7	16.7%	100%	27	53%	7	14%
Other SVOCs																	
bis(2-ethylhexyl)phthalate	µg/Kg	47	78	mg/Kg OC	1300	1700	µg/Kg dw	98%	3	7.1%	0	0.0%	86%	3	6%	0	0%
Pentachlorophenol	µg/Kg	360	690	µg/Kg dw	-	-	-	64%	3	7.1%	0	0.0%	53%	3	6%	0	0%
Total Organic Carbon	Percent								**Total No. of Stations**	**Total Percent**	**Total No. of Stations**	**Total Percent**		**Total No. of Stations**	**Total Percent**	**Total No. of Stations**	**Total Percent**
									32	76%	20	48%		40	78%	26	51%

Notes:
SQS & CSL values from Ecology Sediment Mangement Standards (SMS)
AET values: Ecology (1996); NOAA SQuiRT (1999), used for cobalt, selenium, vanadium; and organic chemicals at stations with
LAET = lowest apparent effects threshold
2LAET = second lowest apparent effects threshold
SL, ML = DMMP criteria, used for antimony and nickel

APPENDIX C

RESPONSE TO EPA COMMENTS

RESPONSE TO EPA'S OVERALL COMMENTS (dated February 24, 2009) REGARDING THE HUMAN HEATH AND ECOLOGICAL DRAFT RISK ASSESSMENTS FOR THE LOCKHEED WEST SUPERFUND SITE.

1. Revise statements that active remediation will mitigate or eliminate all human health and ecological exposures and risks. It is more accurate to state that active remediation is expected to reduce exposures and risks associated with current site conditions (to acceptable or background levels).

   Response: Statements that active remediation will mitigate or eliminate exposures have been changed to state that active remediation is expected to reduce exposures and risks associated with current site conditions.

2. In the introduction of the Human Health Risk Assessment (HHRA) and the Ecological Risk Assessment (ERA), explain the principles used to develop the HHRA and ERA work plans and how it was determined that appropriate sections/elements/values used in the LDW HHRA and ERA were acceptable to use in the LW HHRA and ERA. Make an affirmative statement that this risk assessment conforms to the work plan. Then, delete all the references throughout the LW HHRA and ERA referring to a streamlined approach and the phrase "as per the approved work plan." Since the LDW HHRA and ERA were used to support the LW HHRA and ERA, the LDW HHRA and ERA will be placed in the Lockheed West administrative record.

   Response: Additional text has been added in the introduction of both ERA and HHRA on how the scope of the work plan was developed and the basis for using information from the LDW risk assessments. The added text focuses on the assumptions of similar ecological habitats and human uses as the LDW site, due to location and proximity of the site downstream of the LDW site within the same water body, and similar subtidal and intertidal resources. A statement is added in the Executive Summary and Introduction section that the risk assessments conform to the work plan. Subsequent references in the text that the risk assessments are consistent with the work plan have been deleted as requested.

3. EPA does not agree with statements that the site poses less risk because it is smaller than the LDW site. Delete such statements from the HHRA and ERA. The site-related risk estimates are based on site contaminant levels, relevant exposure scenarios and toxicity data. The size of the site is not considered in calculating risk estimates. Site specific considerations in relation to determining exposure are discussed in the Framework for Selecting and Using Tribal Fish and Shellfish Consumption Rates (EPA, August 2007) (Framework). In particular, the quality and quantity of current and potential fish and shellfish habitat at the site are factors in consultations with affected tribes in selecting seafood consumption rates to be used for risk assessment.

Response: As requested, throughout both the HHRA and ERA documents, multiple references to risks being associated with or influenced by the size of the site, or relative to the size of the LDW site, have been removed. A subsection of the Uncertainty Assessment has been added to discuss uncertainties in the risks estimated for the LW site that may be associated with or influenced by differences in size of the site with the LDW site. The introductory sections of the ERA and HHRA have been edited to include mention of site use factors and fraction contaminated terms, which are set to 1.0 to maintain consistency in estimating cleanup levels with other nearby sites. Consistent cleanup levels among the sites within the Duwamish Waterway/Elliott Bay region are necessary to ensure that cleanups achieve the common goal of health protectiveness for the highest exposed populations that use the resources of the region.

4. The use of LDW exposure scenarios and parameters was meant to allow for a streamlined approach to the baseline risk assessment and to provide consistency in how contiguous sites are addressed. EPA does not agree with statements that the use of the LDW information results in an overestimation of risks related to the Lockheed West site. The uncertainties associated with the LDW HHRA may both over-and under-estimate risks. Delete statements that imply that risk associated with the Lockheed West site are not as significant as those associated with the LDW. Revise and expand the discussion of uncertainties associated with the LDW information in the Uncertainty Sections.

    Response: As described in the response to General Comment 3, multiple references to risks being associated with or influenced by the size of the site, or relative to the size of the LDW site, have been removed. Discussion in the Uncertainty Assessment has been expanded as per response to General Comment 3.

5. In addition to supporting remedy selection, risk assessments provide risk information to affected tribes and the public, and provide context for long-term monitoring and remedy evaluation. This should be clarified in the risk assessments.

    Response: A statement will be added to the introduction section: In addition to supporting remedy selection, risk assessments provide risk information to affected tribes and the public, and provide context for long-term monitoring and remedy evaluation.

6. It is understood that Lockheed is committed to actively remediating the entire Lockheed West site. However, it is premature to assume that at a minimum the entire site will be capped. Please delete all references to specific remedial actions.

   Response: References to capping or other specific remedial actions have been removed; statements have been edited to mention active remediation without specific reference to the type of action.

7. Statements made throughout the Lockheed HHRA that EPA's Framework develops or establishes tribal consumption rates for Lockheed, the LDW or any other site, need to be revised. The underlying basis of the Framework is consultation with potentially impacted tribes. The Suquamish Tribe, in consultation with the Muckleshoot Tribe and EPA, agreed to a risk assessment approach for the Lockheed West site that is consistent with that used for the LDW site. The Tribe specifically requested inclusion of a Suquamish tribal scenario as relevant to Suquamish tribal members and as an estimate of Suquamish consumption and risk. Lockheed should work with the Tribe and EPA to revise statements related to the Framework to more accurately reflect the intent of the document.

   Response: Statements in the LW HHRA that the Framework develops the consumption rates have been revised to state that "The EPA Framework document presents a conceptual framework for selecting and using Tribal fish and shellfish consumption rates for purposes of estimating site-related risks hazardous waste cleanup sites in Puget Sound.", and "The Framework provides that EPA will consult with the Tribes on site-specific exposure assumptions and cleanup decisions at each Superfund site within a Tribal fishing area." The following sentences will also be added: "The Suquamish Tribe, in consultation with the Muckleshoot Tribe and EPA, agreed to a risk assessment approach for the Lockheed West site that is consistent with that used for the LDW site. The Tribe specifically requested inclusion of a Suquamish tribal scenario as relevant to Suquamish tribal members and as an estimate of Suquamish consumption and risk."

8. Inclusion of the Suquamish survey data provides risk assessment information that is relevant to Suquamish tribal members and is an estimate of a high end consumption and exposure. Throughout the HHRA, revise statements about the use of Suquamish data, present quantitative risk estimates to Suquamish tribal members (rather than qualitative estimates relative to Tulalip tribal members), and present tribal populations as a range of exposures. As examples:

   a. Page ES-5 -- In the third paragraph of Section ES.4, include statements of quantitative risk based on Suquamish survey information and tribal children's risk after the statement of risk based on Tulalip survey information.

Response: A statement on the results of the Suquamish survey risk estimates has been added.

b. Page 3-7 -- Revise the second paragraph of Section 3.1.5 to state "The adult tribal scenario based on Suquamish data is evaluated as a high end exposure scenario to characterize a range of tribal consumption rates."

Response: Suggested edit has been made.

c. Page 7-1 -- In the first paragraph of Section 7.1, include quantitative risk estimates for the Suquamish scenario and tribal children.

Response: A statement on the results of the Suquamish survey risk estimates has been added.

9. Consistent with the LDW HHRA, identify dioxins/furans as COCs and risk drivers for the direct contact and seafood ingestion pathways in the main text of the HHRA. Future remediation plans cannot be used as justification for not identifying and evaluating potential risk drivers.

   Response: Statements have been added in Sections ES.4, 5.2.4.1 and 5.2.4.3 (Seafood Consumption Risks), 6.5 (Uncertainty Assessment of Dioxins), and 7.2 (Identification of Risk Drivers) that identify dioxins/furans as COCs and risk drivers for the direct contact and seafood ingestion pathways, based on assumed likely presence in site sediment and seafood from the site (as has been documented in the upstream LDW), and the likelihood of unacceptable risk estimates.

10. EPA does not agree with statements that the site poses less risk than the LDW site because there is limited access to the site. Delete such statements. The Suquamish Tribe has treaty rights to harvest that are not constrained by limited public access. The Tribe also believes that site remediation and potential habitat restoration projects will provide greater opportunities for tribal harvest in the future. Lockheed could include the statement that this site is not currently accessible to the general public.

    Response: Statements that the size poses less risk than the LDW site because there is limited access to the site have been edited to state that "…because of presently limited access by the general public to the site, exposures and risks to the general public from contact with intertidal sediments is currently less than

assumed in the risk assessment. For tribal exposure scenarios, the Suquamish Tribe has treaty rights to harvest that are not constrained by limited public access, and site remediation and potential habitat restoration projects may provide greater opportunities for tribal harvest in the future."

11. EPA does not agree with statements that the site poses less risk than the LDW site because habitat is not as extensive as the LDW. Delete such statements. Risk assessments do not measure the value of natural resources or habitat and cannot be used to make assumptions about tribal consumption patterns, resource management practices or ecological sustainability.

    Response: Similar to the response to General Comment 3, references to risks being influenced by the size of the site, including the size of habitat relative to the LDW site, have been removed.

12. In both the HHRA and ERA, clarify the basis for excluding infrequently detected (detected in <5% of samples) contaminants. Given data gaps related to sources and source control, as well as the approach taken in modeling tissue concentrations rather than analyzing tissue, there is little justification for eliminating contaminants based on a belief that a COPC should not be present.

    Response: Clarification has been added that EPA guidance allows for excluding infrequently detected chemicals, in order to focus the risk assessment. In addition, the past industrial uses of the site were considered in identifying chemicals that could be COPCs. Since past historical uses consisted primarily of shipyard activities, various metals are the main historical use-based chemicals identified as COPCs. Of the chemicals lacking toxicity values or for which RBACGs were exceeded by detection limits, none are identified as COPCs based on past activities at the site. The exclusion of infrequently detected chemicals also conforms with the work plan. A new Section 6.7 has been added to the Uncertainty Assessment that lists chemicals that were excluded based on detection frequency and evaluates their exceedances of RBACGs.

13. Uncertainty regarding modeling and lack of site specific data in the ERA must be discussed in more detail in the Uncertainty Section.

    Response: More detailed discussion on uncertainty regarding modeling and lack of site specific data has been added to the ERA.

Specific HHRA Comments:

14. **Page ES-1. Executive Summary.** The statement that the HHRA provides support for the decision to remediate the Lockheed West site appears to make the HHRA a justification document, not an evaluation document. This is emphasized by statements regarding the use of LDW exposure scenarios, and their assumptions and exposure parameters, as conservative, based on the inconsequential statements that the Lockheed West site is smaller in size than the LDW site and that the public will have limited access to the LW site. Replace the term "conservative" throughout the document, with "health protective" or something similar with preapproval from EPA in writing. It is not appropriate to consider cleanup alternatives in a risk assessment. Risk assessments inform selection decisions among cleanup alternatives, not vice versa. When Lockheed develops the Feasibility Study, it should consider that much of the Lockheed West site is State Owned Aquatic Land (SOAL) administered by either DNR or the Port of Seattle. In order to limit access to the site, institutional controls (ICs) that would limit public access to public lands would have to be instituted. For SOAL administered by DNR, that would typically require a lease. In any case, ICs could not interfere with tribal treaty rights except on consent and may be difficult to implement for certain exposures. It should be noted that in the original Southwest Harbor / Terminal 5 plan, one of the alternatives for a portion of the site was a destination public shoreline access and fish and wildlife habitat.

Response: The statement that the HHRA provides support for the decision to remediate the Lockheed West site in the Executive Summary has been deleted. Later text in the Executive Summary has been edited to remove reference to the HHRA providing support for the decision to remediate, and instead states that it provides support for active remediation of the site. As described in the response to General Comment 3, discussion has been added to the Uncertainty Assessment about the role of the site size in estimating exposures and consequent risks. As per the comment, the term "conservative" in describing risk estimates has been replaced throughout with "health protective", which was previously used in some places.

15. **Page ES-1, Executive Summary, paragraph 2.** Add the bolded text. "Use of the LDW exposure assumptions and exposure parameters should be ~~is a very~~ ~~conservative~~ **health protective** for the Lockheed West Site, **However, it is important to recognize that the Lockheed West Site is one of many cleanup sites affecting the larger Elliott Bay/Duwamish environment. It is important to consistently address all sources of contamination in this larger area. Use of LDW exposure assumptions for all sites within Elliott Bay and the LDW will insure that chemical contamination within the Duwamish corridor and Elliott Bay is appropriately addressed.**"

Response: Text has been edited as follows: "Use of the LDW exposure assumptions and exposure parameters is a health protective approach for the Lockheed West Site."and "The Lockheed West Site is one of many cleanup sites affecting the larger Elliott Bay/Duwamish environment, and the use of the LDW exposure assumptions ensures consistency in how the sources of contamination in this larger area are addressed."

16. **Page ES-3, ES.2 Exposure Assessment.** Add the bolded text. "… either by ingestion ~~in~~ **of contaminants in** sediment or seafood or by **dermal** absorption **of contaminants** ~~across the~~ **from contaminated sediment adhering to the** skin…"

    Response: Text has been edited as requested.

17. **Page ES-3, ES.2 Exposure Assessment.** Add the bolded text. "The total consumption rate **of non-anadromous seafood** for the adult tribal scenario was 97.5 grams of seafood per day (three meals per week, assuming a meal weighs 227 grams, which is about 8 ounces. **Contaminant exposure associated with consumption of anadromous species (i.e., salmon) were not included in the HHRA because it was assumed that the site-associated salmon body burden (as opposed to body burden from open ocean migration) is not substantial.**"

    Response: Text has been edited as requested

18. **Page ES-8, ES.4 Risk Characterization and Uncertainty Analysis.** Add the bolded text, "highlights the ~~conservativeness~~ **health protective nature** of the approach."

    Response: Text has been edited as requested

19. **Page 1-1, 1.1 Purpose of the Streamlined Human Health Assessment.** Discussion of remediation alternatives in this section, especially the emphasis on capping, is premature and inappropriate. The purpose of a risk assessment is to support a decision as to whether remediation is necessary. This comment also applies to the same statement on Page ES-1. See Comment 6 above.

    Response: See response to Comment 6. Text has been edited to state "Although active remediation will reduce exposures of humans to the present sediment contaminants, the presence of Site contamination requires performance of a baseline risk assessment to indicate the potential extent of risk under present site conditions, to provide risk information to affected tribes and the public, to support the remedy selection for the sediments that will mitigate the risk, and to provide context for long-term monitoring and remedy evaluation."

20. **Page 1-3, 1.2 Scope.** The Eastern Softshell Clam, Mya arenaria, seems to prefer a lower salinity environment than other more commonly consumed clam species (e.g., Littleneck and butter clams). Surveys of both the Lockheed West and East Waterway suggest that the Eastern Softshell Clam is not common in the marine environments downstream of the Duwamish estuary. Inorganic arsenic levels in Mya arenaria were much higher than levels found in other clams in the Duwamish corridor. This is an important distinction. The risk assessment must be modified to account for this difference.

    Response: The text has been modified to include discussion on the level of inorganic arsenic that was assumed for clams in the HHRA, the source of the percentage of inorganic arsenic as coming from the Mya studies of the LDW, and that Mya clams are not common at the site due to salinity differences. The assumption of proportional inorganic arsenic concentrations at the LW site is considered to be health protective.

21. **Page 2-2, 2.1.1 Sediment Chemical Data.** Add the bolded text. "The RBACGs are considered to protective of human receptors exposed to chemicals via direct contact ~~or incidental ingestion of~~ **with contaminated** sediment **or by indirect sediment contaminant contact from** ~~and for~~ ingestion of fish and shellfish ~~by human receptors~~ **that have acquired body burdens of contaminants of Site contaminants**.

    Response: Text has been edited as requested

22. **Page 2-2, 2.1.2 Fish and Shellfish Tissue Chemistry.** See comment 20

    Response: Text has been edited as requested

23. **Page 2-2, 2.1.2 Fish and Shellfish Tissue Chemistry**. "**Presumably**…aquatic species identified at the LDW Site **could** use the Lockheed West Site sediment areas, since the Site is located just downstream of the LDW Site." Resolve these questions. Do the aquatic species identified use each Site in the same manner? Are the pathways different, similar, or the same? Does the word "could" adequately characterize the species located at the Site for risk assessment—and could a more definitive statement regarding aquatic species that use the Site be made?

    Response: Whether aquatic species identified use each Site in the same manner as at the LDW site is unknown. The pathways of exposure are assumed to be the same because the species are identical, the same habitats are present, environmental conditions are similar, and food sources are not known to differ

between the sites. Text has been edited to include mention of species that have been documented in the West Waterway.

24. **Page 2-6, 2.2.1 Averaging Duplicate Samples.** The LDW HHRA (See page 22, Section B.2.2.1) used the minimum reporting limit, not half the reporting limit, when all results were non-detects. The same methodology should be used in the LW HHRA.

    Response: For the LW HHRA, all chemicals with all results non-detects are eliminated from further evaluation based on the < 5% detection frequency. Therefore, the use of the minimum or half reporting limits in quantifying exposures do not apply to the LW HHRA.

25. **Page 3-1, 3 Exposure Assessment.** The text states "based on assumed similarities in aquatic habitat and future human uses between the Lockheed West and LDW Sites, the exposure pathways and exposed populations for the Lockheed West and the LDW Sites, the exposure and exposed populations for the Lockheed West HHRA are consistent with scenarios developed for the LDW HHRA." This statement appears to be contradicted by a statement within Page 3-4, Section 3.1.1 Water Recreation: "King County concluded that the frequency of recreational activities would be low in the Duwamish River estuaries compared to Elliott Bay." Lockheed West is located on Elliott Bay, in close proximity to the Armani public boat launch. The possibility that public access would be provided at this Site was considered in the Southwest Harbor design phases. Remove the statement (conjecture) attributed to King County in Section 3.1.1.

    Response: Statement has been removed, as requested.

26. **Page 3-2, 3 Exposure Assessment**. The statement that risks from direct exposure to surface water are less than risks associated with sediment or fish consumption pathways should not mean that the surface water pathway is non-existent and should not be discussed in a narrative. Add an appropriate surface pathway discussion.

    Response: Text has been modified to indicate that the surface water exposure pathway is evaluated qualitatively, based on the previous analysis by King County. Results of the King County assessment have been added to the Exposure Assessment, and an analysis presenting data on exposures and risks from the King County assessment has been added as Section 6.9 of the Uncertainty Assessment.

27. **Page 3-3, Figure 3-1.** Typo ~~comsumtion~~ **consumption**

    Response: Edit has been made.

28. **Page 3-3, 3.1. Conceptual Site Model and Exposure Scenarios.** The rationale for choice of the Tulalip data to parameterize the tribal RME seafood consumption scenario should be presented here. Add the bolded text. ", ~~in compliance with~~ **as suggested by** the EPA Region 10 tribal seafood consumption framework (EPA 2007b). **The Framework includes a policy decision to use Tulalip Tribes' seafood consumption rates to assess tribal seafood consumption risks when current or potential high quality shellfish habitat is limited. Use of Tulalip rates at the Lockheed West Site is consistent with this policy decision."** Add language stating that this choice was allowed by the Suquamish and Muckleshoot Tribes only because the Tribes believe that background concentrations will essentially be the cleanup level for both the LDW and LW Sites.

    Response: Edit has been made as requested.

29. **Page 3-4, 3.1.1 Water Recreation:** Add the bolded text. "…found ~~very low~~ health risks related to water exposures in the LDW **were in the 1 x 10^{-6} range with hazard quotients less than 1**."

    Response: Edit has been made as requested."

30. **Page 3-4, Water Recreation**. This section is confusing. The statement that recreational activities would be less in the Duwamish Waterways than on Elliott Bay because of limited access in the industrial waterways needs to be clarified—a portion of the Lockheed West Site abuts Elliott Bay. Because future development of the Site could include public access, a water recreation scenario should at least be described.

    Response: Text has been edited to remove the statement that recreational activities would be less in the Duwamish Waterways than on Elliott Bay. The quantitative results of the King County risk assessment related to surface water health risks in the Duwamish waterways and Elliott Bay have been added as part of the evaluation of the surface water direct contact pathway. Data and results from the King County direct water contact scenarios have been summarized in Section 6.9 of the Uncertainty Assessment.

31. **Page 3-4, 3.1.2 Beach Play.** "Because of the present lack of public access to the Site, the beach play scenario may greatly overestimate present exposures." Delete this statement in this Section. It would be more appropriate to discuss the impacts of this scenario in the Uncertainty Section.

    Response: As per EPA's follow-up comments at the March 3 meeting, the statement has been edited to refer to the general public, and a sentence has been

added: "In addition, the Suquamish Tribe has treaty rights to harvest in intertidal sediments that are not constrained by limited public access."

32. **Page 3-5, 3.1.2. Beach Play**. Provide a reference for the statement that "the frequency and magnitude of this (direct contact with surface water) is likely to be very low when compared with the magnitude and frequency of contact with the intertidal sediment …." And if this is the case, EPA does not believe that it means that the water contact pathway should not be described. Include this pathway.

    Response: Text has been added to provide reference for the statement, and the water contact pathway is now evaluated in Section 6.9 of the Uncertainty Assessment by inclusion of discussion and summary of the quantitative results of the King County risk assessment related to surface water exposures.

33. **Page 3-6, 3.1.3 Clamming.** Add to the end of first text block at top of page. "**As has been generally noted in tribal seafood consumption risk assessments, none of the exposure parameter values selected have any effect on tribal treaty rights."**

    Response: Text has been edited: "As per the tribal Framework document and the opinion of the tribes, none of the exposure parameter values selected have any effect on tribal treaty rights."

34. **Page 3-6, 3.1.3 Clamming.** Exposure to water is not included. Revise the statement "…while direct contact with surface water may occur, such contact is low compared to the "frequency and magnitude of contact with the intertidal sediment that occurs during clamming activities" to read: "**The contaminant dose and resultant risks associated with clamming sediment exposure are much greater than those associated with surface water exposure.**" Surface water exposure risks from the King County HHRA should be included in the LW risk assessment to clearly identify differences in the magnitude of risk

    Response: Suggested sentence has been added to the existing statement: "The contaminant dose and resultant risks associated with clamming sediment exposure are much greater than those associated with surface water exposure. Therefore, exposure to water is not included in the clamming scenarios; however, a qualitative evaluation of exposure to surface water from direct contact is included in Section 6.9 of the Uncertainty Assessment." As per response to Comment 30, results of the King County risk assessment on surface water risks and sediment risks are now included as part of the qualitative evaluation of the

surface water pathway, and are referred to in discussion of surface water contact risks.

35. **Page 3-6, 3.1.3 Clamming, 2nd paragraph.** In the LDW HHRA 120 day per year tribal clamming scenario, ingestion risks were generally less than dermal risks for bioaccumulative contaminants, however ingestion risks were of the same order of magnitude as dermal contact risks. Arsenic risks were actually higher for ingestion relative to dermal absorption. The difference between ingestion and dermal risks is somewhat overstated. Insert the following language.

    "~~Although the primary exposure pathway for t~~**T**he clamming scenarios ~~is~~ **consider** dermal contact **with and incidental ingestion of** ~~with~~ sediment **contaminants.** ~~, exposure through the incidental ingestion of sediment during clamming is included in the risk analysis for these scenarios~~."

    Response: Edit has been made as requested.

36. **Page 3-7, 3.1.5 Fishing and Shellfishing for Consumption, final paragraph.** Make the following modifications to this section. "The seafood exposure parameters are consistent with those developed for the LDW HHRA. As a ~~conservative~~ **health protective** measure, the seafood consumption scenarios for the Lockheed West HHRA did not include adjustments to account for differing exposure to Site chemicals than those assumed for the LDW HHRA. ~~Exposures could differ from those assumed in the LDW HHRA due to the much smaller size and quality of habitats of the Lockheed West Site, which could affect the availability of seafood and possibly seafood consumption rates, and the lower relative contributions of the Site sediment contamination to the tissue concentrations in seafood that could be exposed to chemicals in areas outside the Site.~~ **The Lockheed West Site is one of many cleanup sites affecting the larger Elliott Bay and Duwamish environment. It is important to consistently address all sources of contamination in this larger area. The use of consistent exposure assumptions for all sites within the Duwamish corridor and Elliott Bay will insure that chemical contamination within the Duwamish corridor and Elliott Bay is appropriately addressed.**"

    Response: Text has been deleted as suggested. See response to General Comment 3 on other text changes. The following text has been added, and is similar to text added to Section 1.2 Scope: "Consistent cleanup levels among the sites within the Duwamish Waterway/Elliott Bay region are necessary to ensure that cleanups achieve the common goal of health protectiveness for the highest exposed populations that use the resources of the region. Use of the LDW exposure scenarios and all inherent assumptions and exposure parameters is a health

protective approach for the Lockheed West Site, and is protective of human populations who might use the site in the future."

37. **Page 3-10, 3.2.1 Screening Procedure.** Add to text in outline item 3 -- "EPA risk assessments compute the risks for contaminants without respect to source (i.e., site or background associated). In characterizing risks, the site and background related components of risk are identified."

    Response: Item 3 has been moved from the outline as per Comment 39, and the edit has been made as requested.

38. **Page 3-10, Section 3.2.1, Frequency of Detection screening procedure**. Clarify the basis for excluding infrequently detected (detected in <5% of samples) contaminants. Given data gaps related to sources and source control, as well as the approach taken in modeling tissue concentrations rather than analyzing tissue, there is little justification for eliminating contaminants based on a belief that a COPC should not be present.

    Response: See response to Comment 12.

39. **Page 3-11, Section 3.2.1, Comparison with Background screening procedure**. Although it is stated that no chemicals were eliminated based on comparison with background, this should not be included as a screening procedure using LDW background estimations. There has been no agreement regarding background values for the Lockheed West Site (nor have the final background value decisions been made for the LDW). Risk assessments typically carry risks from background through the risk characterization. See EPA policy memo regarding background (OSWER 9285.6-07T, 2000). Step 3, comparison with background, should be removed from the COPC development process. A discussion of how contaminant concentrations compare with background levels may be included for informational purposes if it is clearly labeled as such.

    Response: Step 3 has been removed as part of the screening process; the comparison with background is retained and the text has been edited to clarify that use of the background comparison is for informational purposes.

40. **3-14, 3.2.3 Sediment Screening for Seafood Consumption Exposure.** Using the BSAFs presented is appropriate for bioaccumulative organic compounds, but not for metals. This section should be revised to discuss the bioaccumulation of metals. Given the (sufficiently) close proximity of the LDW and LW Sites, and that metals bioaccumulation is Site and organism specific, metals concentrations from organisms and sediment for the LDW are useful to assess metals bioaccumulation for the LW Site. EPA will provide further, more specific, direction for LDW metals BSAFs.

Response: Additional text will be added on metals bioaccumulation taken largely from the Ecology document that provides metals BSAFs. Since this section of the HHRA develops the screening procedure that was taken from the LDW HHRA and was approved in the work plan, and was assumed to be sufficiently health protective in those documents, no changes are made to the metals screening procedure. Text is added that states: "The derivation and use of BSAFs in modeling seafood chemical concentrations for the seafood consumption scenarios in the Lockheed West HHRA, and limitations with BSAF modeling, are described in more detail in Section 3.3.5." Note that the exposure assessment section is revised to include reference to the bioaccumulation factors for metals that EPA developed from LDW site data as mentioned in further comments below.

41. **Page 3-13, 3.2.2 Sediment Direct Contact.** RAGS Part A has some discussion of background considerations in screening out COPCs that have below background concentrations. However, more recent policy guidance on treatment of contaminants with background levels states that risks be computed regardless of the source of the contaminant followed by a separation into background and Site-related components (See http://www.epa.gov/oswer/riskassessment/pdf/bkgpol_jan01.pdf). This section should note that comparison between Site and background concentrations is for informational purposes only.

    Response: Text has been added as requested.

42. **Page 3-17, 3.2.3 Sediment Screening for Seafood Consumption Exposure, Outline item 1.** "…(**anadromous,** pelagic…)"

    Response: Edit has been made as requested.

43. **Page 3-17, 3.2.3 Sediment Screening for Seafood Consumption Exposure.** "The tribal consumption rate of ~~98~~ **194** g/day…"

    Response: Edit has been made as requested.

Using this process, salmon comprised 96.5 g/day of the total consumption rate. EPA (2007b) decided that salmon did not accumulate a significant site-related contaminant body burden from the LDW. **Multiplying a Site related contaminant concentration of zero by the salmon consumption rate results in a contaminant dose of zero for salmon consumption. For all other market basket fractions, the Site related body burden was assumed to be 100% The total consumption rate for all market basket fractions other than salmon was 97.5 g/day** ~~Consequently, the "effective"~~

~~consumption rate was 194 g/day – 96.5 g/day consumption of species with a site related body burden~~… Note that attributing zero to a "not…significant Site-related contaminant body burden" is not a conservative assumption. See Comment 4 above emphasizing that the uncertainties associated with the LDW HHRA may both over-and under-estimate risks.

Response: Edit has been made as requested, and comment noted.

44. **Page 3-18.** Clarify the basis for the exclusion of salmon and be more descriptive of the rational used in the LDW HHRA. LDW looked at the biomass and contaminant concentrations in juvenile salmon to get the total amount of PCBs in the juveniles. Then they determined the PCB ratio in returning adult salmon. The EPA Framework does not recommend that salmon be excluded for all sites, or when using the Tulalip rate.

    Response: The basis for the exclusion of salmon from seafood ingestion pathways, described in the RI/FS work plan, has been clarified by the addition of text edited from the LDW HHRA that provides the rationale based on the analysis of biomass and contaminant concentration in juvenile salmon.

45. **Page 3-18**. It is possible that species at higher trophic levels, with higher lipid content, or longer life cycles, may accumulate or magnify contaminants to a greater degree than clams. Explain how the use of clam RBACGs and BSAFs is designed to be sufficiently protective for consumption of all seafood types. LDW did not use BSAFs with species' with larger home ranges.

    Response: The HHRA contains text from the LDW QAPP and HHRA as rationale for the screening process. The use of clam BSAFs was designed to be sufficiently protective by assigning the consumption rate of the total of all species to the clam BSAF rather than only the clam consumption rate. The approved LDW QAPP was assumed to provide sufficiently health protective RBACGs. Use of the LDW QAPP RBACGs, with modifications for updated toxicity values and tribal seafood ingestion rates as described in the risk assessment, conforms to the LW work plan. Note that updated BSAFs were identified for clams, fish, and crab for use in modeling tissue concentrations to quantify exposures and associated risks through seafood ingestion.

46. **Page 3-20, 3.2.4 Undetected Chemicals.** Add these chemicals to the risk assessment.

> ***Response: RBACGs for clamming for these chemicals have been taken from the EPA PRG list for residential soil, with adjustments of 0.1 to those for non-cancer endpoints. No BSAFs are available for these chemicals so sediment RBACGs for seafood ingestion were not calculated. Results of the RBACG determination for these chemicals have been added to Attachment B and the chemicals have been removed from Table 3-4. None of the reporting limits for these chemicals in sediment exceeded their RBACGs, so no changes were made to Table 3-3.***

3-nitroaniline has both a chronic oral RfD of 3E-4 mg/kg-day and a slope factor of 2.1E-2, See:
http://hhpprtv.ornl.gov/quickview/pprtv.php?chemical=Nitroaniline%2C+3-#pprtv_roc

4,6-dinitro-o-cresol has a chronic oral RfD of 1E-4 mg/kg-day, See:
http://hhpprtv.ornl.gov/quickview/pprtv.php?chemical=Dinitro-o-cresol%2C+4%2C6-#pprtv_roc

Bis(2-chloroethoxy)methane has a chronic oral RfD of 3E-3 mg/kg-day, See:
http://hhpprtv.ornl.gov/quickview/pprtv.php?chemical=Bis%282-chloroethoxy%29methane#pprtv_roc

2-nitroaniline has a chronic oral RfD of 3E-3 mg/kg/day, See:
http://hhpprtv.ornl.gov/quickview/pprtv.php?chemical=Nitroaniline%2C+2-#pprtv_roc

4-nitroaniline has a chronic oral RfD of 3E-3 mg/kg-day and a slope factor of 2.1E-2, See: http://hhpprtv.ornl.gov/quickview/pprtv.php?chemical=Nitroaniline%2C+4-

47. **Page 3-37, Table 3-19. Adult Tribal Consumption of Shellfish (Crabs, Clams, and Mussels) Based on Tulalip and Suquamish Data.** EPA has been made aware that the percentages of crab and clam consumption derived from the Tulalip data set were reversed. The percentage consumption of clams should be 53% while the consumption of crabs should be 46%. Modify the risk assessment accordingly.

> ***Response: This finding has been added to Section 6.1 of the Uncertainty Analysis. The consumption of clams would be 15% higher with the higher percentage of clam consumption. The text now notes that the concentrations of PAHs, PCBs, and TBT are higher in crabs than in clam tissue, so resultant risk estimates for***

those chemicals would decrease proportionately for the Tribal Seafood Consumption scenario, whereas risks from metals, which are higher in clams than crabs, would increase.

48. **Page 3-45, 3.3.5.1 BSAF Modeling 1st paragraph on page.** Describe that metal BSAFs are generally the ratio of the tissue to the sediment concentration.

    Response: Additional text has been added as requested in Comment 40.

49. **Page 3-45, 3.3.5.1 BSAF Modeling 2nd paragraph on page.** Clarify the final sections of the paragraph.

    Response: Text has been edited for clarification.

50. **Page 3-46, 3.3.5.1 BSAF Modeling.** To employ OC normalization, the sediment organic carbon fraction should be greater than 0.05.

    Response: Use of a 0.5% criterion for organic carbon content has not been previously applied in the regulatory arena to the development of BSAFs for organic chemicals. Also, use of a 0.5% criterion is not mentioned in the literature referenced as BSAF sources for this HHRA. No changes regarding organic carbon normalization have been made to the report.

51. **Page 3-47, Table 3-26, Sources of BSAF Values**. Given that metals bioaccumulation is Site and species specific, sediment and tissue contaminant data from the nearby LDW Site, which has environmental conditions similar to the LW Site, should be considered for evaluating metal bioaccumulation at the LW Site. LW Macoma data should be considered for quantification of metals bioaccumulation in shellfish at the LW Site. Note Comment 40 above, particularly that EPA will soon provide further more specific direction for LDW metals BSAFs.

    Response: Section 6.2 of the Uncertainty Analysis now includes text on metals bioaccumulation and the general lack of BSAFs for metals. The text includes discussion of the recent document from EPA that derives BSAFs for metals from the LDW site data, presents alternative metals BSAFs for seafood categories, and recalculates risks for the seafood ingestion pathway using the LW site data and exposure assumptions. Results of that reanalysis are now summarized in Section 6.2. Based on the results, additional COCs are identified as those metals with HQs exceeding 1 when they previously were below 1, and cancer risk estimates that increased by an order of magnitude with the new BSAFs. The EPA

document on metals BSAFs is now appended to the HHRA. Note that the method used for modeling, including the use of Department of Ecology BSAFs for metals, conforms to the work plan.

52. **Page 3-50, 3.3.5.2 Regression Models.** Specifically, the benthic invertebrate regression for arsenic is not appropriate to use to model arsenic uptake by clams. As noted in the previous comment, arsenic bioaccumulation should be calculated using arsenic sediment tissue ratios for Macoma taken from the LW Site. Given the changes in aquatic biota PCB concentrations over time, LDW PCB concentration sediment/tissue regressions were not to be used to model bioaccumulation, literature values were used instead.

    Response: See response to Comment 51; discussion of the results of the EPA reanalysis of arsenic and metals BSAFs and the recalculation of risks for the LW site has been added to the Uncertainty Assessment, and the EPA report is appended to the HHRA. For PCBs, an analysis was performed that compared results of modeled PCBs into seafood tissue at the LW site using the LDW regressions and those using the literature BSAFs. That analysis showed no differences in the excess cancer risk results for the Tribal seafood ingestion scenario with either the LDW regressions or the literature BSAFs. The analysis provides support that cancer risk estimates are not necessarily more certain using either the literature values or the LDW regression equations. The report comparing the risk results from the two modeling approaches for PCBs had been previously submitted to EPA and is now appended to the HHRA.

53. **Page 3-59, 3.3.6.1 Child Lead Model.** The lead BSAF used should be based on LDW data.

    Response: See response to Comment 51; results of the EPA reanalysis of metals BSAFs and the recalculation of risks for the LW site is now mentioned in the Uncertainty Assessment, and the EPA report is appended to the HHRA.

54. **Page 4-3, 4 Toxicity Assessment.** The Provisional Peer Reviewed Toxicity Value database should also be listed as a source of toxicity data. The comment on Page 3-20, 3.2.4, Undetected Chemicals, noting toxicity values for several contaminants should be incorporated here.

    Response: The Provisional Peer Reviewed Toxicity Value database was listed as a source of toxicity data in the bulleted list of Page 4-1. The text has been edited to include the database in the list of sources used in the HHRA. The development of

RBACGs used for the screening process to select COPCs has been modified to include toxicity values for the additional chemicals in Comment 46.

55. **Page 5-1, 5 Risk Characterization.** The statement that risk estimates are considered to be very conservative for the Site "given its small size, limited access, and uncertain habitat quality and contribution to aquatic organism exposure compared to the LDW Site" is conclusory and subjective. Describe the Site's role in the Elliott Bay ecosystem. Size often does not equate with importance. In addition, statements about limited access do not define what future access will be.

    Response: As per the response to General Comment 3, the discussion of risk estimates relative to site size has been deleted. Section 6.1 of the Uncertainty Assessment has been modified to include discussion of the uncertainty in foraging rates and foraging success between the LW and LDW sites. The Risk Characterization text has been edited to clarify that statements about limited access only apply to present conditions for the general public.

56. **Page 5-1, Risk Characterization, 2nd paragraph**. This discussion may identify factors that could lead to an overestimate of risks, but should also include concerns noted in the comment on ES-1, Executive Summary, paragraph 2. See Comment 4.

    Response: Text is edited as follows: "The exposure assumptions used to quantify risk estimates are considered to be ~~very conservative~~ health protective for the Site.~~, given its small size, limited access, and uncertain habitat quality and contribution to aquatic organism exposure compared with the LDW site~~. Uncertainties related to the use of exposure assumptions from the LDW HHRA are discussed in Section 6.1."

57. **Page 6-1, 6. Use of Exposure Scenarios from the LDW Site.** The discussion that follows the statement that LDW exposure scenarios does not take into account any potential differences between the Sites makes a point of describing the small size of the Lockheed West Site subtidal and intertidal areas. A discussion about whether this Site has any importance to the ecosystem of Elliott Bay or the Duwamish system is missing. This section should be consistent with other comments noting inconsequential comparisons between the LDW and LW Sites.

    Response: As per the response to Comment 3, discussion of the influence of site size on exposure modeling and exposure estimates has been edited and clarified. Also see response to Comment 55.

58. **Page 6-1, 6.1 Use of Exposure Scenarios from the LDW Site.** See comment on ES-1, Executive Summary, paragraph 2. Sustainability in this context may be affected by many factors subject to change over time, including land uses, societal attitudes, and the size of a population consuming a resource, among other things. The discussion of sustainability issues should be removed; it cannot be resolved toward any useful end and merely generates unproductive controversy.

    Response: See the response to Comment 15. The text in question was not meant to address sustainability of the resources over time (i.e., whether the present biomass could be sustained at the consumption rates assumed), but rather to compare the differences in the amount of biomass between the LW and LDW site. Additional discussion has been added to this section of the Uncertainty Assessment.

59. **Page 6-2, 6.2, Modeling of Tissue Exposure Point Concentrations.** An additional uncertainty is the percent inorganic arsenic in shellfish. This value is highly variable and the percent inorganic arsenic value found for Mya arenaria collected from the LDW is high and may not be representative of shellfish that favor higher salinity that are found at LW. See Comment 20.

    Response: See response to Comment 20. Text has been modified to note that the differences in inorganic arsenic between the clam species is an uncertainty.

60. **Page 6-5, 6.5 Dioxins and PCB Dioxin Like Congeners.** It is not clear that dioxin-like PCB congeners were not enriched in biota samples from LW. The LDW HHRA could make this statement because PCB tissue congener concentrations were available. The assertion that TEQ and Aroclor PCB risks are similar for the LW must be removed. The discussion of remedial alternatives could be appropriate for the FS, but not for the HHRA. Remove the discussion of total Site remediation.

    Response: The text has been edited to indicate that it is unknown whether PCB congener enrichment in biota at the Lockheed West Site may differ from the enrichment found with biota at the LDW site. Although the same aquatic organisms may be present at both sites, the sources of PCBs to each site may differ, and consequently the weathering and enrichment of dioxin-like PCB congeners may differ between the sites.

61. **6-5, 6.6 Dermal Absorption of Metals.** The magnitude of risk from dermal absorption of metal is clearly related to the concentrations of the metals of concern. What is the relative difference in metals concentrations between LDW and the LW Sites? Would risks/hazards be significant given the difference in concentrations?

Response: This section on the uncertainty of dermal absorption of metals has been modified to present more details on the alternative analysis of dermal metals absorption presented in the LDW HHRA.

62. **Page 6-6, Section 6.7.** Compare modeled tissue concentrations with empirical tissue concentration for Lockheed West clam tissue or empirical tissue samples from similar or nearby sites to more fully discuss uncertainties associated with the modeling approach taken at the Site.

    Response: Modeled tissue concentrations in clams and tissue concentrations from the clam collection at the site are now discussed and tabulated in Table 6-1 in the Uncertainty Assessment.

63. **Page 6-8, Table 6-2.** Modify Table 6-2 to reflect contaminants for which toxicity values were identified (See comment on page 3-20, 3.2.4 Undetected Chemicals).

    Response: Table 6-2 has been modified to remove the chemicals discussed in Comment 46.

64. **Page 7-1**, **Section 7 Risk Estimates Summary and Conclusions.** Remove the reference to Site size.

    Response: See response to Comment 3; reference has been removed.

<u>Draft Ecological Risk Assessment Comments, Lockheed West Superfund Site (November 2008)</u>

<u>Specific Comments</u>

65. **Page 1-1, 1.1 Purpose of Ecological Risk Assessment.** "Although placement of a cap will eliminate all exposures…." Delete this statement and provide a more general statement that the remedy will result in a clean surface across the entire Site below risk levels for all contaminants. This outcome can be achieved by dredging, capping, or a combination of both.

    Response: Statement has been reworded as suggested. Also see responses to Comments 1 and 6.

66. **Page 2-1, Section 2, Problem Formulation.** Explicitly identify the problem evaluated in the opening paragraph of this section.

Response: Text has been modified to include discussion of the site history and to state that the ERA problem is that the presence of contaminants in sediments, related partly to past shipyard activities and other sources, has lead to concerns over potential risks to aquatic receptors.

67. **Page 2-1, 2.1 Aquatic Habitat.** Remove the statement that the use of LDW exposure scenarios is a very conservative approach given the "smaller size of the exposure area at Lockheed West, and limited available ecological habitat under consideration." Other statements regarding the size of the Site and particularly the availability of habitat (page 2-2 for selection of ROCs; page 2-10 for the conceptual model) should be reconciled with Taylor et al (1999, p. 34) concluding that this Site has a wide range of habitat types: sandy pocket beach, cobble beach, boulders, rip rap, microalgae and piling habitats for fish. Appropriately modify or remove these statements. Though the statement is made that the primary habitats at the LW Site include shoreline and subtidal marine environments in Elliott Bay and West Waterway, the use of LDW information appears to emphasize the waterway portion of the Site. A comparison of LW Site habitat with the U.S. Army Corps of Engineers and Environmental Protection Agency *Final Biological Assessment: Pacific Sound Resources Superfund Site* (February 2002) and the Final Monitoring Report for PSR dated August 1, 2008 could be beneficial but is not necessary. A statement regarding the environmental setting as part of the Ecological Risk Model should be included.

Response: Statement has been removed and replaced with one that states that uncertainty regarding the influence of the size of the site relative to the LDW site from which exposure parameters are used is discussed in Section 7.2 under risk characterization for fish. The conceptual site model text has been edited to add the description of Taylor et al. and to clarify the environmental setting at the site.

68. **Page 2-5, 2.2.2 Fish**. Information provided by Ted Turk at the September 5, 2008, LDW meeting included recent work by Jeff Cordell that demonstrated that juvenile Chinook diet in the LDW is made up of polychaetes and clam siphons, unlike juvenile Chinook at other sites in Puget Sound. Because juvenile Chinook are a threatened and endangered (T&E) species and found in abundance in the LDW a conservative approach should be taken. Risk conclusions from the LDW should not be used as supporting data to minimize potential risk.

Response: The LDW ERA recognized that there was uncertainty about modeling dietary exposures to juvenile salmon. The LDW ERA included analyses for modeled dietary exposures using both benthic invertebrate tissue data and

exposures based on measured chemicals in stomach contents of juvenile salmon collected from the LDW. Comparison of the two sources of dietary exposure data showed that the exposures based on the benthic invertebrate concentrations were higher than based on the stomach contents. Thus, the risk estimates for juvenile salmon in the LDW ERA accounted for their unique diet based on stomach contents. Based on that analysis, risk conclusions from the LDW should be considered appropriately protective of juvenile Chinook salmon that may pass through the LW site.

69. **Page 2-5, 2.2.3 Wildlife**. Herons do not require "larger expanses of shallow water." Herons will forage in backyard goldfish ponds if they can find something to eat. Herons may be present regardless of the size of foraging area. Revise accordingly.

    Response: Statement has been reworded to clarify that herons typically forage in shallow water, which is limited at the site.

70. **Page 2-7, 2.2.4 Summary of ROCs**. On June 25, 2001, NMFS sampling caught a very large tadpole in Slip 4 of the LDW. Per WDFW personnel, due to limited information on amphibian populations if their habitat is present we should assume that populations are as well.

    Response: Comment acknowledged. Note that amphibians and amphibian habitat have not been documented at the site, due to the armored intertidal areas and open industrial waterway.

71. **Page 2-7, 2.2.4 Summary of ROCs.** The use of LDW receptors is adequate. Provide a summary comparing the ROCs selected at the PSR and West Waterway Sites.

    Response: The ROCs selected for the PSR and West Waterway ERAs have been added.

72. **Page 2-7, 2.3 Assessment Endpoints**. Even though the draft ERA states that measurement endpoints are more fully described below, there is no summary identifying the assessment endpoints for the Lockheed West Site in the ERA. Societal values can be a factor in selecting assessment endpoints as well. This section appears to be definitional only and is based on the 1992 guidance. The 1998 guidance supersedes the 1992 guidance (http://www.epa.gov/superfund/programs/nrd/era.htm#pagetop).

    Response: Text has been added to indicate the assessment endpoints for the Lockheed West ERA, including societal values. The presentation of assessment endpoints is found in Table 2-2. The guidance specific to performance of ERA for

Superfund sites is the EPA 1997 guidance "Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments" (EPA 540-R-97-006, 1997). The text has been clarified that the presentation of assessment endpoints is consistent with the 1997 EPA guidance.

73. **Page 2-9, 2.4 Conceptual Site Model for Ecological Exposures**. The conceptual model describes the relationship between "ecological stressors" and the stressors as pathways from contaminated sediment to specified organisms. Explain why the only stressors at this site are contaminated sediment as surrogates for "ecological" stressors, and why those stressors are the same or comparable at the LDW Site, including erosion, Elliott Bay currents, tidal fluctuations, groundwater inputs. Page 4-33 of the Work Plan states: "The development of baseline ERA and HHRA will include more specific CSMs." This needs to occur.

    Response: The text has been edited to clarify that the Superfund guidance focuses on chemical stressors as separate from other non-contaminant stressors.

74. **Page 2-10, 2.4 Conceptual Site Model for Ecological Exposures.** This page describes groundwater and its resulting transition zone water as a possible concern to benthic organisms and states that groundwater will be evaluated in the FS for its potential to impact the Lockheed West Site. Risks from transition zone water to benthos should be predicted in this risk assessment using the available porewater and groundwater data, comparing it to AWQC or other benchmarks. The associated uncertainties should also be discussed. Also, delete the statement that "…the entire contaminated sediment area of the Site will be covered…."

    Response: The pathway of groundwater to transition zone has been added to the Section 7.1 of the risk characterization for benthic invertebrates, using available data on groundwater contaminant concentrations from well data and ambient water quality criteria as the effect measure. The groundwater data are from available well data that are over 10 years old, and of a limited analyte list, and hence are evaluated as an uncertainty; additional more recent groundwater data are expected for the FS analysis. . The statement that "...the entire contaminated sediment area of the Site will be covered…" has been deleted.

75. **Page 2-11 2.5.1 Data Selection.** Rewrite the second sentence to state, "Data prior to 2007 environmental investigations are not considered.

    Response: Edit has been made.

76. **Page 2-16, 2.6.1 Criteria #2. See comment numbers 12 and 38.**

Response: See responses to Comments 12 and 38 regarding infrequently detected chemicals.

77. **Page 2-16, 2.6.1 Criteria #3.** A table of the "available background concentrations" should be provided and noted that these are tentative as EPA has not yet agreed to acceptable background concentrations at this Site.

Response: See response to Comment 39.

78. **Page 2-17, Third bullet.** Typo. "NOAA" is the National Oceanic and Atmospheric Administration.

Response: Edit has been made.

79. **Page 3-1, 3.1 Benthic Invertebrate Community Exposure Assessment**. Compare the statement "Modeling is based on a relationship between benthic invertebrate tissue concentrations and sediment characteristics established with data for upstream LDW Site, as per the EPA-approved RI/FS work plan" with Pages 11-32 to 11-4 of the work plan. The rationale for use of LDW technical information for the Lockheed West Site should be explicitly restated in the ERA. This would make the ERA a stand alone document. The differences between the two Sites should also be discussed so that a reviewer could evaluate the conclusions of the ERA. Clarify that the two Sites are different not only because of the LDW's freshwater component, but because of other factors such as tidal and wave energy, among other factors.

Response: See response to Comment 2 on expanded text on the rationale for using LDW information in the risk assessment, and on the risk assessment conforming to the work plan. Text on the additional differences between the sites has been added.

80. **Page 4-7, 4.1.1.2 Regression Models**. "Details of the food web model (FWM) and its calibration for the LDW Site can be found in Appendix D of the LDW RI Report." Generally describe why and how the LDW FWM should apply to Lockheed West.

Response: Additional text from the LDW report describing the model has been added, and text has been added on the application of the food web model to the LW site.

81. **Page 5-5, 5.2 Fish Effects Assessment.** The laboratory effects studies included in the total PCBs assessment used unweathered Aroclor mixtures. PCB residues in fish have undergone physico-chemical weathering and differential accumulation in the food web, which may result in PCB mixtures that may be more biologically active than the commercial mixtures (Parkinson and Safe 1987; Smith et al. 1990). This should be included in the Uncertainty Section.

    Response: Text on the uncertainty over the enrichment of PCB congeners in weathered samples has been added to Section 5.2, and includes discussion from the LDW ERA that dioxin-like congeners were not enriched in tissue samples from the nearby LDW.

82. **Page 5-7, Table 5-5, TRVs for Fish COPCs Evaluated Using the Critical Tissue-residue Approach.** Include PCB TRVs derived from the paper by Hugla and Thome (1999) where reduced fecundity in barbel corresponded to a whole body LOAEL concentration of 0.52 ppm wet weight (ww) and NOAEL of 0.2 ppm ww. In addition, based on Fisher et al (1994), the recommend LOAEL should be 1.08 ppm ww, not 4.02 ppm ww. At 176 days post exposure there was a significant reduction in ww of fry in the 0.625 ppm nominal exposure concentration. The mean tissue concentration for this treatment was 1.08 ppm wet weight but it was measured 31 days post exposure. For the 176 day post exposure significant growth response, these tissue concentrations were likely far lower. Correct Table 5-5.

    Response: Table 5-5 has been corrected and risks have been re-calculated for PCB exposures to fish.

83. **Page 6-1, 6.1.1 Approach**. Birds are not completely covered with feathers. Large portions of their heads, legs, feet, and in some birds seasonal brood spots on their chests, are not feathered. Skin absorption of polyaromatic hydrocarbons from Great Lakes sediment shows that in a worst-case scenario dermal contact can be as important as ingestion.

    Response: Comment acknowledged; text has been modified to note areas that may be exposed.

84. **Page 7-32, 7.2.1.3 Risk Conclusions.** In addition to uncertainty related to the TRVs, there is also uncertainty in modeling concentrations in prey items. If tissue concentrations were underestimated, the risk could also be underestimated. This must be clarified.

    Response: Text has been modified to include uncertainties related to tissue modeling of prey in evaluating dietary exposures.

85. **Pages 7-5 and 7-7, Figures 7-1 and 7-2**. Pages 7-6 and 7-8 are missing. The figures are not double sided. Renumber or otherwise fix.

    Response: Edits have been made on the figure pages.

RESPONSE TO EPA'S COMMENTS (dated MAY 18, 2009) REGARDING THE DRAFT FINAL ECOLOGICAL RISK ASSESSMENT FOR THE LOCKHEED WEST SUPERFUND SITE.

86. Page 1-4, in the first full paragraph. Delete the word "health." The word health used here is hard to define. We can talk about fish health or community health, but generally in ecological risk assessment we are investigating risks.

    Response: The document was reviewed to ensure that the word "health" was removed.

87. Page 2-9, last sentence. Add a sentence that describes how, and in what document, the more recent groundwater data will be evaluated

    Response: The suggested edits were made to the text in the bottom paragraph of Page 7-18, Section 7.1.1.3.

APPENDIX C— BASELINE HUMAN HEALTH RISK ASSESSMENT

HUMAN HEALTH RISK ASSESSMENT FOR LOCKHEED WEST SEATTLE SUPERFUND SITE

FINAL

Prepared for

LOCKHEED MARTIN

Prepared by

TETRA TECH

and

PASCOE environmental consulting

June 2009

EXECUTIVE SUMMARY

This document presents the baseline Human Health Risk Assessment (HHRA) for the Lockheed West Seattle Superfund Site (Site). The Site is located at the West Waterway mouth of the Duwamish waterway system, with the West Waterway along the eastern boundary of the Site and Elliott Bay on the northern side. The HHRA is based on a U.S. Environmental Protection Agency (EPA)-approved work plan that was developed for the Remedial Investigation/Feasibility Study (RI/FS) of the Site. The Site consists of an historic shipyard that ceased operating in 1987 after approximately 45 years of continuous operations. Industrial activities in shipbuilding, ship repair, and ship maintenance have resulted in contamination of aquatic sediments in portions of the West Waterway and Elliott Bay adjacent to the former shipyard. Lockheed Martin Corporation recognizes that “no action” and natural recovery are not likely to meet Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) criteria for remedy selection, and is focused on active remediation of the entire Lockheed West Site. While remediation is expected to reduce exposures and risks associated with current site conditions, the presence of site contamination requires performance of a baseline risk assessment to indicate the potential extent of risk under present site conditions, to provide risk information to affected tribes and the public, to support the remedy selection for the sediments that will mitigate the risk, and to provide context for long-term monitoring and remedy evaluation. The sources of the chemicals for which risks are estimated are not identified or assumed in this risk assessment, but will be evaluated in the RI.

Consistent with the EPA approved RI/FS work plan, the approach to the HHRA for the Lockheed West Site is to use a combination of site-specific sediment chemistry data, exposure parameters developed for the Lower Duwamish Waterway (LDW) site HHRA (located upstream from the Lockheed West Site), and EPA guidance on literature values to estimate risks to human receptors. The LDW site is a 5-mile long segment of the Duwamish waterway with a downstream boundary about 1 mile upstream of the West Waterway portion of the Lockheed West Site. The similarities in aquatic habitat and types of seafood, and the possible future human uses of the Site, were the basis for applying the technical approach and specific exposure and toxicity parameters from the LDW site to the Lockheed West HHRA. Use of the LDW exposure scenarios and all inherent assumptions and exposure parameters is a health-protective approach for the Lockheed West Site, and is protective of human populations who might use the Site in the future. The Lockheed West Site is one of many cleanup sites affecting the larger Elliott Bay/Duwamish environment, and the use of the LDW exposure assumptions ensures consistency in how the sources of contamination in this larger area are addressed.

The baseline HHRA uses surface sediment data collected from the Site in 2007. Tissue concentrations of chemicals in seafood that may be collected and consumed from the Site are modeled from the sediment concentrations. The baseline HHRA identified sediment data useable for assessing risks, developed a conceptual site model to identify pathways that humans might be exposed to site chemicals, estimated exposures to the chemicals, characterized the risks, and discussed uncertainties in the analysis, all of which are briefly summarized below.

ES.1. DATA EVALUATION AND SCREENING

The data evaluation section of the HHRA includes a description of what data were available, a determination of how the data were used in the HHRA, and the suitability of the data for risk assessment purposes. The data available from the Site that were found to be useable in the HHRA consist of surface sediment chemistry collected in 2007. Tissue concentrations were modeled from the surface sediment chemical concentrations as described in the Exposure Assessment below. The sediment data on organochlorine pesticides, such as DDT, were found to be highly uncertain due to unavoidable interferences with the presence of polychlorinated biphenyls (PCBs) during the chemical analyses.

ES.2 EXPOSURE ASSESSMENT

The Exposure Assessment evaluates potential exposure pathways and exposed populations in a conceptual site model. The exposure scenarios selected for evaluation were consistent with the HHRA for the upstream LDW site. The exposure scenarios were selected to be those with potentially the highest risks and that could be applicable to conditions at the Lockheed West Site. The exposure scenarios were identified as reasonable maximum exposure (RME) scenarios, and consisted of child beach play, tribal clamming (i.e., collection of clams by tribal members), tribal netfishing, and the consumption of seafood (including clams) by tribal adults and children. The Suquamish Tribe and Muckleshoot Tribe, in consultation with EPA, agreed to a risk assessment approach for the Lockheed West Site that is consistent with that used for the LDW site. The Suquamish Tribe specifically requested inclusion of a Suquamish tribal scenario as relevant to Suquamish tribal members and as an estimate of Suquamish consumption and risk. The analysis of adult Suquamish seafood consumption is a high-end exposure scenario that depicts upper bound risks for tribal seafood consumers.

The RME is the highest exposure that is reasonably expected to occur at a site. The RME, by definition, likely overestimates exposure for many individuals. In accordance with the EPA tribal seafood consumption framework that has been developed by EPA Region 10, the Tulalip seafood consumption survey data were used to characterize the adult tribal RME and child tribal seafood consumption scenarios.

In the first step of the exposure assessment, risk-based screening was performed using EPA guidance to identify chemicals of potential concern (COPCs). The COPCs were then further evaluated for potential health risks to humans who may be exposed at the Site. Six metals and two groups of organic compounds (carcinogenic polycyclic aromatic hydrocarbons [cPAHs] and total PCBs) were identified as COPCs for direct exposures to sediment. For the seafood consumption scenarios, seven metals plus tributyltin (TBT) and five organic compounds (cPAHs, two individual PAHs, pentachlorophenol, and total PCBs) were identified as COPCs. Additional organochlorine pesticides (total DDTs and total chlordanes) were identified as tentative COPCs based on their tentative identification in sediment. Eight additional organic chemicals that were never detected in site sediments were also identified as potential COPCs based on their analytical detection limits exceeding screening criteria.

The Exposure Assessment quantified the amount of chemical that a person may be exposed to, either by ingestion of contaminants in sediment or seafood, or by dermal absorption of contaminants from contaminated sediment adhering to the skin. Exposures to COPCs from the Site were calculated using EPA equations and exposure parameters from the LDW HHRA, such as time spent at the intertidal sediment area during beach play, time spent in netfishing, and the amount of seafood ingested, including clams, crabs, and fish. The rates of seafood ingestion that were used in the seafood consumption scenarios were developed based on data collected from surveys conducted by the Tulalip and Suquamish Tribes. Consistent with the LDW risk assessment approach, Tulalip data were used as the basis for the tribal RME seafood consumption scenarios. Suquamish data were used as the basis for the Suquamish seafood consumption scenarios and as an upper bound tribal consumption scenario. The total consumption rate of non-anadromous seafood (i.e., seafood other than salmon, which are identified as anadromous species that live in salt water and migrate into freshwater to spawn) for the adult tribal RME scenario was 97.5 grams of seafood per day (three meals per week, assuming a meal weighs 227 grams, which is about 8 ounces); the total consumption rate of non-anadromous seafood for the Suquamish scenario was 583.5 grams of seafood per day (2.6 meals per day, assuming a meal weighs 227 grams). Contaminant exposure associated with consumption of anadromous species (i.e., salmon) were not included in the HHRA because it was assumed that the site-associated salmon body burden (as opposed to body burden from open ocean migration) is not substantial.

There is uncertainty associated with the application of the seafood consumption rates used at the Lockheed West Site. The rates employed assume that all Puget Sound harvested seafood consumed by tribal members comes from the Lockheed West Site. Tribes with treaty rights to obtain seafood from the West Waterway and Elliott Bay areas of the Site may increase their consumption rate in the future as contamination conditions improve in the overall lower Duwamish system and Elliott Bay, including waters of the Lockheed West Site. Any future habitat improvements could also increase the harvestable population of fish and shellfish to some degree.

The exposures of humans were quantified using exposure equations and exposure point concentrations (EPCs) that are the concentrations of COPCs in sediment and seafood tissues. The EPC is either the maximum concentration or the upper 95 percent confidence limit on the mean concentration of a COPC, and is intended to represent a long-term exposure concentration. Sediment EPCs were derived for beach play and clamming exposures to all intertidal sediment as well as for netfishing exposures to subtidal plus intertidal sediment. The exposure frequency for the beach play scenario, set at 65 days per year, was based on a survey of parks adjacent to lakes that was conducted by King County, and represents the 95^{th} percentile of exposure frequency for children up to 6 years old who play in sand near the water. The clamming scenario assumed that people are exposed to COPCs in sediment as they dig for clams. Two clamming scenarios were evaluated: a tribal clamming RME scenario of 120 days of clamming per year, and a tribal clamming scenario of 183 days per year. The 183 days per year clamming scenario was included at the request of EPA and the tribes to represent a high-end clamming frequency, consistent with the scenario evaluated in the LDW HHRA. The clamming scenarios used chemical concentration data from all intertidal areas at the Site, regardless of whether clams may be present or whether habitat may be suitable for clams. The netfishing scenario was based on information on tribal netfishing practices that was used in the LDW HHRA.

Seafood tissue concentrations of COPCs were estimated from the Site sediment concentrations. Modeling was performed using biota-sediment accumulation factors (BSAFs) and regression equations that relate tissue concentrations of chemicals to the concentrations in sediment. BSAFs are single numerical values that were taken from multiple public databases (e.g., the U.S. Army Corps of Engineers [USACE], Washington Department of Health) and the scientific literature. The regression equations were derived from a food web model produced in the RI report for the LDW site, and which was calibrated with LDW site data on chemical concentrations in sediment and in tissues of fish, crabs, and clams. For the seafood consumption scenario, seven seafood categories were evaluated, consistent with the LDW HHRA: pelagic fish (i.e., fish that primarily live and feed in the water column), fillets of benthic fish (i.e., fish that primarily live and feed along the bottom or within the sediments), whole bodies of benthic fish, edible meat of crabs, and whole bodies of crabs, clams, and mussels. Although consumption rates differ for each of these tissue categories, the COPC concentrations for some categories did not differ because they were modeled using the same parameter values (e.g., chemical concentrations in pelagic fish, fillets of benthic fish, and whole body benthic fish were modeled using a single BSAF or regression equation for each chemical due to limitations in their availability).

ES.3 TOXICITY ASSESSMENT

The Toxicity Assessment identifies appropriate toxicity values for all COPCs. Toxicity values consist of the cancer slope factor (CSFs) for evaluation of carcinogenic risks and reference doses (RfDs) for evaluation of effects other than cancer. Toxicity values for each COPC are taken from EPA sources and are based on either laboratory experiments using animals or epidemiological studies of human populations who were unintentionally exposed in the workplace or in the environment. The CSFs provide a health-protective means to evaluate risks because they represent upper bound estimates of carcinogenic potency.

Non-cancer RfDs are health-protective because they are typically based on the most sensitive endpoint and population for which adequate data are available. The derivation of each RfD includes uncertainty and modifying factors to account for sensitive sub-populations or other limitations of the toxicity data on which they were based. The toxicity values are used with the EPCs identified in the Exposure Assessment to quantify the risk estimates, performed in the Risk Characterization section.

ES.4 RISK CHARACTERIZATION AND UNCERTAINTY ANALYSIS

In the Risk Characterization, carcinogenic risks and non-carcinogenic hazards are evaluated separately because of fundamental differences in assumptions about the mechanism of these toxic effects. Carcinogenic risk estimates were calculated by multiplying the estimated chemical intake into the body by the CSF. Where cancer risk estimates exceed 1×10^{-2}, the exponential equation was used in the calculation. Cancer risk estimates were compared with the EPA acceptable risk range of 10^{-6} to 10^{-4} established in the National Contingency Plan for Superfund sites (40 Code of Federal Regulations 300). The American Cancer Society estimates that lifetime risk of developing cancer in the U.S. population is one in two (i.e., 5×10^{-1}) for men and one in three (i.e., 3×10^{-1}) for women. A 1×10^{-6} excess cancer risk represents an additional one-in-one-million chance that an individual may develop cancer over a 70-year lifetime as a result of exposure to chemicals in Lockheed West Site sediments (either through direct exposure or indirect exposure through the consumption of seafood).

Chemicals with non-carcinogenic health effects are generally not toxic below a certain threshold; a critical chemical dose must be exceeded before adverse health effects are observed. The potential for non-carcinogenic health effects is represented by the ratio of the estimated chemical intake to the RfD; it is expressed as a hazard quotient (HQ). Exposures resulting in an HQ less than or equal to 1 are unlikely to result in non-cancer adverse health effects.

Estimated excess cancer risks were higher for the seafood consumption scenarios than the direct sediment exposure scenarios. Estimated cancer risks for seafood consumption scenarios are summarized in Table ES-1. For the adult tribal RME seafood consumption scenario based on Tulalip data, the total cancer risk for all carcinogenic chemicals was 9×10^{-3} (i.e., an additional nine in one thousand chance of developing cancer), with equal contributions to the risk estimates from inorganic arsenic, PCBs, and cPAH (i.e., each contributed 3×10^{-3}). For the Suquamish adult tribal seafood consumption scenario, the cumulative risk for all carcinogenic chemicals was 5×10^{-2}, and the tribal child cumulative risk for all carcinogenic chemicals was 4×10^{-3}.

The excess cancer risks from inorganic arsenic are largely attributable to the inorganic arsenic concentrations that were modeled in clams. The modeling assumed that 40 percent of total arsenic in clams was the inorganic form, based on data presented in the LDW RI. Cumulative excess cancer risks for the child seafood consumption scenarios were lower than those for adults (4×10^{-3} or about 44 percent of adult risks), although the excess cancer risks associated with cPAHs were about the same because of the greater sensitivity of children to cancer from cPAHs. The excess cancer risks for the adult tribal scenario based on Suquamish data were more than five times higher than risks for the adult tribal RME scenario based on Tulalip data, reflecting the much higher seafood consumption rate (almost three meals per day) used in the adult tribal scenario based on Suquamish data.

In the evaluation of non-cancer hazards, the hazard index (which is the sum of the individual chemical hazard quotients) for each seafood consumption scenario was much greater than 1. PCBs and TBT concentrations modeled into seafood accounted for greater than 90 percent of the non-cancer hazards for both the adult tribal RME and the child tribal seafood consumption scenarios. For the adult tribal scenario based on Suquamish data, PCBs and TBT accounted for 76 percent of the non-cancer hazards, with arsenic contributing 14 percent.

Table ES-1. Summary of Risks for Seafood Ingestion Scenarios

Scenario Name	Ingestion Rate (g/day)						Meals per Month[3/]	Excess Cancer Risk	Non-Cancer Hazard Index[4/]
	Pelagic Fish	Benthic Fish[1/]	Crab[2/]	Mussel	Clam	Total			
Adult tribal RME (Tulalip data)[5/]	8.1	7.5	43.4	0.82	37.7	97.5	13.1	9×10^{-3}	173
Child tribal RME (Tulalip data)[6/]	3.24	3	17.4	0.33	15.1	39.0	5.2	4×10^{-3}	372
Adult tribal[7/] (Suquamish data)	56	29.1	54.8	5	438.6	583.5.	78	5×10^{-2}	478

[1/] Includes fillet and whole-body consumption.
[2/] Includes edible meat and whole-body consumption.
[3/] It is assumed that one meal is equal to 227 g. This assumption was applied to both adult and child scenarios, although a child's meal size may be considerably smaller.
[4/] Total across all chemicals. This total is not directly interpretable for risk assessment. The values indicate that the HQ exceeds 1 for individual endpoints.
[5/] Exposure duration of 70 years, body weight 81.8 kg.
[6/] Exposure duration of 6 years, body weight 15.2 kg.
[7/] Exposure duration of 70 years, body weight 79 kg.
Hazard Index – sum of the HQs for individual chemicals
RME – reasonable maximum exposure
Table format adapted from the HHRA report for the LDW site

Excess cancer risks for the direct sediment exposure scenarios were much lower than those for the seafood consumption scenarios (Table ES-2). With the exception of the tribal clamming 183-days-per-year scenario, all excess cancer risk estimates for RME direct sediment exposure scenarios were less than or equal to 1×10^{-4}. Total excess cancer risk from the tribal clamming 183-day-per-year scenario was 2×10^{-4}. For non-cancer risks, the hazard index (which is the sum of the individual chemical hazard quotients) for the child beach play scenario was 2.6, with an arsenic hazard quotient at 1.8; hazard indices for the remaining direct sediment exposure scenarios were less than 1.

The final step of the risk characterization is to identify risk drivers for the Lockheed West Site HHRA. Risk drivers are defined as chemicals contributing the majority of the site risks. The procedure for designating risk drivers followed that of the LDW HHRA, to first identify chemicals of concern (COCs), which are defined as chemicals with excess cancer risk estimates greater than 1×10^{-6} or an HQ greater than 1 for any RME exposure scenario. Risk drivers were then designated from the COC list based on the risk magnitude. In addition, although dioxins and furans were not analyzed at the Site, they are identified as COCs and risk drivers for the direct contact and seafood consumption scenarios, based on their assumed presence in sediment and seafood and assumed cancer risk estimates above regulatory thresholds.

Table ES-2. Summary of Risks for Direct Sediment Exposure Scenarios

Scenario Name	Exposure Area	Age Class	Incidental Sediment Ingestion Rate (g/day)	Exposure Frequency (days/yr)	Exposure Duration (years)	Skin Surface Area Exposed (cm^2)	Excess Cancer Risk	Non-Cancer Hazard Index[1/]
Beach play	all intertidal area	0 to 6 yrs	0.20	65	6	varies by age[2/] (1,330 to 2,751)	7×10^{-5}	2.6
Tribal clamming RME scenario	all intertidal area	adult	0.1	120	64	6,040[3/]	1×10^{-4}	0.5
Tribal clamming 183 days per year	all intertidal area	adult	0.1	183	70	6,040[3/]	2×10^{-4}	0.7
Netfishing	all subtidal and intertidal	adult	0.050	119	44	3,600[4/]	3×10^{-5}	0.1

1/ Total across all chemicals. This total is not directly interpretable for risk assessment, but a value greater than 1 suggests that an HQ may exceed 1 for individual endpoints.

2/ Assumes that 35% of the total child body surface area is exposed, roughly corresponding to an individual wearing a short-sleeve shirt and short pants but no shoes.

3/ Assumes that 39% of the total adult body surface area is exposed, roughly corresponding to a barefoot individual wearing a short-sleeve shirt and short pants.

4/ Recommended surface area for commercial/industrial worker. Assumes that head, hands, and forearms are exposed.

Hazard Index – sum of the HQs for individual chemicals

RME – reasonable maximum exposure

Table format adapted from the HHRA report for the LDW site

The RME scenario with the highest excess cancer risks was the tribal adult seafood consumption based on Tulalip data, whereas the tribal child seafood consumption scenario had the highest non-cancer risks. Of the nine chemicals identified as COCs, four are identified as risk drivers for seafood consumption: PCBs, arsenic, cPAHs, and TBT. For direct sediment exposures, the RME scenario with the highest excess cancer risks was the tribal clamming at 120 days per year. Only two chemicals were identified as COCs for the tribal clamming RME scenario and are thereby identified as risk drivers: arsenic and cPAHs.

As part of the characterization of risks for the Lockheed West Site, numerous uncertainties were examined that could affect interpretation of risks or the management of risks. Of primary importance to this HHRA, all exposure scenarios that were considered relevant to the Lockheed West Site conditions and their inherent exposure parameters were borrowed directly from the LDW site HHRA; whereas the sediment chemistry data are specific to the Lockheed West Site. The use of exposure parameters that are not site-specific and the use of modeling to determine the concentrations of chemicals in seafood entail high levels of uncertainty.

Modeling seafood tissue concentrations of chemicals entails substantial uncertainty because of the limited availability of BSAFs in the databases and literature, and uncertainty over their application to the conditions of the Site. For metals accumulation in particular, very few BSAFs were available. As an alternative to the limited database and literature BSAF values that were used in the modeling of seafood consumption scenarios, EPA performed an analysis of site data from the LDW for fish and crabs, and site data collected on clams from the Lockheed West Site, in order to calculate BSAFs for metals. Results of analyzing collocated sediment and tissue concentrations by subarea of the LDW for fish and crab, and collocated sediment and tissue samples for clams from the Lockheed West Site, demonstrated a lack of association between sediment and tissue concentrations of all metals for all organisms. EPA therefore developed BSAFs using site-wide sediment and tissue data. Application of the alternative BSAFs to the modeling of exposures and risks for the adult and child RME tribal seafood consumption scenarios showed that excess cancer risks from arsenic would increase from the 10^{-3} range to the 10^{-2} range for adults, and from the 10^{-4} range to the 10^{-3} range for children. For non-cancer effects, chromium and mercury would be identified as additional COCs for the Site. Arsenic is already identified as a risk driver for the Site based on the modeling performed with database BSAFs, and the estimated hazards for the non-cancer metals would not be sufficient to identify these metals as additional risk drivers.

Although the Lockheed West Site is much smaller than the upstream LDW site, with much smaller exposed intertidal areas for collection of clams and smaller areas for fish and crab to contact sediments and take up chemicals from the site, the risks calculated for direct exposures to sediments and for ingestion of seafood were higher than risks estimated for the LDW site. The use of the LDW exposure scenarios provides consistency between the two sites in the identification of risk drivers and future cleanup decisions. This comparison with the LDW HHRA highlights the health-protective nature of the approach to the HHRA for the Lockheed West Site. This approach resulted in the determination of human health risk estimates that support active remediation for the Lockheed West Site.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACRONYMS AND ABBREVIATIONS

ABS	dermal absorption factor
AF	adherence factor
ALM	Adult Lead Model
ATSDR	Agency for Toxic Substances and Disease Registry
BAF	bioaccumulation factor
BSAF	biota-sediment accumulation factor
BW	body weight
CalEPA	California Environmental Protection Agency
CDI	chronic daily intake
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
COC	chemical of concern
COPC	chemical of potential concern
cPAH	carcinogenic polycyclic aromatic hydrocarbon
CSF	cancer slope factor
CSM	conceptual site model
CSO	combined sewer overflow
dw	dry weight
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
ERA	Ecological Risk Assessment
FWM	food web model
GC/ECD	gas chromatography/electron capture detector
GC/MS	gs chromatography/mass spectrometry
GSD	geometric standard deviation
g/day	grams per day
HEAST	Health Effects Assessment Summary Tables
HHRA	Human Health Risk Assessment
HI	hazard index
HQ	hazard quotient
HSDB	Hazardous Substances Data Bank

IEUBK	Integrated Exposure Uptake Biokinetic Model
IRIS	Integrated Risk Information system
IR	ingestion rate
LDW	Lower Duwamish Waterway
LOAEL	lowest-observed-adverse-effect-level
µg/kg	micrograms per kilogram
µg/L	micrograms per liter
mg/kg	milligrams per kilogram
mg/kg-OC	milligrams per kilograms organic carbon normalized
mg/L	milligrams per liter
MLLW	mean lower low water
NCEA	National Center for Exposure Assessment
NOAA	National Oceanic Atmospheric Administration
NOAEL	no-observed-adverse-effect-level
NPL	National Priorities List
OC	organic carbon
OSWER	Office of Solid Waste and Emergency Response
PAH	polycyclic aromatic hydrocarbons
Pb	lead
PCB	polychlorinated biphenyls
PEF	potency equivalency factor
PSAMP	Puget Sound Ambient Monitoring Program
QAPP	Quality Assurance Project Plan
RBACG	risk-based analytical concentration goal
RBC	risk-based concentration
RBTC	risk-based threshold concentration
RCRA	Resource Conservation and Recovery Act
RfD	reference dose
RI/FS	Remedial Investigation/Feasibility Study
RL	reporting limit
RME	reasonable maximum exposure
Site	Lockheed West Seattle Superfund Site

SVOC	semivolatile organic compound
TBT	tributyltin
TEQ	toxic equivalent
UCL	upper confidence limit
USACE	U.S. Army Corps of Engineers
WDOH	Washington State Department of Health
ww	wet weight

1. INTRODUCTION

This document presents the baseline human health risk assessment (HHRA) as part of the remedial investigation and feasibility study (RI/FS) for the Lockheed West Site. The Lockheed West Site was added to the U.S. Environmental Protection Agency (EPA) National Priorities List (NPL) under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), also known as Superfund, as the "Lockheed West Seattle Superfund Site" (herein referred to as the Lockheed West Site or the Site). The Site was formerly known as Lockheed Shipyard No. 2, and is located in West Seattle, Washington (Figure 1-1).

The baseline HHRA for the Lockheed West Site is performed as per Section II, Subtask 1.8 of the Statement of Work, Appendix A to the Administrative Settlement Agreement and Order on Consent for the Lockheed West Site. This introductory text describes the purpose and scope of the HHRA as well as an overview of the technical approach to performing the HHRA that is consistent with the EPA-approved RI/FS work plan and EPA guidance for performing risk assessments under CERCLA.

1.1 PURPOSE OF THE HUMAN HEALTH RISK ASSESSMENT

Consistent with the EPA (1991a) Office of Solid Waste and Emergency Response (OSWER) Directive 9355.0-30, the overall purposes of the baseline HHRA for the Lockheed West Site are to identify potential human health risks at the Site, identify chemicals of concern (COCs) for human health, support remedy selection, and provide information for selecting risk-based cleanup levels and remediation monitoring criteria. Lockheed Martin Corporation recognizes that "no action" and natural recovery are not likely to meet CERCLA criteria for remedy selection, and is focused on active remediation of the entire Lockheed West Site, which is described in the RI/FS Work Plan (Tetra Tech 2008a). Although active remediation will reduce exposures of humans to the present sediment contaminants, the presence of Site contamination requires performance of a baseline risk assessment to indicate the potential extent of risk under present site conditions, provide risk information to affected tribes and the public, support the remedy selection for the sediments that will mitigate the risk, and provide context for long-term monitoring and remedy evaluation.

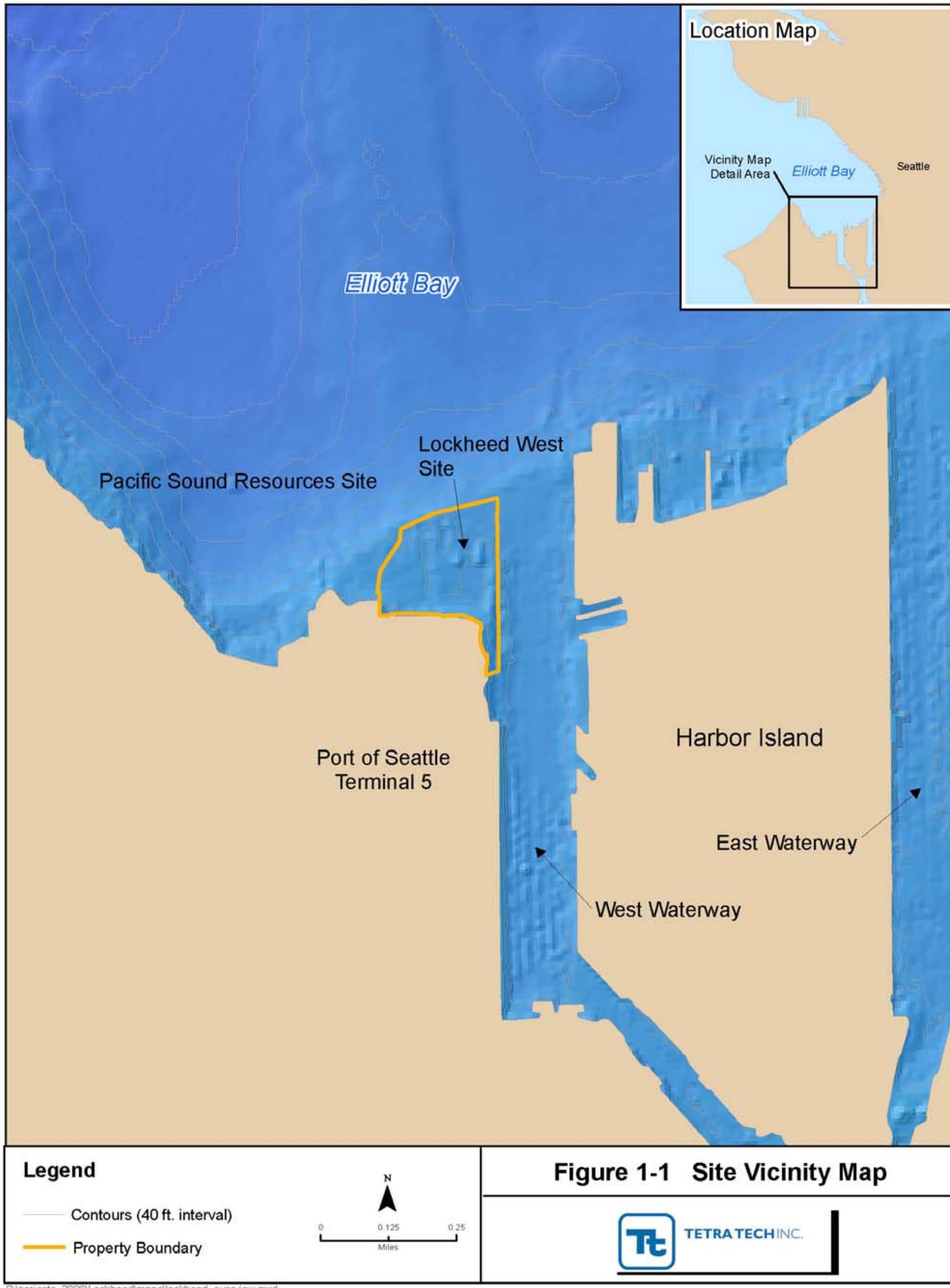


Figure 1-1 Site Vicinity Map

P:\projects_2006\Lockheed\maps\lockheed_overview.mxd

The plan to actively remediate the entire site minimizes the need to calculate site-specific risks at a level of specificity to demonstrate acceptability of the no-action alternative or natural recovery of sediments. As described in more detail below, the overall approach to this HHRA is considered to be appropriate for the potential future human populations and potential future exposure conditions at the Site. In particular, the resultant risk estimates of this HHRA will be protective of tribal consumers of seafood, who have treaty rights for seafood collection from the Site, and of children who may play in the intertidal sediment.

1.2 SITE DESCRIPTION

The Site includes both the aquatic property occupied by the former shipyard and the areas of Elliott Bay and the West Waterway immediately adjacent to the former shipyard property. The Site is bounded by Elliott Bay on the north, Harbor Island West Waterway on the east, and Pacific Sound Resources (PSR) Superfund Site on the west (Figure 1-1). It includes approximately 7 acres of aquatic land now owned by the Port of Seattle (formerly owned by Lockheed Martin Corporation) and approximately 20 acres owned by Washington Department of Natural Resources (DNR) and historically leased to Lockheed Martin.

Lockheed Martin Corporation discontinued operations at Lockheed Shipyard No. 2 in 1987 after approximately 45 years of continuous operations by Lockheed and others that included shipbuilding, ship repair, and ship maintenance. Shipbuilding, including repair and maintenance, has been associated with the production of metals wastes. The contaminants found in the aquatic area of the Site include hazardous substances associated with shipbuilding, repair, and maintenance activities, consistent with the historical uses of the facility. Other contaminants not directly associated with shipyard activities may be present at the Site. Historical shipyard contaminants include, but are not limited to, polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), mercury, other metals, and other organic compounds.

1.3 SCOPE OF THE HUMAN HEALTH RISK ASSESSMENT

The scope of the HHRA consists of a baseline risk assessment following EPA guidance for Superfund sites, which is described more fully below. Methodology is consistent with EPA guidelines for performing HHRA at Superfund sites (e.g., EPA 1989, 1996, 1998a, 2004), particularly the guidance for assessing risks under the EPA Region 10 tribal framework (EPA 2007b).

The HHRA follows an EPA-approved work plan developed as part of the RI/FS work plan for the Site (Tetra Tech 2008a). In development of the work plan for the Lockheed West Site RI/FS and risk assessments, preliminary screening-level risk estimates indicated that cancer risks would exceed EPA CERCLA regulatory threshold levels for a tribal seafood consumption scenario, based on existing sediment data and using exposure parameters developed in the HHRA for the nearby Lower Duwamish Waterway (LDW) CERCLA site (Windward 2007a), located upstream of the Lockheed West Site. Because of the expectation that cancer risk would exceed regulatory thresholds, and also because of the commitment of Lockheed Martin Corporation to actively remediate the entire site, the approach to satisfy the risk assessment goals for the Lockheed West Site was to streamline the HHRA design and to use technical information on exposure assessment from the HHRA performed at the nearby LDW site. Not all exposure parameters needed to be site-specific; sediment chemistry data collected from the Site were used as site-specific exposure data. Thus, the approach to the HHRA was designed to use exposure parameters taken from the LDW site together with sediment chemistry data collected from the Lockheed West Site.

The use of LDW HHRA technical information for the Lockheed West HHRA is based on the assumptions that the types of seafood resources and human uses at the Lockheed West Site are similar, or could be similar under future conditions, to those present or assumed for the LDW site. The assumption that seafood resources are similar to those evaluated in the LDW HHRA is based on the proximity of the Lockheed West Site downstream of the LDW site within the same water body (see Figure 1-2), the presence of similar subtidal and intertidal habitat, and the results of several seafood consumption surveys for the lower Duwamish River and Elliott Bay regions. The results of past seafood consumption surveys for the area were summarized in the HHRA for the West Waterway site (ESG 1999), which is located adjacent to the Lockheed West Site. The seafood species that were documented as consumed in the West Waterway and lower Duwamish River were subsequently used for selecting seafood categories for both the West Waterway HHRA and the LDW HHRA, and are used in this HHRA for the Lockheed West Site. In addition, an earlier HHRA performed for the Pacific Sound Resources CERCLA site (Weston 1998b), located on Elliott Bay adjacent to the western boundary of the Lockheed West Site, also selected similar seafood categories for a tribal seafood consumption scenario. The seafood categories were partly based on shellfish surveys and trawl catch from Elliott Bay, which documented various marine clam and fish species in subtidal Elliott Bay that are consistent with those found during later surveys in the West Waterway (ESG 1999) and in the LDW (Windward 2007a). As summarized in Windward (2007a), shiner surfperch, snake prickleback, Pacific sandlance, Pacific staghorn sculpin, longfin smelt, English sole, and starry flounder were particularly abundant in these studies, as were juvenile Chinook, chum, and coho salmon.

Arsenic was identified as a risk driver chemical in the LDW HHRA based on site-specific data. For the Lockheed West HHRA, in the absence of site data, the assumption was made that the tissue of clams contained inorganic arsenic as a percent of total arsenic at the level found with the Eastern softshell clam, *Mya arenaria*, at the LDW site. However, the Eastern softshell clam generally prefers a lower salinity environment than other more commonly consumed clam species found in the lower Duwamish waterways (e.g., Littleneck and butter clams). Surveys of both the Lockheed West Site (i.e., West Waterway and Elliott Bay areas) and East Waterway suggest that the Eastern softshell clam is not common in the marine environments downstream of the Duwamish estuary. The percent of inorganic arsenic in *M. arenaria* was much higher than percents found in other clams in the Duwamish corridor, including those that prefer a more saline environment and have been found at the Lockheed West Site. Therefore, the assumption of proportional inorganic arsenic concentrations may over-estimate inorganic arsenic in tissues of clams that have been found or would likely be found at the Lockheed West Site, and is considered to be health protective.

The Lockheed West, West Waterway, and LDW sites are all estuarine, although the LDW site has a greater freshwater component, which increases in the upstream reaches. Nonetheless, the LDW site was evaluated for seafood consumption risks using marine/estuarine species typical of Puget Sound bays, consistent with the species earlier identified in surveys for HHRAs in Elliott Bay and the West Waterway. Thus, although the Lockheed West Site environment may be more saline than the LDW site due to the presence of Elliott Bay on the north side, the estuarine/marine species evaluated in the LDW HHRA will generally be present at the Lockheed West Site as food sources for humans.

Besides seafood consumption, additional present or possible future human uses of the Lockheed West Site were identified in the work plan, and are evaluated in this HHRA. The selection of additional human uses for the HHRA is based on the similarity of site conditions to those of the West Waterway and LDW sites. For each human use selected for evaluation at Lockheed West, the work plan identified specific exposure scenarios and pathways, and sources for parameter values for estimating exposures and risks. All exposure pathways and parameter values are taken from the LDW HHRA.

The work plan describes several approaches to modeling tissue concentrations from the sediment chemistry data. These approaches consist of using literature and database values

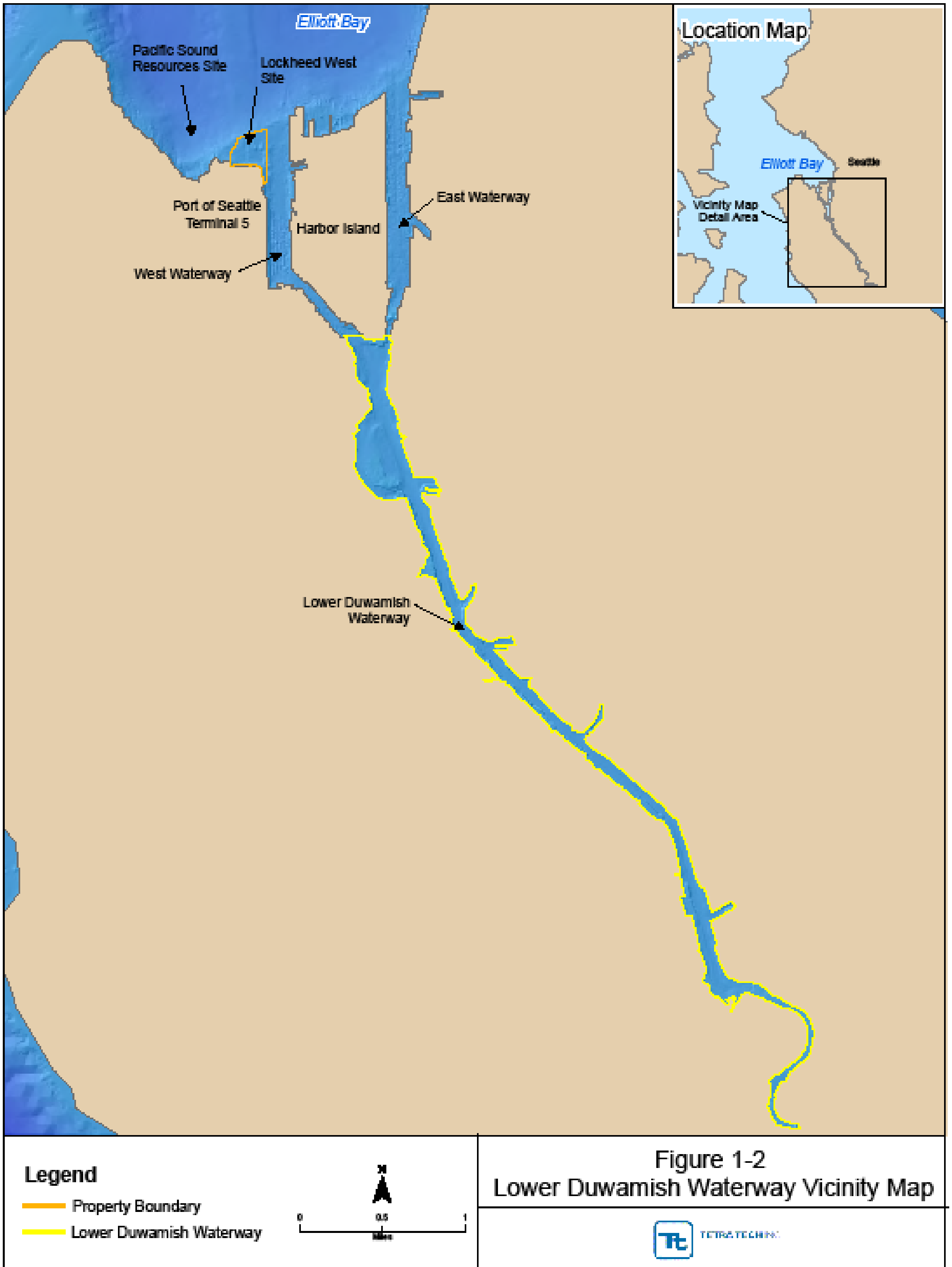


Figure 1-2
Lower Duwamish Waterway Vicinity Map

P:\projects_2008\Lockheed\maps\LDW_overview_1-2.mxd for biota-sediment accumulation factors (BSAFs) for both organic chemicals and metals, regression equations from the LDW site that relate chemical concentrations in benthic invertebrate tissue with sediment levels, and regression equations developed from a food web model (FWM) for PCBs that relate PCB concentrations as total Aroclors in tissues of various aquatic organisms to sediment concentrations. The work plan identified the procedures for using existing BSAFs and for calculating percentiles from database values, and identified the specific sources of the BSAFs, which included compilations in technical reports, summaries in peer-reviewed scientific literature, and federal agency electronic databases. The work plan also recognized that field data from the nearby LDW site could be compiled and used to develop regional BSAFs for various organisms.

In summary, the approach to the HHRA for the Lockheed West Site is to use a combination of site-specific sediment chemistry data, exposures parameters developed for the LDW site HHRA, and EPA guidance on literature values to estimate risks to human receptors. In using all of the LDW exposure parameters for the Lockheed West HHRA, the size of the contaminated area of the Site is not factored into the exposure estimates. In other words, area use factors for aquatic organisms for which tissue concentrations are modeled and fraction contaminated terms are not used in the modeling of exposures; they are assumed to be 1.0 for this HHRA. Although the important consideration in contaminant accumulation by organisms is the specific location where the organisms feed, area use factors would consider the fraction of exposure related to foraging ranges when modeling uptake of sediment chemicals into organisms (EPA 1997c, 2000a, 2001, 2005c), and the fraction contaminated term is a parameter indicating the fraction of contaminated seafood consumed by humans that comes from the Site (EPA 1989). The purpose of setting these terms to 1.0 is to maintain consistency in estimating cleanup levels with other nearby sites. Consistent cleanup levels among the sites within the Duwamish Waterway/Elliott Bay region are necessary to ensure that cleanups achieve the common goal of health protectiveness for the highest exposed populations that use the resources of the region. Use of the LDW exposure scenarios and all inherent assumptions and exposure parameters is a health-protective approach for the Lockheed West Site, and is protective of human populations who might use the site in the future.

The format of the HHRA document and presentation of technical information follows the LDW HHRA document. The HHRA is presented below under sections of Data Evaluation and Screening (Section 2), Exposure Assessment (Section 3), Toxicity Assessment (Section 4), Risk Characterization (Section 5), Uncertainty Analysis (Section 6), and Summary of Risk Conclusions (Section 7). The sources of the chemicals for which risks are estimated are not identified or assumed in this risk assessment, but will be evaluated in the RI.

2. DATA EVALUATION AND SCREENING

The following presents the data and their sources for the baseline HHRA for the Lockheed West Site. The subsections describe data availability, data reduction, and the suitability of data for risk assessment purposes.

2.1 DATA AVAILABILITY AND SELECTION

The Lockheed West HHRA evaluates human health risks associated with exposure to contaminated sediment and seafood tissue that may be consumed from the Site. Environmental data for the Lockheed West Site are available for sediment chemistry, and are discussed in the following section. Tissue chemical concentration data are modeled from the sediment data, as described in Section 3.

2.1.1 Sediment Chemical Data

Surface sediment chemistry data are available for the Lockheed West Site from the 2007 sampling event, as described in the data report (Tetra Tech 2008b). Both intertidal and subtidal sediment chemistry data are used in the baseline HHRA. An elevation of -2 ft mean lower low water (MLLW) was used to divide intertidal and subtidal locations, which corresponds to the shoreline (i.e., land/water interface) elevation identifiable in aerial photos. Nine surface sediment samples were collected from intertidal locations, and 42 surface sediment samples were collected from subtidal locations, for a total of 51 surface sediment samples. All surface sediment samples were collected from 0 - 10 cm depth. Surface sediment station locations that were sampled in 2007 at the Lockheed West Site are shown in Figure 2-1.

The chemical analyte list for the 2007 sampling event was compiled from existing data and chemicals that were suspected to be present in Lockheed West Site sediments. For example, hydrophobic organic chemicals, such as organochlorine pesticides, that have been detected in LDW sediments upstream of the Lockheed West Site are included in the list of chemical analytes for sediments at the Lockheed West Site. Their inclusion is based on the assumption that they could transport downstream as particle-bound constituents that may deposit in the aquatic environment of the Lockheed West Site.

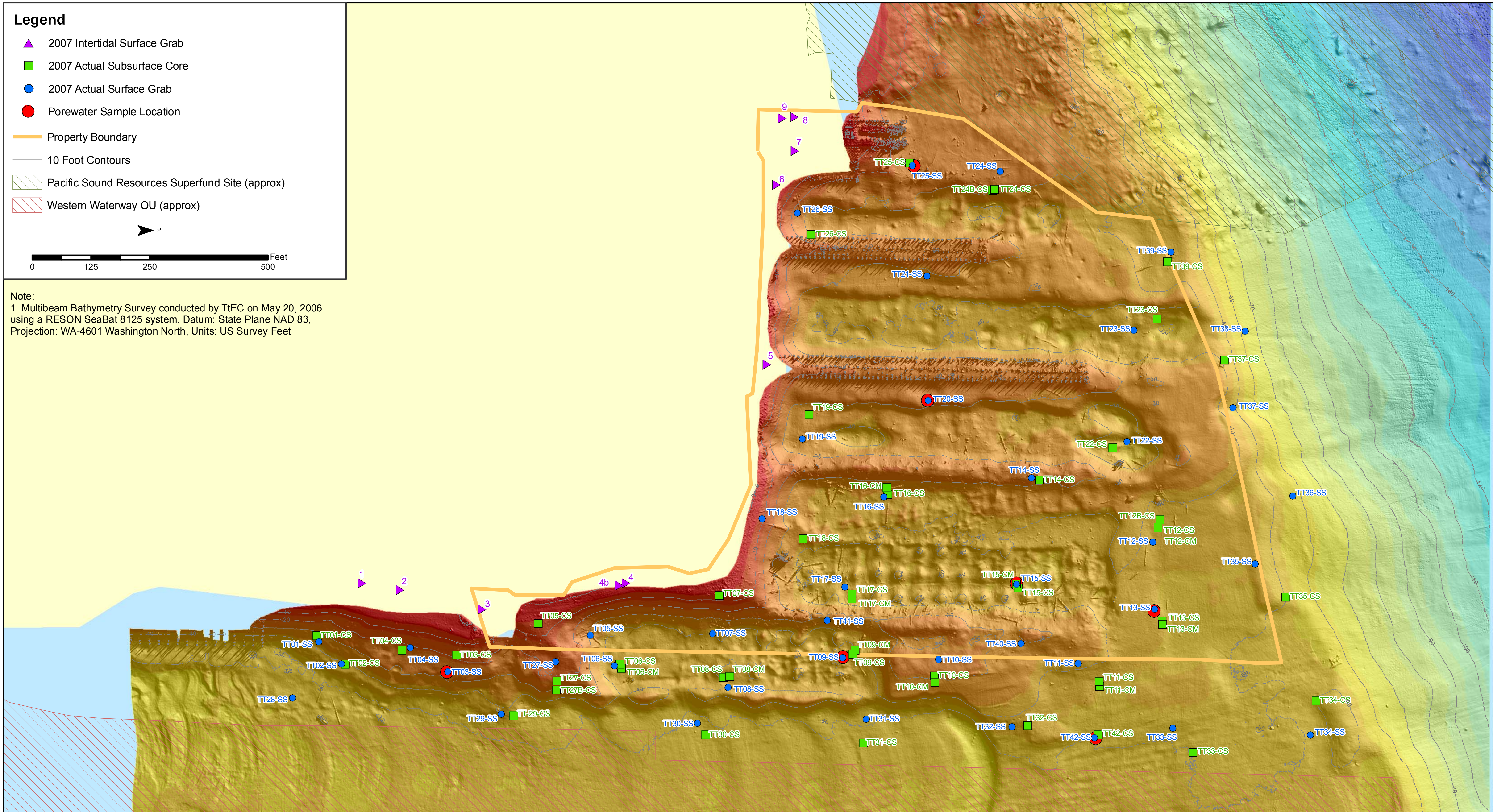
The methods for data collection and analysis of surficial sediments at the Lockheed West Site were consistent with reporting limits that best met risk-based analytical concentration goals (RBACGs). The RBACGs were presented in the RI/FS work plan (Tetra Tech 2008a) and were used for comparison with method detection limits for sediment sampling in order to ensure that the detection limits were low enough to detect concentrations of chemicals below risk-based concentrations. For sediments, RBACGs are concentrations of chemicals in sediment that are associated with an acceptable risk level as derived from state standards, the toxicity literature, or human health guidance documents. Sediment RBACGs were taken from the quality assurance project plan (QAPP) for sampling sediments at the LDW site (Windward 2005). The RBACGs are considered protective of human receptors exposed to chemicals via direct contact with contaminated sediment, or by indirect sediment contaminant contact from ingestion of fish and shellfish that have acquired site-related body burdens of contaminants.

In the development of RBACGs for the LDW site, Windward (2005) first identified or derived sediment risk-based concentrations (RBCs) for the protection of human exposures. RBCs for the protection of human health were derived for both direct and indirect (i.e., seafood consumption) exposure pathways. For the seafood consumption pathway, RBCs were calculated for bioaccumulative chemicals identified in Table 4-2 of EPA (2000a). Sediment RBCs for the seafood consumption pathway were based on modeling acceptable levels from clam tissue to sediment based on BSAF relationships. From the list of RBCs for indirect and for direct exposures, the RBACGs for sediment were then set equal to the lowest RBC for each chemical. (Further discussion of the development of the RBACGs is presented below in Sections 3.2.2 and 3.2.3 that describe their use as screening criteria for human health.)

2.1.2 Fish and Shellfish Tissue Chemistry

Concentrations of chemicals in tissues of seafood items are derived from modeling using the sediment concentrations from the 2007 dataset. The methods for modeling tissue data are described in the Exposure Assessment (Section 3) of this HHRA.

At the upstream LDW site, fish, shellfish, and other macroinvertebrate species were identified that were considered of importance to human users of the site (Windward 2007a). Presumably, many if not most of the aquatic species identified at the LDW site could use the Lockheed West Site sediment areas, since the Site is located just downstream of the LDW site. In addition, the species identified at the LDW site and that are evaluated for human consumption exposures are marine species that are found in Puget Sound, including Elliott Bay, and would generally be expected to be found throughout the lower Duwamish waterway, including the West Waterway portion of the Lockheed West Site.



TETRA TECH INC.

Lockheed West
Shipyard No. 2
Seattle, WA

Figure 2-1 Sediment Sampling Locations

Z:\projects_2006\Lockheed\maps\EA_figs_10-22-08\Figure_2-2_2007_samples.mxd

Fifty-three resident and non-resident fish species were captured in the lower Duwamish waterway during sampling to support the RI for the LDW site (Windward 2007a). Abundant species included shiner surfperch, snake prickleback, Pacific sandlance, Pacific staghorn sculpin, longfin smelt, English sole, and starry flounder, as well as juvenile Chinook, chum, and coho salmon. Benthic invertebrates found in the LDW include various species of clams, crabs, mussels, sea stars, and shrimp. The observed fish species reported in the LDW surveys (Windward 2007a) are summarized in the Ecological Risk Assessment (ERA) that accompanies this HHRA for the Lockheed West Site. Predominant species that were collected from the West Waterway and Elliott Bay for the West Waterway and PSR risk assessments (ESG 1999, Weston 1998b) were similar to those evaluated in the LDW HHRA. These include English sole, slender sole, shiner and surf perch, rock crab, and clams.

For exposure pathways involving the ingestion of clams, the LDW HHRA used tissue chemistry data collected on the Eastern softshell clam, *Mya arenaria*, as the predominant clam species in the LDW. *M. arenaria* tissue contained much higher content of inorganic arsenic as a percentage of total arsenic than other types of clams collected from the Site or from other areas of Puget Sound. Because surveys of both the Lockheed West Site and East Waterway suggest that the Eastern softshell clam is not common in the more saline environments at those sites, the assumption of proportional inorganic arsenic concentrations that was used in the modeling of inorganic arsenic in tissues of clams at the Lockheed West Site may over-estimate exposures to inorganic arsenic in clams.

2.2 DATA REDUCTION

Data reduction refers to computational methods used to aggregate data. Several concentrations that had laboratory qualifiers were used without modification in subsequent calculations, including all concentrations qualified as estimated concentrations (i.e., J-flagged data), as diluted samples (i.e., D-flagged data), as detected in a blank sample (i.e., B-flagged data), and as a tentatively identified compound (N-flagged). Some J-flagged data were also N-flagged or D-flagged. JD-flagged data are still used in the risk assessment, but the uncertainty associated with these results is higher than the uncertainty associated with J-flagged results. JN-flagged data are qualified as estimated and tentatively identified, and are discussed further in Section 2.3 as to the suitability of the data for risk assessment.

The most significant use of aggregated data was for the calculation of exposure point concentrations (EPCs), which are intended to represent long-term estimates of exposure in the HHRA. The EPC computation methods are described in detail in the exposure assessment (Section 3.3.4).

Additional procedures related to averaging, selection of the best data points when multiple data are available, selection of significant figures and rounding procedures, and calculating totals for chemical groupings (e.g., polychlorinated biphenyls [PCBs], DDTs) are described below. These procedures are taken from the HHRA for the LDW site (Windward 2007a) for consistency purposes.

2.2.1 Averaging Duplicate Samples

Chemical concentrations obtained from the analysis of laboratory duplicates were averaged for a closer representation of the "true" concentration compared to the results of a single analysis. Three subtidal sediment stations (locations 4, 5, and 6) had duplicate sampling data. Averaging rules were dependent on whether the individual results were detected or undetected chemicals. If both concentrations were detected for a given parameter, the values were averaged arithmetically. If all concentrations were undetected for a given parameter, the minimum reporting limit (RL) was reported. If the concentrations were a mixture of detected and undetected, the detected concentration was adopted.

2.2.2 Significant Figures and Rounding

Analytical laboratories reported results with various numbers of significant figures depending on QAPP instructions, the instrument, parameter, and the concentration relative to the RL. Tracking of significant figures becomes important when calculating averages and performing other data summaries. In the analytical data, if a number was reported with only one significant figure (i.e., 5 or 0.5), it was treated as two significant figures (i.e., 5.0 or 0.50).

When a calculation involves addition, such as totaling PCBs or polycyclic aromatic hydrocarbons (PAHs), the calculation can be only as precise as the least precise number that went into the calculation. For example (assuming two significant figures):

> 210 + 19 = 229 would be reported as 230 because 19 is reported only to 2 significant digits, and the enhanced precision of the trailing zero in the number 210 is not significant.

When a calculation involves multiplication or division using a measured value, such as carbon normalization, the original figures for each value are carried through the calculation (i.e., individual values are not adjusted to a standard number of significant figures; instead the appropriate adjustment is made to the resultant value at the end of the calculation). The result is rounded at the end of the calculation to reflect the value used in the calculation with the fewest significant figures. For example:

> 59.9 × 1.2 = 71.88 would be reported as 72 because there are two significant figures in the number 1.2.

When rounding, if the number following the last significant figure is less than 5, the digit is left unchanged. If the number following the last significant figure is equal to or greater than 5, the digit is increased by 1.

2.2.3 Calculating Totals

Concentrations for several analyte sums were calculated following the procedures in the LDW HHRA:

- Total PCBs were calculated using only detected concentrations for nine Aroclor mixtures that were analyzed (1016, 1221, 1232, 1242, 1248, 1254, 1260, 1262, and 1268) in accordance with Washington State Department of Ecology's (Ecology) Sediment Management Standards (Washington Administrative Code 173-204). Only Aroclors 1254, 1260, and 1268 were detected in the 51 sediment samples. All 51 sediment samples had at least one detected Aroclor (Aroclor 1254).
- Potency equivalency factors (PEFs) were used for totaling carcinogenic PAHs (cPAHs). PEFs relate the carcinogenic potency of carcinogenic PAHs to that of benzo(a)pyrene. cPAH totals were calculated for each sample by summing the products of the concentrations of each individual carcinogenic PAH (benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene) and its compound-specific PEF. If a concentration was identified as undetected, one-half the reported concentration was substituted for the reported concentration. The PEFs were taken from the California Environmental Protection Agency (CalEPA 1994), and are presented in Section 4, Toxicity Assessment.
- Total DDTs were calculated for each sample as the sum of detected concentrations of six isomers and degradation products: 2,4'-DDD, 2,4'-DDE, 2,4'-DDT, 4,4'-DDD, 4,4'-DDE, and 4,4'-DDT. For samples in which all individual isomers were undetected, the single highest RL for that sample was assigned to represent total DDT.
- Total Chlordanes were calculated for each sample as the sum of detected concentrations of five chlordanes: nonachlor (cis), nonachlor (trans), alpha-chlordane, gamma-chlordane, and oxychlordane. For samples in which all individual isomers were undetected, the single highest RL for that sample was assigned to represent total chlordanes.

2.3 SUITABILITY OF DATA FOR RISK ASSESSMENT

The sediment data collected in early 2007 at the Lockheed West Site were collected for use in the risk assessments and RI for the Site. The QAPP for their collection was presented in the RI/FS work plan for the Site (Tetra Tech 2008a). The data underwent third party data validation and are considered suitable for use in the risk assessments for the Site. The only data qualified as rejected (i.e., flagged with the "R" qualifier) and unusable for risk assessment by the data validators were undetected concentrations for benzoic acid. These data were not used in the HHRA, and since all samples of benzoic acid were undetected, benzoic acid was not evaluated further.

The analytical laboratory data reviewers and the data validators identified all organochlorine pesticide samples to have analytical interference from the presence of PCB congeners. The organochlorine pesticides were analyzed using EPA Method 8081 (gas chromatography with electron capture detection [GC/ECD]), which is a standard method used in many environmental investigations for organochlorine pesticides. All detected results for organochlorine pesticide analyses in sediment samples were qualified JN, which indicates "the presence of an analyte that has been 'tentatively identified' and the associated numerical value represents its approximate concentration" (EPA 1999). These data were qualified based on the probable interference in the analysis from PCB congeners. Similar interference and validation qualifiers occurred during the pesticide analysis of sediment and benthic invertebrate, fish, and crab tissues at the upstream LDW site (Windward 2007a). The JN-qualified pesticide data are further evaluated in the uncertainty analysis.

3. EXPOSURE ASSESSMENT

Identification of potentially exposed populations, pathways of exposure, and exposure media make up the conceptual site model (CSM) for the baseline HHRA. Based on assumed similarities in aquatic habitat and potential future human uses between the Lockheed West and LDW sites, as described in Section 1.2 above, the exposure pathways and exposed populations for the Lockheed West HHRA are consistent with the scenarios developed for the LDW HHRA. The exposure scenarios described below are selected from the exposure scenarios investigated in the HHRA for the LDW site. Although the Lockheed West Site is substantially smaller than the LDW site, and general public access to the Lockheed West Site is limited from the upland due to property access restrictions, the subtidal and intertidal areas are accessible from the water by boat. In addition, the Suquamish and Muckleshoot Tribes have treaty rights to harvest that are not constrained by limited public access, and site remediation and potential habitat restoration projects may provide greater opportunities for tribal harvest in the future. With the assumption that access to the Site may increase in the future, the exposure scenarios evaluated in this HHRA sufficiently address potential future exposures and risks, as described in the development of the scenarios in the LDW HHRA (Windward 2007a).

This exposure assessment describes scenarios in which people may come in contact with sediment-associated chemicals and provides equations and parameters so that potential exposures can be quantified. Section 3.1 presents the CSM that introduces the exposure scenarios that are evaluated in this HHRA. Section 3.2 describes the risk-based screening procedure to identify which chemicals are evaluated as chemicals of potential concern (COPCs) in the HHRA. Section 3.3 describes how the exposure scenarios are quantified, including equations used for calculations, and Section 3.4 presents chronic daily intake (CDI) estimates for all chemicals evaluated.

3.1 CONCEPTUAL SITE MODEL AND EXPOSURE SCENARIOS

A CSM is a graphical representation of chemical sources, transport mechanisms, exposure pathways, exposure routes, and potentially exposed populations. It provides the basis for developing exposure scenarios that are evaluated in the exposure assessment component of the HHRA.

The human health CSM for the Lockheed West Site HHRA is presented in Figure 3-1. For the purposes of this HHRA, sediments are the assumed source of chemicals for all exposures at the site, regardless of actual exposure medium, which may consist of tissue, sediment, or surface water. The exposure assessment focuses only on scenarios that include a direct pathway to chemicals in sediment (i.e., ingestion or dermal contact) or an indirect pathway (i.e., consumption of fish or shellfish). As mentioned earlier and under the water recreation evaluation below, the risks from direct exposure to surface water in West Waterway and Elliott Bay were previously evaluated quantitatively by King County (1999a) and found to be lower than risks associated with the sediment or fish consumption pathways. Thus, water is not evaluated as an exposure source in this HHRA.

Exposure scenarios investigated in this assessment are depicted in the CSM (Figure 3-1), corresponding to potentially exposed populations described below. Each exposure scenario (e.g., beach play) involves at least one potential exposure pathway to contaminated sediments (e.g., dermal contact with sediments and incidental ingestion of sediments in the beach play scenario) and a potential exposure route through which contaminants can enter the body of an exposed individual (e.g., dermal absorption of contaminants through exposed skin surfaces, gastrointestinal absorption of ingested contaminants). The importance of some pathway/route combinations is minor or incomplete for some scenarios, as depicted in the CSM. For example, ingestion of drinking water was considered to be an incomplete pathway for all scenarios considered in the LDW HHRA, and the present HHRA follows the same assumption. The exposure scenarios presented in the CSM are not mutually exclusive. Several of the scenarios are evaluated cumulatively in the risk characterization, as described in Section 5.2.5 (e.g., exposures associated with the collection of clams and with their consumption).

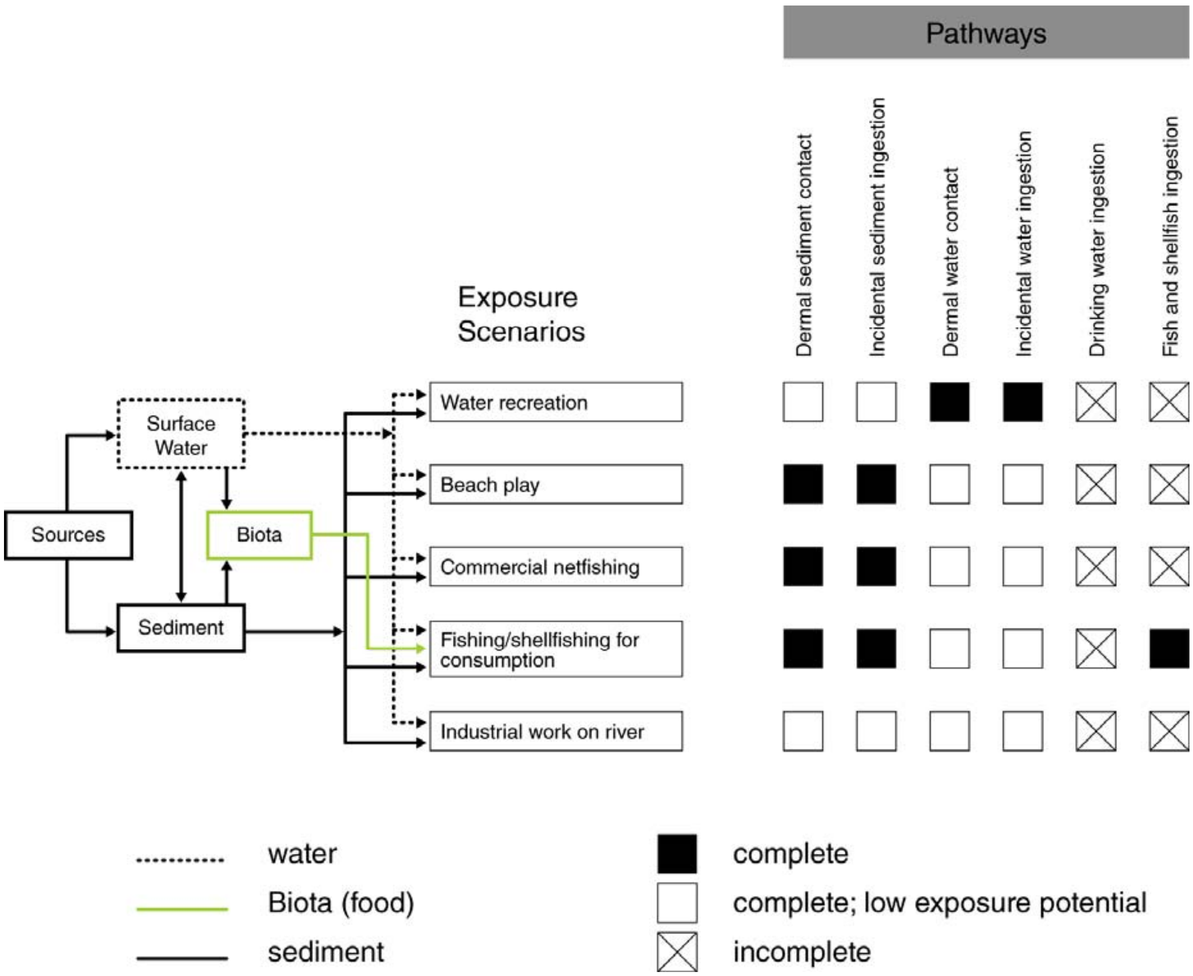


Figure 3-1. Conceptual Site Model for Lockheed West Human Health Risk Assessment

The exposure scenarios identified for this assessment are either reasonable maximum exposure (RME) scenarios or high end exposure scenarios, as initially defined in the LDW HHRA (Windward 2007a). RME is the highest exposure that is reasonably expected to occur at a site, and therefore represents the upper limit of potential risk. EPA generally uses RME scenarios to evaluate remedial actions at a site (EPA 1989). RME by definition likely overestimates exposure for many individuals. The adult tribal seafood consumption RME scenario follows the approach in the LDW HHRA to use the Tulalip seafood consumption survey data to characterize adult tribal RME and tribal child seafood consumption. The framework document (EPA 2007b) includes a policy decision to use Tulalip Tribes' seafood consumption rates to assess tribal seafood consumption risks when current or potential high quality shellfish habitat is limited. The Suquamish and Muckleshoot Tribes recognize that background concentrations will likely be the cleanup levels for both the LDW and Lockheed West Sites and hence decided that use of Tulalip rates to characterize seafood consumption risks for the Lockheed West Site was tolerable. An additional tribal scenario is also evaluated in this HHRA based on Suquamish seafood consumption survey data, as per a request of the Suquamish tribe and consistent with both the LDW HHRA and as suggested by the Region 10 tribal framework (EPA 2007b). This scenario is described as a high end exposure scenario to characterize a range of tribal consumption rates, and it represents an upper bound on risk from seafood consumption for the Lockheed West Site.

Each scenario shown in the CSM (Figure 3-1) is discussed qualitatively below. The exposure parameters for each scenario are presented in detail in Section 3.4.

3.1.1 Water Recreation

Water recreation at the Site could include kayaking/canoeing, swimming, scuba diving, and windsurfing. The primary exposure medium for these activities is water, although individuals may also come in contact with contaminated sediments that have been resuspended in the water column. The King County risk assessment (King County 1999a) estimated health risks associated with swimming in the LDW and concluded that the risks were generally within the range of risks considered to be acceptable by EPA. Swimming risks were associated with chemicals measured in the water. Excess cancer risks were highest for arsenic and PCBs, ranging from a low of 1×10^{-10} for older children exposed to PCBs to 4×10^{-6} for young children exposed to arsenic. All hazard indices for non-cancer risks were less than 1. The cancer risks associated with the water component of the swimming scenario were small (25% or less) compared to the cancer risks associated with the sediment component. In addition, as reported in the LDW HHRA, PCB water data collected more recently by King County suggest that the modeled PCB water concentrations used in the 1999 assessment likely overestimated the true concentrations. Because of the likely low exposures to site-related chemicals and associated low health risks, and in keeping with the LDW HHRA, a water recreation scenario was not quantitatively assessed for the Lockheed West Site HHRA. Potential health risks from contact with surface water are evaluated in Section 6.9 of the Uncertainty Assessment by inclusion of the risk estimates for direct water contact from the King County risk assessment.

3.1.2 Beach Play

A beach play scenario was evaluated as an RME scenario to assess the risk to young children (i.e., up to 6 years of age) visiting the shoreline of the Lockheed West Site. In keeping with the approach to this HHRA, the beach play scenario was evaluated regardless of whether the public may have present or future access to the shoreline of the Site. Because of the present lack of public access to the Site, the beach play scenario may overestimate present exposures to the general public, although the scenario may address potential future activities. In addition, the Suquamish Tribe has treaty rights to harvest in intertidal sediments that are not constrained by limited public access. Although the beach play scenario focuses on young children, it also serves to represent health-protective estimates of the risk to older children and adults who may visit the Site, to volunteers and public-sector employees responsible for any future habitat restoration within intertidal areas of the Site, and to individuals who may access intertidal areas by passing through private property boundaries. Because young children have a higher incidental soil ingestion rate and a lower body weight than adults, exposure estimates for children are higher than those for adults who might visit at the same frequency. Thus, because of the higher exposures for children, the beach play scenario is health-protective for the evaluation of other potential visitors to the Site.

The exposure frequency of 65 days per year for children playing in intertidal sediment was taken from the LDW HHRA. The frequency of 65 days per year was originally taken from a King County survey of lake beaches (Lake Union, Lake Washington, and Lake Sammamish) (Parametrix 2003). This exposure frequency represents the 95th percentile for children from birth to 6 years of age who engage in playing and digging in sand adjacent to the water. This behavior is consistent with the behavior that was assumed for the beach play scenario in the LDW HHRA, and is used for the Lockheed West Site beach play scenario.

The primary exposure pathways for the beach play scenario are dermal contact and incidental ingestion of intertidal sediment. While direct contact with surface water may occur, the exposures and risks related to surface water contact during beach play are likely to be very low when compared to the exposures and risks related to contact with the intertidal sediment. The low exposures and risks for surface water contact are based on the King County (1999a) risk assessment for water recreation activities in the Duwamish waterways, including West Waterway, and Elliott Bay. As mentioned above in Section 3.1.1, the King County (1999a) assessment found that exposures and risk estimates were much lower for direct surface water contact than those associated with sediment exposures during recreational activities. Health risks from contact with surface water are evaluated in Section 6.9 by inclusion of the risk estimates for direct water contact from the King County risk assessment.

3.1.3 Clamming

A clam survey of the Lockheed West Site conducted in 2008 demonstrated the presence of clams in the intertidal sediment that is available along the West Waterway shoreline of the

Site. Individuals may be exposed to chemicals in sediment in the intertidal areas of the Lockheed West Site during the harvesting of clams. This exposure scenario is depicted in Figure 3-1 as shellfishing. The clamming exposure scenario for the Lockheed West Site evaluates the exposures and risks from direct contact with sediment during clam harvesting. The scenario is adopted from the clamming scenario that was developed in the LDW HHRA. Two clamming scenarios are evaluated. The RME clamming scenario is based 120-day-per-year of tribal clamming, which addresses the access available to individuals collecting clams at the Site by shore and/or by boat, particularly tribal members. In addition to the clamming RME scenario, a tribal clamming 183-day-per-year scenario was evaluated to represent a high-end clamming frequency, similar to the scenario evaluated in the LDW HHRA.

Tribal members have access via treaty rights to harvest clams and other shellfish on both public and private property along the entire shoreline of the Duwamish waterway, including the West Waterway, as well as any intertidal habitat of the Elliott Bay portion of the Site. Thus, the assumed exposure area for the tribal clamming RME scenario includes all of the intertidal areas within the Lockheed West Site. As per the tribal framework document and the opinion of the tribes, none of the exposure parameter values selected has any effect on tribal treaty rights. In addition to the clamming RME scenario, a tribal clamming 183-day-per-year scenario was evaluated to represent a high-end clamming frequency, similar to the scenario evaluated in the LDW HHRA.

The clamming scenarios consider dermal contact with and incidental ingestion of sediment contaminants. The contaminant dose and resultant risks associated with clamming sediment exposure are much greater than those associated with surface water exposure. Therefore, exposure to water is not quantitatively evaluated in the clamming scenarios; however, a qualitative evaluation of exposure to surface water from direct contact is included in the Uncertainty Assessment in Section 6. Exposure to chemicals from ingesting clams that are harvested from the Lockheed West Site is addressed in the seafood consumption scenario (Section 3.2.5).

3.1.4 Occupational Exposure (Netfishing)

The Lockheed West Site is located on both West Waterway and Elliott Bay where water-dependent commercial uses occur. Many of the industrial facilities near the Site rely on vessel traffic on the West Waterway. Workers on these vessels could potentially come in contact with sediment and surface water, but most workers are typically aboard vessels and well above the water surface. Consequently, the contact frequency is expected to be low relative to other direct contact scenarios quantified in this HHRA, and exposure of workers aboard vessels is not evaluated.

Workers involved in commercial netfishing in the West Waterway or in Elliott Bay offshore of the Lockheed West Site may come in contact with sediment and surface water. As described in the LDW HHRA (Windward 2007a), individuals from the Muckleshoot Indian Tribe participate annually in a commercial gillnetting operation in the Lower Duwamish Waterway, including West Waterway. The gillnet lead lines typically come in contact with sediments during normal operations. The netfishers may contact this sediment incidentally upon net retrieval and may then also have incidental contact with surface water and sediment suspended in surface water. Data from sediment samples taken throughout the Lockheed West Site, including intertidal and subtidal areas, are included in this exposure scenario. The commercial netfishing scenario is evaluated for adult exposures as an RME scenario that assumes netfishing at a higher than average frequency and longer than normal time period. The primary exposure pathway during netfishing is evaluated as dermal contact with sediment. Exposure parameters for this scenario are taken from Windward (2007a), in which they were developed based on consultation with tribal members.

3.1.5 Fishing and Shellfishing for Consumption

People who consume fish or shellfish, including clams, crabs, and mussels, harvested from the Lockheed West Site could be exposed to site-related chemical contamination contained in the tissues of the consumed seafood. Various seafood consumption scenarios are evaluated that address exposures and risks from the consumption of fish and shellfish collected or caught at the Site and that may be contaminated with Site sediment-related chemicals. The exposures due to direct contact with sediment from collecting shellfish are evaluated above under the clamming scenario. Although fishers may also come in direct contact with surface water and sediment, the extent of contact is likely to be incidental for fishers. Three seafood consumption scenarios are evaluated: (1) adult tribal scenario based on Tulalip exposure data (the RME scenario for seafood consumption), (2) child tribal scenario based on Tulalip exposure data (a child RME scenario), and (3) an adult tribal scenario based on Suquamish exposure data (the high-end exposure scenario).

Consistent with the HHRA performed for the LDW site and as suggested by the EPA Region 10 tribal framework for conducting seafood consumption risk assessments in the Duwamish River waterways (EPA 2007b), the tribal adult and child seafood consumption scenarios based on Tulalip exposure data are evaluated as the RME scenarios in this HHRA. Also consistent with the LDW HHRA, the child tribal scenario is based on a seafood consumption rate that is 40 percent of the adult consumption rate based on the Tulalip survey data. The adult tribal scenario based on Suquamish data is evaluated as a high-end exposure scenario to characterize a range of tribal consumption rates. Additional information on the specific seafood consumption surveys is provided in Section 3.3.2.

The seafood exposure parameters are consistent with those developed for the LDW HHRA. As a health-protective measure, the seafood consumption scenarios for the Lockheed West HHRA do not assume any differences in the exposures to Site chemicals from those assumed for the LDW HHRA. Uncertainties with this assumption are examined in Section 6.1 of the Uncertainty Assessment. Consistent cleanup levels among the sites within the Duwamish Waterway/Elliott Bay region are necessary to ensure that cleanups achieve the common goal of health protectiveness for the exposed populations that use the resources of the region. Use of the LDW exposure scenarios and all inherent assumptions and exposure parameters is a health protective approach for the Lockheed West Site, and is protective of human populations who might use the Site in the future. The cumulative risks associated with consuming clams and coming into contact with the sediment during clam harvesting are addressed in Section 5.2.5.

3.1.6 Selection of Exposure Scenarios for Quantification

Specific exposure assumptions are used to quantify the exposure pathways shown in the CSM of Figure 3-1. A complete exposure pathway includes an exposure medium and exposure point; a potentially exposed population, including receptor age (i.e., adult vs. child); and an exposure route. The exposure parameters under both current and future land use at the site are presented in Section 3.3 for all exposure pathways quantified. A summary of the exposure scenarios evaluated for the Lockheed West Site HHRA is presented in Table 3-1.

Central tendency scenarios are not evaluated in the Lockheed West HHRA. The rationale for focusing the HHRA on RME scenarios is consistent with the approach to the assessment, and as described in Section 1.2, this focus is designed to support risk management and cleanup decisions that are consistent with the LDW site.

Table 3-1. Selected Exposure Scenarios and Pathways

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Population	Receptor Age	Exposure Route	Type of Analysis	Rationale for Selection of Exposure Pathway
Current/Future	Sediment	Surface Sediment (0-10 cm)	Intertidal Sediment	120-Day Tribal Clammer	Adult (18+ years)	Incidental Ingestion	Quantitative	Intertidal sediments are present at the site. Clamming and beach play are assumed to occur in the future. Exposure pathways focus on RME and high end scenarios showing the highest risk estimates in the LDW HHRA.
						Dermal Absorption	Quantitative	
				183-Day Tribal Clammer	Adult (18+ years)	Incidental Ingestion	Quantitative	
						Dermal Absorption	Quantitative	
				Beach Player	Child 0 - 6 yrs	Incidental Ingestion	Quantitative	
						Dermal Absorption	Quantitative	
			Intertidal and Subtidal Sediment	Tribal Netfisher	Adult (18+ years)	Incidental Ingestion	Quantitative	Intertidal and subtidal sediments are present at the site. Tribes use West Waterway and Elliott Bay for netfishing.
						Dermal Absorption	Quantitative	
	Seafood	Fish and Shellfish Tissue	Fish, Crab and Clam Tissue	Tulalip Tribal Member Survey-based	Adult	Consumption of Seafood	Quantitative	Seafood is present in Elliott Bay and West Waterway areas of the Site, including clams in intertidal sediment. Tribes can consume clams and seafood from the site. Exposure pathways focus on RME and high end scenarios showing the highest risk estimates in the LDW HHRA
					Child	Consumption of Seafood	Quantitative	
				Suquamish Tribal Member Survey-based	Adult	Consumption of Seafood	Quantitative	

3.2 CHEMICAL SCREENING AND COPC SELECTION

A comprehensive set of chemicals has been analyzed in sediment collected from the Lockheed West Site. In accordance with EPA (1996) guidelines, risk-based screening was conducted to determine which chemicals should be quantitatively evaluated in the baseline HHRA. Screening helps to focus the HHRA on the chemicals and parameters that may pose a risk. The result of the screening process is to identify a list of COPCs that are subsequently evaluated for exposures and characterization of risks.

3.2.1 Screening Procedure

The following steps constituted the COPC screening process for human health exposures for the Lockheed West Site, using the 2007 sediment data:

1. Non-detected chemicals – For chemicals that were not detected in any sample, if detection limits were below RBACGs, they were screened out from further evaluation. Undetected chemicals with detection limits exceeding RBACGs are noted through the evaluation. Development of RBACGs is discussed above in Section 2.1.1.
2. Frequency of detection – Chemicals that are detected in less than 5 percent of sediment samples are screened out from further evaluation. EPA (1989) guidance allows for excluding infrequently detected chemicals in order to focus the risk assessment. An infrequently detected contaminant was excluded if there was no reason to believe that the contaminant should be found at a higher frequency, and there was no unique site feature that may explain the presence of the contaminant. Past industrial uses of the Site were considered in identifying chemicals that could be potential COPCs. Because past historical uses consisted primarily of shipyard activities, various metals, butyltins, PAHs, and PCBs are the main historical use-based chemicals identified as COPCs. Of the chemicals lacking toxicity values or for which RBACGs were exceeded by detection limits, none are identified as possible COPCs based on past activities at the Site. With a total of 51 sediment stations in the 2007 surface sediment data set, chemicals detected in only one or two stations of the 51 are rejected as below the frequency of detection criterion. No chemicals were rejected on the basis of frequency of detection for the intertidal data set, since nine sediment station samples comprise the intertidal sediment data set. Chemicals that were undetected are further evaluated for detection limit exceedances of screening criteria in Section 3.2.4. Chemicals that were detected

below 5 percent frequency are identified and evaluated for exceedances of screening criteria in Section 6.7.

3. Bioaccumulative chemicals – For seafood consumption scenarios, chemicals were not selected as COPCs if the chemical was not on the EPA's bioaccumulative compound list (EPA 2000a). Generally, chemicals not on the bioaccumulative list also did not have BSAF values for use in modeling tissue concentrations for the seafood scenarios.
4. Comparison with risk-based screening criteria – Sediment chemicals that are not excluded by the above steps are screened against risk-based screening criteria based on acceptable risk levels from direct and indirect contact with sediment. Maximum concentrations are screened against the screening criteria. The criteria are concentrations in sediment associated with acceptable risks for human exposures. Maximum concentrations in the top 10 cm of sediment from the 51 sediment stations are screened against the screening criteria identified for each exposure scenario, and concentrations above the criteria are identified as COPCs.

At the end of these steps, chemicals with maximum concentrations in site sediments that exceed risk-based screening criteria are identified as COPCs. Results of the comparison of sediment chemistry data with the risk-based screening criteria, identification of COPCs, and the rationale for each COPC selection are presented below.

Screening to identify COPCs is performed for each of the exposure scenarios described above. Screening is performed in Appendix A for scenarios associated with exposures to intertidal sediments (Table A-1), to subtidal and intertidal sediments (Table A-2), and to sediment chemicals that may bioaccumulate and pose a risk in seafood (Table A-3). Risk-based screening criteria for application to sediment have not been developed by EPA, so screening was conducted separately for intertidal sediment exposure (i.e., beach play scenario and clamming scenario), combined intertidal and subtidal sediment exposure (i.e., netfishing scenarios), and seafood consumption (i.e., seafood consumption scenario). For the direct sediment contact scenarios (i.e., beach play, clamming, and netfishing scenarios), surrogate criteria that are considered by EPA to be sufficiently health protective for application to sediment exposures are used, consisting of soil criteria, as modified from the criteria developed for the LDW site. For seafood consumption exposures, the bioaccumulative COPCs are identified by screening sediment chemistry against lists of bioaccumulative criteria, as described below.

In evaluating Step 2 above, the site was examined for unique features that may affect selection of COPCs. The site history in shipbuilding was identified as a unique feature of the site that may set it apart from other properties in the area. Shipbuilding, including repair and maintenance, has been associated with the production of metals wastes. The Site sediments in shallower areas where industrial activities occurred are contaminated with metals. As the results of the COPC selection process demonstrate below, many metals were selected as COPCs because of their elevated concentrations in these sediments.

Concentrations of metals in sediments at the Site were also compared with available background concentrations. For the purpose of comparison, background is defined as the background concentrations identified in the LDW HHRA; background data for metals are tabulated in Appendix A. The background concentrations are considered tentative because EPA has not agreed to acceptable background concentrations for the Site. This comparison was not performed as part of the screening process, and no chemicals were eliminated from further evaluation based on this comparison. EPA risk assessments compute the risks for contaminants without respect to the source (i.e., site or background associated). In characterizing risks, the site and background related components of risk are identified.

3.2.2 Sediment Direct Contact

Because EPA has not developed RBCs specifically for sediment, RBCs for soils are used to screen the scenarios that include incidental ingestion and dermal contact with sediment. RBCs developed by EPA Region 6 (2008) were selected for this HHRA. Region 6 screening levels are intended to be protective of humans exposed to residential soils ("Residential Soils") and to soils during outside work ("Industrial Worker Outdoor"). The equations used to calculate the screening levels incorporate the cumulative exposures to soil via ingestion, dermal contact, and inhalation of soil particles. Residential soil screening levels from EPA Region 6 were used to screen the beach play and clamming exposures, and the industrial outdoor screening levels from Region 6 were used to screen the netfishing exposures. The Region 6 screening levels for carcinogenic endpoints correspond to a cancer risk level of 1×10^{-6}. Region 6 screening levels for noncarcinogenic toxicity endpoints were decreased by a factor of 10 to account for the target hazard quotients (HQs) of 0.1 used in screening by EPA Region 10 (EPA 1996).

The tables of comparison and identification of COPCs for direct sediment contact are presented in Tables A-1 and A-2 in Appendix A to this HHRA. The tables compare the maximum sediment concentrations for each chemical with the applicable RBC and include summary statistics, such as detection frequency, minimum detected concentration, and range of reporting limits. In some cases, surrogate RBCs were used if an RBC was not available for a particular COPC. For example, mercury concentrations were compared to the RBC for methyl mercury, chromium concentrations were compared to the RBC for hexavalent chromium, and thallium concentrations were compared to the RBC for thallium and compounds. All surrogate RBCs are identified in the tables in Appendix A. For the netfishing scenario, data for subtidal and intertidal sediments were combined in the screening because nets may come in contact with sediments at both water depths. Only intertidal sediment chemistry data were used in the screening for the beach play and clamming scenarios.

The screening process to select COPCs focuses on detected chemicals in Site sediments. Chemicals that were never detected in sediment samples at the Lockheed West Site are discussed in Section 3.2.4 below, and listed in Appendix B to this HHRA. Appendix B also presents the RBCs that the reported detection limits for each sample were compared with during selection of COPCs. An analysis of undetected chemicals, particularly those with reported DLs that exceeded their respective RBCs, is presented in Section 6.7.

A summary of the COPCs selected based on the screening for the three direct contact sediment exposures is presented in Table 3-2.

Table 3-2. Summary of COPCs for Direct Sediment Exposures

	Beach Play and Clamming Scenarios		Netfishing Scenario	
Chemical[1/]	**COPC?**	**Rationale**	**COPC?**	**Rationale**
Metals				
Antimony	Yes	maximum detection > RBC	Yes	maximum detection > RBC
Arsenic	Yes	maximum detection > RBC	Yes	maximum detection > RBC
Chromium	Yes	maximum detection > RBC	Yes	maximum detection > RBC
Copper	Yes	maximum detection > RBC	No	maximum detection < RBC
Lead	Yes	maximum detection > RBC	Yes	maximum detection > RBC
Vanadium	Yes	maximum detection > RBC	No	maximum detection < RBC
Organics				
cPAHs	Yes	maximum detection > RBC	Yes	maximum detection > RBC
Total PCBs	No	maximum detection < RBC	Yes	maximum detection > RBC

[1/] Only those chemicals identified as a COPC for direct sediment contact are listed; the complete list of screened chemicals is presented in Appendix A.
cPAH – carcinogenic polycyclic aromatic hydrocarbon
COPC – chemical of potential concern
PCB – polychlorinated biphenyl
RBC – risk-based concentration

A total of seven COPCs were identified for the beach play and clamming scenarios, using intertidal sediment chemistry (Table 3-2). All seven of the COPCs were detected in all nine of the intertidal sediment samples. The COPC screening process for the netfishing scenario identified six COPCs, using the combined intertidal and subtidal sediment chemistry (Table 3-2). All six of the netfishing COPCs were detected in all 51 sediment samples. All of the COPCs were identified based on the maximum detected concentration being greater than the RBC for that chemical.

All COPCs identified in Table 3-2 are quantitatively evaluated in this HHRA. For the direct contact sediment exposures, there were no undetected chemicals with RLs exceeding screening criteria.

EPA Superfund guidance (EPA 1989, 2002b,c) includes provisions for distinguishing site-related contamination from naturally occurring or other non-site-related chemical concentrations. Because metals and trace elements occur naturally in sediments in the absence of any human influence, site sediment concentrations of naturally occurring chemicals were compared with data from background areas. However, due to the limited number of site sediment samples, and the lack of a background data set that is specific to the Lockheed West Site, chemicals were not screened out based on the comparison with background. The comparison between site and background concentrations was performed for informational purposes only.

In the absence of data on background for the Lockheed West Site, the background comparison was performed following the approach presented in the HHRA for the LDW site. Windward (2007a) compiled sediment chemistry data for metals from non-urban areas from the joint Ecology/Puget Sound Ambient Monitoring Program (PSAMP) for central Puget Sound (National Oceanic Atmospheric Administration [NOAA] and Ecology 2000) for comparison purposes. Background for this purpose was defined as areas not influenced by human activities. As such, urban areas sampled under PSAMP, such as Elliott Bay and Sinclair Inlet, were excluded from the dataset used to estimate background concentrations. More details on the location of the background samples are provided in an attachment to the HHRA for the LDW site (Windward 2007a).

Tables A-1 and A-2 of Appendix A present the comparison of the mean concentration for each metal or trace element in Lockheed West Site surface sediments with the mean concentration for the 52 samples collected from central Puget Sound. For most metals, the Lockheed West Site sediment mean concentration was much higher than the central Puget Sound mean concentration. The mean concentrations for cadmium and thallium were below the mean Puget Sound concentration, and the mean concentrations for nickel and silver are very close to the mean concentration of Puget Sound. Statistical analyses were not performed, and none of these chemicals was screened out from further evaluation based on background (note that these metals were instead screened out based on comparison with toxicity-based criteria). All the metal and trace element COPCs shown in Table 3-2 were retained for further evaluation.

3.2.3 Sediment Screening for Seafood Consumption Exposure

Screening criteria that are applicable to sediments for the protection of seafood consumption have not been developed by EPA. This pathway of exposure to sediment chemicals is also termed the indirect sediment exposure pathway, since the exposure is not directly to sediments but through the consumption of seafood that has taken up chemicals from sediment. Screening criteria for the indirect sediment exposure pathway were developed as RBCs in sediment, based on acceptable RBCs in tissues, following the procedure described for the LDW HHRA. The sediment RBCs are applied to sediment at the Lockheed West Site to account for the protection of seafood consumption in the selection of sediment COPCs for seafood consumption.

The screening criteria for indirect exposure are based on the relationship between chemical concentrations in sediment and those in seafood tissue. Sediment RBCs were developed from acceptable risk thresholds for seafood consumption, corresponding concentrations of chemicals in the seafood tissue, and the application of BSAFs to the tissue concentrations to identify the associated RBCs in sediment.

BSAFs describe the relationship between sediment and tissue as the following:

$$BSAF = \frac{C_{WB} \div F_L}{C_{sed} \div F_{oc}}$$ **Equation 3-1**

where:

C_{WB} = chemical concentration in whole-body tissue (mg/kg ww)
C_{sed} = chemical concentration in sediment (mg/kg dw)
F_L = fraction lipid in tissue (kg lipid/kg ww)
F_{oc} = fraction organic carbon in sediment (kg OC/kg dw)

Equation 3-1 can be rearranged to solve for C_{sed} as follows:

$$C_{sed} = \frac{(C_{WB} \div F_L) \times F_{oc}}{BSAF}$$ **Equation 3-2**

The BSAFs used to calculate the seafood-based screening criteria for sediment (i.e., C_{sed} in Equation 3-2) were taken from four sources originally provided in Windward (2007a):

- US Army Corps of Engineers (USACE) Environmental Residue-Effects Database (ERED) - http://www.wes.army.mil/el/ered/ (USACE 2008).
- Tracey, GA, and D.J. Hansen. 1996. Use of biota-sediment accumulation factors to assess similarity of nonionic organic chemical exposure to benthically-coupled organisms of differing trophic mode. Arch Environ Contam Toxicol 30:467-475.

- EPA. 1997b. The incidence and severity of sediment contamination in surface waters of the United States. Volume 1: National Sediment Quality Survey. EPA 823-R-97-006. US Environmental Protection Agency, Office of Science and Technology, Washington, DC.
- Washington State Department of Health. 1995. Tier I report, development of sediment quality criteria for the protection of human health. Washington State Department of Health, Olympia, Washington.

Although BSAFs for bivalve mollusks were the primary source for this screening criteria calculation, some fish BSAFs were used in Windward (2005) when bivalve BSAFs were not available. RBACGs for the LDW HHRA were developed in the QAPP for surface sediment chemical analysis (Windward 2005), and the BSAFs used in the derivation for sediment RBACGs for protection of human consumption of seafood were identified in the QAPP for benthic invertebrate sample collection (Windward 2004b). The derivation and use of BSAFs in modeling seafood chemical concentrations for the seafood consumption scenarios in the Lockheed West HHRA, and limitations with BSAF modeling, are described in more detail in Section 3.3.5.

The BSAF equation (Equation 3-1) is based on the assumption that the concentration of chemical in sediment (C_{sed}) represents the average chemical concentration in sediment to which the organism is exposed. For animals with very small home ranges, such as clams, this assumption may be reasonable if sediment data are collected concurrently with tissue data at the tissue collection locations. For animals with larger home ranges, such as fish, there is greater uncertainty in this assumption because many fish are highly mobile and are not likely to inhabit all areas of their home range with equal frequency. Consequently, Windward (2005) found that fish BSAFs for a given chemical ranged over at least an order of magnitude (USACE 2003), and given this large uncertainty, BSAFs for clams rather fish were used to derive the sediment screening criteria for seafood consumption.

The values for the tissue concentrations in clams (C_{WB}) that were used to derive the sediment criteria (i.e., C_{sed}) were acceptable RBCs in tissue, originally calculated as RBACGs for clam tissue in the benthic invertebrate sampling QAPP for the LDW site (Windward 2004b). The tissue RBCs were recalculated in this HHRA to update toxicity values, and are adjusted to account for tribal exposures, following the procedure used to calculate the RBACGs for the LDW site.

The equation used to calculate tissue RBCs based on the carcinogenic endpoint is the following:

$$C_T = \frac{10^{-6} \times BW \times AT}{EF \times IR \times ED \times CF \times CSF}$$

Equation 3-3

Where:

C_T = concentration in tissue (mg/kg)
10^{-6} = cancer risk threshold
IR = ingestion rate (g/day)
EF = exposure frequency (days per year)
ED = exposure duration (years)
CF = conversion factor (kg/g)
BW = body weight (kg)
AT = averaging time (days), equivalent to the ED for non-carcinogenic COPCs and 70 years for carcinogenic COPCs
CSF = cancer slope factor.

The equation for calculating tissue RBCs for non-cancer endpoints is the following:

$$C_T = \frac{RfD \times 0.1 \times BW \times AT \times CF}{EF \times IR \times ED}$$

Equation 3-4

Where:

C_T = concentration in tissue (mg/kg)
RfD = reference dose
BW = body weight (kg)
AT = averaging time (days), equivalent to the ED for non-carcinogenic COPCs and 70 years for carcinogenic COPCs
CF = conversion factor (kg/g)
EF = exposure frequency (days per year)
IR = ingestion rate (g/day)
ED = exposure duration (years)

The following parameter values were used in the calculation of the tissue RBCs:

- Ingestion rate (IR) – 98 g/day, modified from 54 g/day, as described below.
- Exposure frequency (EF) – 365 days/yr, modified from 350 days/yr
- Body weight (BW) – 81.8 kg modified from 70 kg, as per EPA (2007b)
- Exposure duration (ED) – 70 years, modified from 30 years, as per EPA (2007b).

EPA Region 6 provides RBCs in tissue that are calculated using the same procedure but different parameter values that do not account for tribal seafood ingestion. The calculations of tissue RBCs using the above parameters result in more health-protective values for the tissue RBCs than using the unmodified Region 6 RBCs. For chemicals missing sediment RBCs for seafood consumption, values were taken from Windward (2005).

The RME ingestion rate (IR) of 98 g/day was developed from the tribal seafood consumption rate of 194 g/day (EPA 2007b) using the market basket approach. The market basket approach consists of determining an ingestion rate of total seafood that is based on the ingestion of multiple species or types of seafood. The ingestion of individual types of seafood (with each one being a fraction of the market basket) is not specifically evaluated for exposure or risk. The tribal RME consumption rate was developed from the following:

1. The consumption rates of Puget Sound harvested seafood (anadromous fish, pelagic fish, benthic/demersal fish, and shellfish) by surveyed Tulalip Tribal members were determined (Toy et al. 1996).
2. These rates were rank ordered and used to determine a 95th percentile consumption rate of 194 g/day.
3. The total rate was allocated to individual market basket fractions by the following calculation:

   Market basket rate = total rate x average rate for a market basket fraction ÷ sum of all average market basket rates.

Using this process, salmon comprised 96.5 g/day of the total consumption rate. EPA (2007b) decided that salmon did not accumulate a significant site-related contaminant body burden from the LDW. Multiplying a site-related contaminant concentration of zero by the salmon consumption rate results in a contaminant dose of zero for salmon consumption. For all other market basket fractions, the site-related body burden was assumed to be 100 percent. The total consumption rate for all market basket fractions other than salmon was 97.5 g/day. The 95th percentile consumption rate values are provided in Table 2 of EPA (2005a), as provided in Appendix B of the final tribal framework document (EPA 2007b).

The decision that adult salmon that may be caught and consumed from the LDW did not accumulate a significant site-related contaminant body burden from the LDW was examined in the LDW HHRA (Windward (2007a). The adult salmon that migrate through the Duwamish estuary on their way to upstream spawning areas would have been exposed to chemicals within the LDW very briefly as juveniles as they passed through the Site on the way downstream. In addition, adult salmon in the LDW could be exposed to chemicals transported from the LDW to Puget Sound. The contribution of these exposures to adult salmon body burdens is likely to be insignificant because the large majority of a salmon's growth occurs in marine waters outside the LDW (O'Neill et al. 1998). The LDW HHRA provides as an example a 10-g juvenile Chinook salmon with a total PCB concentration of 140 µg/kg ww, which is the mean concentration reported by Varanasi et al. (1993), contains 1.4 µg of PCBs in its body. A 15-kg returning adult Chinook salmon captured in the LDW with a total PCB concentration of 56 µg/kg ww, the mean concentration reported by West et al. (2001), would contain 840 µg of PCBs, almost all of which would be derived from the ingestion of food in Puget Sound and the Pacific Ocean. Based on these data and the analysis presented by O'Neill et al. (1998), less than 1% of the PCB body burden contained in adult salmon migrating through the LDW could have been obtained from prey items consumed in the LDW. Because the Lockheed West Site presents a small fraction of foraging area for salmon compared with the much larger LDW site, the percent of PCBs or other chemicals in salmon tissue that could be obtained from prey items consumed from the Lockheed West Site would be less than that estimated for the LDW site. For that reason, adult salmon are not included in the derivation of RBACGs or in the exposure assessment for the Lockheed West HHRA. The small amount of PCBs or other chemicals in adult salmon that may be related to Lockheed West Site sediment could result in a slight underestimation of human exposures and risks related to seafood ingestion.

In order to be health protective for screening sediment concentrations, the sediment RBACGs for seafood consumption in Windward (2005) were calculated with the assumption that all of the seafood consumed is made up of clams, but rather than use a clam consumption rate, the consumption rate for total seafood consumed from Puget Sound was used at 98 g/day, with the exclusion of salmon as per the tribal framework guidance (EPA 2007b). In other words, the RBACGs calculated for clam tissue were based on the assumption that clams were consumed at the total tribal seafood consumption rate of 98 g/day. These clam tissue RBACGs were then used as the values for C_{WB} in Equation 3-2 to derive C_{sed} as the sediment RBACG for seafood consumption. Assigning the full seafood consumption rate to clams to derive C_{WB} and then using the clam BSAFs in deriving the RBACGs was designed to be sufficiently protective of exposures through consumption of combined fish, crabs, and clams as total seafood exposures. This approach was also considered appropriate because of the high percentage of tribal diet made up by clams. This approach was acceptable by EPA Region 10 for the derivation of RBACGs for sediment in the LDW QAPP, and for developing sediment screening criteria for protection of seafood consumption at the Lockheed West Site (Tetra Tech 2008a).

Given that one purpose of the HHRA for the Lockheed West Site is to estimate risks with the assumption that risk estimates will be high enough to justify cleanup of Site sediments, based on a prior commitment to remediate the entire Site, EPA Region 10 has recommended that this procedure is a quick and protective approach to identify COPCs for seafood consumption at the Lockheed West Site.

The calculated sediment RBCs for protection of seafood consumption, modeled as described in the above paragraphs, are used as the RBC criteria for indirect sediment exposure. Note that BSAF modeling of tissue concentrations is also performed below in Section 3.3 of this HHRA to estimate exposures to chemicals in seafood. For the exposure modeling described in Section 3.3, BSAFs were updated from the values used by Windward (2005) to develop the sediment RBACGs.

Table A-3 in Appendix A to this HHRA compares the maximum concentration for each chemical analyzed in the combined intertidal and subtidal sediment samples with the applicable sediment RBC for seafood consumption, and includes summary statistics such as detection frequency, minimum and maximum sediment concentrations, and frequency of detection. The development of the sediment RBCs from tissue RBCs is presented in Table A-4 of Appendix A. The COPCs for the seafood consumption scenarios are summarized in Table 3-3 below, which is excerpted from Table A-3 of Appendix A. Table 3-3 also lists those chemicals that were never detected but the RL exceeded the RBC in at least one sediment sample. The comparison of the RLs with RBCs for undetected chemicals is presented in Appendix B to this HHRA.

Fifteen COPCs were identified for the seafood consumption scenario (Table 3-3). These COPCs are evaluated quantitatively in this HHRA. In addition, dioxins and furans are identified as COPCs for the tribal seafood ingestion pathways, based on their likely presence in site sediment and seafood from the site (as has been documented in the upstream LDW). Eight undetected chemicals, consisting of two organic compounds and six organochlorine pesticides, are identified as tentative COPCs based on a percentage of the sample RLs exceeding RBCs.

Table 3-3. Summary of Sediment COPCs for the Seafood Consumption Scenario

Chemical	Rationale
Detected Chemicals	
Metals	
Arsenic (inorganic)	maximum detection > RBC
Cadmium	maximum detection > RBC
Chromium	maximum detection > RBC
Copper	maximum detection > RBC
Lead	maximum detection > RBC

Table 3-3. Summary of Sediment COPCs for the Seafood Consumption Scenario (continued)

Chemical	Rationale
Mercury	maximum detection > RBC
Zinc	maximum detection > RBC
Tributyltin	maximum detection > RBC
Organics	
cPAHs	maximum detection > RBC
Fluoranthene	maximum detection > RBC
Pyrene	maximum detection > RBC
Pentachlorophenol	maximum detection > RBC
Total PCBs	maximum detection > RBC
Total Chlordane	maximum detection > RBC
Total DDT	maximum detection > RBC
Undetected Chemicals[1/]	
Hexachlorobutadiene	4% of RLs > RBC
N-Nitroso-di-n-propylamine	2% of RLs > RBC
Aldrin	82% of RLs > RBC
alpha-Chlordane	82% of RLs > RBC
beta-BHC	82% of RLs > RBC
Dieldrin	100% of RLs > RBC
Heptachlor	82% of RLs > RBC
Toxaphene	10% of RLs > RBC

[1/] Undetected chemicals are not quantified for risks but are evaluated in the uncertainty analysis. All instances of RLs exceeding RBCs occurred in subtidal sediment samples, except for dieldrin where all intertidal and subtidal samples had RLs greater than the RBC.
cPAH – carcinogenic polycyclic aromatic hydrocarbon
COPC – chemical of potential concern
RBC – risk-based concentration
RL – reporting limit

3.2.4 Undetected Chemicals

Appendix B presents a comparison of the RLs for chemicals that were never detected with their respective RBCs. Chemicals that were never detected and for which RBCs were not identified for either the direct or indirect sediment contact pathways are listed in Table 3-4.

Table 3-4. Undetected Chemicals without Identified Risk-Based Concentrations

Exposure Point	Chemical	Units	Sediment RBC for Seafood Consumption	RBC Netfishing or Clamming	Max. Detection Limit[1/]
Intertidal-Subtidal					
Seafood and Netfishing					
SVOCs	2-Nitrophenol	µg/kg	NO BSAF	NA	94
	4-Bromophenyl phenyl ether	µg/kg	NO BSAF	NA	51
	4-Chloro-3-methylphenol	µg/kg	NO BSAF	NA	76
	4-Chlorophenyl phenyl ether	µg/kg	NO BSAF	NA	72
Pesticides	delta-BHC	µg/kg	NA	NA	3.6
	o,p-DDE	µg/kg	NO BSAF	NA	27
	Oxychlordane	µg/kg	NO BSAF	NA	15

Table 3-4. Undetected Chemicals without Identified Risk-Based Concentrations (continued)

Exposure Point	Chemical	Units	Sediment RBC for Seafood Consumption	RBC Netfishing or Clamming	Max. Detection Limit[1/]
Intertidal					
Clamming/Beach Play					
SVOCs	2-Nitrophenol	µg/kg	NA	NA	3.5
	4-Bromophenyl phenyl ether	µg/kg	NA	NA	1.9
	4-Chloro-3-methylphenol	µg/kg	NA	NA	2.9
	4-Chlorophenyl phenyl ether	µg/kg	NA	NA	2.7
	4-Nitrophenol	µg/kg	NA	NA	41
Pesticides	delta-BHC	µg/kg	NA	NA	0.17
	Endosulfan sulfate	µg/kg	NA	NA	0.11
	Nonachlor (cis)	µg/kg	NA	NA	0.5
	Nonachlor (trans)	µg/kg	NA	NA	0.92
	o,p-DDE	µg/kg	NA	NA	1.2
	Oxychlordane	µg/kg	NA	NA	0.5

[1/] Maximum detection limit for those chemicals that were never detected in any sample.
RBACG – Risk-based analytical concentration goal
RBC – Risk-based concentration
BSAF – Biota-sediment accumulation factor
NA – RBC not available from the LDW QAPP; toxicity value not available
No BSAF – No BSAF value available for calculating a sediment RBACG from a tissue RBACG in the LDW QAPP

3.3 CALCULATION OF EXPOSURES

The exposure of humans to COPCs in sediment or fish and shellfish through direct contact, sediment ingestion, or seafood ingestion is expressed as the CDI, which is the estimated daily chemical dose for an individual averaged over the averaging time (AT) for each scenario. The CDI is calculated using exposure parameters, which characterize the amount of exposure to chemicals for specific pathways, and the EPCs, which are the concentrations of COPCs in the media of exposure. The following describes the procedure for calculating the CDI, presents EPCs for the COPCs identified for the Site, and the exposure parameters for each scenario and pathway.

3.3.1 Chronic Daily Intake

Two routes of exposure are relevant: ingestion and dermal contact. The CDI for ingestion is calculated as:

$$CDI_o = \frac{EPC \times IR \times FI \times EF \times ED \times CF}{BW \times AT} \qquad \textbf{Equation 3-5}$$

Where:

CDI_o = chronic daily intake from oral exposure route (mg/kg-day)
EPC = chemical-specific exposure point concentration (mg/kg)
IR = ingestion rate (g/day)

FI = fractional intake of media derived from contaminated source (unitless)
EF = exposure frequency (days per year)
ED = exposure duration (years)
CF = conversion factor (kg/g)
BW = body weight (kg)
AT = averaging time (days), equivalent to the ED for non-carcinogenic COPCs and 70 years for carcinogenic COPCs

The CDI for dermal exposure is calculated as:

$$CDI_d = \frac{EPC \times ABS \times SA \times AF \times FI \times EF \times ED \times CF}{BW \times AT}$$ **Equation 3-6**

Where:

CDI_d = chronic daily intake from dermal exposure route (mg/kg-day)
EPC = chemical-specific exposure point concentration (mg/kg)
ABS = dermal absorption factor (unitless)
SA = skin surface area exposed (cm^2)
AF = sediment to skin adherence factor by event (mg/cm^2-event)
FI = fractional intake of media derived from contaminated source (unitless)
EF = exposure frequency (events/year)
ED = exposure duration (years)
CF = conversion factor (kg/mg)
BW = body weight (kg)
AT = averaging time (days)

Although CDI technically refers to oral exposure only, this term is also used in this HHRA to refer to dermal exposure, which is technically an absorbed dose rather than intake. Consistent with the LDW HHRA, the adjustment between orally administered doses and dermally administered doses was made by adjusting the oral toxicological benchmarks, as appropriate, according to EPA guidance (2004) (see Section 3.4.2 for additional details). Separate CDIs are calculated for chemicals with carcinogenic and non-carcinogenic effects because the ATs over which the doses are calculated are different.

Parameters for quantifying the exposure scenarios in this HHRA are tabulated in this section. The tables are presented in formats generally consistent with EPA risk assessment, and present the same information as tables in the LDW HHRA. For ease of comparison with the LDW HHRA, the table sequences for the Lockheed West HHRA are consistent with the table sequences in the LDW HHRA. Table 3-5 summarizes the exposure scenario for seafood ingestion, and Table 3-6 summarizes the scenario for direct sediment exposures. These tables include key exposure parameters so that the scenarios can be compared to each other, and provides references to more detailed tables (Tables 3-7 through 3-17), in keeping with the format for the LDW HHRA, in which all exposure parameters for each scenario are presented. Following the presentation of these scenario-specific tables, additional discussion is provided for derivation of seafood consumption rates (Section 3.3.2), direct sediment contact parameters (Section 3.3.3), and EPCs for sediment and seafood tissue (Sections 3.3.4 and 3.3.5, respectively).

Table 3-5. Summary of Seafood Ingestion Scenarios

Scenario	Ingestion Rate (IR) (g/day)					Exposure Duration (years)	Location of Scenario-Specific Details
	Pelagic Fish	Benthic Fish	Crab[1/]	Other Shellfish[2/]	Total		
Adult tribal RME (Tulalip data)	8.1	7.5	43.4	38.5	97.5	70	Table 3-7
Child tribal RME (Tulalip data)	3.2	3.0	17.4	15.4	39.0	6	Table 3-8
Adult tribal (Suquamish data)	56	29.1	54.8	443.6	583.5	70	Table 3-9

1/ Crab IR includes whole body and edible meat
2/ Other shellfish IR consists of mussels and clams combined
IR – ingestion rate
na – not applicable
RME – reasonable maximum exposure

Table 3-6. Summary of Direct Sediment Exposure Scenarios

Scenario	Incidental Sediment IR (g/day)	Exposure Frequency (days/yr)	Exposure Duration (years)	Skin Surface Area Exposed (cm^2)	Location of Scenario-Specific Details	
					Incidental Ingestion	Dermal
Netfishing RME	0.05	119	44	3,600	Table 3-10	Table 3-11
Beach play RME	0.2	65	6	varies with age[1/]	Table 3-12	Table 3-13
Tribal clamming RME	0.1	120	64	6,040	Table 3-14	Table 3-15
Tribal clamming 183 days per year	0.1	183	70	6,040	Table 3-16	Table 3-17

1/ For the beach play RME scenarios, children are evaluated from birth through 6 years of age.
IR – ingestion rate
RME – reasonable maximum exposure

Table 3-7. Daily Intake Calculations – Seafood Ingestion, Adult Tribal RME Scenario Based on Tulalip Data

Scenario timeframe: Current/future
Medium: Sediment
Exposure medium: Fish and shellfish tissue
Exposure route: Ingestion
Intake equation/model name: Chronic daily intake (CDI) (mg/kg-day) = [(EPC-p × IR-p) + (EPC-b × IR-b) + (EPC-bwb × IR-bwb) + (EPC-c × IR-c) + (EPC-cwb × IR-cwb) + (EPC-m × IR-m) + (EPC-cl × IR-cl)] × FI × EF × ED-a × CF × 1/BW-a × 1/AT

Parameter Code	Parameter Definition	Units	Value	Rationale/ Reference
EPC-p	exposure point concentration in pelagic fish	mg/kg ww	Table 3-31	Section 3.3.5
EPC-b	exposure point concentration in benthic fish, fillet	mg/kg ww	Table 3-31	Section 3.3.5
EPC-bwb	exposure point concentration in benthic fish, whole body	mg/kg ww	Table 3-31	Section 3.3.5
EPC-c	exposure point concentration in crabs, edible meat	mg/kg ww	Table 3-31	Section 3.3.5
EPC-cwb	exposure point concentration in crabs, whole body	mg/kg ww	Table 3-31	Section 3.3.5
EPC-m	exposure point concentration in mussels	mg/kg ww	Table 3-31	Section 3.3.5
EPC-cl	exposure point concentration in clams	mg/kg ww	Table 3-31	Section 3.3.5
IR-p	ingestion rate – pelagic fish	g/day	8.1	Section 3.3.2
IR-b	ingestion rate – benthic fish	g/day	7.5	Section 3.3.2
IR-bwb	ingestion rate – benthic fish, whole body	g/day	0	Section 3.3.2
IR-c	ingestion rate – crabs, edible meat	g/day	33	Section 3.3.2
IR-cwb	ingestion rate – crabs, whole body	g/day	10.4	Section 3.3.2
IR-m	ingestion rate – mussels	g/day	0.82	Section 3.3.2
IR-cl	ingestion rate – clams	g/day	37.7	Section 3.3.2
FI	fractional intake derived from source	unitless	1 [1/]	EPA (2007b)
EF	exposure frequency	days/yr	365[2/]	EPA (1991b)
ED-a	exposure duration – adult	Years	70	EPA (2005a)
CF	conversion factor	kg/g	0.001	na
BW-a	body weight-adult	Kg	81.8	Toy et al. (1996)
AT-C	averaging time – cancer	Days	25,550	EPA (1989)
AT-N	averaging time – non-cancer	Days	25,550	EPA (1989)

[1/] A fractional intake derived from source of 1 was directed by EPA in the tribal framework guidance document (2006b).
[2/] Default exposure frequency of 350 days/yr modified to 365 days/yr to account for the fact that seafood consumption rate estimates are based on 365 days/yr.
na – not applicable
RME – reasonable maximum exposure
ww – wet weight
Source: Standard Table 4 in EPA (1998a), as modified from Windward (2007a)

Table 3-8. Daily Intake Calculations – Seafood Ingestion, Child Tribal RME Scenario Based on Tulalip Data

Scenario timeframe: Current/future
Medium: Sediment
Exposure medium: Fish and shellfish tissue
Exposure route: Ingestion
Intake equation/model name: Chronic Daily Intake (CDI) (mg/kg-day) = [(EPC-p × IR-p) + (EPC-b × IR-b) + (EPC-bwb × IR-bwb) + (EPC-c × IR-c) + (EPC-cwb × IR-cwb) + (EPC-m × IR-m)+(EPC-cl × IR-cl)] × FI × EF × ED-a × CF × 1/BW-ct × 1/AT

Parameter Code	Parameter Definition	Units	Value	Rationale/ Reference
EPC-p	exposure point concentration in pelagic fish	mg/kg ww	Table 3-31	Section 3.3.5
EPC-b	exposure point concentration in benthic fish, fillet	mg/kg ww	Table 3-31	Section 3.3.5
EPC-bwb	exposure point concentration in benthic fish, whole body	mg/kg ww	Table 3-31	Section 3.3.5
EPC-c	exposure point concentration in crabs, edible meat	mg/kg ww	Table 3-31	Section 3.3.5
EPC-cwb	exposure point concentration in crabs, whole body	mg/kg ww	Table 3-31	Section 3.3.5
EPC-m	exposure point concentration in mussels	mg/kg ww	Table 3-31	Section 3.3.5
EPC-cl	exposure point concentration in clams	mg/kg ww	Table 3-31	Section 3.3.5
IR-p	ingestion rate – pelagic fish	g/day	3.2	Section 3.3.2
IR-b	ingestion rate – benthic fish	g/day	3.0	Section 3.3.2
IR-bwb	ingestion rate – benthic fish, whole body	g/day	0	Section 3.3.2
IR-c	ingestion rate – crabs, edible meat	g/day	13.2	Section 3.3.2
IR-cwb	ingestion rate – crabs, whole body	g/day	4.2	Section 3.3.2
IR-m	ingestion rate – mussels	g/day	0.33	Section 3.3.2
IR – cl	ingestion rate – clams	g/day	15.1	Section 3.3.2
FI	fractional intake derived from source	unitless	1 [1/]	EPA (2007b)
EF	exposure frequency	days/yr	365[2/]	EPA (1991b)
ED-c	exposure duration – child	years	6	EPA (1991b)
CF	conversion factor	kg/g	0.001	na
BW-ct	body weight – child Tulalip	kg	15.2	Toy et al. (1996)
AT-C	averaging time – cancer	days	25,550	EPA (1989)
AT-N	averaging time – non-cancer	days	2,190	EPA (1989)

[1/] A fractional intake derived from source of 1 was directed by EPA in the tribal framework guidance document (2006b).
[2/] Default exposure frequency of 350 days/yr modified to 365 days/yr to account for the fact that seafood consumption rate estimates are based on 365 days/yr.
na – not applicable
RME – reasonable maximum exposure
Source: Standard Table 4 in EPA (1998a), as modified from Windward (2007a)

Table 3-9. Daily Intake Calculations – Seafood Ingestion, Adult Tribal Scenario Based on Suquamish Data

Scenario timeframe: Current/future
Medium: Sediment
Exposure medium: Fish and shellfish tissue
Exposure route: Ingestion
Intake equation/model name: Chronic daily intake (CDI) (mg/kg-day) = [(EPC-p × IR-p) + (EPC-b × IR-b) + (EPC-bwb × IR-bwb) + (EPC-c × IR-c) + (EPC-cwb × IR-cwb) + (EPC-m × IR-m)+(EPC-cl × IR-cl)] × FI × EF × ED-a × CF × 1/BW-a × 1/AT

Parameter Code	Parameter Definition	Units	Value	Rationale/ Reference
EPC-p	exposure point concentration in pelagic fish	mg/kg ww	Table 3-31	Section 3.3.5
EPC-b	exposure point concentration in benthic fish, fillet	mg/kg ww	Table 3-31	Section 3.3.5
EPC-bwb	exposure point concentration in benthic fish, whole body	mg/kg ww	Table 3-31	Section 3.3.5
EPC-c	exposure point concentration in crabs, edible meat	mg/kg ww	Table 3-31	Section 3.3.5
EPC-cwb	exposure point concentration in crabs, whole body	mg/kg ww	Table 3-31	Section 3.3.5
EPC-m	exposure point concentration in mussels	mg/kg ww	Table 3-31	Section 3.3.5
EPC-cl	exposure point concentration in clams	mg/kg ww	Table 3-31	Section 3.3.5
IR-p	ingestion rate – pelagic fish	g/day	57.4	Section 3.3.2
IR-b	ingestion rate – benthic fish	g/day	26	Section 3.3.2
IR-bwb	ingestion rate – benthic fish, whole body	g/day	3.2	Section 3.3.2
IR-c	ingestion rate – crabs, edible meat	g/day	43	Section 3.3.2
IR-cwb	ingestion rate – crabs, whole body	g/day	13	Section 3.3.2
IR-m	ingestion rate – mussels	g/day	5.1	Section 3.3.2
IR-cl	ingestion rate – clams	g/day	450	Section 3.3.2
FI	fractional intake derived from source	unitless	1[1/]	EPA (2007b)
EF	exposure frequency	days/yr	365[2/]	EPA (1991b)
ED-a	exposure duration – adult	years	70	EPA (2005a)
CF	conversion factor	kg/g	0.001	na
BW-a	Body weight – adult	kg	79[3/]	Suquamish Tribe (2000)
AT-C	averaging time – cancer	days	25,550	EPA (1989)
AT-N	averaging time – non-cancer	days	25,550	EPA (1989)

[1/] A fractional intake derived from source of 1 was directed by EPA in the tribal framework guidance document (2006b).
[2/] Default exposure frequency of 350 days/yr modified to 365 days/yr to account for the fact that seafood consumption rate estimates are based on 365 days/yr.
[3/] Average body weight based on information provided by the Suquamish Tribe to EPA for the LDW site.
na – not applicable
ww – wet weight
Source: Standard Table 4 in EPA (1998a), as modified from Windward (2007a)

Table 3-10. Daily Intake Calculations – Incidental Sediment Ingestion during Netfishing, Adult Tribal RME Scenario

Scenario timeframe: Current/future
Medium: Sediment
Exposure medium: Sediment
Exposure route: Ingestion (incidental)
Intake equation/model name: Chronic daily intake (CDI) (mg/kg-day) = EPC × IR-s × FI × EF × ED × CF × 1/BW-a × 1/AT

Parameter Code	Parameter Definition	Units	Value	Rationale/ Reference
EPC	exposure point concentration in sediment	mg/kg dw	Table 3-24	Section 3.3.4
IR-s	incidental ingestion rate	g/day	0.050	EPA (1991b)
FI	fractional intake derived from source	unitless	1[1/]	na
EF	exposure frequency	days/yr	119[2/]	na
ED	exposure duration	years	44[2/]	na
CF	conversion factor	kg/g	0.001	na
BW-a	body weight – adult	kg	81.8	Toy et al. (1996)
AT-C	averaging time – cancer	days	25,550	EPA (1989)
AT-N	averaging time – non-cancer	days	16,060	EPA (1989)

1/ Fractional intake of 1 used to be consistent with EPA direction for seafood consumption scenarios.
2/ Value recommended by EPA for the LDW based on the length of the 2001 salmon season and on conversations with Muckleshoot Indian Tribe Assistant Harvest Manager regarding fishing frequency. This approach assumes that a fisher is present for each day of the fishing season. See Subappendix B.3 in Windward (2003) for more details on the derivation of this value.
na – not applicable
RME – reasonable maximum exposure
dw – dry weight
Source: Standard Table 4 in EPA (1998a), as modified from Windward (2007a)

Table 3-11. Daily Intake Calculations – Dermal Contact with Sediment during Netfishing, Adult Tribal RME Scenario

Scenario timeframe: Current/future
Medium: Sediment
Exposure medium: Sediment
Exposure route: Dermal
Intake equation/model name: Chronic daily intake (CDI) (mg/kg-day) = EPC × ABS × SA × AF × FI × EF × ED × CF × 1/BW-a × 1/AT

Parameter Code	Parameter Definition	Units	Value	Rationale/ Reference
EPC	exposure point concentration in sediment	mg/kg dw	Table 3-24	Section 3.3.4
ABS	dermal absorption factor	unitless	Table 3-22	Section 3.3.3
SA	skin surface area exposed	cm^2	3,600[1/]	EPA (1997a)
AF	adherence factor by event	mg/cm^2-event	0.2	EPA (2004)
FI	fractional intake derived from source	unitless	1[2/]	Na
EF	exposure frequency	events/yr	119[3/]	Na
ED	exposure duration	years	44[3/]	Na
CF	conversion factor	kg/mg	0.000001	Na
BW-a	body weight – adult	kg	81.8	Toy et al. (1996)
AT-C	averaging time – cancer	days	25,550	EPA (1989)
AT-N	averaging time – non-cancer	days	16,060	EPA (1989)

[1/] Recommended surface area for commercial/industrial worker. Assumes that head, hands, and forearms are exposed. Selected value represents sum of 50th percentile surface areas for men (most netfishers are men) for these body parts; taken from Table 6-2 in EPA (1997a). Given the higher body weight of individuals surveyed in Toy et al. (1996) compared to the general US population, the surface area values selected here for commercial/industrial workers may underestimate the surface area of tribal fishermen body parts. However, no conversion data are available at the present time.
[2/] Fractional intake of 1 used to be consistent with EPA direction for seafood consumption scenarios.
[3/] Value recommended by EPA for the LDW based on conversation with Muckleshoot Indian Tribe Assistant Harvest Manager. See Subappendix B.3 in Windward (2003) for more details on the derivation of this value.
dw – dry weight
na – not applicable
RME – reasonable maximum exposure
Source: Standard Table 4 in EPA (1998a), as modified from Windward (2007a)

Table 3-12. Daily Intake Calculations – Incidental Sediment Ingestion during Child Beach Play RME

Scenario timeframe: Current/future
Medium: Sediment
Exposure medium: Sediment
Exposure route: Ingestion (incidental)
Intake equation/model name: Chronic daily intake (CDI) (mg/kg-day) = (EPC × IR-s × FI × EF × CF × 1/AT) × Γ (ED_i × 1/BW_i-c)

Parameter Code	Parameter Definition	Units	Value	Rationale/ Reference
EPC	exposure point concentration in sediment	mg/kg dw	Table 3-23	Section 3.3.4
IR-s	incidental sediment ingestion rate	g/day	0.200	EPA (1997a)
FI	fractional intake derived from source	unitless	1	Na
EF	exposure frequency	days/yr	65[1/]	Parametrix (2003)
ED_i	exposure duration – by age class	years	Varies[2/]	EPA (1991b)
CF	conversion factor	kg/g	0.001	Na
BW_i-c	body weight – child	kg	Varies[3/]	EPA (2006a)
AT-C	averaging time – cancer	days	25,550	EPA (1989)
AT-N	averaging time – non-cancer	days	2,190	EPA (1989)

[1/] Based on 95th percentile for children from birth through 6 years old playing or digging in sand immediately adjacent to or in water at King County beach parks on Lake Union, Lake Washington, and Lake Sammamish (Parametrix 2003).
[2/] Doses for six different age classes are calculated separately: < 1, 1 to 2, 2 to 3, 3 to 4, 4 to 5, and 5 to 6. Total exposure duration is 6 years, but duration for each year class is 1 year.
[3/] Body weights for each age class are means for boys and girls combined (EPA 2006a).

Age class	BW_i (kg)	Age class	BW_i (kg)
< 1	9.1	3 to 4	15.3
1 to 2	11.3	4 to 5	17.4
2 to 3	13.3	5 to 6	19.7

dw – dry weight
na – not applicable
Source: Standard Table 4 in EPA (1998a), as modified from Windward (2007a)

Table 3-13. Daily Intake Calculations – Dermal Contact with Sediment during Child Beach Play RME

Scenario timeframe: Current/future
Medium: Sediment
Exposure medium: Sediment
Exposure route: Dermal
Intake equation/model name: Chronic daily intake (CDI) (mg/kg-day) = (EPC × ABS × AF × FI × EF × CF × 1/AT) × Γ (SA_i × ED_i × 1/BW_i-c)

Parameter Code	Parameter Definition	Units	Value	Rationale/ Reference
EPC	exposure point concentration in sediment	mg/kg dw	Table 3-23	Section 3.3.4
ABS	dermal absorption factor	unitless	Table 3-22	Section 3.3.3
SA_i	skin surface area exposed – by age class	cm^2	Varies[1/]	EPA (1997a)
AF	adherence factor by event	mg/cm^2-event	0.2	EPA (2004)
FI	fractional intake derived from source	unitless	1	Na
EF	exposure frequency	events/yr	65[2/]	Parametrix (2003)
ED_i	exposure duration – by age class	years	Varies[3/]	EPA (1991b)
CF	conversion factor	kg/mg	0.000001	Na
BW_i-c	body weight, child – by age class	kg	Varies[4/]	EPA (2006a)
AT-C	averaging time – cancer	days	25,550	EPA (1989)
AT-N	averaging time – non-cancer	days	2,190	EPA (1989)

1/ Assumes that 35% of the total body surface area is exposed, roughly corresponding to an individual wearing a short-sleeve shirt and short pants but no shoes (EPA 1992). Body surface area data taken from EPA (2006a). Values below are means of the 50th percentile surface areas for male and female children (total surface area × 0.35).

Age class	SA_i (cm^2)	Age class	SA_i (cm^2)	Age class	SA_i (cm^2)
< 1	1,330	2 to 3	2,069	4 to 5	2,515
1 to 2	1,750	3 to 4	2,298	5 to 6	2,751

2/ Based on 95th percentile for children from birth to 6 years old playing or digging in sand immediately adjacent to or in water at King County beach parks on Lake Union, Lake Washington, and Lake Sammamish (Parametrix 2003).

3/ Doses for six different age classes are calculated separately: : < 1, 1 to 2, 2 to 3, 3 to 4, 4 to 5, and 5 to 6. Total exposure duration is 6 years, but duration for each year class is 1 year.

4/ Body weights for each age class are means for boys and girls combined (EPA 2006a).

Age class	BW_i (kg)	Age class	BW_i (kg)
< 1	9.1	3 to 4	15.3
1 to 2	11.3	4 to 5	17.4
2 to 3	13.3	5 to 6	19.7

dw – dry weight
na – not applicable
Source: Standard Table 4 in EPA (1998a), as modified from Windward (2007a)

Table 3-14. Daily Intake Calculations – Incidental Sediment Ingestion during Tribal Clamming RME

Scenario timeframe: Current/future
Medium: Sediment
Exposure medium: Sediment
Exposure route: Ingestion (incidental)
Intake equation/model name: Chronic daily intake (CDI) (mg/kg-day) = EPC × IR-s × FI × EF × ED × CF × 1/BW-a × 1/AT

Parameter Code	Parameter Definition	Units	Value	Rationale/ Reference
EPC	exposure point concentration in sediment	mg/kg dw	Table 3-23	Section 3.3.4
IR-s	Incidental ingestion rate	g/day	0.1	EPA (1997a)
FI	fractional intake derived from source	unitless	1[1/]	na
EF	exposure frequency	days/yr	120[2/]	Kissinger (2007)
ED	exposure duration	years	64[3/]	Kissinger (2007)
CF	conversion factor	kg/g	0.001	na
BW-a	body weight – adult	kg	81.8	Toy et al. (1996)
AT-C	averaging time – cancer	days	25,550	EPA (1989)
AT-N	averaging time – non-cancer	days	23,360	EPA (1989)

[1/] Fractional intake of 1 used to be consistent with EPA direction for seafood consumption scenarios.
[2/] Exposure frequency determined by EPA to reflect tribal clamming patterns for the LDW (Kissinger 2007).
[3/] Exposure duration determined by EPA to reflect tribal clamming patterns for the LDW (Kissinger 2007).
dw – dry weight
na – not applicable
Source: Standard Table 4 in EPA (1998a), as modified from Windward (2007a)

Table 3-15. Daily Intake Calculations – Dermal Contact with Sediment during Tribal Clamming RME

Scenario timeframe: Current/future
Medium: Sediment
Exposure medium: Sediment
Exposure route: Dermal
Intake equation/model name: Chronic daily intake (CDI) (mg/kg-day) = EPC × ABS × SA × AF × FI × EF × ED × CF × 1/BW-a × 1/AT

Parameter Code	Parameter Definition	Units	Value	Rationale/ Reference
EPC	exposure point concentration in sediment	mg/kg dw	Table 3-23	Section 3.3.4
ABS	dermal absorption factor	unitless	Table 3-22	Section 3.3.3
SA_i	skin surface area exposed	cm^2	6,040[1/]	EPA (1997a)
AF	adherence factor by event	mg/cm^2-event	0.2	EPA (2004)
FI	fractional intake derived from source	unitless	1[2/]	Na
EF	exposure frequency	events/yr	120[3/]	Kissinger (2007)
ED_i	exposure duration	years	64[4/]	Kissinger (2007)
CF	conversion factor	kg/mg	0.000001	Na
BW-a	body weight – adult	kg	81.8	Toy et al. (1996)
AT-C	averaging time – cancer	days	25,550	EPA (1989)
AT-N	averaging time – non-cancer	days	23,360	EPA (1989)

1/ Assumes that 39% of the total body surface area is exposed, roughly corresponding to a barefoot individual wearing a short-sleeve shirt and short pants (EPA 1992). Body surface area data taken from Tables 6-2, 6-3 and 6-4 in EPA (1997a) and corresponds to head, lower arms, hands, lower legs, and feet.
2/ Fractional intake of 1 used to be consistent with EPA direction for seafood consumption scenarios.
3/ Exposure frequency determined by EPA to reflect tribal clamming patterns for the LDW (Kissinger 2007).
4/ Exposure duration determined by EPA to reflect tribal clamming patterns for the LDW (Kissinger 2007).
dw – dry weight
na – not applicable
Source: Standard Table 4 in EPA (1998a), as modified from Windward (2007a)

Table 3-16. Daily Intake Calculations – Incidental Sediment Ingestion during Tribal Clamming, 183-day-per-year Scenario

Scenario timeframe: Current/future
Medium: Sediment
Exposure medium: Sediment
Exposure route: Ingestion (incidental)
Intake equation/model name: Chronic daily intake (CDI) (mg/kg-day) = EPC × IR-s × FI × EF × ED × CF × 1/BW-a × 1/AT

Parameter Code	Parameter Definition	Units	Value	Rationale/ Reference
EPC	exposure point concentration in sediment	mg/kg dw	Table 3-23	Section 3.3.4
IR-s	Incidental ingestion rate	g/day	0.1	EPA
FI	fractional intake derived from source	unitless	1[1/]	na
EF	exposure frequency	days/yr	183[2/]	Kissinger (2007)
ED	exposure duration	years	70[3/]	Kissinger (2007)
CF	conversion factor	kg/g	0.001	na
BW-a	body weight – adult	kg	81.8	Toy et al. (1996)
AT-C	averaging time – cancer	days	25,550	EPA (1989)
AT-N	averaging time – non-cancer	days	25,550	EPA (1989)

[1/] Fractional intake of 1 used to be consistent with EPA direction for seafood consumption scenarios.
[2/] Exposure frequency requested by Suquamish Tribe for the LDW (Kissinger 2007).
[3/] Exposure duration requested by Suquamish Tribe for the LDW (Kissinger 2007).
dw – dry weight
na – not applicable
Source: Standard Table 4 in EPA (1998a), as modified from Windward (2007a)

Table 3-17. Daily Intake Calculations – Dermal Contact with Sediment during Clamming, 183-day-per-year Scenario

Scenario timeframe: Current/future
Medium: Sediment
Exposure medium: Sediment
Exposure route: Dermal
Intake equation/model name: Chronic daily intake (CDI) (mg/kg-day) = EPC × ABS × SA × AF × FI × EF × ED × CF × 1/BW-a × 1/AT

Parameter Code	Parameter Definition	Units	Value	Rationale/ Reference
EPC	exposure point concentration in sediment	mg/kg dw	Table 3-23	Section 3.3.4
ABS	dermal absorption factor	unitless	Table 3-22	Section 3.3.3
SA_i	skin surface area exposed	cm^2	6,040[1/]	EPA (1997a)
AF	adherence factor by event	mg/cm^2-event	0.2	EPA (2004)
FI	fractional intake derived from source	unitless	1[2/]	na
EF	exposure frequency	events/yr	183[3/]	Kissinger (2007)
ED_i	exposure duration	years	70[4/]	Kissinger (2007)
CF	conversion factor	kg/mg	0.000001	na
BW-a	body weight – adult	kg	81.8	Toy et al. (1996)
AT-C	averaging time – cancer	days	25,550	EPA (1989)
AT-N	averaging time – non-cancer	days	25,550	EPA (1989)

1/ Assumes that 39% of the total body surface area is exposed, roughly corresponding to a barefoot individual wearing a short-sleeve shirt and short pants (EPA 1992). Body surface area data taken from Tables 6-2, 6-3 and 6-4 in EPA (1997a) and corresponds to head, lower arms, hands, lower legs, and feet.
2/ Fractional intake of 1 used to be consistent with EPA direction for seafood consumption scenarios.
3/ Exposure frequency requested by Suquamish Tribe for the LDW (Kissinger 2007).
4/ Exposure duration requested by Suquamish Tribe for the LDW (Kissinger 2007).
dw – dry weight
na – not applicable
Source: Standard Table 4 in EPA (1998a), as modified from Windward (2007a)

3.3.2 Seafood Ingestion Rates

Three seafood ingestion scenarios are evaluated in this HHRA, consisting of RME and high end exposure scenarios. The human exposure scenarios are taken from the LDW HHRA. There are no surveys of tribal resources that specifically focus on the West Waterway and Elliott Bay portions of the Lockheed West Site. Based on recent regional tribal consumption surveys from Puget Sound (Toy et al. 1996; Suquamish Tribe 2000), the following scenarios were developed in the LDW HHRA and are evaluated in the present HHRA for the Lockheed West Site: (1) RME adult tribal scenario based on Tulalip data (Table 3-7), (2) RME child tribal scenario based on Tulalip data (Table 3-8), and (3) a high end adult tribal scenario based on Suquamish survey data (Table 3-9). The LDW HHRA scenarios and parameters were developed in consultation with the Muckleshoot and Suquamish Tribes, using the conceptual approach developed in EPA's tribal framework (EPA 2007b). Details on the development of the seafood consumption scenarios and reviews of seafood ingestion studies that may be applicable to this HHRA can be found in the LDW HHRA (Windward 2007a). The following subsections summarize the relevant parameters used in the present HHRA.

3.3.2.1 Adult Tribal Seafood Consumption Scenarios Based on Tulalip and Suquamish Data

EPA Region 10 has developed a conceptual framework for selecting and using Tribal fish and shellfish consumption rates for purposes of estimating site-related risks hazardous waste cleanup sites in Puget Sound. The Framework provides that EPA will consult with the Tribes on site-specific exposure assumptions and cleanup decisions at each Superfund site within a Tribal fishing area. In the tribal Framework document, EPA identifies consumption rates for tribal members for each type of seafood (i.e., seafood category) based on surveys conducted by the Tulalip and Suquamish Tribes. EPA identified the Tulalip Tribes consumption rate for application as the RME for the Duwamish Waterway (EPA 2005a). As mentioned in the LDW HHRA (Windward 2007a), EPA stated in comments on the draft LDW HHRA that "…based on policy consideration, EPA is intending to use the Tulalip Tribes seafood consumption rate as the principal rate to compute health protective tribal seafood consumption risks." The tribal adult RME scenario as developed for the LDW HHRA is adapted herein for the adult tribal seafood consumption scenario.

A scenario to represent the consumption rate for Tulalip tribal children is also taken from the LDW HHRA. In the child tribal seafood consumption scenario, the seafood ingestion rate is assumed to be 40 percent of the adult ingestion rate.

Consistent with the LDW approach, a Suquamish exposure scenario has also been included as relevant to Suquamish tribal members and as an estimate of Suquamish consumption and risk. EPA Region 10 has provided guidance for the inclusion of this scenario with the intent to "…assist in characterizing the range of seafood consumption risks," provided in comments on draft versions of the LDW HHRA (Windward 2007a). Also consistent with the LDW HHRA and RI (Windward 2007a, 2007c), the results from the Suquamish consumption scenario will not be used to develop a list of risk drivers or associated risk-based threshold concentrations (RBTCs) for the purpose of developing and evaluating remedial alternatives in the Feasibility Study for the Lockheed West Site.

Windward (2007a) summarized the sources of the consumption rates that are used for the tribal seafood consumption scenarios; these are briefly summarized here. The consumption rates in EPA's guidance are based on seafood consumption surveys of the Tulalip Tribes (Toy et al. 1996) and the Suquamish Tribe (Suquamish Tribe 2000). The 95th percentile of total seafood consumption from Puget Sound was attributed to different seafood categories (anadromous, bottom feeding, and pelagic fish, as well as shellfish) assuming the proportion of consumption in each category calculated for average consumption (including both consumers and non-consumers) also applied to the 95th percentile consumption of Puget Sound seafood. For example, the average consumption of anadromous fish divided by the sum of the averages of consumption of all seafood categories was 49.7 percent. Thus, it was assumed that 49.7 percent of the 95th percentile of total seafood consumed from Puget Sound by Tulalip Tribal members (194 g/day) was anadromous fish (96.4 g/day) (EPA 2007b). The total quantity of non-anadromous seafood consumed for the tribal adult scenario based on Tulalip data was calculated as 97.5 g/day for the RME scenario. Total non-anadromous seafood consumed for the tribal adult scenario based on Suquamish data was 583.5 g/day.

Table 3-18 presents the tribal seafood consumption rates for different components of the market basket specified by EPA for application to the LDW. Consumption of anadromous fish is not included in the tribal exposure and risk estimates because the bulk of the body burden of bioaccumulative contaminants in adult salmon is not thought to be obtained from the site (EPA 2005a). Because the site-related contaminant body burden is low, most risks associated with salmon consumption were deemed not to be site-related.

Table 3-18. Seafood Species Consumed by Tulalip and Suquamish Adults and Species used to Represent Consumed Species

Seafood Category	Members	Grams per Day		Rationale for Inclusion/Exclusion and Representative Species Presumably Present at the Site
		Adult Tulalip RME[1/]	Adult Suquamish[2/]	
Anadromous fish	Salmon	96.4	183.5	Consumption rate not used in this HHRA. Although adult salmon are common in the West Waterway and Elliott Bay, EPA guidance (EPA 2005a) recommended against including them in the LDW HHRA because of the migratory behavior of salmon.
Pelagic fish	including cod and perch	8.1	56	Perch are common in the West Waterway and Elliott Bay.
Benthic/ demersal fish	halibut, sole, rockfish, snappers	7.5	29.1	English sole are common in West Waterway and Elliott Bay; presence of other benthic and demersal fish, such as rockfish, is uncertain.
Shellfish	bivalves, snails, shrimp, crabs	81.9	498.4	Many marine shellfish species (crabs, clams, and mussels) are expected to be present in West Waterway and Elliott Bay.

1/ From Table 1 of EPA (2005a), 95th percentile of the total seafood consumption rate from Puget Sound = 194 g/day.
2/ From Table B1 of EPA (2005a); 95th percentile of the total seafood consumption rate from Puget Sound = 785 g/day.
HHRA – human health risk assessment; LDW – Lower Duwamish Waterway; RME – reasonable maximum exposure

The consumption of different types of shellfish within the shellfish seafood category for the adult tribal RME scenario based on Tulalip data and adult tribal scenario based on Suquamish data was specified by EPA in the application of their framework to sites of the Lower Duwamish (EPA 2005a). For the present Lockheed West HHRA, the species-specific ingestion rate was used together with modeled concentration data for that species in the market basket estimate of exposure intake. In the market basket approach, average consumption rates (for consumers and non-consumers) of clams, mussels, and crabs were calculated and used by EPA to develop concentration weighting factors that could be applied to the shellfish seafood category.

Using the adult tribal RME clam consumption rate based on Tulalip data as an example, average clam consumption was 46 percent of the sum of averages of other shellfish consumed (clams, mussels, and crabs). This percentage was applied to the adult tribal shellfish consumption rate (81.9 g/day, 95th percentile of Puget Sound shellfish consumption) to generate a clam consumption rate of 37.7 g/day for the adult tribal RME scenario based on Tulalip data. Similar procedures were used to develop consumption rates for the adult tribal scenario based on Suquamish data. Table 3-19 presents the concentration weighting factors (as percentages) for clams, mussels, and crabs and the calculated consumption of each within the framework of the adult tribal RME scenario based on Tulalip data and adult tribal scenario based on Suquamish data.

Table 3-19. Adult Tribal Consumption of Shellfish (Crabs, Clams, and Mussels) Based on Tulalip and Suquamish Data

Shellfish Type	Percentage of Total Shellfish Consumption	RME or 95th Percentile Scenario Consumption Rate (g/day)[1]
Adult Tribal Based on Tulalip Data[2/]		
Crabs	53	43.4
Clams[3/]	46	37.7
Mussels	1	0.82
Adult Tribal Based on Suquamish Data[4/]		
Crabs	11	54.8
Clams[3/]	88	438.6
Mussels	1	5.0

1/ The adult consumption rate is the product of the percentage of total consumption and the overall shellfish consumption rate for the Tulalip and Suquamish Tribes, as applicable. The rate based on the Tulalip Tribes study (Toy et al. 1996) was determined by EPA to be the most appropriate for application to the LDW site (Windward 2007a) and is therefore defined as the adult tribal RME scenario for the Lockheed West Site HHRA. The scenario based on Suquamish data is provided for estimation of upper bound risks and is not designated as an RME scenario.
2/ Tulalip Tribes 95th percentile total Puget Sound shellfish consumption = 81.9 g/day, consumption percentages from Table B-1 of EPA (2007b). Note that the percentages for crab and clam consumption were found to have been reversed in the LDW HHRA – see Section 6.1 for explanation and the potential impact on risk estimates.
3/ Includes Manila/littleneck clams, horse clams, butter clams, cockles, oysters, and scallops (EPA 2005a).
4/ Suquamish Tribe 95th percentile total Puget Sound shellfish consumption = 498.4 g/day, consumption percentages from Table B-2 of EPA (2007b).
na – not applicable
RME – reasonable maximum exposure
Source: Windward (2007a)

The EPA tribal seafood consumption framework did not provide specific guidance on the portions of seafood consumed (e.g., whole body vs. filleted fish) within a specific seafood category. Quantification of these portions would typically result in refinement of the risk estimates and a reduction of uncertainty. However, for the Lockheed West Site, tissue data are not available for whole body or fillets of fish. Because BSAF values are available only for a seafood category but not for specific tissues within that category, modeling of chemical concentrations in different tissue types within a species or seafood category was not performed. Instead, for simplicity, the concentrations of modeled concentrations of COPCs into different tissues of the same seafood type are assumed to be equivalent (i.e., the same concentrations are modeled for fish whole body as for fillet). See Section 3.3.5 for more detail on tissue concentration modeling.

Information on the relative percentage of consumption of different seafood categories is available from the seafood consumptions surveys of the Tulalip Tribes (Toy et al. 1996) and the Suquamish Tribe (2000). To maintain consistency with the LDW HHRA, the same consumption rates for each seafood tissue category used in the LDW HHRA are used in the Lockheed West HHRA, as presented in Table 3-20. Thus, the consumption rates for the different seafood categories differ from one another and are taken from the LDW HHRA, although the concentrations of COPCs in subtissues within each category do not differ.

Table 3-20. Portions of Benthic Fish and Crab Consumed – Adult Tribal RME Scenario Based on Tulalip Data and Adult Tribal Scenario Based on Suquamish Data

Seafood Category	Percentage of Consumption	RME Scenario or 95th Percentile Consumption Rate (g/day)[1/]
Adult Tribal Scenario Based on Tulalip Data		
Crab, edible meat	76[2/]	33
Crab, whole body	24[2/]	10
Benthic fish, fillet	100[3/]	7.5
Benthic fish, whole body	0[3/]	0
Adult Tribal Scenario Based on Suquamish Data		
Crab, edible meat	76[4/]	41.6
Crab, whole body	24[4/]	13.2
Benthic fish, fillet	89[4/]	25.9
Benthic fish, whole body	11[4/]	3.2

1/ Product of percentage of consumption and the consumption rate for total crab or benthic fish, from EPA framework (EPA 2005a). The rate based on the Tulalip Tribes study (Toy et al. 1996) was determined by EPA to be the most appropriate for application to the LDW (Windward 2007a) and is therefore defined as the adult tribal RME scenario for the Lockheed West Site HHRA. The scenario based on Suquamish data is provided for estimation of upper-bound risks and is not designated as an RME scenario.
2/ Portions of crab consumed were not reported for Tulalip Tribes (Toy et al. 1996); values from the Suquamish Tribe (Suquamish Tribe 2000) were used as surrogates.
3/ No Tulalip Tribe respondents reported consumption of benthic whole-body fish (Toy et al. 1996).
4/ Values from the Suquamish Tribe (Suquamish Tribe 2000).
RME – reasonable maximum exposure
Source: Windward (2007a)

3.3.2.2 Child Tribal Seafood Consumption Based on Tulalip Data

The LDW HHRA derived seafood consumption rates for the child tribal scenario based on consultation with EPA; the derivation is summarized in the following. EPA noted in their initial framework guidance document for selecting and using tribal fish and shellfish consumption rates for risk-based decisions (EPA 2007b) that child-specific rates appropriate for use in the framework are not available from the two Puget Sound studies (Toy et al. 1996; Suquamish Tribe 2000). The two consumption studies included adult-reported child seafood consumption for children under 5 years of age (Tulalip study, n = 21) and under 6 years of age (Suquamish study, n = 31).

As noted above, the Tulalip Tribes study (Toy et al. 1996) was considered most relevant for the RME scenario for the LDW, and is thereby used as the RME for the Lockheed West Site. In comments on draft versions of the LDW HHRA, EPA specified that the total consumption rate for the child tribal RME scenario based on Tulalip data should be equal to 40 percent of the adult tribal RME consumption rate based on Tulalip data (Windward 2007a). The rationale provided by EPA included concerns about the small number of children surveyed in the Tulalip Tribes study (i.e., low sample size), and the relatively low consumption rates reported as compared to other regional tribal fish and seafood consumption studies (CRITFC 1994; Toy et al. 1996) and national fish consumption studies

(EPA 2002d). The 40 percent ratio is based on a comparison of child and adult fish and seafood consumption data from these regional and national studies (Windward 2007a).

The limitations in sample size for estimating total seafood consumption rates for children also limit these data for use in estimating the percentage breakdown of the seafood categories consumed by children. Therefore, the same percentages for consumption of the different seafood categories and portions used for the adult tribal scenario based on Tulalip data were used for the child tribal scenarios. In other words, adult tribal RME consumption rates based on Tulalip data for each seafood category and portion (Tables 3-19 and 3-20) were multiplied by 40 percent to estimate child tribal RME consumption rates based on Tulalip data, as shown in Table 3-21. Thus, no child-specific data from the Tulalip study, other than body weight, was used for the development of the child tribal exposure scenarios based on Tulalip data. As with the adult tribal seafood consumption scenarios, consumption of anadromous fish was not included for child tribal exposure, which considers only the consumption of resident seafood organisms. The total non-anadromous seafood consumed in the tribal child scenario based on Tulalip data was 39.0 g/day for the RME scenario.

Table 3-21. Rates of Child Tribal Seafood Consumption Based on Tulalip Data Associated with Different Seafood Categories

Seafood Category	RME Scenario Consumption Rate (g/day)[1/]
Anadromous fish[2/]	38.6
Pelagic fish	3.2
Benthic fish, fillet	3.0
Benthic fish, whole body	0
Crab, edible meat	13.2
Crab, whole body	4.2
Clams[3/]	15.1
Mussels	0.33

[1/] Total consumption rate = 77.6 g/day. Total consumption rate and consumption rates for seafood categories calculated as 40% of the adult tribal RME consumption rates based on Tulalip data.
[2/] Consumption rate not used in this HHRA.
[3/] Includes Manila/littleneck clams, horse clams, butter clams, cockles, oysters, and scallops (EPA 2005a).
RME – reasonable maximum exposure
Source: Windward (2007a)

3.3.3 Sediment Exposure Parameters

Sediment exposure scenarios were developed in Section 3.1 for clamming, netfishing, and beach play. All scenarios include exposures from dermal contact and incidental ingestion of sediment. Most of the exposure parameters relative to these exposure routes are provided in the above Tables 3-10 to 3-17. Two parameters related to dermal exposures that warranted additional discussion in the LDW HHRA are summarized from Windward (2007a) below.

3.3.3.1 Dermal Adherence Factor

The dermal adherence factor (AF) is used to characterize the adherence of soil, or sediment, to the skin during direct contact. However, EPA does not provide a dermal adherence factor specifically for sediment, and the high moisture content of sediment would lead to higher adherence than for typical dry soils (Kissel et al. 1996). As sediment loading increases, the fraction of chemical in soil that adheres to the skin and is available to be absorbed will remain constant until all of the skin is covered by a thin layer of soil (known as the mono-layer) (Duff and Kissel 1996). Once this mono-layer threshold is crossed, the fraction of chemical that can be absorbed will decrease, inasmuch as not all of the soil is in constant, direct contact with skin. Both the amount of dry soil required to form the mono-layer and the associated adherence capability of the dry soil depend on grain size. Generally, larger particles will have a lower adherence factor than smaller particles, but for sediments, adherence is a function of moisture content as well as grain size. Consistent with the LDW HHRA, for the purposes of the Lockheed West HHRA, the EPA-recommended value of 0.2 mg/cm^2-event for children playing in wet soil as a high-activity event (EPA 2004) is used in the risk calculations for the RME scenario.

3.3.3.2 Dermal Absorption

Two parameters can be used in the calculation of exposure to chemicals through dermal absorption. One is the dermal absorption fraction (ABS), which refers to the fraction of the chemical in sediment applied to the skin surface that is absorbed into the bloodstream. The second is an adjustment to the toxicity value to account for differences between the absorbed dose and ingested dose. There is considerable uncertainty regarding chemical-specific values for ABS (EPA 1992). EPA (2004) has developed supplemental guidance for dermal risk assessment that provides ABS values for the organic COPCs identified for sediment contact in Table 3-2, but provides an ABS value for only one metal COPC, arsenic (Table 3-22). EPA (2004) states that speciation of inorganic substances is crucial to estimating dermal absorption, but data are insufficient to derive default values for other inorganic substances. Where absorption values are not provided by EPA (2004), the dermal absorption pathway was not evaluated quantitatively. The uncertainty analysis in the LDW HHRA (Windward 2007a) demonstrated that the use of alternative absorption factors for metals in sediment contact scenarios did not significantly alter the conclusions of the dermal contact risks. For that reason, alternative absorption factors are not evaluated further in the Lockheed West HHRA.

Table 3-22. Dermal Absorption Fractions for Direct Contact COPCs

Chemical	ABS (unitless)	Oral Absorption Adjustment
Antimony	None	RfD × 0.15
Arsenic	0.03	None
Chromium	none	RfD × 0.025
Copper	none	None
Lead	none	none
Vanadium	none	RfD × 0.026
cPAHs	0.13	None
Total PCBs	0.14	None

ABS – dermal absorption fraction
cPAH – carcinogenic polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
RfD – reference dose
Source: Risk Assessment Guidance for Superfund Part E (EPA 2004)

The toxicity values to quantify non-carcinogenic and carcinogenic endpoints (reference doses [RfDs] and CSFs, respectively) become more potent when based on an absorbed dose as occurs during dermal exposure, rather than ingested dose. To account for this difference, an oral absorption adjustment is made to each toxicity value when applying it to exposures from dermal absorption. The oral absorption adjustment is intended to reflect the internal dose from the dermally absorbed exposure, which is higher than the dose from oral exposure from which the toxicity values are derived. The toxicological benchmarks presented in Section 3.0 are based on orally administered doses, which are not necessarily equivalent to dermally absorbed doses because of incomplete oral and or dermal absorption. For this HHRA, a gastrointestinal absorption factor of 1 was used for organic chemicals (i.e., oral toxicological benchmarks were applied without modification). However, of the direct contact sediment COPCs, none have both a recommended dermal absorption factor and reduced oral absorption (Table 3-22), and no adjustments were made to the RfDs or CSFs for oral absorption.

3.3.4 Exposure Point Concentrations for Sediment

Exposure point concentrations are used as the concentrations in environmental media to estimate exposures to site-related chemicals. Exposure point concentrations are developed for sediment exposures at the Site and for exposures to various seafood items through their ingestion.

Exposure point concentrations in sediment were calculated using the EPA ProUCL 4.0 software (EPA 2007c). This software uses both detected and undetected values, and creates interpolated values for non-detects based on the estimated distribution of the detected concentrations. For chemicals with non-detected values, ProUCL uses robust regression on order statistic (ROS) methods to fill-in a set of concentrations for nondetects that would result in a better estimate of central tendency than other substitution methods (e.g., use of ½ the detection limit for the non-detected value). ProUCL assumes the distribution of the non-detected values based on the distribution of the detected concentrations, and substitutes values for the non-detects based on that assumed distribution. The full dataset, including the substituted concentrations, is then used by ProUCL to calculate the 95 percent upper confidence limit (UCL) on the mean concentration.

Once any necessary data substitution is performed, the software analyzes the data to identify the underlying distribution of the data set, to estimate 95 percent upper confidence limits on the mean value (95 UCL) for various distribution types, and to recommend the most appropriate 95 UCL based on the data distribution. The technical guidance document for this software states that the 95 UCL calculated from datasets with very few (i.e., 6 or less) detected concentrations are not reliable enough for deriving EPCs. In this HHRA, EPCs for any COPCs with 6 or less detections in sediment are not based on the 95 UCL but on the maximum concentration instead. Thus, in determining the EPCs, none of the UCLs are based on the use of ½ detection limits, and sediment EPCs are either the ProUCL-recommended value for the 95 UCL or the maximum concentration.

The procedures for estimating EPCs for grouped compounds such as cPAHs, total PCBs, and total DDTs were described previously in Section 2.2.3. Once the cPAHs, total PCBs, or total DDTs are calculated on a per sample basis, the methods for calculating the EPC for each of those is the same as that for other chemicals.

As described in Table 3-1, different exposure areas were defined for each of the direct sediment exposure scenarios. For the beach play and clamming exposure scenarios, exposures are assumed to occur with the intertidal sediment of the Site along both the West Waterway and Elliott Bay sides of the Site. For the netfishing scenario, exposures are assumed to occur with the combined subtidal and intertidal sediment areas of the Site, which includes the West Waterway and Elliott Bay sides of the Site.

EPCs were determined for all COPCs for each dermal contact and incidental ingestion sediment exposure scenario using ProUCL 4.0. Summary statistics, the distribution type, the UCL on the mean chemical concentrations, and EPCs in intertidal sediment and in subtidal plus intertidal sediments for all direct exposure scenarios are presented in Tables 3-23 and 3-24, respectively.

Table 3-23. Exposure Point Concentrations for COPCs in Intertidal Sediment

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL	Distribution[1/]	Maximum Concentration (Qualifier)[2/]	Exposure Point Concentration		
							Value	Units	Statistic[3/]
Intertidal Sediment	Antimony	mg/kg	54.7	81.7	L	126 [J]	81.7	mg/kg	95% UCL
Beach Play and Clamming	Arsenic	mg/kg	127	192	Nn	330	192	mg/kg	95% UCL
	Chromium	mg/kg	138	198	L	289	198	mg/kg	95% UCL
	Copper	mg/kg	534	840	Nn	1,310	840	mg/kg	95% UCL
	Lead	mg/kg	367	660	L	1,420	367	mg/kg	Mean[4/]
	Vanadium	mg/kg	41.0	51.8	Nn	68.6	51.8	mg/kg	95% UCL
	cPAH	mg/kg	0.113	0.182	N	0.344	0.182	mg/kg	95% UCL

1/ Distribution type for the "95% UCL" term, as identified by ProUCL: G - Gamma; L - Lognormal; N - Normal; Nn - Nonparametric
2/ Qualifier Definitions: J - Estimated
3/ EPC Statistic Definitions: 95% UCL = 95% Upper Confidence Limit as calculated by ProUCL 4.0; Mean = Average of sample results.
4/ Lead exposures and risks are modeled using Integrated Exposure Uptake Biokinetic Model for Lead in Children (IEUBK) (EPA 1994) and the Adult Lead Model (ALM) (EPA 2003b), which recommend use of mean concentrations for lead.

Table 3-24. Exposure Point Concentrations for COPCs in Combined Subtidal Plus Intertidal Sediment

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL	Distribution[1/]	Maximum Concentration (Qualifier)[2/]	Exposure Point Concentration		
							Value	Units	Statistic[3/]
Intertidal and Subtidal Sediment	Antimony	mg/kg	20.3	37.0	L	194 [J]	37.0	mg/kg	95% UCL
Tribal Netfisher	Arsenic	mg/kg	47.5	109	Nn	330	109	mg/kg	95% UCL
	Chromium	mg/kg	73.2	90.0	L	504	90.0	mg/kg	95% UCL
	Lead	mg/kg	146	200	L	1,420	146	mg/kg	Mean[4/]
	cPAH	mg/kg	0.762	0.958	G	2.9	0.958	mg/kg	95% UCL
	PCBs (total)	mg/kg	0.370	0.498	G	2.2	0.498	mg/kg	95% UCL

1/ Distribution type for the "95% UCL" term, as identified by ProUCL: G - Gamma; L - Lognormal; Nn - Nonparametric
2/ Qualifier Definitions: J - Estimated
3/ EPC Statistic Definitions: 95% UCL = 95% Upper Confidence Limit as calculated by ProUCL 4.0; Mean = Average of sample results.
4/ Lead exposures and risks are modeled using Integrated Exposure Uptake Biokinetic Model for Lead in Children (IEUBK) (EPA 1994) and the Adult Lead Model (ALM) (EPA 2003b), which recommend mean concentrations for lead.

3.3.5 Exposure Point Concentrations for Seafood

Tissue concentrations of bioaccumulative chemicals detected in Lockheed West Site sediment were estimated by applying a BSAF to the sediment EPC. In addition to the BSAF method, as described below, regression models taken from the LDW reports on the ERA and the RI are used to model some COPCs. EPCs of COPCs in surficial sediment from the 2007 sampling data are used in the modeling, and consist of 95 percent UCLs or maximum concentrations if less then six detections. EPCs in seafood are modeled for the COPCs identified in Section 2, which are based on exceedance of bioaccumulation screening criteria. The sediment EPCs for COPCs in seafood and results of the modeling of tissue concentrations of the COPCs are presented at the end of this section after discussion of the modeling methods.

3.3.5.1 BSAF Modeling

The BSAF method was used to model tissue concentrations of most COPCs at the Lockheed West Site. The BSAF is essentially the ratio of the contaminant concentration in tissue to the contaminant concentration in sediment. In sediment, organic material (i.e., organic carbon derived from decayed plant matter and microorganisms) is a major factor in chemical-sediment sorption, particularly for non-ionic organic chemicals but also some metals. Measures of partition coefficients and BSAF values for the same compound from different sediments have shown that the major source of variability of BSAF values is reduced by normalization to sediment organic carbon (Washington State Department of Health [WDOH] 1995).

Organic compounds also vary in their affinity for lipids. Chemicals with log K_{ow} values greater than 1.0 partition into lipid to a greater extent than into an aqueous environment. The concentrations of hydrophobic organic chemicals in tissues have been found to correlate with percent lipid content (WDOH 1995). In order to account for differing lipid contents of organisms, organic chemical concentrations in tissue are normalized to the lipid content of the organism. To account for the normalization to organic carbon in sediment and to lipid in tissue in the derivation of the BSAF, concentrations in tissue are normalized to lipid fraction in tissue and concentrations in sediment are normalized to the organic carbon content of sediment.

For ionic or polar organic compounds and metals, bioaccumulation is not controlled by a single common property such as partitioning to organic phases. The BSAFs used to model uptake of metals, which are also called bioaccumulation factors (BAFs), are based on a mix of laboratory and empirical field data (PTI 1995a). The factors that govern the partitioning of metals between sediment and tissues in the field studies are not clear, but are generally not related to the lipid content of tissue and organic carbon content of sediments. As summarized in PTI (1995a), observations of bioaccumulation of metals into fish have been mixed, with some studies finding substantial uptake with certain fish species and metals, and other studies finding no uptake. Bioaccumulation of metals appears to be dependent on the species of organism and chemical properties of the metal, as well as on the experimental or site conditions for studies performed with field data. Although studies on metals uptake with benthic organisms are more available than studies with fish, the relationships between metals in tissues of detritus or deposit feeders has been characterized as weak. Factors that appear to govern metals uptake into aquatic organisms have been identified as temperature, oxygen content, water hardness, pH, physiology, life cycle and history, seasonal variations, species and individual variability, and food content of intestines.

Because of the lack of correlation of uptake with known factors, BSAFs for metals are not based on lipid-normalization or organic carbon normalization, and instead are calculated as the ratio of dry weight concentrations in tissue and sediment. The availability of published BSAFs for metals accumulation in fish and crabs was very limited, and those for bivalves fairly uncertain due to the limitations described above. For those reasons, the resultant modeled tissue concentrations are uncertain. The uncertainty with modeled tissue concentrations and impact on subsequent risk estimates is further examined in Section 6.2, which discusses alternative BSAFs using LDW site data, and risk recalculation.

The sources of BSAF values used in the modeling of tissue concentrations for the Exposure Assessment are discussed below. For those BSAFs that were compiled from databases, whether electronic or printed, those based on dry weight values were preferred, but those based on wet weight values were used if the number of dry-weight derived BSAF values was less than two. Consistent with partitioning theory and also reflected in the BSAF equation (Equation 3-7), the resultant BSAF value is unitless and independent of whether wet weight or dry weight values are used for the sediment data in its derivation, as long as the sediment and organic carbon fraction are in the same units.

BSAFs are derived using the following equation:

$$BSAF = \frac{C_T \div F_L}{C_{sed} \div F_{oc}}$$

Equation 3-7

where:

C_T	=	chemical concentration in tissue (mg/kg ww)
C_{sed}	=	chemical concentration in sediment (mg/kg dw)
F_L	=	fraction lipid in tissue (kg lipid/kg ww)
F_{oc}	=	fraction organic carbon in sediment (kg OC/kg dw)

To model tissue concentrations (C_T) of non-polar organic compounds, the BSAFs are used with the sediment concentration (C_{sed}), sediment total organic fraction (F_{oc}), and tissue lipid fraction (F_L) by rearranging Equation 3-7 to solve for C_T, as follows:

$$C_T = \frac{(C_{sed} \times F_L) \times BSAF}{F_{OC}}$$ **Equation 3-8**

In using Equation 3-8 to model tissue concentrations, the sediment concentration (C_{sed}) and organic carbon fraction (F_{oc}) were expressed in dry weight units, and the lipid fraction (F_L) was in wet weight units, to result in a modeled tissue concentration (C_T) in wet weight units. The wet weight tissue concentrations were converted to dry weight concentrations based on moisture content of the organisms (Table 3-25).

The lipid fractions (F_L) for the clams, fish, and crabs that make up the market basket of consumed seafood for this HHRA were taken from data presented in the LDW draft final RI (Windward 2008, Appendix D). Application of the LDW data on lipid fractions to the BSAF modeling of each Lockheed West Site seafood organism, rather than using values from the literature, helps minimize uncertainty in the resultant tissue concentrations. The lipid fractions and moisture contents used for BSAF modeling of seafood tissue concentrations at the Lockheed West Site are shown in Table 3-25.

Table 3-25. Lipid and Moisture Contents of Seafood Organisms

Parameter	Mean Values	Source
Clam		
Lipid content (%)	0.71	LDW Phase 2 data (n = 14).
Moisture (%)	85	LDW Phase 2 data (n = 14).
Dungeness Crab[1/]		
Lipid content (%)	2.6	LDW Phase 1 and 2 data (n = 12).
Moisture (%)	82	LDW Phase 1 and 2 data (n = 12).
English Sole[2/]		
Lipid content (%)	5.5	LDW Phase 2 data (n = 42).
Moisture (%)	75	LDW Phase 2 data (n = 42).

[1/] Lipid and moisture content of Dungeness crab were used to model chemical concentrations in all crab tissues
[2/] Lipid and moisture content of English sole were used to model chemical concentrations in all fish tissues
Source: Table D.4-1, Food web model, Appendix D of the LDW draft final RI (Windward 2008). Phase 1 and Phase 2 refer to two phases of data collection in the LDW to support the RI.

The organic carbon fractions (F_{oc}) of 0.0126 and 0.003 are the mean organic carbon fractions from the full sediment data set (i.e., subtidal plus intertidal sediments) and for the intertidal sediments, respectively, from the 2007 sampling of the Lockheed West Site. These values are specific to the Lockheed West Site and differ from the organic carbon contents of sediment used for derivation of RBACGs at the LDW site by the BSAF method, which was described above in Section 2 on the selection of COPCs.

BSAFs were not available for uptake of tributyltin (TBT) or any other organotin by any species of fish, so empirical data from the LDW site were used to derive a field-based BSAF for fish. The site-wide mean concentrations of TBT in surficial sediment reported in the draft RI for the LDW site (Windward 2007c) was 0.09 mg/kg dry weight, and the mean concentration of TBT in side-wide shiner surfperch reported in Attachment 11 of the LDW ERA (Windward 2007a) was 0.058 mg/kg wet weight. Shiner surfperch tissue data were used for this comparison because they had the highest TBT tissue concentration of all fish collected from the LDW. The OC fraction (F_{oc}) was used as 0.0165, taken from the LDW draft RI (Windward 2007c), and the lipid fraction (F_L) of 0.046 for shiner surfperch, also taken from the LDW RI, was used because it was the highest of all LDW fish, resulting in a more health-protective estimate of a field-based BSAF. Using these F_{oc} and F_L values and the site-wide concentrations of sediment TBT and TBT in shiner surf perch, with Equation 3-7, the resultant field-based BSAF for TBT in fish is calculated as 0.23.

BSAFs for modeling chemical uptake into tissues are taken from sources specific to fish, crab, and clam, where available. No BSAFs were found for mussels, therefore mussel tissue EPCs are based on clams. The sources of BSAFs and notes on their use are provided in Table 3-26. In addition to these sources, a recent EPA database on BSAFs calculated from CERCLA site data was consulted, but no values were used from that database. As a health-protective measure, the 90th percentile BSAFs were used or calculated for use in modeling tissue concentrations, except where indicated in Table 3-26 for Washington Department of Health values (WDOH 1995) and EPA (1997b).

Table 3-26. Sources of BSAF Values

BSAF Source	Notes
USACE. 2003. US Army Corps of Engineers Environmental BSAF Database http://el.erdc.usace.army.mil/bsaf/BSAF.html	Values were taken as the averages of dry weight values unless unavailable; wet weights were derived assuming the average moisture contents of aquatic organisms from the LDW shown in Table 3-25. Specific selections of BSAFs for clams, benthic invertebrates, and crabs are described in footnotes to the tables on estimated tissue concentrations. No marine/estuarine fish BSAFs were available for COPCs from this source.
Tracey GA and DJ Hansen. 1996. Use of biota-sediment accumulation factors to assess similarity of nonionic organic chemical exposure to benthically-coupled organisms of differing trophic mode. Arch Environ Contam Toxicol 30:467-475.	Values were taken from the PAH group for *Macoma nasuta* for clams; from the PCB group for rock crab for crab and *M. nasuta* for clams; and from the pesticides group for *M. nasuta* for clams and for white perch for fish. No other crab or fish species values were available; chemical-specific values not available.
EPA. 1997b. The incidence and severity of sediment contamination in surface waters of the United States. Volume 1: National Sediment Quality Survey. EPA 823-R-97-006. US Environmental Protection Agency, Office of Science and Technology, Washington, DC.	BSAFs are available for fish and were obtained from the EPA Office of Research and Development (EPA ORD) Environmental Research Laboratories at Duluth, Minnesota, and Narragansett, Rhode Island. The BSAFs developed by EPA ORD-Narragansett are mean values for benthic organisms and demersal (bottom-dwelling) fishes. The BSAFs developed by EPA ORD-Duluth are for benthically coupled pelagic (open-water) fishes. Species of organism is not specified.
Washington State Department of Health. 1995. Tier I report, development of sediment quality criteria for the protection of human health. Washington State Department of Health, Olympia, Washington.	BSAFs were taken from the chemical class groups, which are recommended as 75th percentile values from multiple databases for various fish species. Values are based on a mix of empirical national data and surrogates using chemical groupings.
PTI. 1995a. Bioaccumulation Factor Approach Analysis for Metals and Polar Compounds. Washington Department of Ecology.	BSAFs for metals were used as 90th percentile values for marine/estuarine deposit feeder clams (cadmium, lead, zinc), or filter feeders where deposit feeder data were unavailable. (chromium, copper, mercury) As per the document, BSAFs for metals are used without normalizing tissues for lipid content or sediment for organic carbon content.
Windward. 2007. Ecological Risk Assessment, Lower Duwamish Waterway, Attachment 11.	Regression equations on collocated benthic invertebrates and sediment data were developed for arsenic and TBT using LDW site data and applied to clams and mussels.
Windward. 2008. Remedial Investigation, Draft Final, Lower Duwamish Waterway, Appendix D, Food Web Model.	Regression equations for total PCBs in clam, fish, and crab tissues, developed from the food web model, as calibrated with LDW site data.

Because fish represent a different trophic level than shellfish, their metabolic processes differ. Consequently, fish and shellfish will have different exposures to contaminated sediment and the resulting accumulation rates (i.e., the BSAF) can differ as well.

3.3.5.2 Regression Models

In addition to the numerical BSAFs used in modeling described above, two sets of regression models taken from LDW site documents are available for select chemicals and tissues: 1) regression equations based on relationships between sediment and benthic invertebrate tissue concentrations at the LDW site; and 2) regression equations for total

PCBs developed in the LDW RI from a numerical FWM. Each of these sets of regression equations is described below.

Benthic Invertebrate Regression Model

For modeling arsenic and TBT into clams and mussels, regression equations based on relationships between sediment and benthic invertebrate tissue concentrations at the LDW site were used. Significant regressions were found for arsenic, TBT, and PCBs between co-located sediment and benthic invertebrate tissue data in the LDW (Attachment 11 to the LDW ERA, Windward 2007b). Benthic invertebrate tissue samples were collected from 10 intertidal locations and 10 subtidal locations, with co-located sediment collected from each location. The sample locations were selected to represent areas that covered the range of arsenic, TBT, and PCB concentrations measured throughout the LDW so that a relationship between chemical concentrations in sediment and benthic invertebrate tissue could be established (Windward 2007b).

The concentrations of total arsenic and TBT in tissue of clams and mussels at the Lockheed West Site were modeled using the regression equations for benthic invertebrates and the 95 UCL concentrations of these chemicals in sediment from the Lockheed West Site. The LDW regression equations for benthic invertebrates are as follows:

Arsenic: y = 5.1x^0.47, R^2 = 0.96, exponential model; units in mg/kg dw.

TBT: y = 145x^0.18; R^2 = 0.59; exponential model; units in mg/kg dw.

The suitability of using benthic invertebrate arsenic bioaccumulation data to characterize sediment/tissue arsenic bioaccumulation relationships in bivalves is highly uncertain. The Lower Duwamish project found it difficult to develop a predictive sediment tissue bioaccumulation relationship for arsenic in bivalves. The uncertainty assessment section discusses a comparison of arsenic tissue concentrations in Macoma clams collected at the Lockheed West Site with concentrations modeled into intertidal clams using the LDW benthic invertebrate sediment/tissue relationship.

Food Web Model Regression Equations for PCBs

A second set of regression equations were used to model total PCB concentrations in clam, fish, and crab tissues, using regression equations developed in the RI report for the LDW site. The regression equations for total PCBs were developed from the FWM in Appendix D, Food Web Model, of the draft final RI for the LDW site. The LDW FWM was used to develop the relationships between sediment and various marine tissues at the LDW site. The application of the LDW FWM to model tissue concentrations at the Lockheed West

Site was based on the understanding that the aquatic organisms that were modeled at the LDW site are also present in the estuarine environment of the Lockheed West Site, that the subtidal and intertidal habitats of the two sites are similar, and that the range of concentrations of PCBs in Lockheed West Site sediment is similar to that range found in the sediments of the LDW site. Due to the similar habitats and continuity of the Lockheed West site with the LDW site, the food resources and various physiological and chemical parameters used in the modeling of the LDW site would be expected to be present in the aquatic ecosystem of the Lockheed West Site.

The FWM was developed in the LDW RI to estimate the relationship between total PCB concentrations in tissue and sediment in order to estimate risk-based threshold concentrations (RBTCs) in sediment for the RI. The structure of the FWM was based on the Arnot and Gobas model (Arnot and Gobas 2004), a steady-state bioaccumulation model. The FWM provides estimates of total PCB concentrations for nine species or species groups, many of which were ecological receptors, prey for ecological receptors, or seafood organisms evaluated for human consumption in the ERA and HHRA for the LDW site. The species or species groups included English sole, crabs, clams, and pelagic fish species, which are also seafood organisms for the Lockheed West Site HHRA.

Input parameter values and distributions for the model were based on literature-derived and site-specific environmental data. The model was calibrated to identify sets of parameter values that best estimated empirical tissue PCB concentration data. For many model input parameters, distributions of estimates of mean values were developed to reflect uncertainty in their values. Calibration was performed using a probabilistic approach in order to systematically explore all combinations of plausible parameter sets and their corresponding estimated total PCB concentrations in tissue. Through the calibration process, a best-fit parameter set was identified that estimated total PCB concentrations for all modeled fish and crab species within a factor of 2 (1.2 on average) of empirical data. The input parameters that most influenced the model output were dietary absorption for crabs, relative fractions of benthic versus pelagic food items in the diet of fish and crabs, and parameters that characterized prey species (such as lipid content and porewater ventilation rate).

The FWM was calibrated at a LDW-wide spatial scale, and tested at smaller scales within the LDW. Based on these analyses, application of the FWM appeared to be most appropriate at the modeling area scale for shiner surfperch. This modeling area scale is approximately a 1-mile length segment of the waterway, which is approximately similar to the total length of the aquatic shoreline of the Lockheed West Site. The FWM was also found to perform well for clams at locations in the LDW with sediment concentrations of total PCBs at 3,300 µg/kg dw or lower. The exposure point concentration of total PCBs in combined subtidal and intertidal sediment at the Lockheed West Site is 498.3 µg/kg dw, which is less than the value identified above for the FWM performance. The FWM was used to model tissue concentrations into crab and fish from the combined subtidal and intertidal sediment total PCB concentrations at the Lockheed West Site, as described below.

Figure 3-2 below presents a graph from the Appendix D of the LDW draft RI that shows an output of the model displaying the best fit relationships between sediment PCBs (total) and tissue PCBs (total) for various organisms. These are modeled outputs, not the actual data from the site. The modeled output data on tissue concentrations are based on best fit modeling of concentrations using empirical data for numerous site-specific parameters related to the LDW. The FWM is based on the full sediment data set for PCBs, and is not specific to clam data collected from intertidal areas. Hence the FWM was not calibrated with empirical clam data as it was with data from fish and other benthic invertebrates that were collected from throughout the LDW site. The regression lines of the graph in Figure 3-2 show up as steps due to the incorporation in the model of differing water concentrations in intervals. Further details on the development of the FWM and its calibration for the LDW site can be found in Appendix D of the RI report for the LDW site (Windward 2008).

Based on the tabulated data predicted by the FWM for the LDW, which are graphed in Figure 3-2, simple regression equations for total PCBs in clams, fish, and crab were developed in Appendix D of the LDW RI:

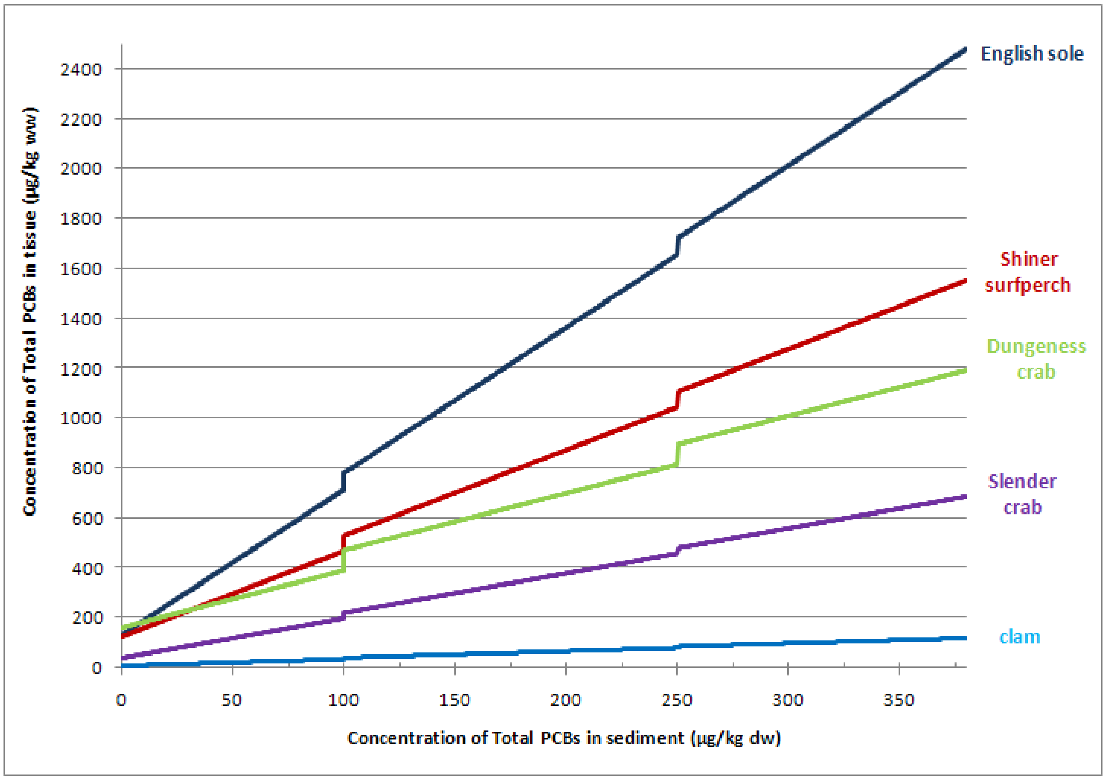
Clams: $y = 0.2879x + 9.4827$

English sole whole body: $y = 6.2255x + 118.05$

Dungeness crab whole body: $y = 2.779x + 145.28$

The regression equations are used in place of numerical BSAFs for modeling PCBs into fish (English sole whole body equation), crab (Dungeness crab whole body equation), and clam/mussel (clam equation) tissues for the Lockheed West Site.

The LDW regression equations for total PCBs were used instead of BSAF values partly because of the limited availability of PCB BSAFs, particularly for fish. In addition, use of the regression equations for modeling was considered to be more specific to the Lockheed West Site than using literature-based BSAFs, given the proximity of the Lockheed West Site to the LDW site from which site data were used to calibrate the FWM. Food web modeling was not performed for the Lockheed West Site, instead it was assumed that the food web modeling performed for the upstream LDW site was sufficiently health protective for application of the regression equations to the Lockheed West Site HHRA, based on the above discussion.



Source: LDW Draft Final RI (Windward 2008)

Figure 3-2. LDW Food Web Model Output of Total PCB Concentrations in Whole-body Tissues of Seafood as a Function of Total PCB Concentrations in Sediment

3.3.5.3 Results of Tissue Modeling at Lockheed West

The sediment EPCs for COPCs in seafood are determined in Table 3-27 for intertidal sediment, which is modeled into clam and mussel tissue, and in Table 3-28 for combined subtidal and intertidal sediment for modeling into fish and crab tissue. The BSAFs and the EPCs modeled for tissues are presented for clams/mussels, fish, and crabs in Tables 3-29, 3-30, and 3-31, respectively. The EPCs are based on application of Equation 3-8 and the BSAFs, or the above regression equations. These tissue EPCs are used with exposure parameters identified in the above tables in subsequent estimations of daily intake of COPCs at the Lockheed West Site.

Table 3-27. Concentrations of COPCs in Intertidal Sediment used in Modeling Clam Tissue Concentrations

Chemical of Potential Concern for Seafood	Units	Arithmetic Mean	95% UCL	Distribution[1/]	Maximum Concentration (Qualifier)[2/]	Intertidal Sediment EPC		
						Value	Units	Statistic[3/]
Metals								
Arsenic	mg/kg dw	126.5	192	N	330	192	mg/kg dw	95% UCL
Cadmium	mg/kg dw	0.328	0.449	N	0.646	0.45	mg/kg	95% UCL
Chromium	mg/kg dw	138	198	N	289	198	mg/kg	95% UCL
Copper	mg/kg dw	534	840	N	1,310	840	mg/kg	95% UCL
Lead (mean)[b]	mg/kg dw	367	660	G	1,420	367	mg/kg	Mean[4/]
Mercury	mg/kg dw	0.119	0.256	G	0.423	0.256	mg/kg	95% UCL
Zinc	mg/kg dw	769	1,000	N	1,360	1,000	mg/kg	95% UCL
PAHs								
Fluoranthene	µg/kg dw	233	366	N	610	366	µg/kg dw	95% UCL
Pyrene	µg/kg dw	160	263	N	520	263	µg/kg dw	95% UCL
cPAH	µg/kg dw	113	176	N	344	176	µg/kg dw	95% UCL
Organometals								
Tributyltin	µg/kg dw	22.0	36.4	N	57	36.4	µg/kg dw	95% UCL
SVOCs								
Pentachlorophenol	µg/kg dw	ND	ND	-	ND	-	-	-
PCBs								
PCBs (total)	µg/kg dw	27.8	41.8	N	77	41.8	µg/kg dw	95% UCL
Pesticides								
Total DDT	µg/kg dw	1.68	3.08	G	9.4 (JN)	3.08	µg/kg dw	95% UCL
Total Chlordane	µg/kg dw	0.373	0.622	N	1.1 (JN)	1.1	µg/kg dw	Maximum

1/ Distribution type for the "95% UCL" term, as identified by ProUCL: G - Gamma; N - Normal
2/ Qualifier Definitions: JN – Estimated and tentatively identified pending confirmation
3/ Statistic Definitions: 95% UCL = 95% Upper Confidence Limit as calculated by ProUCL 4.0; Mean = Average of sample results; Maximum value used for < 6 detections.
4/ Lead exposures and risks are modeled using Integrated Exposure Uptake Biokinetic Model for Lead in Children (IEUBK) (EPA 1994) and the Adult Lead Model (ALM) (EPA 2003b), which recommend use of mean concentrations for lead.
ND – Not detected in intertidal sediment

Table 3-28. Concentrations of COPCs in Combined Subtidal and Intertidal Sediment used in Modeling Crab and Fish Tissue Concentrations

Chemical of Potential Concern for Seafood	Units	Arithmetic Mean	95% UCL	Distribution[1/]	Maximum Concentration (Qualifier)[2/]	Intertidal+Subtidal Sediment EPC Value	Units	Statistic[3/]
Metals								
Arsenic	mg/kg dw	47.5	109	Nn	330	109	mg/kg dw	95% UCL
Cadmium	mg/kg dw	0.311	0.36	G	0.73	0.36	mg/kg dw	95% UCL
Chromium	mg/kg dw	73.21	90.0	L	504	90.0	mg/kg dw	95% UCL
Copper	mg/kg dw	282	618	Nn	1,900	618	mg/kg dw	95% UCL
Lead (mean)[b]	mg/kg dw	146	200	L	1,420	146	mg/kg dw	Mean[4/]
Mercury	mg/kg dw	0.479	0.61	G	2.94	0.61	mg/kg dw	95% UCL
Zinc	mg/kg dw	343	473	L	1,430	473	mg/kg dw	95% UCL
PAHs								
Fluoranthene	µg/kg dw	1,700	2381	G	33,000	2,381	µg/kg dw	95% UCL
Pyrene	µg/kg dw	1,469	2,042	G	23,000	2,042	µg/kg dw	95% UCL
cPAH	µg/kg dw	762	958	G	2,911	958	µg/kg dw	95% UCL
Organometals								
Tributyltin	µg/kg dw	665	2,810	L	4,500	2,810	µg/kg dw	95% UCL
SVOCs								
Pentachlorophenol	µg/kg dw	82.9	124	Nn	570	124	µg/kg dw	95% UCL
PCBs								
PCBs (total)	µg/kg dw	370	498	G	2,240	498	µg/kg dw	95% UCL
Pesticides								
Total DDT	µg/kg dw	16.3	75.5	L	294 (JN)	75.5	µg/kg dw	95% UCL
Total Chlordane	µg/kg dw	5.47	7.5	G	46 (JN)	7.5	µg/kg dw	95% UCL

[1/] Distribution type for the "95% UCL" term, as identified by ProUCL: G - Gamma; L - Lognormal; Nn – Nonparametric, N – Normal
[2/] Qualifier Definitions: JN – Estimated and tentatively identified pending confirmation
[3/] Statistic Definitions: 95% UCL = 95% Upper Confidence Limit as calculated by ProUCL 4.0; Mean = Average of sample results.
[4/] Lead exposures and risks are modeled using Integrated Exposure Uptake Biokinetic Model for Lead in Children (IEUBK) (EPA 1994) and the Adult Lead Model (ALM) (EPA 2003b), which recommend mean concentrations for lead.

Table 3-29. Clam and Mussel Tissue Concentrations Modeled from Intertidal Sediment for Seafood Consumption Exposure

COPC	Intertidal Sediment EPC	Intertidal Sediment EPC (mg/kg dw)	F_l	F_{oc}	BSAF[1/]	BSAF Reference	Clam/Mussel Tissue Concentration (mg/kg ww)	Clam/Mussel Tissue Concentration (mg/kg dw)
Metals	mg/kg dw	mg/kg dw						
Arsenic	192	192	-	-	Regression	3	9.1	60.4
Cadmium	0.449	0.449	-	-	26.9	2	1.8	12.1
Chromium	198	198	-	-	0.0043	2	0.13	0.85
Copper	840	840	-	-	0.452	2	57	380
Lead (mean)[2/]	367	367	-	-	2.54	2	140	933
Mercury	0.256	0.256	-	-	0.92	2	0.035	0.24
Zinc	1000	1000	-	-	3.62	2	544	3,630
PAHs	µg/kg dw	mg/kg dw						
Fluoranthene	366	0.366	0.0071	0.003	0.094	1	0.082	0.54
Pyrene	263	0.263	0.0071	0.003	0.515	1	0.32	2.14
cPAHs	176	0.176	0.0071	0.003	0.59	1	0.25	1.64
Organometals	µg/kg dw	mg/kg dw						
Tributyltin	36.4	0.036	-	-	Regression	3	0.042	0.28
SVOCs	µg/kg dw	mg/kg dw						
Pentachlorophenol	ND	-	-	-	-	-	-	-
PCBs	µg/kg dw	mg/kg dw						
PCBs (total)	41.8	0.042	-	-	Regression	4	0.022	0.14
Pesticides	µg/kg dw	mg/kg dw						
Total DDT	3.08	0.0031	0.0071	0.003	6.26	1	0.046	0.30
Total Chlordane	1.10	0.0011	0.0071	0.003	2.7	1	0.007	0.047

[1/] BSAFs are for deposit feeding clams where available, or filter feeding clams, or based on regression modeling (arsenic, TBT, PCBs).
[2/] Mean concentration is used for modeling exposures of children and adults to lead, as per EPA guidance.
BSAF – Biota-sediment accumulation factor
EPC – Exposure point concentration in sediment, converted to units of mg/kg dry weight for use with Foc.
Foc – fraction of organic carbon in Lockheed West Site sediment; average organic carbon for nine intertidal sediment stations is 0.3%, from 2007 data; in dry weight.
Fl – fraction lipid in clams from the LDW RI (Windward 2007b); assumed to be wet weight.
ND – Pentachlorophenol was not detected in intertidal sediment, but was selected as a tissue COPC based on detected concentrations in subtidal sediment.
Moisture content assumed at 85%, based on LDW clam data in the LDW RI.
BSAF references:

1. Environmental Residue-Effects Database, http://el.erdc.usace.army.mil/bsaf/BSAF.html – *Macoma nasuta* for clams. Dry weight values if n>2, otherwise wet weight values used (fluoranthene). Values are 90th percentile values. For pesticides, marine mollusk species used.
2. PTI 1995a. Bioaccumulation Factor Approach Analysis for Metals and Polar Compounds. Washington Department of Ecology. Developed 90th percentile values for deposit feeder clams, or filter feeders if no deposit feeder data.
3. Based on a regression equation using LDW site data on benthic invertebrates, as reported in Windward (2007b), Attachment 11 to the ERA. Equation for arsenic: tissue concentration = 5.1 x (sediment concentration^0.47); units in mg/kg dw. Equation for TBT: tissue concentration = sediment concentration^0.1801 x 145.4; units calculated as µg/kg dw sediment, and µg/kg dw tissue, converted to mg/kg ww.
4. Based on a regression equation from the LDW food web model, Appendix D, draft final RI (Windward 2008). Equation PCBs: tissue concentration = 0.2879 x sediment concentration + 9.4827; units in µg/kg dw.

Table 3-30. Fish Tissue Concentrations Modeled from Subtidal and Intertidal Sediment for Seafood Consumption Exposure

Chemical	Intertidal+ Subtidal Sediment EPC	Intertidal+Subtidal Sediment EPC (mg/kg dw)	F_l	F_{oc}	BSAF[1/]	BSAF Reference	Fish Tissue Concentration (mg/kg ww)	Fish Tissue Concentration (mg/kg dw)
Metals	mg/kg dw	mg/kg dw						
Arsenic	109	109	-	-	0.12	3	3.28	13.1
Cadmium	0.363	0.363	-	-	2	3	0.18	0.73
Chromium	90.0	90.0	-	-	0.043	3	0.97	3.87
Copper	618	618	-	-	0.452	3	69.8	279
Lead (mean)[2/]	146	146	-	-	0.35	3	12.7	51
Mercury	0.609	0.609	-	-	0.535	3	0.081	0.33
Zinc	473	473	-	-	4.64	3	549	2,196
PAHs	µg/kg dw	mg/kg dw						
Fluoranthene	2380	2.38	0.055	0.0126	0.105	2	1.09	4.37
Pyrene	2040	2.04	0.055	0.0126	0.105	2	0.94	3.74
cPAHs	958	0.958	0.055	0.0126	0.105	2	0.44	1.76
Organometals	µg/kg dw	mg/kg dw						
Tributyltin	2,810	2.81	0.055	0.0126	0.23	4	2.84	11.3
SVOCs	µg/kg dw	mg/kg dw						
Pentachlorophenol	124	0.124	0.055	0.0126	0.105	2	0.057	0.23
PCBs	µg/kg dw	mg/kg dw						
PCBs (total)	498	0.498	-	-	Regression	5	3.22	12.9
Pesticides	µg/kg dw	mg/kg dw						
Total DDT	75.5	0.076	0.055	0.0126	7.7	1	2.54	10.2
Total Chlordane	7.50	0.008	0.055	0.0126	4.77	1	0.15	0.62

[1/] BSAFs presented for fish groupings where available.
[2/] Concentration for lead is based on mean value, for use in lead models as per EPA guidance.
BSAF – Biota-sediment accumulation factor
EPC – Exposure point concentration in sediment, converted to units of mg/kg dry weight for use with Foc.
Foc – fraction of organic carbon in Lockheed West sediment; average organic carbon for 42 subtidal plus 9 intertidal sediment stations is 1.26%, from the 2007 data set; in dry weight.
Fl – fraction lipid in English sole from the LDW RI (Windward 2007b), assumed to be wet weight; percent lipids from other fish species were lower and would result in less health protective lower EPCs.
Moisture content assumed at 75%, based on LDW English sole data in the LDW RI.
BSAF references:

1. EPA. 1997b. The incidence and severity of sediment contamination in surface waters of the United States. Volume 1: national sediment quality survey. EPA 823-R-97-006. US Environmental Protection Agency, Office of Science and Technology, Washington, DC.
2. Washington State Department of Health. 1995. Tier I report, development of sediment quality criteria for the protection of human health. Washington State Department of Health, Olympia, WA. BSAFs are developed as 75th percentile values for upper trophic level fish (species not identified), and grouped into chemical classes based on Kow.
3. PTI 1995a. Bioaccumulation Factor Approach Analysis for Metals and Polar Compounds. Washington Department of Ecology. Developed 90th percentile values for fish, except a single value for chromium; fish species not identified but stated as high trophic species. Copper based on 90th percentile for filter clams.
4. BSAF derived from mean TBT concentrations in site wide sediment and whole body pelagic fish for the LDW site (Windward 2007b).
5. Based on the regression equation for English sole from the LDW food web model, Appendix D, draft final RI (Windward 2008). Equation PCBs: tissue concentration = 6.2255 x sediment concentration + 118.05; units in µg/kg dw.

Table 3-31. Crab Tissue Concentrations Modeled from Subtidal and Intertidal Sediment for Seafood Consumption Exposure

COPC	Intertidal+ Subtidal Sediment EPC	Intertidal+Subtidal Sediment EPC (mg/kg dw)	F_l	F_{oc}	BSAF[1]	BSAF Reference	Crab Tissue Concentration (mg/kg ww)	Crab Tissue Concentration (mg/kg dw)
Metals	mg/kg dw	mg/kg dw						
Arsenic	109	109	-	-	0.022	3	0.41	2.40
Cadmium	0.363	0.363	-	-	0.049	3	0.003	0.02
Chromium	90.0	90.0	-	-	0.0043	4	0.07	0.39
Copper	618	618	-	-	0.14	3	14.7	87
Lead (mean)	146	146	-	-	0.028	3	0.69	4.1
Mercury	0.609	0.609	-	-	0.13	3	0.013	0.079
Zinc	473	473	-	-	0.16	3	12.9	76
PAHs	µg/kg dw	mg/kg dw						
Fluoranthene	2380	2.38	0.026	0.0126	0.77	2	3.80	22.4
Pyrene	2040	2.04	0.026	0.0126	0.51	2	2.13	12.5
cPAHs	958	0.958	0.026	0.0126	0.14	2	0.28	1.58
Organometals	µg/kg dw	mg/kg dw						
Tributyltin	2,810	2.81	0.026	0.0126	4.18	2	24.2	134
SVOCs	µg/kg dw	mg/kg dw						
Pentachlorophenol	124	0.124	0.026	0.0126	0.105	1	0.027	0.15
PCBs	µg/kg dw	mg/kg dw						
PCBs (total)	498	0.498	0.026	0.0126	Regression	5	1.53	8.5
Pesticides	µg/kg dw	mg/kg dw						
Total DDT	75.5	0.076	0.026	0.0126	2.852	2	0.44	2.47
Total Chlordane	7.50	0.008	0.026	0.0126	2.21	2	0.034	0.19

[1/] BSAFs are for marine/estuarine crustaceans or crab species where available, otherwise values are from marine/estuarine clam. Single values were available for metals and crabs from reference 3.
BSAF – Biota-sediment accumulation factor
EPC – Exposure point concentrations in sediment are converted to units of mg/kg dry weight for use with Foc.
Foc – fraction of organic carbon in Lockheed West sediment; average organic carbon for 42 subtidal plus 9 intertidal sediment stations is 1.26%, from the 2007 data set; in dry weight.
Fl – fraction lipid in Dungeness crab from the LDW RI (Windward 2008), assumed to be wet weight; percent lipids from slender crab were lower.
Moisture content assumed at 83%, based on average for crabs from the LDW RI.
BSAF references:

1. Washington State Department of Health. 1995. Tier I report, development of sediment quality criteria for the protection of human health. Washington State Department of Health, Olympia, WA.
2. Environmental Residue-Effects Database - Averages of marine crustacean if n>1, or of marine crustacean and mollusk marine/estuarine.
3. PTI 1995a. Bioaccumulation Factor Approach Analysis for Metals and Polar Compounds. Washington Department of Ecology. Single BSAF for crab.
4. Taken from reference 3 for clams, as per the QAPP for sediment sampling at the LDW, Windward (2004a); Table D-1, QAPP, Benthic Invertebrate Sampling of the LDW, Appendices A-E. Final. July 30.
5. Based on the regression equation for Dungeness crab from the LDW food web model, Appendix D, draft final RI (Windward 2007c). Equation PCBs: tissue concentration = 2.779 x sediment concentration + 145.28; units in µg/kg dw.

Summary of Tissue EPCs

As described above, the seafood consumption exposure scenarios are based on consumption of specific seafood types that were quantitatively evaluated in the HHRA for the upstream LDW site (Windward 2007a). The seafood types consist of the following:

- Pelagic fish
- Benthic fish, fillet
- Benthic fish, whole body
- Clams
- Mussels
- Crab, edible meat
- Crab, whole body

For each of these seafood types, tissue concentrations of COPCs were assigned from the modeled concentrations in clams, fish, and crabs shown in Tables 3-29 to 3-31. The BSAF modeling provided model parameters only for limited types of marine organism tissue. For example, BSAFs for fish were available for only whole body fish, and generally the species were not identified. Hence, for each COPC, a single fish tissue concentration was modeled for application to all fish seafood tissue types; i.e., it is assumed that the single modeled fish tissue concentration is applicable to pelagic and benthic fish, and to whole body and fillets. Similarly for crabs, BSAFs were available only for crab without specification as to whole body or other tissue (e.g., edible meat or hepatopancreas). Therefore a single crab tissue concentration is assumed to be applicable to all crab seafood types. For mussels, insufficient BSAFs were found for use in modeling, so the BSAFs and subsequent modeled tissue concentrations for clams were used for mussels.

The BSAFs or regression equations are applied to the EPCs for sediment. For clams and mussels, the intertidal sediment EPCs are used to model tissue concentrations. For crab and fish, the combined subtidal and intertidal sediment EPCs are used to model tissue concentrations.

Arsenic concentrations in seafood tissues are presented as inorganic arsenic, which is the carcinogenic form for which carcinogenicity toxicity values have been developed. Inorganic arsenic was assumed to be a percent of total arsenic that was modeled in all seafood tissues. The inorganic arsenic percentages of total arsenic are shown in Table 3-32, and are taken from the LDW RI (Windward 2007c).

Table 3-32. Inorganic Arsenic as a Percent of Total Arsenic in Seafood Tissues

Tissue Type	Number of Samples	Inorganic Arsenic as a Fraction of Total Arsenic		
		Mean	Minimum	Maximum
Fish, whole body				
English sole	7	0.02	0.01	0.03
Shiner surfperch	8	0.07	0.02	0.13
Starry flounder	1	0.09	0.09	0.09
Mean fish, whole body		**0.06**		
Fish, fillet				
English sole	7	0	0	0
Pile perch	1	0.01	0.01	0.01
Starry flounder	1	0	0	0
Striped perch	1	0.02	0.02	0.02
Mean fish, fillet		**0.0075**		
Crab, edible meat				
Dungeness crab	2	0	0	0
Slender crab	4	0.01	0.01	0.01
Mean crab, edible meat		**0.005**		
Crab, hepatopancreas				
Dungeness crab	2	0.02	0.01	0.03
Slender crab	4	0.1	0.02	0.15
Mean crab, hepatopancreas		**0.06**		
Crab, whole body				
Dungeness crab	2	0.01	0.01	0.01
Slender crab	4	0.04	0.01	0.05
Mean crab, whole body		**0.025**		
Shellfish, whole body				
Soft-shell clam	8	0.4	0.1	0.68
Mean clam		**0.4**		

Source: Modified from Table 4-23, Draft RI, LDW site Windward (2007c).

In summary, the following sources of modeled tissue concentrations are identified for application to each of the seafood types that are evaluated quantitatively in this HHRA. The resultant modeled tissue EPCs for each seafood type are summarized in Table 3-33.

- Clams – Clam tissue (Table 3-29)
- Mussels – Clam tissue (Table 3-29)
- Pelagic fish – Fish tissue (Table 3-30)
- Benthic fish, fillet – Fish tissue (Table 3-30)
- Benthic fish, whole body – Fish tissue (Table 3-30)
- Crab, edible meat – Crab tissue (Table 3-31)
- Crab, whole body – Crab tissue (Table 3-31)

Table 3-33. Summary of Exposure Point Concentrations for COPCs in Seafood Tissue

		Exposure Point Concentrations in Seafood (mg/kg ww)						
Exposure Point	**Chemical of Potential Concern**	**Benthic Fish, Fillet**	**Benthic Fish, Whole Body**	**Pelagic Fish, Whole Body**	**Clams**	**Mussels**	**Crab, Edible Meat**	**Crab, Whole Body**
Clam, Fish and Shellfish Tissue (modeled from sediment EPC)	Arsenic (inorganic)[1/]	0.02	0.20	0.20	3.62	3.62	0.002	0.010
	Cadmium	0.18	0.18	0.18	1.81	1.81	0.003	0.003
	Chromium	0.97	0.97	0.97	0.13	0.13	0.066	0.066
	Copper	70.0	70.0	70.0	57.0	57.0	14.7	14.7
	Lead (mean)[2/]	12.7	12.7	12.7	140	140	0.69	0.69
	Mercury	0.081	0.081	0.081	0.035	0.035	0.013	0.013
	Zinc	549	549	549	544	544	12.9	12.9
	cPAH[3/]	0.44	0.44	0.44	0.25	0.25	0.28	0.28
	Fluoranthene	1.09	1.09	1.09	0.082	0.54	3.8	3.8
	Pyrene	0.94	0.94	0.94	0.32	0.32	2.13	2.13
	Tributyltin	2.84	2.84	2.84	0.042	0.042	24.2	24.2
	Pentachlorophenol	0.057	0.057	0.057	nd	nd	0.027	0.027
	PCBs (total)[4/]	3.22	3.22	3.22	0.022	0.022	1.53	1.53
	Total DDT	2.54	2.54	2.54	0.046	0.046	0.45	0.45
	Total Chlordanes[5/]	0.16	0.16	0.16	0.007	0.007	0.034	0.034

1/ EPCs for arsenic in seafood are for inorganic arsenic modeled from total arsenic in sediment and an assumed percent as inorganic in tissue.
2/ Lead exposures and risks are modeled using Integrated Exposure Uptake Biokinetic Model for Lead in Children (IEUBK) (EPA 1994) and the Adult Lead Model (ALM) (EPA 2003b); EPCs are modeled from mean concentrations in sediment.
3/ EPCs for cPAH are based on the modeled EPCs for benzo(a)pyrene-equivalents.
4/ PCBs based on LDW food web model regressions (see text).
5/ EPCs for total chlordane are based on the modeled EPCs for chlordane-gamma.
nd – not detected in intertidal sediment

3.3.6 Lead Modeling

Health risks from exposure to lead at the Lockheed West Site are estimated using the Integrated Exposure Uptake Biokinetic Model for Lead in Children (IEUBK) (EPA 1994) and the Adult Lead Model (ALM) (EPA 2003b). Description and parameterization of each model are discussed in separate sections below. Results are presented in the Risk Characterization section.

3.3.6.1 Child Lead Model

The EPA model IEUBK version 1.0, build 264, for Windows, was used in the modeling of child risks from lead exposure. The IEUBK model predicts blood-lead concentrations for children exposed to lead in their environment, and compares the concentrations with a health-based standard. The model is based on exposures to lead from multiple sources and pathways in the environment, including inhalation of air, ingestion of dietary items, ingestion of soil and house dust, and ingestion of water. The model provides default exposure concentrations for all of these sources, and allows the input of site-specific data for each potential source and pathway. Model input also include absorption parameters. Based on the multiple source exposures and subsequent intakes, the model uses a complex set of equations to calculate probable concentrations of lead in the blood for a population of children represented by the exposure parameters, from ages 6 months to 7 years.

For the Lockheed West Site HHRA, all default parameters recommended for use in the model by EPA were maintained except for alternate dietary source and soil lead concentrations. Site-specific data were used to calculate lead intake based on the alternate dietary source and the percentage of total dietary input that is represented by the alternate dietary source. The potential exposure of children to sediment at the site was incorporated into the model by using alternate soil lead concentration based on the sediment concentrations at the site. The alternate dietary and sediment concentrations are added to the other source data to derive a combined intake from all sources.

The “Build 264” version of the model provides default values for lead intake from diet for different age groups of children that range from 5.53 to 7.0 µg/day. Fields for alternate dietary concentrations are provided in the model, which include fish from fishing, home grown fruits and vegetables, and game animals from hunting. For each alternate diet source, the model requires input on both the concentration of lead and the proportion of total dietary intake the category represents (the default concentration for all replacement foods = 0 mg/kg, default percentage of all food consumed = 0 percent). For an alternate diet source for the Lockheed West Site, the modeled lead concentrations in seafood were used.

As described in the previous section, the lead concentrations in tissues of the various seafood categories were modeled from sediment concentrations. The guidance for using the IEUBK lead model specifies the use of mean concentrations of lead in dietary items to model blood lead concentrations. Therefore, the mean concentrations of lead were modeled in each of the seafood categories and used to calculate the alternate fish consumption lead concentration, rather than the 95 UCL of the mean concentrations that are used as the EPCs for all remaining COPCs in the child seafood consumption scenario. Lead concentrations in clams were modeled using the mean concentration of lead in intertidal sediment; lead concentrations in crab and fish were modeled using the mean concentration from the full sediment dataset. The mean lead sediment concentrations and calculated tissue concentrations are shown in Table 3-34. The modeling of tissue lead concentrations followed the BSAF modeling methodology described earlier for calculating the EPCs for the seafood consumption scenarios. The resultant modeled lead concentrations in the seafood categories as modeled from mean sediment lead concentrations are shown in Table 3-35.

Table 3-34. Mean Lead Concentrations in Tissues

Seafood Category	Sediment Data Source	Sediment EPC (mean) (mg/kg dw)	BSAF[1/]	Tissue EPC (mean) (mg/kg ww)
Clams/Mussels	Intertidal sediment	367	2.54	140
Fish (benthic fillet and whole body, pelagic)	Subtidal plus intertidal sediment	146	0.35	12.7
Crab (edible meat, whole body)	Subtidal plus intertidal sediment	146	0.028	0.69

[1/] Sources of BSAF values and modeling as described in Section 3.3.5. See Section 6.2 for an analysis of an alternative BSAF value for lead.

Table 3-35. Results of Modeling Lead Intake for Children

Exposure Medium	Consumption Category	Modeled Lead Concentration (mg/kg ww)	Child Seafood Median Consumption Rate (g/day)	Ingestion Rate x Modeled Concentration (µg/day)
Diet	benthic fish, fillet	12.7	0.48	6.1
	benthic fish, whole body	12.7	0	0.0
	clams	140	2.32	325
	crab, edible meat	0.69	2	1.4
	crab, whole body	0.69	0.64	0.4
	mussels	140	0.04	5.6
	pelagic fish, whole body	12.7	0.52	6.6
	Anadromous[1/]	0.04	5.96	0.2
	Sum		**11.96**	**345**
	Mean lead concentration in diet:[2/]		**28.8**	**µg Pb/g**
Soil/Sediment	Mean lead concentration in intertidal sediment		367	mg/kg dw
	Time-weighted average lead concentration based on sediment and default soil concentrations		230	mg/kg dw

Calculation of time-weighted lead concentration in sediment + soil:

Parameter	Description	mg/kg dw	
Pbsed	Mean lead concentration in sediment	367	
EF sed	Child exposure days	65	
EF sed c+ EF soil	Days per year	365	
PB soil	Lead default concentration	200	
EF soil	Days per year - EF sed	300	
(Pbsed x EF sed) + (Pbsoil x EF soil)/(EFsed + EF soil)		230	= time-weighted lead concentration

[1/] Consistent with the LDW HHRA, as directed by EPA, anadromous fish were included in the seafood consumption rate for children in the IEUBK model. This model is intended to quantify the cumulative exposure to lead for children living in the area, regardless of source. There are dietary sources other than seafood that may contain lead, but there are no site-specific data to quantify the exposure so the default food lead concentration was used as a surrogate for all other food-borne sources of lead exposure.

[2/] Mean concentration of lead in diet = 345 µg/day/11.96 g/day = 28.8 µg Pb/g.

Source: Integrated Exposure Uptake Biokinetic Model for Lead in Children (IEUBK) (EPA 1994)

Site-specific data were used to adjust the pre-set soil lead concentration in the IEUBK model of 200 µg/g, which EPA guidance indicates represents a "plausible value for urban soil lead concentration" (EPA 2002e). Exposure to lead in soil was calculated as a time weighted average in accordance with child direct sediment exposure scenarios. On days a child was assumed to visit the site, all of their lead exposure was assumed to come from the site, while on days when the site was not visited, the pre-set value of 200 µg/g was used. Using a weighted average allowed for a better estimate of true soil exposure. Indoor, or household dust lead concentrations were calculated according to model guidelines based on the pre-set value of 200 µg/g soil lead (EPA 2002e). This value represents the concentration of lead immediately outside the home (compared to sediment exposure at the site which is further away from the home). The alternate food source fraction was set at 12 percent, based on 12 g/day (median amount of Puget Sound seafood consumed per day)/98.05 g/day (total meat consumed per day).

As per the child exposure scenario developed for the LDW site, direct exposure to lead in sediment was assumed to occur on each of the 65 days specified by the exposure frequency for the beach play scenario. In the beach play RME scenario, exposure to soils at 200 µg/g soil lead was assumed to occur on the days when sediment exposures did not occur (i.e., 300 days per year). A time-weighted average EPC was calculated for the intertidal exposure by multiplying the number of days exposed to either default soil lead or Lockheed West sediment lead concentrations and dividing the sum of those by 365 days.

Alternate dietary data from the child tribal scenario based on Tulalip data for the consumption of fish and shellfish were included in the model as listed above in Table 3-35. The IEUBK model applies average estimates for all input parameter terms (EPA 1994). For seafood consumption rates, the median child seafood consumption rate was identified based on 40 percent of the median adult tribal seafood consumption rate based on Tulalip data of 29.9 g/day, as applied to the LDW HHRA (Windward 2007a). Furthermore, the percentage of the alternate food source (fish) of its food group (all meat) was set at 12 percent, as described above. The results of the IEUBK model runs are presented in Section 5.4, where risks under the child exposures are characterized. In order to calculate the average food lead concentration in the variety of fish consumed by tribal children, the median ingestion rate was multiplied by the mean lead concentration for each seafood category. The sum of the results of this calculation was then divided by the total ingestion rate to get the modeled average lead concentration for the seafood categories, at 28.8 µg/g, as shown in Table 3-35.

3.3.6.2 Lead Exposure to the Developing Fetus

In addition to estimating health risks to children from exposure to lead in their environment and diet, health risks are estimated to the fetus of a pregnant woman who may be exposed to lead at the Site. Exposures and risks are estimated using the ALM, which is based on protecting the developing fetus of a pregnant woman, considered the most sensitive subpopulation affected by adult lead exposure. Although the model was developed to assess soil exposures, it has been applied to the Lockheed West Site, consistent with its application to the LDW site, to evaluate exposure to lead in both sediments and as modeled in seafood at the Site. Adjustments were made to the model to account for seafood intake. The algorithm that was developed by EPA for the LDW site (Kissinger 2002) was used in the modeling, which was revised from the algorithm of the ALM to incorporate an exposure term for seafood consumption. Application of the revised ALM provides a way to evaluate cumulative exposure to lead from the site through ingestion of both sediment and seafood.

The revised ALM estimates an average blood lead level in adults based on additional exposure (above a baseline level) to lead in sediments and seafood. An estimated fetal blood lead level is then calculated from the estimated adult blood lead levels. The contribution of lead from air at the site was considered negligible because blood lead levels are much less sensitive to passive re-entrainment of lead from soil in air. The equation for the adult blood lead is the following:

$$PbB_{adult,central} = \frac{PbB_0 + BKSF \times FI \times ((PB_s \times IR_s \times AF_s \times EF_s) + (PB_f \times IR_f \times AF_f \times EF_f))}{AT}$$

Equation 3-9

where $PbB_{adult,central}$ is the geometric mean blood lead level (μg/dL) in exposed adults.

The exposure of adults to lead in sediment was modeled for the tribal clamming scenario and for the netfishing scenario, both of which include direct sediment exposures. The exposure to lead through seafood ingestion was modeled from the mean lead concentration in total seafood and the ingestion rates shown in Table 3-36. The ALM incorporates exposures to lead through contact with sediment in the tribal clamming scenario and the netfishing scenario with lead exposure from seafood consumption.

The adult tribal central tendency (CT) ingestion rate based on Tulalip data was used in the lead model to be consistent with the LDW modeling (Hiltner 2007) and because EPA guidance calls for use of median ingestion rates in the ALM. The adult Tulalip CT ingestion rates were combined with the mean lead concentrations for each seafood category to calculate a weighted average lead concentration for all seafood, as shown in Table 3-37. Anadromous fish consumption was not specifically addressed in the tissue lead calculations because it was considered to be part of baseline dietary exposure, which is included in the baseline blood lead level.

Table 3-36. Input Parameters for the Adult Lead Model

Parameter	Description	Value	Units
PbB_0	adult baseline (geometric mean) blood lead level	1.7[1/]	µg/dL
GSD	geometric standard deviation	2.29[1/]	-
BKSF	biokinetic slope factor	0.4 (EPA default)	µg/dL per µg/day
FI	fractional intake	1	unitless
IR_s	sediment ingestion rate – beach play RME and netfishing	50 (EPA default)[b]	mg/day
IR_s	sediment ingestion rate – clamming	100 (EPA default)[2/]	mg/day
IR_f	seafood ingestion rate	15[3/]	g/day
Pb_s	mean lead concentration in intertidal sediment – tribal clamming RME	367	mg/kg dw
Pb_s	mean lead concentration in sediment – netfishing	146	mg/kg dw
EF_s	exposure frequency for tribal clamming RME	120	days/yr
EF_s	exposure frequency for netfishing RME	119	days/yr
Pb_f	lead concentration in seafood (Table 3-37)	57.5[4/]	mg/kg ww
EF_f	exposure frequency for seafood consumption	365	days/yr
AF_s	gastrointestinal absorbance fraction for lead in sediment	0.12 (EPA default for soil)	unitless
AF_f	gastrointestinal absorbance fraction for lead in tissue	0.12	unitless
AT	averaging time	365	days

1/ Because communities in the Duwamish River basin include a sizable Mexican-American population, the average baseline blood lead level and geometric standard deviation of Mexican-American women in the US was used (EPA 2002a), consistent with the LDW HHRA.
2/ Although EPA has not developed default exposure assumptions for sediments, a health protective assumption was applied that assumes that daily sediment consumption would be equivalent to 100% of the assumed soil and dust intake, consistent with the modeling for the LDW.
3/ Median Puget Sound seafood consumption rate (Hiltner 2007).
4/ Lead concentration in seafood equals the sum (mean lead concentration calculated by ProUCL × ingestion rate) for each seafood category/total IR.
dw – dry weight
ww – wet weight

Table 3-37. Derivation of Exposure Point Concentration for Lead in Seafood

Fish or Shellfish Consumed	Modeled Mean Tissue Lead (µg/g ww)	Median Ingestion Rate (g/day) [2/]	Median Ingestion Rate x Mean Tissue Concentration
Clam	140	5.8	812
Mussel	140	0.1	14
Crab edible meat	0.69	5	3.47
Crab whole body	0.69	1.6	1.11
Fish, benthic fillet	12.7	1.2	15.3
Fish, benthic whole body	12.7	0	0
Fish, pelagic	12.7	1.3	16.6
Total consumption rate:		15	
Sum of product of ingestion rates × median concentrations (µg/day)			862
Median lead concentration in seafood (µg/g) [1/] = 862/15 =			57.5

1/ Median lead concentration in seafood equals the sum of (mean tissue concentration × median ingestion rate) for each seafood category/total median ingestion rate for all seafood categories. Mean tissue concentrations of lead were calculated from the same set of samples used to calculate EPCs for other chemicals.
2/ Median Puget Sound seafood ingestion rates provided by EPA (Hiltner 2007).
EPC – exposure point concentration
ww – wet weight

The model output includes both geometric mean and 95th percentile fetal blood lead levels. The 95th percentile fetal blood lead level is calculated using Equation 3-10:

$$PbB_{fetal95} = PbB_{adult,central} \times GSD_{i,adult}^{1.645} \times R_{fetal/maternal} \qquad \textbf{Equation 3-10}$$

Where:

- $PbB_{fetal95}$ = 95th percentile fetal blood lead level (µg/dL)
- $PbB_{adult,central}$ = central estimate of maternal adult blood lead concentration
- $GSD_{i,adult}$ = geometric standard deviation of the blood lead distribution
- 1.645 = 95th percentile value for the Student's t distribution
- $R_{fetal/maternal}$ = proportionality constant between fetal and maternal blood lead concentration

The geometric standard deviation (GSD) is an estimation of variation in blood lead levels around the geometric mean. It is used to estimate upper percentile blood lead levels for an individual and provide a health-protective estimate of the probability of an individual exceeding a given blood lead level (target risk goal). Because communities in the Duwamish River basin include a sizable Mexican-American population, the average baseline blood lead level and GSD of Mexican-American women in the US was used (EPA 2002a), consistent with the LDW HHRA. Fetal blood lead levels were predicted based on the EPA assumption that fetal blood lead levels at birth are 90 percent of the maternal blood lead level. Thus, a 10 µg/dL blood lead level for a fetus is associated with an 11.1 µg/dL blood lead level for the mother.

3.4 CHRONIC DAILY INTAKE RATES

CDI rates represent the estimated daily chemical dose for an individual averaged over the exposure duration for each scenario. Separate CDIs are calculated for COPCs with carcinogenic and non-carcinogenic effects because the AT over which the doses are calculated are different. CDIs for all COPCs are presented in the risk calculation tables of Section 5, and are calculated using Equations 3-5 and 3-6 in Section 3.3 and the exposure parameters given in Tables 3-7 through 3-17.

4. TOXICITY ASSESSMENT

The toxicity assessment presents the quantitative relationship between estimated exposure (dose) to COPCs and the likelihood of adverse effects on the basis of their non-carcinogenic and/or carcinogenic potential. The quantitative relationships are toxicity values used to quantify risk, and are expressed as CSFs for carcinogenic effects and RfDs for non-carcinogenic effects.

The CSFs are used to estimate the probability that a person would develop cancer given exposure to site-specific contaminants. This site-specific risk is in addition to the risk of developing cancer due to other causes over a lifetime. Consequently, site-specific risk estimates are frequently referred to as “incremental” or “excess lifetime” cancer risks. EPA has recently updated their guidance for carcinogenic risk assessment to emphasize consideration of mode of action (e.g., mutagenesis) in the development of CSFs (EPA 2005b). Generally, the SF is based on a dose-response curve using available carcinogenic data for a given chemical. Mathematical models are used to extrapolate from high experimental doses to the low doses expected for human contact in the environment. The selection of the mathematical model for dose extrapolation (e.g., linear or nonlinear) is informed by the mode of action of the chemical. The CSF is expressed in units of the inverse of chemical intake or dose $(mg/kg\text{-}day)^{-1}$.

RfDs represent a daily contaminant intake, with uncertainty spanning perhaps an order of magnitude or greater, below which no adverse human health effects are expected to occur during a lifetime. In developing toxicity values for non-cancer effects, EPA reviews available data to identify the most sensitive endpoint and population (i.e., the effects that occur at the lowest concentration). These available data include effects on children and other sensitive subpopulations. Chemicals may have additional adverse effects that occur at higher exposure levels.

Quantitative estimates of toxicity potential have been developed by EPA and other agencies. Sources of toxicity criteria are identified following the USEPA hierarchy (EPA 2003a):

- Tier 1 – Integrated Risk Information System (IRIS) database
- Tier 2 – Provisional Peer-Reviewed Toxicity Values (PPRTVs), EPA Office of Research and Development/National Center for Environmental Assessment (NCEA)
- Tier 3 – Other toxicity values. Tier 3 includes additional EPA and non-EPA sources of toxicity information. Priority is given to those sources of information that are the most current, the basis for which is transparent and publicly available, and which

have been peer reviewed. Sources include EPA regional offices, EPA Health Effects Assessment Summary Tables (HEAST) values, California EPA, and Agency for Toxic Substance and Disease Registry (ATSDR) minimal risk levels.

The sources for the PPRTV, NCEA, HEAST, and ATSDR toxicity values are the EPA Region 6 screening tables (EPA 2008) as updated in the Oak Ridge National Laboratory Risk Assessment Information System (ORNL 2008). Carcinogenic PAHs were evaluated for excess cancer risk as a group compound, where the carcinogenic potency of each cPAH is based on the potency of benzo(a)pyrene. The relative potency of each cPAH is related to benzo(a)pyrene by the potency equivalency factor (PEF). The concentrations of cPAHs in sediment samples were calculated using the PEFs produced by CalEPA (1994), which are shown in Table 4-1. The total cPAH concentrations were calculated for each sediment sample by summing the products of the concentrations of each individual carcinogenic PAH (benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene) and its compound-specific PEF, which was introduced in Section 2 on summing group compounds.

Table 4-1. Potency Equivalency Factors for cPAHs

Compound	Potency Equivalency Factor
cPAHs[1/]	
Benzo[a]pyrene	1
Benz[a]anthracene	0.1
Benzo[b]fluoranthene	0.1
Benzo[k]fluoranthene	0.1
Chrysene	0.01
Dibenz[a,h]anthracene	0.4
Indeno[1,2,3-cd]pyrene	0.1

[1/] PEFs for cPAHs were defined by the California Environmental Protection Agency, Office of Environmental Health Hazard Assessment (CalEPA 1994).
cPAH – carcinogenic polycyclic aromatic hydrocarbon

Descriptive information on the toxicity of the COPCs responsible for the majority of the risk is presented, based on information provided in the IRIS database and ATSDR toxicity profiles. In keeping with the approach to this HHRA, toxicity profiles are provided in Appendix C of this HHRA that are taken from Attachment 4 to the LDW HHRA (Windward 2007a).

The toxicity values used in this HHRA are summarized in Table 4-2 for non-cancer endpoints and in Table 4-3 for carcinogens. The toxicological endpoints that were used in IRIS to establish the RfDs are included in Table 4-4. The pharmacokinetics, acute toxicity, chronic toxicity, and potential carcinogenicity of each COPC are discussed in further detail in Appendix C. Some of the discussion of toxic effects in Appendix C includes exposure routes that are not relevant to environmental exposure at the Lockheed West Site, such as occupational inhalation exposure; the exposure routes are included only for completeness. In addition, for chemicals that may be present in different chemical forms, toxicity values are listed for the most toxic forms. For example, the RfD for methylmercury is used for mercury, although methylmercury was not included in the analytical suite for the site sediment data. Mercury may likely be primarily in methylated form in seafood tissue, but the form in sediment is more uncertain. Similarly, the toxicity value for hexavalent chromium, which is the carcinogenic form of chromium, was used for chromium, although the presence of hexavalent chromium in site sediment is unknown.

Toxicity information came from the following sources, which were updated for the Lockheed West HHRA:

- EPA IRIS database (www.epa.gov/iris)
- Provisional Peer-Reviewed Toxicity Values (PPRTVs), EPA Office of Research and Development/National Center for Environmental Assessment (NCEA)
- EPA 1997 values contained in HEAST
- Toxicological profiles presented in EPA *Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories* (EPA 2000b), as cited in Windward (2007a)
- EPA Office of Ground Water and Drinking Water (OGWDW; www.epa.gov/OGWDW/hfacts.html), as cited in Windward (2007a)
- ATSDR ToxFAQs (www.atsdr.cdc.gov/toxfaq.html)
- Hazardous Substance Data Bank (HSDB; toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?HSDB)

Table 4-2. Non-cancer Toxicity Values (Oral) for COPCs

Chemical	Chemical Class	Oral RfD (mg/kg-day)	Critical Effect	Uncertainty Factor	RfD Source	Source Date[1/]	Notes
Antimony	metal	0.0004	longevity, blood glucose, and cholesterol	1,000	IRIS	10/08/2008	
Arsenic	metal	0.0003	hyperpigmentation, keratosis, and possible vascular complications	3	IRIS	10/08/2008	surrogate = inorganic arsenic
Cadmium	metal	0.001	significant proteinuria	10	IRIS	10/08/2008	cadmium RfD for food was used for this risk assessment
Chromium	metal	0.003	none reported	300	IRIS	10/08/2008	surrogate = hexavalent chromium
Copper	metal	0.04	na	na	HEAST	09/12/2008	date of Region 3 database
Mercury (methyl)	metal	0.0001	developmental neuropsychological impairment	10	IRIS	10/08/2008	surrogate = methylmercury
Vanadium	metal	0.005	na	na	Region 3	09/12/2008	date of Region 3 database
Zinc	metal	0.3	decreases in erythrocyte Cu, Zn-superoxide dismutase activity in healthy adults	3	IRIS	10/08/2008	
Tributyltin as ion	organo-metal	0.00015	immunosuppression	100	IRIS	10/08/2008	surrogate = by conversion from tributyltin oxide (multiply by 0.49)
Fluoranthene	PAH	0.04	nephropathy, increased liver weights, hematological alterations, and clinical effects	3000	IRIS	10/08/2008	
Pyrene	PAH	0.03	kidney effects (renal tubular pathology, decreased kidney weights)	3000	IRIS	10/08/2008	
Total PCBs	PCB	0.00002	ocular exudate, inflamed and prominent Meibomian glands, distorted nail growth, decreased antibody response	300	IRIS	10/08/2008	surrogate = Aroclor 1254, the lowest and most protective RfD available for PCBs in IRIS; total includes Aroclors 1016, 1221, 1232, 1242, 1248, 1254, and 1260
Pentachlorophenol	SVOC	0.03	liver and kidney pathology	100	IRIS	10/08/2008	
Total DDTs	pesticide	0.0005	liver lesions	100	IRIS	10/08/2008	surrogate = 4,4'-DDT; total includes isomers of DDD, DDE, and DDT
Total chlordane	pesticide	0.0005	hepatic necrosis	300	IRIS	10/08/2008	surrogate = chlordane (technical); total chlordane includes alpha-chlordane, gamma-chlordane, and chlordane samples

[1/] The IRIS date is the date the database was searched; the HEAST date is the date that the EPA Region 6 table (the source of the HEAST value) was updated.
HEAST – Health Effects Assessment Summary Tables
IRIS – Integrated Risk Information System
na – not available; no RfD has been developed for this chemical
PAH –polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
RfD – reference dose
SVOC – semivolatile organic compound

Table 4-3. Cancer Toxicity Values (Oral/Dermal) for COPCs

Chemical[1]	Parameter Classification	Oral Cancer Slope Factor $(mg/kg\text{-}day)^{-1}$	Cancer Description Guideline[2/]	Source	Source Date[3]	Notes
Arsenic (inorganic)	metal	1.5	A	IRIS	10/08/2008	inorganic arsenic
Mercury	metal	na	C	IRIS	10/08/2008	surrogate = methylmercury
cPAHs	PAH	7.3	B2	IRIS	10/08/2008	slope factor based on benzo(a)pyrene
Total PCBs	PCB	2	B2	IRIS	10/08/2008	upper-bound slope factor, total PCBs include Aroclors 1016, 1221, 1232, 1242, 1248, 1254, and 1260
Pentachlorophenol	SVOC	0.12	B2	IRIS	10/08/2008	
Total DDTs	pesticide	0.34	B2	IRIS	10/08/2008	surrogate = 4,4'-DDT; total DDT includes isomers of DDD, DDE, and DDT
Total Chlordane	pesticide	0.35	B2	IRIS	10/08/2008	surrogate = chlordane (technical); total chlordane includes alpha-chlordane, gamma-chlordane, and chlordane samples

[1/] Chemicals included in this table are either class A, B, or C chemicals with regard to their cancer-causing potential. Cadmium and chromium, although known carcinogens, are excluded from this table because they are carcinogens only via the inhalation pathway.
[2/] A = known human carcinogen; B1 = probable human carcinogen (based on limited evidence of carcinogenicity in humans); B2 = probable human carcinogen (sufficient evidence in animals and inadequate or no evidence in humans); C = possible human carcinogen (limited evidence from animal studies and inadequate or no data in humans); D = not classifiable as to human carcinogenicity.
[3/] Date that the IRIS database was searched.
cPAH – carcinogenic polycyclic aromatic hydrocarbon
IRIS – Integrated Risk Information System
PCB – polychlorinated biphenyl
SVOC – semivolatile organic compound

Table 4-4. Toxicological Endpoints for COPCs with Non-carcinogenic Effects

Chemical	Endpoint										
	Kidney	**Liver**	**Development**	**Cardiovascular System**	**Endocrine System**	**Hematologic System**	**Immune System**	**Nervous System**	**Skin**	**Eyes**	**Reproductive System**
Antimony					X	X					
Arsenic				X					X		
Cadmium	X										
Chromium (as hexavalent chromium)											
Copper[2/]	X	X									
Lead[1/]											
Mercury (as methylmercury)			X					X			
Vanadium[5/]				X							
Zinc						X					
Tributyltin as ion (by conversion from tributyltin oxide)							X				
Fluoranthene		X				X		X			
Pyrene	X										
cPAHs[1/]											
Total PCBs (based on Aroclor 1254)[3/]			X				X	X[4/]			
Pentachlorophenol	X	X									
Total DDTs		X									
Total chlordane		X									

Note: Endpoints were identified as those associated with the RfD; additional endpoints may occur at exposures above the RfD, as described in the toxicological profiles in Appendix C.
[1/] No RfD is available for this COPC.
[2/] The RfD for copper is from a source other than IRIS. The endpoints were identified using ATSDR (2004).
[3/] PCB effects on skin (chloracne) are well-documented, but these are associated with acute exposures at levels much higher than the RfD (ATSDR 2000).
[4/] Nervous system effects for PCBs were not identified in IRIS for development of the RfD, but such effects, particularly neurodevelopmental effects, are well-documented (ATSDR 2000) and so are indicated in this table.
[5/] The RfD for vanadium is from a source other than IRIS. The endpoint was identified from ATSDR (1995).
X – Indicates that the IRIS RfD for a particular chemical was calculated for the identified endpoint.
COPC – chemical of potential concern
PAH – polycyclic aromatic hydrocarbon
PCB – polychlorinated hydrocarbon

5. RISK CHARACTERIZATION

Risk characterization is the integration of calculated exposures and the toxicity information developed in the preceding sections. The equations used to calculate the risk estimates are presented, followed by the calculation results. The risk estimates are used for identifying COCs, which are defined here as chemicals with an excess cancer risk estimate greater than 1×10^{-6} or a non-cancer HQ greater than 1. Conclusions about cancer and noncarcinogenic risks and exceedances of EPA risk ranges under CERCLA are presented.

The primary purpose of the HHRA is to characterize health risks from site-related exposures, which provides support for risk management decisions and remedial options. Site-specific HHRAs typically provide information to the public about possible health risks if they were to engage in activities at the exposure levels assumed in the assessment. The exposure assumptions used to quantify the risk estimates in this HHRA are considered to be health protective for the Site. Uncertainties related to the use of exposure assumptions from the LDW HHRA are discussed in Section 6.1. Risks are characterized and estimated in this section for chemicals detected in Lockheed West Site sediment and for those chemicals that are modeled into seafood based on the sediment concentrations.

5.1 RISK ESTIMATE CALCULATIONS

Carcinogenic risks and non-carcinogenic health effects were evaluated separately because of fundamental differences in their critical toxicity values. Equations for each type of effect are presented in separate subsections that follow.

5.1.1 Cancer Risks

For carcinogens, risks are expressed as the incremental probability of an individual developing cancer over a lifetime as a result of exposure to the carcinogen. Risks are probabilities that usually are expressed in scientific notation (e.g., 1×10^{-6} or 1E-6). An excess lifetime cancer risk of 1E-6 indicates that an individual experiencing the RME estimate has a 1 in 1,000,000 chance of developing cancer as a result of site-related exposure. The cancer risk range generally considered acceptable by EPA under the National Contingency Plan and CERCLA guidance is 1E-4 to 1E-6. Excess cancer risks below 1E-6 are generally considered insignificant for the purposes of CERCLA cleanup.

For chemicals with carcinogenic effects, EPA guidance for their evaluation (EPA 1989) is based on the theory that the risk of cancer is proportional to the dose, with the assumption that there is no threshold. In other words, the approach to evaluating the carcinogenic risk of a chemical assumes that there is a finite probability of cancer risk when exposed to these chemicals at any concentration. For relatively low probabilities (i.e., below 1 in 100), carcinogenic risks are calculated by multiplying the estimated exposure level (the CDI) by the CSF for each chemical (Equation 5-1).

$$\text{Risk} = \text{CDI} \times \text{SF}$$ **Equation 5-1**

Where:

Risk	=	estimated chemical-specific individual excess lifetime excess cancer risk (unitless)
CDI	=	chemical-specific chronic daily intake (mg/kg-day)
CSF	=	route- and chemical-specific carcinogenic slope factor $(\text{mg/kg-day})^{-1}$

The linear Equation 5-1 is valid for calculating low risk levels (i.e., below estimated risks of 0.01). For estimated cancer risks above 0.01, the exponential equation is used (Equation 5-2), which is consistent with the linear low-dose model of Equation 5-1.

$$\text{Risk} = 1 - \exp(-\text{CDI} \times \text{CSF})$$ **Equation 5-2**

where:

Risk	=	estimated chemical-specific individual excess lifetime excess cancer risk (unitless)
exp	=	mathematical constant, base of the natural logarithm
CDI	=	chemical-specific chronic daily intake (mg/kg-day)
CSF	=	route- and chemical-specific carcinogenic slope factor.

Cancer risk is expressed as a lifetime excess cancer risk. Excess cancer risk refers to risks associated with site-specific exposure, above and beyond risks associated with exposure from all other causes, including exposure to carcinogenic sources outside the site. This concept assumes that the risk of cancer from a given chemical is in “excess” of the background risk of developing cancer. The American Cancer Society (2007) indicates that approximately one of every two men and one of every three women will get some form of cancer during their lifetimes.

EPA has recently provided additional guidance for children’s carcinogenic risk assessment (EPA 2006a). For cPAHs, which have been identified as having a mutagenic mode of action, dose estimates are adjusted upwards in the risk calculation to account for potential greater susceptibility of children from 0 to 2 and from 2 to 6 years of age compared with older children and adults. Risks are adjusted by a 10-fold increase for ages 0 to 2 and 3-fold increase for ages 2 to 6.

For all exposure routes (i.e., ingestion of seafood or sediment and dermal contact with sediment), this dose adjustment has been made in the final risk calculation rather than an adjustment to exposures or to carcinogenic potency. Implementation of this approach results in approximately a 5-fold increase in the cancer risk estimate for cPAHs for children and is based on the assumption that toxicity of carcinogens with a mutagenic mode of action could be greater for young children than for older children or adults.

Excess cancer risks are presented with only one significant figure to acknowledge the uncertainty in the underlying CSFs, per EPA guidance (1989), and in the exposure assumptions underlying the calculations.

5.1.2 Potential for Non-Carcinogenic Health Effects

The potential for noncarcinogenic effects is evaluated by the hazard quotient (HQ), which compares an exposure level over a specified time period (e.g., lifetime) with an RfD derived for a similar exposure period.

$$HQ = CDI/RfD$$ **Equation 5-3**

where:

HQ	=	estimated chemical-specific hazard quotient (unitless)
CDI	=	route- and chemical-specific chronic daily intake (mg/kg-day)
RfD	=	route- and chemical-specific reference dose (mg/kg-day)

HQs are not statistical probabilities; the likelihood of an adverse effect does not usually increase linearly with the calculated value. An HQ greater than 1 indicates potential adverse health effects from the chemical exposure, although the same HQ may not equate to the same magnitude of adverse health effects for all chemicals. HQ interpretation considers the shape and slope of the dose-response curve in the area of observation, the magnitude of uncertainty and modifying factors to the RfD, and the confidence assigned to the RfD by EPA.

An HQ less than 1 indicates that the dose of a chemical to an individual is less than the RfD, and toxic effects from the chemical are unlikely. A hazard index (HI) is generated by adding the HQs for all COPCs that affect the same target organ (e.g., liver) or act through the same mechanism of action within a medium or across all media to which a given individual may reasonably be exposed. An HI less than 1 indicates that, based on the sum of all HQ’s from different chemicals and exposure routes, toxic noncarcinogenic effects from all chemicals are unlikely. An HI greater than 1 indicates that site-related exposures may present a risk to human health; target organ or effects-specific HQs are then developed for the COPCs having similar modes of action or target organs.

5.2 RISK CHARACTERIZATION RESULTS

Risk characterization results are presented for the Lockheed West Site in this subsection. The format for presenting excess cancer risks and HQs is consistent with the format recommended in EPA (1998a).

Excess cancer risks are summed for all COPCs within each exposure scenario. Exposure scenarios in which the same receptor is exposed via multiple pathways simultaneously were addressed by summing the RME estimates for those pathways. This approach was applied to all direct sediment exposure scenarios that involved both dermal absorption and incidental sediment ingestion. In addition, excess cancer risk estimates were summed across potentially related scenarios (e.g., netfishing and seafood consumption), although not all possible combinations of scenarios were evaluated. For some combinations of scenarios, the highest RME pathway risk estimate may be several orders of magnitude higher than the other scenarios. Because of the much higher risk estimates for seafood consumption, the resulting risk estimate for the combination of multiple scenarios tends to differ only slightly or not at all from the risk estimate for the seafood consumption scenario.

CDIs are presented with two significant figures, while excess cancer risks and HQs are presented with only one significant figure. The former reflects the accuracy of the CDI equations, and the latter reflects the accuracy of the cancer slope factors and reference doses, as per the EPA IRIS database. Sums of excess cancer risk estimates are reported with one significant figure as well. For example, the sum of excess risk estimates of 2×10^{-4} and 3×10^{-5} would be reported as 2×10^{-4}, not 2.3×10^{-4}. Hazard indices (HIs, sums of HQs) are presented with one significant figure if they are less than 1, or to the nearest integer if they are greater than 1. This is to allow the reader to follow summations. For example, HQs of 4 and 10 would be summed to an HI of 14, not 10. However, HQs of 0.01 and 0.001 would be summed to an HI of 0.01, not 0.011.

Risk estimates are presented for each of the RME exposure scenario identified in the exposure assessment: child beach play (Section 5.2.1), clamming (Section 5.2.2), netfishing (Section 5.2.3), and seafood consumption (Section 5.2.4). Excess cancer risks and HQs for the various exposure scenarios are presented in tables, as appropriate, in these subsections.

5.2.1 Beach Play

Upper bound excess cancer risks and non-cancer hazards were estimated individually for the beach play intertidal exposure area. No site-specific data other than sediment chemistry are available to estimate actual exposures to sediment at the Lockheed West Site through child beach play; parameters to estimate beach play exposures were taken from the LDW HHRA. Total cancer risk estimates for the beach play scenario are presented in Table 5-1, and are estimated at 7×10^{-5}, which exceeds the total excess cancer risk threshold of 1×10^{-6}. Almost all of the total excess cancer risk was attributable to incidental ingestion of arsenic in intertidal sediment, at 7×10^{-5}.

Table 5-1. Excess Cancer Risk Estimates for the Beach Play Scenario Based on Exposure by Incidental Sediment Ingestion and Dermal Absorption

Scenario timeframe: Current/future
Medium: Sediment
Exposure medium: Intertidal Sediment
Receptor population: Residents
Receptor age: Child

		Cancer CDI (mg/kg-day)			Excess Cancer Risk		
COPC	**EPC (mg/kg dw)[1/]**	**Incidental Ingestion**	**Dermal Absorption**	**Cancer Slope Factor $(mg/kg\text{-}day)^{-1}$**	**Incidental Ingestion**	**Dermal Absorption**	**Total**
Arsenic	192	4.4E-05	2.6E-06	1.5	6.6E-05	3.9E-06	7×10^{-5}
cPAHs[2/, 3/]	0.18	4.0E-08	1.0E-08	7.3	1.6E-06	7.6E-08	2×10^{-6}
						Total for all COPCs	$\mathbf{7 \times 10^{-5}}$

[1/] All EPCs are medium-specific, rather than route-specific (i.e., the same EPC was used for the dermal absorption and incidental sediment ingestion exposure routes).
[2/] Because of the potential for increased susceptibility of children to carcinogens with mutagenic activity, as described in EPA guidance (EPA 2006a), the risk estimate for cPAHs is based on dose adjustments across the 0-6 year age range of children. See Section 5.1 for more information.
[3/] cPAH concentrations are presented as benzo(a)pyrene equivalents.
CDI – chronic daily intake
COPC – chemical of potential concern for intertidal sediments
dw – dry weight
EPC – exposure point concentration
cPAH – carcinogenic polycyclic aromatic hydrocarbon

Non-cancer HQs for beach play are shown in Table 5-2, and were greater than 1 for arsenic and less than 1 for the remaining COPCs. Total HI for all chemicals was greater than 1, with the endpoint-specific HIs for cardiovascular and dermal endpoints exceeding 1 based on arsenic exposures.

Table 5-2. Non-cancer Hazard Estimates for Beach Play Scenario Based on Exposure by Incidental Sediment Ingestion and Dermal Absorption

Scenario timeframe: Current/future
Medium: Sediment
Exposure medium: Intertidal Sediment
Receptor population: Residents
Receptor age: Child

COPC	EPC (mg/kg dw)[1/]	Non-Cancer CDI (mg/kg-day) Incidental Ingestion	Non-Cancer CDI (mg/kg-day) Dermal Absorption	Reference Dose (mg/kg-day)	Hazard Quotient Incidental Ingestion	Hazard Quotient Dermal Absorption	Total
Antimony	81.7	2.2E-04	na[3/]	4.0E-04	0.5	na[3/]	0.5
Arsenic	192	5.1E-04	3.1E-05	3.0E-04	1.7	0.10	1.8
Chromium	198	5.3E-04	na[3/]	3.0E-03	0.2	na[3/]	0.2
Copper	840	2.2E-03	na[3/]	4.0E-02	0.1	na[3/]	0.1
Vanadium	51.8	1.4E-04	na[3/]	5.0E-03	0.03	na[3/]	0.03
				Total hazard index across both exposure routes[4/]			**2.6**
Hazard indices by effect:							
Hazard Index for Cardiovascular Endpoint[5/]					**1.8**		
Hazard Index for Endocrine Endpoint[6/]					**0.5**		
Hazard Index for Hematologic Endpoint[7/]					**0.5**		
Hazard index for Kidney Endpoint[8/]					**0.1**		
Hazard index for Liver Endpoint[9/]					**0.1**		
Hazard index for Dermal Endpoint[10/]					**1.8**		

1/ All EPCs are medium-specific, rather than route-specific (i.e., the same EPC was used for the dermal absorption and incidental sediment ingestion exposure routes).
2/ No data exist for this chemical in this area
3/ No absorption factor available for this chemical. Dermal exposures are discussed in the Uncertainty Assessment (Section 6).
4/ The value indicates that the HI may exceed 1 for individual endpoints. Therefore, HIs were calculated for individual endpoints.
5/ Cardiovascular endpoint is for arsenic and vanadium.
6/ Endocrine endpoint is for antimony.
7/ Hematologic endpoint is for antimony.
8/ Kidney endpoint is for copper.
9/ Liver endpoint is for copper.
10/ Dermal endpoint is for arsenic.
CDI – chronic daily intake
COPC – chemical of potential concern for intertidal sediments
dw – dry weight
EPC – exposure point concentration
na – not available
RfD – reference dose

5.2.2 Clamming

Risks were estimated for two clamming scenarios, consisting of a tribal clamming RME scenario (120 days per year) and a tribal clamming 183-days-per-year scenario. The clamming scenarios consist of exposures to sediment via incidental ingestion and dermal contact. Risks related to consumption of clams are evaluated in the seafood consumption scenarios. The effect of summing risks from clamming with those from clam consumption is evaluated in Section 5.2.5.

The total excess cancer risk estimates for the combined exposure routes (dermal absorption and incidental sediment ingestion) for clamming (120 days per year) were 1×10^{-4} (Table 5-3).

Table 5-3. Excess Cancer Risk Estimates for the Tribal Clamming RME Scenario (120 days per year)

Scenario timeframe: Current/future
Medium: Sediment
Exposure medium: Intertidal Sediment
Receptor population: Tribal/subsistence clam collectors
Receptor age: Adult

Chemical	EPC (mg/kg dw)[1/]	Cancer CDI (mg/kg-day) Incidental Ingestion	Cancer CDI (mg/kg-day) Dermal Absorption	Cancer Slope Factor $(mg/kg\text{-}day)^{-1}$	Excess Cancer Risk Incidental Ingestion	Excess Cancer Risk Dermal Absorption	Excess Cancer Risk Total
Arsenic	192	7.07E-05	2.6E-05	1.5	1.1E-04	3.8E-05	1×10^{-4}
cPAHs[2/]	0.18	6.46E-08	1.0E-07	7.3	4.7E-07	7.4E-07	1×10^{-6}
Total cancer risk across both exposure routes							$\mathbf{1 \times 10^{-4}}$

[1/] All EPCs are medium-specific, rather than route-specific (i.e., the same EPC was used for the dermal absorption and incidental sediment ingestion exposure routes).
[2/] cPAH concentrations are presented as benzo(a)pyrene equivalents.
CDI – chronic daily intake
dw – dry weight
EPC – exposure point concentration
cPAH – carcinogenic polycyclic aromatic hydrocarbons

For the tribal clamming 183-days-per-year scenario, the total excess cancer risk for incidental ingestion and dermal absorption pathways was 2×10^{-4} (Table 5-4). The highest contributor to excess cancer risk was arsenic, with an excess cancer risk of 2×10^{-4}.

Table 5-4. Excess Cancer Risk Estimates for the Tribal Clamming 183-days-per-year Scenario

Scenario timeframe: Current/future
Medium: Sediment
Exposure medium: Intertidal Sediment
Receptor population: Tribal/subsistence clam collectors
Receptor age: Adult

Chemical	EPC (mg/kg dw)[1/]	Cancer CDI (mg/kg-day) Incidental Ingestion	Cancer CDI (mg/kg-day) Dermal Absorption	Cancer Slope Factor $(mg/kg\text{-}day)^{-1}$	Excess Cancer Risk Incidental Ingestion	Excess Cancer Risk Dermal Absorption	Excess Cancer Risk Total
Arsenic	192	1.2E-04	4.3E-05	1.5	1.8E-04	6.4E-05	2×10^{-4}
cPAHs[2/]	0.18	1.1E-07	1.7E-07	7.3	7.9E-07	1.2E-06	2×10^{-6}
Total cancer risk across all exposure routes / pathways							$\mathbf{2 \times 10^{-4}}$

[1/] All EPCs are medium-specific, rather than route-specific (i.e., the same EPC was used for the dermal absorption and incidental sediment ingestion exposure routes).
[2/] cPAH concentrations are presented as benzo(a)pyrene equivalents.
CDI – chronic daily intake
dw – dry weight
EPC – exposure point concentration
cPAH – carcinogenic polycyclic aromatic hydrocarbons

For non-cancer hazard estimates for both the 120 day per year and the 183 day per year clamming scenarios, HQs for all chemicals were less than 1 (Tables 5-5 and 5-6). Effect-specific HIs were not calculated because the total HI across all effects did not exceed 1.

Table 5-5. Non-cancer Hazard Estimates for the Tribal Clamming RME Scenario (120 days per year)

Scenario timeframe: Current/future
Medium: Sediment
Exposure medium: Intertidal Sediment
Receptor population: Tribal/subsistence clam collectors
Receptor age: Adult

Chemical	EPC (mg/kg dw)[1/]	Non-Cancer CDI (mg/kg-day) Incidental Ingestion	Non-Cancer CDI (mg/kg-day) Dermal Absorption	Reference Dose (mg/kg-day)	Hazard Quotient Incidental Ingestion	Hazard Quotient Dermal Absorption	Hazard Quotient Total
Antimony	81.7	3.28E-05	na[2/]	4.0E-04	0.08	na[2/]	0.08
Arsenic	192	7.73E-05	2.8E-05	3.0E-04	0.26	0.09	0.35
Chromium	198	7.95E-05	na[2/]	3.0E-03	0.03	na[2/]	0.03
Copper	840	3.38E-04	na[2/]	4.0E-02	0.01	na[2/]	0.01
Vanadium	51.8	2.08E-05	na[2/]	5.0E-03	0.004	na[2/]	0.004
						Total hazard index across both exposure routes[3/]	**0.5**

[1/] All EPCs are medium-specific, rather than route-specific (i.e., the same EPC was used for the dermal absorption and incidental sediment ingestion exposure routes).
[2/] No absorption factor available for this chemical. Dermal exposures are discussed in the Uncertainty Assessment (Section 6).
[3/] The value indicates that the HI does not exceed 1 for individual endpoints. Therefore, HIs were not calculated for individual endpoints.
CDI – chronic daily intake
dw – dry weight
EPC – exposure point concentration

Table 5-6. Non-cancer Hazard Estimates for the Tribal Clamming 183-days-per-year Scenario

Scenario timeframe: Current/future
Medium: Sediment
Exposure medium: Intertidal Sediment
Receptor population: Tribal/subsistence clam collectors
Receptor age: Adult

Chemical	EPC (mg/kg dw)[1/]	Non-Cancer CDI (mg/kg-day) Incidental Ingestion	Non-Cancer CDI (mg/kg-day) Dermal Absorption	Reference Dose (mg/kg-day)	Hazard Quotient Incidental Ingestion	Hazard Quotient Dermal Absorption	Hazard Quotient Total
Antimony	81.7	5.0E-05	na[2/]	4.0E-04	0.13	na[2/]	0.13
Arsenic	192	1.2E-04	4.3E-05	3.0E-04	0.39	0.14	0.53
Chromium	198	1.2E-04	na[2/]	3.0E-03	0.04	na[2/]	0.04
Copper	840	5.1E-04	na[2/]	4.0E-02	0.01	na[2/]	0.01
Vanadium	51.8	3.2E-05	na[2/]	5.0E-03	0.01	na[2/]	0.01
						Total hazard index across both exposure routes[3/]	**0.7**

[1/] All EPCs are medium-specific, rather than route-specific (i.e., the same EPC was used for the dermal absorption and incidental sediment ingestion exposure routes).
[2/] No absorption factor available for this chemical. Dermal exposures are discussed in the Uncertainty Assessment (Section 6).
[3/] The HI does not exceed 1 for individual endpoints. Therefore, HIs were not calculated for individual endpoints.
CDI – chronic daily intake
dw – dry weight
EPC – exposure point concentration

5.2.3 Netfishing

Netfishing risks were estimated for exposures to the combined subtidal and intertidal sediment areas of the West Waterway and Elliott Bay sides of the Lockheed West Site. Netfishing risks are associated with incidental sediment ingestion and dermal absorption exposure routes.

For the netfishing RME scenario, the total excess cancer risk was 3×10^{-5} (Table 5-7). The greatest contributor to the netfishing RME excess cancer risk was arsenic, which at 3×10^{-5} cancer risk, accounted for almost all of the total excess cancer risk.

Non-cancer hazards for the netfishing scenario were found to be low, with HQs substantially less than 1 (Table 5-8). Effect-specific HIs were not calculated because the total HI across all effects was less than 1.

Table 5-7. Excess Cancer Risk Estimates for the Netfishing RME Scenario

Scenario timeframe: Current/future
Medium: Sediment
Exposure medium: Subtidal and Intertidal Sediment
Receptor population: Commercial fishermen
Receptor age: Adult

Chemical	EPC (mg/kg dw)[1/]	Cancer CDI (mg/kg-day) Incidental Ingestion	Cancer CDI (mg/kg-day) Dermal Absorption	Cancer Slope Factor (mg/kg-day)$^{-1}$	Excess Cancer Risk Incidental Ingestion	Excess Cancer Risk Dermal Absorption	Excess Cancer Risk Total
Arsenic	109	1.4E-05	5.9E-06	1.5	2.1E-05	8.9E-06	3×10^{-5}
cPAHs[2/]	0.96	1.2E-07	2.2E-07	7.3	8.8E-07	1.6E-06	3×10^{-6}
Total PCBs	0.50	6.2E-08	1.3E-07	2	1.2E-07	2.5E-07	4×10^{-7}
Total cancer risk across both exposure routes							$\mathbf{3 \times 10^{-5}}$

1/ All EPCs are medium-specific, rather than route-specific (i.e., the same EPC was used for the dermal absorption and incidental sediment ingestion exposure routes).
2/ cPAH concentrations are presented as benzo(a)pyrene equivalents.
CDI – chronic daily intake
EPC – exposure point concentration
cPAH – carcinogenic polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
dw – dry weight

Table 5-8. Non-cancer Hazard Estimates for the Netfishing RME Scenario

Scenario timeframe: Current/future
Medium: Sediment
Exposure medium: Subtidal and Intertidal Sediment
Receptor population: Commercial fishermen
Receptor age: Adult

Chemical	EPC (mg/kg dw)[1/]	Non-Cancer CDI (mg/kg-day) Incidental Ingestion	Non-Cancer CDI (mg/kg-day) Dermal Absorption	Reference Dose (mg/kg-day)	Hazard Quotient Incidental Ingestion	Hazard Quotient Dermal Absorption	Hazard Quotient Total
Antimony	37.0	7.4E-06	na[2/]	4.0E-04	0.018	na[2/]	0.02
Arsenic	109	2.2E-05	9.4E-06	3.0E-04	0.073	0.031	0.1
Chromium	90.0	1.8E-05	na[2/]	3.0E-03	0.006	na[2/]	0.006
Total PCBs	0.50	9.9E-08	2.0E-07	2.0E-05	0.005	0.010	0.02
Total hazard index across both exposure routes[3/]							**0.1**

1/ All EPCs are medium-specific, rather than route-specific (i.e., the same EPC was used for the dermal absorption and incidental sediment ingestion exposure routes).
2/ No absorption factor available for this chemical. Dermal exposure is discussed in the Uncertainty Assessment (Section 6).
3/ The HI does not exceed 1 for individual endpoints. Therefore, HIs were not calculated for individual endpoints.
CDI – chronic daily intake
dw – dry weight
EPC – exposure point concentration
PCB – polychlorinated biphenyl

5.2.4 Seafood Consumption

Risks were estimated for seafood consumption for three exposure scenarios: adult tribal RME seafood consumption based on the Tulalip survey, child tribal RME seafood consumption based on the Tulalip survey, and the high end tribal seafood consumption based on the Suquamish survey. As has been noted previously, determining the relationships between metals concentrations in sediment and tissues is highly uncertain. The Uncertainty Assessment (Section 6) discusses the use of data from the nearby LDW site as well as Lockheed West specific bivalve data to characterize metals risks and hazards.

5.2.4.1 Excess Cancer Risk Estimates

Total upper bound excess cancer estimates for seafood consumption significantly exceeded 1×10^{-6} for each of the three scenarios (Tables 5-9 through 5-11). The highest excess cancer risk estimates were for the adult tribal scenario based on Suquamish data (5×10^{-2}) (Table 5-11), followed by the adult tribal RME scenario based on Tulalip data (9×10^{-3})[1] (Table 5-9), and the child tribal RME scenario based on Tulalip data (4×10^{-3}) (Table 5-10).

[1] Consideration of alternative methods for computing metals bioaccumulation in the uncertainty assessment (Section 6) resulted in significant cancer risk increases for arsenic. The adult tribal RME arsenic risk using Tulalip data increased from 3×10^{-3} to 9.9×10^{-3}. The child tribal RME arsenic risk increased from 5.5×10^{-4} to 1.8×10^{-3}. Increases in arsenic risk associated with different bioaccumulation assessment approaches may be offset by the fact that the percentage of inorganic arsenic in shellfish is likely lower than assumed.

The differences in risk estimates across these scenarios reflect the differences in the overall rates of seafood consumed and differences in the relative consumption rates for various seafood categories within each scenario, which resulted in dissimilar estimates of chemical intakes among the scenarios. Differences in body weight and exposure duration across scenarios also contributed to the different risk estimates.

The majority of the total excess cancer risk for all the seafood consumption scenarios is attributable to a combination of inorganic arsenic, cPAHs, and PCBs.

All COPCs evaluated in the risk characterization for the adult tribal RME scenario based on Tulalip data are designated COCs based on excess cancer risk estimates greater than 1×10^{-6}, including chemicals that were detected infrequently (e.g., pentachlorophenol) as well as those with high detection frequencies such as arsenic and total PCBs. Inclusion of the JN-qualified chemicals (total DDTs and total chlordanes) in each of the scenarios did not change the total risk estimates. The uncertainty associated with risk estimates for JN-qualified and infrequently detected chemicals is discussed in the uncertainty assessment (Section 6). In addition, dioxins and furans are identified as COCs for the tribal seafood ingestion pathways, based on their likely presence in site sediment and seafood from the site (as has been documented in the upstream LDW), and the likelihood of high estimates of cancer risk based on their presence.

Table 5-9. Excess Cancer Risk Estimates for the Adult Tribal RME Seafood Consumption Scenario Based on Tulalip Data

Scenario timeframe: Current/future
Medium: Sediment
Exposure medium: Fish and shellfish tissue
Receptor population: Tulalip tribal fish and shellfish consumers
Receptor age: Adult

Chemical	EPC (mg/kg ww)[1/]	Cancer CDI (mg/kg-day)	Cancer Slope Factor $(mg/kg\text{-}day)^{-1}$	Excess Cancer Risk
Arsenic[2/]	Table 3-33	1.7E-03	1.5	3×10^{-3}
cPAHs[3/]	Table 3-33	3.5E-04	7.3	3×10^{-3}
Total PCBs	Table 3-33	1.4E-03	2	3×10^{-3}
Pentachlorophenol	Table 3-33	2.5E-05	0.12	3×10^{-6}
			Subtotal	$\mathbf{9 \times 10^{-3}}$
Tentatively identified chemicals (JN-qualified)				
Total chlordane	Table 3-33	5.1E-05	0.35	2×10^{-5}
Total DDTs	Table 3-33	7.4E-04	0.34	3×10^{-4}
			Subtotal	$\mathbf{3 \times 10^{-4}}$
Total excess cancer risk				$\mathbf{9 \times 10^{-3}}$

1/ An EPC for each seafood category was calculated in the exposure section (see Tables 3-29 through 3-31).
2/ Arsenic EPCs and risk estimates are based on inorganic arsenic. Additional cancer risk estimates are presented in Section 6.2.5 based on alternative BSAFs for modeling metals exposures.
3/ cPAH concentrations are presented as benzo(a)pyrene equivalents.
CDI – chronic daily intake
dw – dry weight
EPC – exposure point concentration
cPAH – carcinogenic polycyclic aromatic hydrocarbon
PCBs – polychlorinated biphenyls

Table 5-10. Excess Cancer Risk Estimates for the Child Tribal RME Seafood Consumption Scenario Based on Tulalip Data

Scenario timeframe: Current/future
Medium: Sediment
Exposure medium: Fish and shellfish tissue
Receptor population: Tulalip tribal fish and shellfish consumers
Receptor age: Child

Chemical	EPC (mg/kg ww)[1/]	Cancer CDI (mg/kg-day)	Cancer Slope Factor $(kg/mg\text{-}day)^{-1}$	Excess Cancer Risk
Arsenic[2/]	Table 3-33	3.2E-04	1.5	5×10^{-4}
cPAHs[3/, 4/]	Table 3-33	3.4E-04	7.3	3×10^{-3}
Total PCBs	Table 3-33	2.7E-04	2	5×10^{-4}
Pentachlorophenol	Table 3-33	4.6E-06	0.12	6×10^{-7}
			Subtotal	$\mathbf{4 \times 10^{-3}}$
Tentatively identified chemicals (JN-qualified)				
Total chlordane	Table 3-33	9.4E-06	0.35	3×10^{-6}
Total DDTs	Table 3-33	1.4E-04	0.34	5×10^{-5}
			Subtotal	$\mathbf{5 \times 10^{-5}}$
Total excess cancer risk				$\mathbf{4 \times 10^{-3}}$

[1/] An EPC for each seafood category was calculated in the exposure section (see Tables 3-29 through 3-31).
[2/] Arsenic EPCs and risk estimates are based on inorganic arsenic. Additional cancer risk estimates are presented in Section 6.2.5 based on alternative BSAFs for modeling metals exposures.
[3/] Because of the potential for increased susceptibility of children to carcinogens with mutagenic activity, as described in EPA guidance (EPA 2006a), the risk estimate for carcinogenic PAHs is based on dose adjustments across the 0-6 year age range of children. See section 5.1 for more information.
[4/] cPAH concentrations are presented as benzo(a)pyrene equivalents.
CDI – chronic daily intake
dw – dry weight
EPC – exposure point concentration
cPAH – carcinogenic polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl

Table 5-11. Excess Cancer Risk Estimates for the Adult Tribal Seafood Consumption Scenario Based on Suquamish Data

Scenario timeframe: Current/future
Medium: Sediment
Exposure medium: Fish and shellfish tissue
Receptor population: Suquamish tribal fish and shellfish consumers
Receptor Age: Adult

Chemical	EPC (mg/kg ww)[1/]	Cancer CDI (mg/kg-day)	Cancer Slope Factor $(mg/kg\text{-}day)^{-1}$	Excess Cancer Risk
Arsenic[2/, 3/]	Table 3-33	2.1E-02	1.5	3×10^{-2}
cPAHs[3/, 4/]	Table 3-33	2.1E-03	7.3	2×10^{-2}
Total PCBs	Table 3-33	4.7E-03	2	9×10^{-3}
Pentachlorophenol	Table 3-33	7.8E-05	0.12	1×10^{-5}
			Subtotal	**5×10^{-2}**
Tentatively identified chemicals (JN-qualified)				
Total chlordane	Table 3-33	2.3E-04	0.35	8×10^{-5}
Total DDTs	Table 3-33	3.3E-03	0.34	1×10^{-3}
			Subtotal	**1×10^{-3}**
Total excess cancer risk				**5×10^{-2}**

1/ An EPC for each seafood category was calculated in the exposure section (see Tables 3-29 through 3-31).
2/ Arsenic EPCs and risk estimates are based on inorganic arsenic
3/ Because the excess cancer risk is greater than or equal to 0.01 (1×10^{-2}), risk was calculated using the exponential equation.
4/ cPAH concentrations are presented as benzo(a)pyrene equivalents.
CDI – chronic daily intake
ww – wet weight
EPC – exposure point concentration
cPAH – carcinogenic polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl

5.2.4.2 Non-cancer Hazard Estimates

Unacceptable non-cancer hazards (HIs > 1) were predicted for all seafood consumption scenarios.[2] Effect-specific HIs were calculated for cardiovascular, developmental, hematologic, immunological, kidney, liver, neurological and dermal effects, as described in Section 5.1.2. The chemicals associated with each endpoint for seafood consumption are identified in the footnotes of Tables 5-12 to 5-14.

The cardiovascular, hematologic, developmental, immunological, kidney, liver, neurological, and dermal HIs exceeded 1 for all scenarios. These HIs were higher for the adult tribal scenario based on Suquamish data than the adult or child tribal RME scenarios based on Tulalip data. The highest HIs (over 300 for both the tribal child and the adult tribal-Suquamish scenarios) were for the immunological endpoint, due to combined HQs for PCBs and TBT.

---

[2] Consideration of alternative methods for computing metals bioaccumulation in the uncertainty assessment (Section 6) resulted in significant hazard quotient increases for chromium and mercury. The child tribal RME chromium and mercury HQs increased from 0.2 to 2 and 0.9 to 2, respectively.

Table 5-12. Non-cancer Hazard Estimates for the Adult Tribal RME Seafood Consumption Scenario Based on Tulalip Data

Scenario timeframe: Current/future
Medium: Sediment
Exposure medium: Fish and shellfish tissue
Receptor population: Tulalip tribal fish and shellfish consumers
Receptor age: Adult

Chemical	EPC (mg/kg ww)[1/]	Non-Cancer CDI (mg/kg-day)	Reference Dose (mg/kg-day)	Hazard Quotient
Arsenic[2/]	Table 3-33	1.7E-03	3.0E-04	5.8
Cadmium	Table 3-33	8.9E-04	1.0E-03	0.89
Chromium[2/]	Table 3-33	2.8E-04	3.0E-03	0.09
Copper	Table 3-33	4.8E-02	4.0E-02	1.2
Mercury	Table 3-33	4.0E-05	1.0E-04	0.40
Zinc	Table 3-33	3.7E-01	3.0E-01	1.2
Fluoranthene	Table 3-33	2.3E-03	4.0E-02	0.06
Pyrene	Table 3-33	1.5E-03	3.0E-02	0.05
TBT (as ion)	Table 3-33	1.3E-02	3.0E-04	89
Pentachlorophenol	Table 3-33	2.5E-05	3.0E-02	0.001
Total PCBs	Table 3-33	1.4E-03	2.0E-05	72
			Subtotal	**171**
Tentatively identified chemicals (JN-qualified)				
Total chlordane	Table 3-33	5.1E-05	5.0E-04	0.1
Total DDTs	Table 3-33	7.4E-04	5.0E-04	1.5
			Subtotal	**1.6**
	Total hazard index across all exposure routes/pathways[3/]			**173**
Hazard indices by effect:				
Hazard Index for Cardiovascular Endpoint[4/]				**5.8**
Hazard Index for Developmental Endpoint[5/]				**72**
Hazard Index for Hematologic Endpoint[6/]				**1.2**
Hazard Index for Immunological Endpoint[7/]				**161**
Hazard index for Kidney Endpoint[8/]				**2.1**
Hazard index for Liver Endpoint[9/]				**2.8**
Hazard index for Neurological Endpoint[10/]				**72**
Hazard index for Dermal Endpoint[11/]				**5.8**

1/ An EPC for each seafood category was calculated in the exposure section (see Tables 3-29 through 3-31).
2/ Arsenic EPCs and risk estimates are based on inorganic arsenic. Additional hazard quotients are presented in Section 6.2.5 based on alternative BSAFs for modeling metals exposures. The alternative chromium HQ exceeds 1.0.
3/ This total is not directly interpretable for risk assessment. The value indicates that the HI may exceed 1 for individual endpoints. Therefore, HIs were calculated for individual endpoints.
4/ Cardiovascular endpoint is for arsenic.
5/ Developmental endpoint is for PCBs and mercury.
6/ Hematologic endpoint is for zinc and fluoranthene.
7/ Immunological endpoint is for PCBs and TBT.
8/ Kidney endpoint is for cadmium, copper, pyrene, and pentachlorophenol.
9/ Liver endpoint is for chlordane, copper, total DDTs, fluoranthene, and pentachlorophenol.
10/ Neurological endpoint is for mercury and total PCBs.
11/ Dermal endpoint is for arsenic.
CDI – chronic daily intake
ww – wet weight
EPC – exposure point concentration
PCB – polychlorinated biphenyl
TBT – tributyltin

Table 5-13. Non-cancer Hazard Estimates for the Child Tribal RME Seafood Consumption Scenario Based on Tulalip Data

Scenario timeframe: Current/future
Medium: Sediment
Exposure medium: Fish and shellfish tissue
Receptor population: Tulalip tribal fish and shellfish consumers
Receptor age: Child

Chemical	EPC (mg/kg ww)[1/]	Non-Cancer CDI (mg/kg-day)	Reference Dose (kg/mg-day)	Hazard Quotient
Arsenic[2/]	Table 3-33	3.7E-03	3.0E-04	12
Cadmium	Table 3-33	1.9E-03	1.0E-03	1.9
Chromium[2/]	Table 3-33	6.0E-04	3.0E-03	0.20
Copper	Table 3-33	1.0E-01	4.0E-02	2.6
Mercury[2/]	Table 3-33	8.5E-05	1.0E-04	0.85
Zinc	Table 3-33	7.9E-01	3.0E-01	2.6
Fluoranthene	Table 3-33	4.9E-03	4.0E-02	0.12
Pyrene	Table 3-33	3.2E-03	3.0E-02	0.11
TBT (as ion)	Table 3-33	2.9E-02	3.0E-04	193
Pentachlorophenol	Table 3-33	5.4E-05	3.0E-02	0.002
Total PCBs	Table 3-33	3.1E-03	2.0E-05	154
			Subtotal	**368**
Tentatively identified chemicals (JN-qualified)				
Total chlordane	Table 3-33	1.0E-04	5.0E-04	0.22
Total DDTs	Table 3-33	1.4E-03	5.0E-04	3.2
			Subtotal	**3**
Total hazard index across all exposure routes/pathways[3/]				**372**
Hazard indices by effect:				
Hazard Index for Cardiovascular Endpoint[4/]				**12**
Hazard Index for Developmental Endpoint[5/]				**155**
Hazard Index for Hematologic Endpoint[6/]				**3**
Hazard Index for Immunological Endpoint[7/]				**347**
Hazard index for Kidney Endpoint[8/]				**5**
Hazard index for Liver Endpoint[9/]				**6**
Hazard index for Neurological Endpoint[10/]				**155**
Hazard index for Dermal Endpoint[11/]				**12**

[1/] An EPC for each seafood category was calculated in the exposure section (see Tables 3-29 through 3-31).
[2/] Arsenic EPCs and risk estimates are based on inorganic arsenic. Additional hazard quotients are presented in Section 6.2.5 based on alternative BSAFs for modeling metals exposures. The alternative chromium and mercury HQs exceed 1.0.
[3/] This total is not directly interpretable for risk assessment. The value indicates that the HI may exceed 1 for individual endpoints. Therefore, HIs were calculated for individual endpoints.
[4/] Cardiovascular endpoint is for arsenic.
[5/] Developmental endpoint is for PCBs and mercury.
[6/] Hematologic endpoint is for zinc and fluoranthene.
[7/] Immunological endpoint is for PCBs and TBT.
[8/] Kidney endpoint is for cadmium, copper, pyrene, and pentachlorophenol.
[9/] Liver endpoint is for chlordane, copper, total DDTs, fluoranthene, and pentachlorophenol.
[10/] Neurological endpoint is for mercury and total PCBs.
[11/] Dermal endpoint is for arsenic
CDI – chronic daily intake
ww – wet weight
EPC – exposure point concentration
PCB – polychlorinated biphenyl
TBT – tributyltin

Table 5-14. Non-cancer Hazard Estimates for the Adult Tribal Seafood Consumption Scenario Based on Suquamish Data

Scenario timeframe: Current/future
Medium: Sediment
Exposure medium: Fish and shellfish tissue
Receptor population: Suquamish tribal fish and shellfish consumers
Receptor age: Adult

Chemical	EPC (mg/kg ww)[1/]	Non-Cancer CDI (mg/kg-day)	Reference Dose (mg/kg-day)	Hazard Quotient
Arsenic[2/]	Table 3-33	2.1E-02	3.0E-04	68
Cadmium	Table 3-33	1.0E-02	1.0E-03	10
Chromium	Table 3-33	1.8E-03	3.0E-03	0.6
Copper	Table 3-33	4.1E-01	4.0E-02	10
Mercury	Table 3-33	3.0E-04	1.0E-04	3.0
Zinc	Table 3-33	3.7E+00	3.0E-01	12
Fluoranthene	Table 3-33	4.3E-03	4.0E-02	0.11
Pyrene	Table 3-33	4.3E-03	3.0E-02	0.14
TBT (as ion)	Table 3-33	2.0E-02	3.0E-04	134
Pentachlorophenol	Table 3-33	8.0E-05	3.0E-02	0.003
Total PCBs	Table 3-33	4.7E-03	2.0E-05	233
			Subtotal	**471**
Tentatively identified chemicals (JN-qualified)				
Total chlordane	Table 3-33	2.3E-04	5.0E-04	0.46
Total DDTs	Table 3-33	3.3E-03	5.0E-04	6.6
			Subtotal	**7**
Total hazard index across all exposure routes/pathways[3/]				**478**
Hazard indices by effect:				
Hazard Index for Cardiovascular Endpoint[4/]				**68**
Hazard Index for Developmental Endpoint[5/]				**236**
Hazard Index for Hematologic Endpoint[6/]				**12**
Hazard Index for Immunological Endpoint[7/]				**367**
Hazard index for Kidney Endpoint[8/]				**20**
Hazard index for Liver Endpoint[9/]				**17**
Hazard index for Neurological Endpoint[10/]				**236**
Hazard index for Dermal Endpoint[11/]				**68**

1/ An EPC for each seafood category was calculated in the exposure section (see Tables 3-29 through 3-31).
2/ Arsenic EPCs and risk estimates are based on inorganic arsenic.
3/ This total is not directly interpretable for risk assessment. The value indicates that the HI may exceed 1 for individual endpoints. Therefore, HIs were calculated for individual endpoints.
4/ Cardiovascular endpoint is for arsenic.
5/ Developmental endpoint is for PCBs and mercury.
6/ Hematologic endpoint is for zinc and fluoranthene.
7/ Immunological endpoint is for PCBs and TBT.
8/ Kidney endpoint is for cadmium, copper, pyrene, and pentachlorophenol.
9/ Liver endpoint is for chlordane, copper, total DDTs, fluoranthene, and pentachlorophenol.
10/ Neurological endpoint is for mercury and total PCBs.
11/ Dermal endpoint is for arsenic
CDI – chronic daily intake
ww – wet weight
EPC – exposure point concentration
PCB – polychlorinated biphenyl
TBT – tributyltin

For all scenarios, the highest HIs were for the developmental, immunological, and neurological endpoints. The majority of the HIs for the developmental and neurological endpoints (> 95 percent) was attributable to PCBs, and the immunological endpoint HIs were attributable to PCBs and TBT.

5.2.4.3 Risk Estimates by Seafood Category for Chemicals Contributing the Greatest Amount to Seafood Consumption Risk Estimates

The previous sections summarized excess cancer risks and non-cancer hazards for seafood consumption. This section discusses the specific chemicals and the seafood categories contributing most to these estimates. Chemicals are selected for this discussion based on the exceedance of risk thresholds and by their contribution to the total risk estimate. Arsenic, cPAHs, and total PCBs were determined to be the dominant contributors to cancer risk estimates for seafood consumption (Tables 5-9 through 5-11), with excess cancer risks for each of these chemicals greater than 1×10^{-6} in each scenario. In addition, dioxins and furans are assumed to risk drivers for the seafood consumption scenarios, based on their likely presence in sediment and tissue at the Site and assumed associated cancer risks above regulatory thresholds. Non-cancer risk estimates for seafood consumption are driven by TBT, PCBs, and to a lesser extent arsenic (Tables 5-12 through 5-14).

The majority of cancer risk estimated for inorganic arsenic in the adult tribal RME seafood ingestion scenarios was attributable to clam consumption (96 percent of total excess cancer risk). The modeled concentrations of arsenic into clams was higher than for other tissues due to a high BSAF for clams (over 10 times higher than the next highest seafood category), and clams were assumed to be heavily consumed compared to other seafood categories. For cPAHs, excess cancer risks associated with clam consumption was 33 percent of total seafood consumption risks. For PCBs, the consumption of fish and crab was a more predominant contribution to the seafood risk estimates, at 99 percent of total excess cancer risk, than consumption of clams. The modeled uptake of PCBs into fish and crab tissue from Site sediment was much higher for fish and crab than for clams, based on the regression relationships using LDW data.

For the adult tribal scenario based on Suquamish data, clam consumption accounted for the vast majority of estimated risks, largely because clams constituted the majority of the seafood diet (438.6 g of 583.5 g total daily non-anadromous seafood consumption).

5.2.5 Cumulative Risks across Clamming Scenarios (Collection and Consumption)

Risks associated with both the collection of clams and eating of clams are evaluated in this HHRA. The combined risks from engaging in both of these activities at the Lockheed West Site are presented in Table 5-15. Total risks are calculated as the sum of risks associated with tribal RME clam consumption (seafood exposure) and with tribal 120 days-per-year clamming (sediment exposure). Almost all (i.e., over 95 percent) of the total cancer risk and non-cancer hazard for each chemical is attributed to the consumption of clams. Similar comparison using the Suquamish exposures of higher clam consumption rate (438.6 g/day vs 37.7 g/day for the RME scenario) and 183 days per year clam collection would result in higher cumulative risk estimates than shown for the RME scenarios in Table 5-15. If needed in the future, risk estimates could be calculated using the high-end Suquamish exposures. The risk results for Suquamish exposures would show a greater percentage of total risks due to clam consumption compared with clam collection because of the much higher clam ingestion rate in the Suquamish seafood scenario.

Table 5-15. Cumulative Risk Estimates for Example Chemicals for the Tribal RME Clam Collection Scenario and the Tribal Adult Consumption of Clams Based on Tulalip Data

	Excess Cancer Risk			Non-Cancer Hazard Quotient		
Chemical	**Consumption[1/]**	**Collection[2/]**	**Total**	**Consumption[1/]**	**Collection[2/]**	**Total**
Arsenic	3E-03	1.1E-04	3E-03	5.6	0.26	6
cPAHs[3/]	9E-04	4.7E-07	9E-04	na	na	na
Total PCBs	2E-05	na	2E-05	0.5	na	0.5

1/ Risk from the consumption of clams in the adult tribal RME seafood exposure scenario based on Tulalip data.
2/ Risk from dermal absorption and incidental sediment ingestion during the collection of clams in the tribal clamming scenario (120 days per year).
3/ cPAH concentrations are presented as benzo(a)pyrene equivalents.
cPAHs - carcinogenic polycyclic aromatic hydrocarbons
PCBs – polychlorinated biphenyls (not a COPC for clam collection in intertidal sediments)
na – not available, chemical either not evaluated for that exposure pathway or mode of toxicity

5.3 LEAD

As described in Section 3.3.6, risks from exposure to lead are not quantified following the exposure model used for other COPCs. Because the toxicokinetics (absorption, distribution, metabolism, and excretion) of lead are well understood, health risks from lead exposure are evaluated based on blood lead concentration, which can be modeled. The results of blood lead modeling for children, using the IEUBK model, and the developing fetus through exposure of pregnant women, using the ALM, are presented in the subsections below. The assessment of lead risks follows EPA guidance on modeling, and the exposure parameters and presentation of models follows from the LDW HHRA (Windward 2007a).

5.3.1 Children

The IEUBK lead model was run using default parameters, except for the inclusion of site-specific sediment and tissue concentration data, as described earlier in Tables 3-34 and 3-35. Model output is provided in the form of a probability density curve that describes the probability of blood lead concentrations occurring in a hypothetical population of children. The Centers for Disease Control and Prevention (CDC) has established 10 µg/dL as a level of concern threshold for childhood blood level above which appropriate medical follow-up is warranted. The probability density curve designates the percent of children that are predicted to have blood lead levels that may exceed the threshold.

A probability density curve was generated using the time-weighted average EPC from the beach play scenario (Figure 5-1). See Section 3.3.3 for further explanation of the time-weighted average approach to calculating EPC values. The IEUBK model was run using the time-weighted EPC from the beach play scenario along with a weighted EPC for seafood consumption (see Section 3.3.3). Risk estimates were not generated for the netfishing or clamming scenarios because young children presumably would not likely engage in those activities at the Lockheed West Site. This assumption is consistent with the lead exposure scenario evaluated for the LDW site. The time-weighted average intertidal sediment EPC at the Lockheed West Site was 230 mg/kg dry weight.

The modeled mean lead concentrations in various seafood tissues were based on BSAF modeling, and resulted in health-protective estimates of tissue lead concentrations, as shown earlier in Table 3-33. Actual lead concentrations in seafood tissues were not available for the Site. Based on the modeling of lead into tissue, and using the input values of the time-weighted sediment EPC, the IEUBK model predicts that almost 99 percent of the modeled child population that may consume seafood with site-related lead concentrations would have blood lead levels that exceed the CDC level of concern (shown in the graph in Figure 5-1 as the area under the curve to the right of the vertical line, which represents 10 µg/dL). EPA's risk reduction goal for contaminated sites is to limit the probability of a child's blood lead concentration exceeding the 10 µg/dL threshold to 5 percent or less. Based on the results of the IEUBK model using the intertidal sediment lead concentration and modeled concentrations into tissue, lead is considered to be a COC for children in this HHRA.

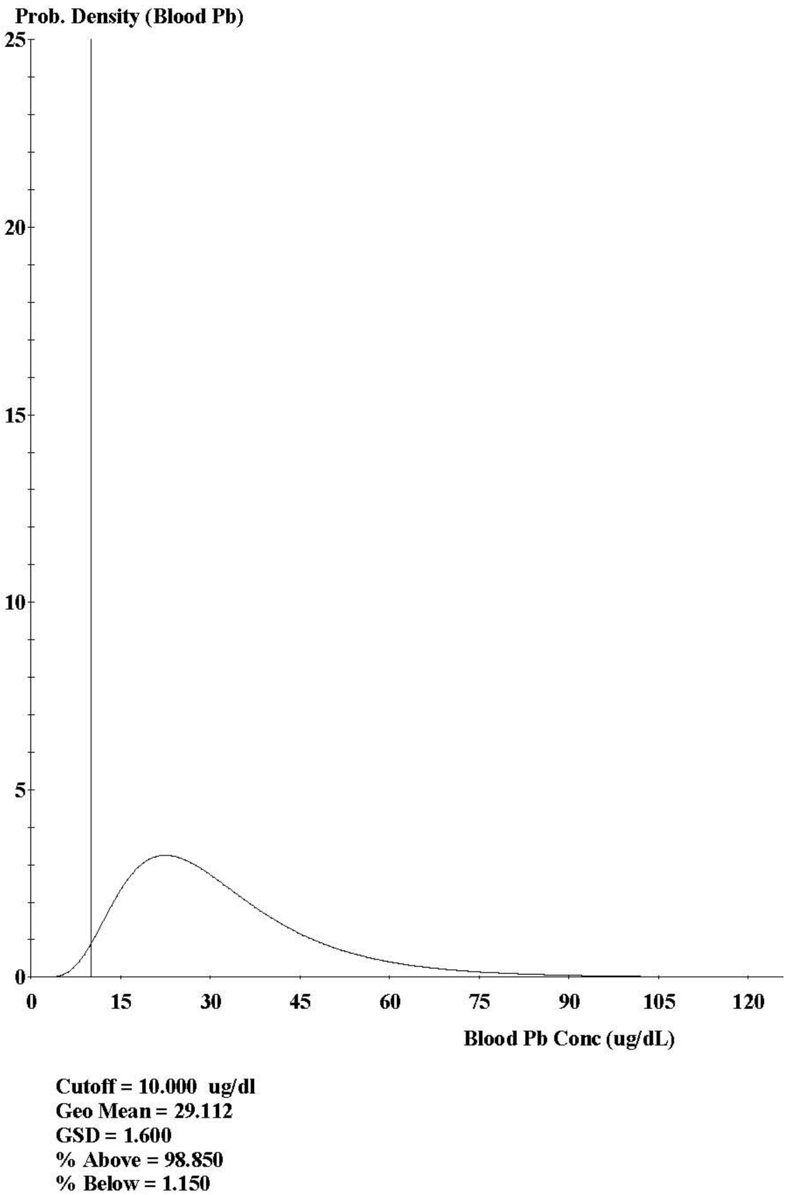


Figure 5-1. Probability Density Curve for Predicted Blood Lead Concentration Using Input Data from Child Beach Play and Modeled Seafood Consumption Values

5.3.2 Developing Fetus

The ALM estimates risks from lead exposure to the most sensitive human population, which is a developing fetus. Lead risks were assessed by estimating the probability of exceeding the threshold blood lead level of 10 µg/dL in the fetus through evaluation of exposure of a pregnant mother. As described in Section 3.3, the model was run in two modes, with and without seafood consumption, so that the incremental effects of seafood consumption could be evaluated. The runs of the ALM are shown in Table 5-16 for the tribal clamming RME and netfishing scenarios, which are the two RME scenarios with adult exposures to lead in sediment at the Site. The model runs estimate the fetal blood lead levels resulting from sediment ingestion alone, and coupled with seafood ingestion, based on the adult tribal RME scenario. A summary of the model runs and comparisons of the resultant fetal blood levels with EPA guidelines is presented in Table 5-17.

The 95th percentiles of predicted blood lead concentrations for the developing fetus range from 6.4 to 8.0 µg/dL for the two sediment exposure scenarios without consumption of seafood from the Site (Table 5-17). The probability of exceeding the 10 µg/dL blood lead threshold ranges from 1 to 3 percent for the sediment exposure scenarios. With the inclusion of seafood consumption, the 95th percentiles of blood lead concentrations and probabilities of exceeding the 10 µg/dL threshold are substantially higher, primarily due to the high modeled concentrations of lead in clam tissues. The probability for exceeding the 10 µg/dL blood lead threshold in the developing fetus through the consumption of seafood by pregnant women is estimated at 95 percent.

The results of the modeling of exposure of the developing fetus to lead are consistent with the results from the IEUBK model for children. The results of both the child and fetus modeling indicate that lead is considered to be a COC for the HHRA. The results of modeling lead exposures for both the child and fetus are driven by the exposure assumptions of the seafood consumption scenarios. For both the child lead receptor and developing fetus receptor, the incorporation of the seafood consumption pathway results in the estimation of significant risks from lead exposure. Incorporation of the median Suquamish tribal survey seafood ingestion rates into the ALM modeling would result in substantially greater estimated blood lead levels in the developing fetus, due to the much higher seafood ingestion rates than the RME scenario used herein. If needed in the future, the ALM model could be run for the high-end Suquamish exposures if the median seafood ingestion rates are developed from the Suquamish seafood ingestion survey. As described earlier, the direct contact pathways (i.e., beach play, tribal clamming, and tribal netfishing) and the RME seafood consumption pathways are taken directly from the LDW HHRA.

Table 5-16. Application of the Adult Lead Model to Lockheed West

$PbB_{adult, central}=(PbB_{adult.0}+BKSF*FI*((Pb_S*IR_s*AF_s*EFs)+(PB_F*IR_f*AF_f*EF_f)))/AT$			Tribal Scenario	
Parameter	**Units**	**Abbreviation**	**Netfishing**	**Clamming**
Sediment concentration (EPC)	mg/kg	Pb_s	146	367
Baseline blood lead[1/]	µg/dL	PbB_0	1.7	1.7
Biokinetic slope factor	µg/dL per µg/day	BKSF	0.4	0.4
Sediment ingestion rate	g/day	IR_s	0.05	0.1
Fraction sediment ingested from site	unitless	FI	1	1

Table 5-16. Application of the Adult Lead Model to Lockheed West (continued)

$PbB_{adult,\ central}$=($PbB_{adult.0}$+BKSF*FI*((Pb_S*IR_s*AF_s*EFs)+(PB_F*IR_f*AF_f*EF_f)))/AT			Tribal Scenario	
Parameter	**Units**	**Abbreviation**	**Netfishing**	**Clamming**
Sediment absorption factor	percent	AF_s	12%	12%
Exposure frequency	days/yr	EF_s	119	120
Averaging time	days/yr	AT	365	365
Geometric standard deviation	unitless	GSD	2.29	2.29
Fetal to maternal blood lead ratio	unitless	R_{FtoM}	0.9	0.9
Target blood lead level	µg/dL	PbB_{target}	10	10
Estimates for Direct Contact with Intertidal Sediment				
Predicted blood lead levels, CTE	**µg/dL**		**1.8**	**2.3**
Predicted blood lead levels, 95th percentile	**µg/dL**		**6.4**	**8**
Probability of exceeding 10 µg/dL (lognormal)	**%**		**1%**	**3%**
Seafood weighted lead concentration (Tulalip-basis)	µg/g	Pb_f	57.5	57.5
Seafood consumption rate	g/day	IR_f	15	15
Fraction fish ingested from site	unitless	FI	1	1
Fish lead absorption factor	unitless	AF_f	12%	12%
Fish Exposure frequency	days/year	EF_f	365	365
Estimates including Subsistence Level Fish Consumption				
Predicted blood lead levels, CTE	**µg/dL**		**43.2**	**43.6**
Predicted blood lead levels, 95th percentile	**µg/dL**		**152**	**154**
Probability of exceeding 10 µg/dL (lognormal)	**%**		**95%**	**95%**

1/ PbB_0 and GSD based on all U.S., Mexican-American, as per LDW HHRA.
$PbB_{central}$ = PbB_0 + (Pb × BKSF × IR_s × FI × AF × (EF/AT)). Central tendency estimate (CTE) of blood lead concentration calculated for exposures to lead in sediments and fish.
$PbB_{95th\ percentile}$ = $PbB_{central}$ × R_{FtoM} × $GSD^{1.645}$. Estimate of 95th percentile blood lead concentration
Percent chance of exceeding EPA's target blood lead level of 10 µg/dL (EPA 2003b).
Percent Above Target = 1 – normsdist (Z score); expressed as %, where:
Z score = (LN (PbB_{target} /($PbB_{central}$ × R_{FtoM})) / LN (GSD))
"normsdist" is the Microsoft Excel function providing the fraction of the distribution below the calculated z-score.

Table 5-17. Summary of Predicted Fetal and Adult Lead Levels Using the Adult Lead Model

		Scenario	
Results	**Units**	**Netfishing**	**Tribal Clamming RME**
Estimates for Soil and Sediment Incidental Ingestion Only			
Predicted adult blood lead levels[a]	µg/dL	1.8	2.3
Predicted fetal blood lead levels, 95th percentile[b]	µg/dL	6.4	8.0
Probability of fetal blood lead level exceeding 10 µg/dL (lognormal)[c]	%	1	3
Estimates Including Adult Tulalip Seafood Consumption			
Predicted adult blood lead levels, CTE[d]	µg/dL	43.2	43.6
Predicted fetal blood lead levels, 95th percentile[b]	µg/dL	152	154
Probability of fetal blood lead level exceeding 10 µg/dL (lognormal)[c]	%	95	95

1/ Geometric mean of adult blood lead concentration for sediment intake only, sediment ingestion rate of 0.05 g/day for netfishing and 0.1 g/day for clamming.
2/ Estimate of 95th percentile fetal blood lead concentration.
3/ Probability of exceeding EPA's threshold for fetal exposure, a blood lead level of 10 µg/dL (EPA 2003b).
4/ Central tendency estimate of adult blood lead concentration for sediment ingestion and seafood consumption.
CTE – central tendency estimate
RME – reasonable maximum exposure

6. UNCERTAINTY ASSESSMENT

The uncertainty assessment describes uncertainties in the exposure and toxicity assessments, and the risk characterization for the Site. Uncertainties are described qualitatively, with an estimate of the impact of the uncertainty on the risk estimates. Risks to human health typically may be over- or underestimated based on the appropriateness of the assumptions regarding exposure, the availability and assumptions associated with the derivation of toxicity factors, and the use of modeling to represent EPCs. For the Lockheed West Site, two of the major sources of uncertainty in the risk assessment are 1) the use of exposure assumptions from the upstream LDW site without modification to conditions specific to the Lockheed West Site, and 2) the use of modeling to determine tissue concentrations of COPCs for evaluating exposures via seafood consumption. These two sources of uncertainty are discussed further below, in addition to uncertainties in other aspects of the risk assessment. Many of the other uncertainties in exposures and toxicity are similar to those described in the LDW HHRA, particularly since most of the exposure parameter and toxicity information was taken from the LDW HHRA. Hence, the description of uncertainties for these other sources parallels the descriptions in the LDW HHRA. As an indication of the impact of typical uncertainties in toxicity criteria and exposure characterization on the risk assessment, EPA (1989) notes that risk estimates are only accurate to within an order of magnitude, as they were expressed in Section 5.

6.1 USE OF EXPOSURE SCENARIOS FROM THE LDW SITE

The scope of this HHRA fully relied on the exposure scenarios and inherent exposure parameters that were developed for the LDW HHRA. The Lockheed West Site lies just downstream of the LDW site, at the mouth of the Duwamish River where the West Waterway segment of the Duwamish flows into Elliott Bay. Because of the proximity of the Lockheed West Site to the LDW, it was anticipated that potentially exposed human populations may be similar between the two sites, and that the use of exposure scenarios and parameters from the LDW site would support the development of risk management decisions for the Lockheed West Site that are consistent with those of the LDW site.

As discussed in Section 1.2 of the Introduction, although the parameter values for estimating human exposures to site-related chemicals are taken from the LDW site, any differences in sizes of the site are not considered. Specifically, the parameters of area use factor (AUF) and fraction of contaminated seafood consumed from the site are set at 1.0. EPA guidance on quantifying exposures in risk assessments includes a term to make adjustments to the exposures of ecological organisms based on the differences between their foraging area and the size of the site (EPA 1997c, 1998b, 2000a, 2001, 2003c, 2005c). The AUF is defined as the ratio of an organism's home range, breeding range, or feeding/foraging range to the area of contamination, and accounts for the fraction of the exposures that are expected to occur at the site (EPA 1997c, 2001, 2005c). This term is also commonly referred to as the site use factor (SUF). EPA guidance documents specifically addressing accumulation of chemicals from sediment refer to this term as the exposure fraction (EF), defined as a measure of the proportion of study area relative to the entire home range of aquatic or terrestrial organisms for modeling tissue concentrations of sediment chemicals (EPA 2000a). EPA also refers to this term as FR_k, which is the fraction of intake of the k_{th} food type that is from the contaminated area (EPA 1998b, 2003c). The AUF or EF is used to indicate the portion of an animal’s home range or foraging range that would be represented by the site. If the home range or foraging range is larger than the site, the AUF or EF equals the site area divided by the home or foraging range area. If the site area is greater than or equal to the home range or foraging range, the AUF or EF is equal to 1.

For the Lockheed West Site, English sole and crabs are food sources in the seafood consumption scenarios that have foraging ranges much larger than the area of the Lockheed West Site. Studies summarized in the LDW HHRA document their foraging ranges to include Elliott Bay and upstream into the West Waterway and the LDW (see Figure 1-2 for locations). With foraging ranges larger than the Lockheed West Site, their body burden of chemicals would be influenced by the contaminant loads in food sources and sediment and surface waters of those areas outside the Site. Thus, the assumption that their entire body burden of chemicals comes from the Lockheed West Site (i.e., the AUF or EF is set to 1) is highly uncertain and overestimates the chemical load from the Site.

Although the amount of foraging at the Lockheed West Site by organisms with large home ranges is expected to be less than in the LDW site because of the large differences in site sizes, the difference in foraging rates of these receptors at each of the two sites is unknown. Foraging rates and success at the Lockheed West Site for marine species could be higher because of the relatively more saline environment compared to the LDW site (i.e., the Lockheed West Site’s role to the local ecosystem could provide more foraging success per acre than the LDW site for marine species). However, due to the large differences in site sizes, it remains probable that the contribution of Lockheed West Site chemicals to total body load of organisms with large home ranges is less than the contribution from the LDW site or other nearby areas.

The other exposure parameter term that is related to site size and has been set to 1.0 is the fraction of contaminated seafood that is consumed from the Site. The term is called the fractional intake (FI) term in EPA (1989) guidance, and is used to quantify exposures through consumption of contaminated fish and shellfish. Setting the FI to 1.0 assumes that 100 percent of the contaminated seafood consumed in the seafood ingestion scenarios over the duration of exposure comes from the Site. The total amount of contaminated seafood consumed for the tribal adult RME seafood ingestion scenario is 97.5 g/day for 70 years. Whether this amount of seafood could come from the Lockheed West Site is uncertain; estimates of the amount of seafood that could be consumed from the Site are unknown. In the Framework document, EPA Region 10 sets the fraction ingested from the source (FI) at the fraction of seafood harvested from Puget Sound. This is a health protective assumption assuming that an individual's Puget Sound intake might be obtained locally. EPA's internal policy choice is described in the following paragraph from the Framework:

> "Although the degree to which site-related risks could be overestimated by the use of any of the fish and shellfish consumption rates presented in this Framework cannot be known precisely, these methods are preferable to alternatives that would be likely to underestimate site-related risks, such as basing a consumption rate (or site-related estimates of risk) on the size of the cleanup site, or reducing the site's estimated contribution to fish and shellfish contamination because nearby sites or sources are associated with similar contaminants. This Framework includes the assumption that the selected Tribal fish and shellfish consumption rates and their associated risk estimates will not be reduced based on consideration of the size of the cleanup site or the presence of additional sources of contamination."

The assumption that all contaminated seafood other than anadromous fish is consumed from the Lockheed West Site is considered to be health protective and is designed to result in consistent risk estimates for seafood consumption and subsequently consistent cleanup levels with the LDW site.

In quantifying exposures from shellfish consumption in the tribal adult seafood consumption scenario, the Lockheed West HHRA uses consumption rates for specific categories of shellfish that were presented in the LDW HHRA and that were developed by EPA (see Table 3-19). Since publication of the LDW HHRA and submission to EPA of the draft HHRA for the Lockheed West Site, EPA has been made aware that the percentages of crab and clam consumption derived from the Tulalip data set were reversed in the LDW HHRA. The percentage consumption of clams should be 53 percent, while the consumption of crabs should be 46 percent. With these new percentages, the consumption of clams would be 15 percent higher, and consumption of crabs would be proportionally lower than was assumed in the tribal adult RME seafood consumption scenario. However, the concentrations of PAHs, PCBs, and TBT were modeled at higher levels in crab than in clam tissue, meaning that use of corrected percentage would result in risk estimates for those chemicals decreasing proportionately for the tribal adult RME seafood consumption scenario. On the other hand, metals including arsenic were modeled at higher concentrations in clams than crabs, and risks would increase for those chemicals in the tribal RME seafood consumption scenario. The net result of these differences is that inclusion of the corrected percentages of clam and crab ingestion does not change the total cancer risk estimate for the tribal adult RME seafood consumption scenario, with total cancer risk estimates at 9 × 10-3 (Table 5-9).

The method used to identify sediment COPCs for the seafood consumption scenarios is based on the tribal RME scenario developed for the LDW site. As described in Section 3.2.3, sediment COPCs for seafood consumption are identified through a screening process using risk-based analytical concentration goals (RBACGs) that were originally developed for the LDW site based on the tribal RME scenario. The RBACGs are derived from seafood tissue RBCs, which in turn are derived using the Tulalip survey seafood ingestion rates as the tribal RME seafood consumption scenario. The Suquamish survey seafood ingestion rates are higher than the Tulalip survey ingestion rates. Derivation of tissue RBCs and in turn sediment RBACGs based on the Suquamish survey ingestion rates would result in lower sediment RBACGs than those derived using the Tulalip survey rates. The application of lower RBACGs to the screening process to select COPCs, whereby maximum concentrations of sediment chemicals would be compared against lower Suquamish-based RBACGs, could result in additional chemicals screening above the lower RBACGs. As COPCs, by definition, these additional chemicals would be identified as possibly contributing to risk estimates for the Suquamish seafood consumption scenario. However, they would not necessarily contribute to risk estimates for the tribal RME scenario based on the Tulalip survey, because of the lower seafood ingestion rates used to estimate exposures in that scenario.

The extent of contribution of any additional chemicals to the total health risk in the Suquamish seafood consumption scenario would be so low as to not affect the total cancer risk estimate for that scenario. For example, the total cancer risk estimate for the Suquamish seafood consumption scenario is 5 x 10-2, which is driven mostly by arsenic and cPAHs in sediment, each contributing about one-half of the estimated cancer risk. Total PCBs contribute about one-fifth to this risk estimate and pentachlorophenol contributes about 0.02 percent. Any additional COPCs identified by using lower RBACGs would contribute less than 0.02 percent to the total cancer risk. Because these additional COPCs contribute a relatively small amount to the total cancer risk estimates compared to the present risk drivers, they would not add to the list of risk driver chemicals for the Suquamish seafood consumption scenario. In addition, the use of lower RBACGs would not add risk drivers to the tribal RME seafood consumption scenario (because that scenario is based on a lower seafood ingestion rate), and they would not change the identification of chemicals of concern (COCs) for the tribal RME seafood consumption scenario, nor would they change risk-based cleanup levels that may be calculated for RME COCs.

6.2 MODELING OF TISSUE EXPOSURE POINT CONCENTRATIONS

One of the major uncertainties in the risk estimate for seafood consumption in this HHRA comes from the use of modeling to estimate exposure concentrations in seafood tissue rather than use of field-collected tissue data. The tissue modeling was based on BSAFs and regression equations, and site-specific sediment data, and was performed for those COPCs selected based on their potential to bioaccumulate from site sediments. In keeping with the approach to this HHRA, the BSAFs were selected to be reasonably health protective, and were mostly 90th percentile values, with 75th percentile values used for fish, depending on the source of the BSAFs. BSAFs were taken from established sources, and the regression equations were taken from LDW reports; BSAFs followed the recommendations of the publishing agency. The approach to the fish tissue modeling was intended to not underestimate potential exposures of fish to sediment chemicals at the Site, and was intended to streamline the HHRA process rather than attempt to achieve site specificity with regards to fish tissue concentrations. Uncertainties related to sources of the BSAFs, assumptions about modeling inorganic arsenic in clam tissue, use of regression equations from the LDW site, and use of metals data from the LDW site to develop BSAFs for metals are discussed in the following sections.

6.2.1 BSAF Sources

The BSAFs that were used in the modeling were taken from sources that had compiled the values from Puget Sound or from nationwide sources. BSAFs specific to each seafood category organism were preferred over the use of surrogate values from other aquatic organisms. Where BSAFs were unavailable for a given organism, a 90th percentile value for clams was preferred. The WDOH (1995) source of BSAFs recommended for use in Puget Sound were compiled from numerous sources on empirical studies with fish, and were recommended at the 75th percentile values of the ranges of BSAFs. For some chemicals, particularly PAHs, few values were available or the distribution of values was highly skewed. Both of these conditions resulted in highly variable BSAF estimates. Although the USACE BSAF database screened studies to eliminate values of high uncertainty, the details of the derivation of values in other sources were not reviewed. Species of fish were not identified in the WDOH or EPA (1997b) studies, other than use of a high trophic organism. The applicability of these studies to conditions at the Site is uncertain because the species are unknown. The use of 90th and 75th percentile values is a health-protective approach to BSAF modeling and likely biases the tissue concentrations high. The health protectiveness of the BSAFs, and the lack of incorporating foraging areas or area use factors into the modeling, ensures that the site-related fish tissue concentrations and resultant risks would not be underestimated given the conditions of the Site, and are likely highly over-estimated.

The hazard estimates for consuming fish with TBT modeled from Site sediments were very high for all exposure scenarios. A BSAF to model TBT concentrations in fish was not available, so an apparent BSAF was developed from field data collected in the LDW. The BSAF of 0.23 was developed from field data reported in summary tables in the LDW ERA (Windward 2007b), and resulted in a modeled tissue concentration of TBT in fish whole body of 2.4 mg/kg wet weight. The derivation of this apparent BSAF entails some uncertainty since it was based on LDW site wide data for shiner surf perch and sediments. Whether the locations of the sediment TBT data and the perch tissue data that were used in estimating this relationship are related is uncertain. Nonetheless, this approach was useful in developing fish tissue concentrations of TBT in lieu of using surrogate values that would entail higher uncertainty.

Generally, the use of BSAFs to model non-polar organic chemicals in tissue rather than collecting tissue data from a site is believed to not underestimate tissue concentrations. The analysis presented in the following section that compares modeled clam tissue concentrations based on literature BSAFs with data on clam tissue collected from the Lockheed West Site supports this assumption. In addition, published results of a bioaccumulation study in bivalves that compared field-collected tissue data with modeled concentrations of non-polar organic chemicals also found modeling to not underestimate tissue concentrations. Modeling of bivalve tissue concentrations of PAHs resulted in over-estimation of the measured PAH concentrations in bivalves in 41 percent of comparisons, with underestimation found in 10 percent of comparisons (Clarke and McFarland 2000).

6.2.2 Comparison of Modeled Clam Tissue Concentrations with Site Clam Data

Data on chemical concentrations in clams were collected from various locations at the Lockheed West Site during spring of 2008 (Tetra Tech 2008c). The purpose of the sampling was to collect data on chemical concentrations in collocated sediment and clam tissue to verify that the literature BSAFs were suitable for use at the Lockheed West Site. Because deposit and detrital feeding clams have higher exposures to sediment than do filter feeding clams that acquire food primarily from the water column, the sampling focused on deposit/detrital feeder *Macoma* species. Because of the limited intertidal habitat and low abundance of clams in intertidal and subtidal sediment at the Site, clams were collected from a single intertidal location and three subtidal locations. Each clam sample was a composite of all *Macoma* clams collected at the location. Details of the sampling effort and data are provided in Tetra Tech (2008c).

The clam tissue data collected from the intertidal location were used to evaluate the uncertainty in the modeling of clam tissue concentrations that were used in the seafood consumption scenarios of the HHRA. The seafood consumption scenarios were based on modeled concentrations of chemicals into tissues of clams/mussels, crabs, and fish. Because the modeling of clam tissue concentrations for the HHRA was performed using intertidal sediment data, the comparison is made only to the tissue data from the composited clam sample collected from the single intertidal sediment station (Station A-1-IT).

Results of the comparison of modeled and measured tissue concentrations of COPCs in intertidal clams are shown in Table 6-1. Modeled concentrations are shown in dry weight for metals and in wet weight for organics for comparison with the measured data. Results of the comparison show that the modeled concentrations of almost all COPCs in intertidal clams were similar to or higher than the measured concentrations with the exception of chromium, tributyltin, and total PCBs. For chromium, the difference between the modeled and measured concentrations was 10-fold. The comparison suggests that the chromium BSAF may be too low. The exposure scenario with the highest non-cancer risk for chromium was the tribal child RME seafood consumption scenario, with an HQ of 0.2 for chromium. Use of the higher measured concentration for chromium in clam tissue would result in an increase in the chromium HQ in the child tribal seafood consumption scenario to 0.6.

The modeled concentration of total PCBs in intertidal clams was found to be 76 percent of the measured concentration. Use of the higher measured concentration of total PCBs in the tribal adult RME seafood consumption scenario, which presented the highest cancer risk estimates of the seafood consumption scenarios, would not change the total excess cancer risk estimate for PCBs of 3×10^{-3} (Table 5-9). Use of the higher measured concentration of total PCBs in the Suquamish adult seafood consumption scenario would also not change the total excess cancer risk estimate for PCBs of 9×10^{-3} (Table 5-11). The modeled concentrations of PCBs in tissues of other seafood categories are much higher than that modeled for intertidal clams, so a change in the clam tissue concentration has minimal influence on the total PCB cancer risk estimates.

The modeled tributyltin concentration in clams was about 60 percent of the measured concentration. The non-cancer risk that was estimated for tributyltin for seafood ingestion for the tribal child RME seafood consumption scenario greatly exceeded 1, and tributyltin was identified as a COC and risk driver for seafood ingestion. Use of a higher concentration of tributyltin in clams in the HHRA would not change the identification of tributyltin as a COC and risk driver for the child or adult RME seafood ingestion scenarios.

Table 6-1. Comparison of Lockheed West Clam Tissue Data with Modeled Data

Intertidal Clam Tissue COPC	Lockheed West Clam Tissue Concentration Station A1 Intertidal	Modeled Intertidal Clam Tissue Concentration
METALS (mg/kg dw)		
Arsenic	17.2	60.4
Cadmium	0.38	12.1
Chromium	8.26	0.85
Copper	264	380
Lead	27.6	933
Mercury	0.071	0.24
Zinc	331	3,630
PAHs (mg/kg ww)		
Fluoranthene	0.078	0.082
Pyrene	0.058	0.32
cPAHs	0.10	0.25
ORGANOMETALS (mg/kg ww)		
Tributyltin	0.071	0.042
PCBs (mg/ kg ww)		
PCBs (total)	0.029	0.022
PESTICIDES (mg/kg ww)		
Total DDT	0.004	0.046
Total Chlordane	0.002	0.007

Lockheed West intertidal clam tissue data from tissue data report (Tetra Tech 2008c)
Modeled intertidal clam tissue data from Table 3-29, as modeled from intertidal sediment data

The intent of this comparison was to determine whether the modeled chemical concentrations in intertidal clams that were used in the seafood consumption scenarios were verified by the measured site clam data. The modeled clam tissue concentration data were used in the tribal RME seafood consumption scenario and the Suquamish seafood consumption scenario. These scenarios assume that tribal members consume clams from the intertidal areas of the site. Thus, the modeling of chemical concentrations in these clams was based on intertidal sediment data and clam BSAFs, or the LDW regression equations for benthic invertebrates for arsenic and TBT, and the LDW food web model for PCBs. Because the modeled clam tissue concentrations are based on intertidal sediment data, the comparison with measured clam tissue data was made with clams collected from the intertidal area of the Lockheed West Site.

This comparison differs from the analysis of clam BSAFs for metals that was performed by EPA (see Appendix E) and summarized in Section 6.2.5. The EPA analysis was designed to evaluate the health protectiveness of the clam BSAFs that are used to model tissue concentrations in the seafood consumption scenarios. The approach used in the EPA analysis was to calculate site-specific BSAFs for clams using co-located clam tissue data and sediment data collected during the clam study of the Site. EPA used all the Site clam samples, which consist of a single intertidal clam sample and three subtidal clam samples. The EPA analysis of clam BSAFs differs from the above verification of the modeled clam concentrations used in the seafood consumption scenario in that EPA used the full set of intertidal and subtidal sediment and clam data to develop BSAFs whereas the verification study was only for intertidal clam data. The EPA study found that many site-specific BSAFs for metals calculated from the co-located intertidal and subtidal data sets were higher than those used in the modeling of the seafood consumption scenarios. The verification evaluation performed herein found that most of the modeled intertidal clam tissue concentrations of organic chemicals and metals were similar to or higher than the measured intertidal clam tissue concentrations. The comparison of intertidal *Macoma* tissue data with the modeling results indicates that the modeling is health protective. However, EPA's analysis using intertidal and subtidal *Macoma* data suggests that at higher subtidal metals concentrations, modeling may underestimate actual metals bioaccumulation. Given that tribal members are assumed to access clams in the intertidal zone, metals bioaccumulation for the human health risk analysis was based on intertidal data.

6.2.3 Inorganic Arsenic in Clam Tissue

Concentrations of inorganic arsenic in seafood tissues modeled at the Lockheed West Site were assumed to be represented by the inorganic arsenic percentage of total arsenic that was found in tissues at the LDW site (see Table 3-32). For clams, the assumption was made that inorganic arsenic was 40 percent of total arsenic, which was the level found with the Eastern softshell clam, *Mya arenaria*, at the LDW site. However, the Eastern softshell clam generally prefers a lower salinity environment than other more commonly consumed clam species (e.g., Littleneck and butter clams). Surveys of both the Lockheed West and East Waterway suggest that the Eastern softshell clam is not common in the marine environments downstream of the Duwamish estuary. The percent of inorganic arsenic in *M. arenaria* was much higher than percents found in other clams in the Duwamish corridor, including *Macoma* species that prefer a more saline environment and have been found at the

Lockheed West Site. Percentages of inorganic arsenic in non-Mya clams generally range around 10 percent or lower. Therefore, the assumption of proportional inorganic arsenic concentrations based on *M. arenaria* may over-estimate inorganic arsenic in tissues of clams that have been found or would likely be found at the Lockheed West Site, and is considered to be health protective. Cancer risks related to inorganic arsenic in clams using the inorganic percentage for non-Mya clams would be approximately one-quarter those estimated using the 40 percent inorganic arsenic assumption.

6.2.4 Regression Equations from the LDW Food Web Model for PCBs

For modeling PCBs into tissues for the Lockheed West HHRA, regression equations were developed from the FWM for the LDW site. The regression equations come from the FWM output data reported in the appendix to the draft RI report for the LDW site. Because the FWM has been calibrated using site data from the LDW, there may be less uncertainty with predicted results than using literature values. The literature values for PCB BSAFs come from multiple studies that are unrelated to the Lockheed West Site and where the various conditions governing PCB movement into tissue are not clear. As a result there may be more unknowns regarding the data used to derive the literature BSAFs than there are with the FWM for the LDW site. Because the LDW is much more closely related to conditions of the Lockheed West Site than the sites or conditions used to develop the literature BSAFs, uncertainty is expected to be less.

In addition, an analysis was performed that compared results of modeled PCBs into seafood tissue at the Lockheed West Site using the LDW FWM regressions and those using the literature BSAFs. That analysis showed no differences in the excess cancer risk results for the Tribal seafood ingestion scenario between modeling using the LDW regressions or modeling with the literature BSAFs. The analysis provides support that cancer risk estimates are not necessarily more certain using the literature values than using the LDW regression equations. The report comparing the two modeling approaches for PCBs had been previously submitted to EPA and is included as Appendix D to this HHRA**.**

6.2.5 Bioaccumulation of Metals

For metals, the use of BSAFs in modeling tissue concentrations entails greater uncertainty than for non-polar organic chemicals. The metals BSAFs were available from only two literature or database sources: the compilation of values by Ecology (PTI 1995a) that was used by WDOH (1995) in their initial derivation of sediment screening criteria for human exposures; and the ERED database (see Section 3.3.5). In those sources, multiple values for some chemicals in clams were available for derivation of 90th percentile BSAFs, but fewer

BSAFs were available for fish and crab, and frequently only single values were available for use in modeling. Because of the scarcity of BSAFs for fish and crab and the frequent lack of correlation between tissue and sediment metals concentrations in bivalves (PTI 1995a), the metals BSAFs are highly uncertain. As recommended in the review of metals BSAFs (PTI 1995a), the use of site-specific or regional-specific data for derivation of BSAFs is generally considered to provide more certainty than the use of literature values.

As an exercise to determine the effect of BSAFs derived from regional data or Site data on modeled tissue concentrations and subsequent risk estimates in the Lockheed West HHRA, US EPA Region 10 developed BSAFs for metals in fish, crab, and clam using LDW site data and Lockheed West clam tissue data. The BSAFs were then used to recalculate health risks using Lockheed West sediment data and exposure scenarios of the HHRA. The data sources, calculated BSAFs, and recalculated risk estimates are provided in a report from EPA Region 10 that is attached to this HHRA as Appendix E. The study approach and results are briefly summarized below.

The results of comparison of LDW sediment metals data with tissue data for the seafood categories evaluated in the seafood ingestion scenarios showed a lack of association between sediment and tissue metal concentrations for all metals. Similar findings have been reported in PTI (1995a) for other data sets. Because of the lack of discernable tissue – sediment metal concentration relationships, EPA used LDW-wide data on sediment and tissue concentrations to derive LDW BSAFs for metals. Comparison of the LDW-wide BSAFs for fish with the BSAF values used to model tissue concentrations in the Lockheed West HHRA (see Table 3-30) found that most of the cadmium, copper, lead, and zinc literature-based fish BSAFs were several fold greater than those computed from LDW data. The finding demonstrated that use of the literature-based BSAFs for modeling fish tissue concentrations of metals was health protective for those chemicals. However, literature BSAFs that were used for arsenic, chromium and mercury are less than those computed using LDW fish data, and the resultant modeling of individual tissue metals concentrations is less health protective. For crabs, all of the metal literature-based BSAFs used in the Lockheed West HHRA were lower than the corresponding LDW BSAFs, demonstrating a potential lack of health protectiveness of the crab metal BSAFs. Lockheed West arsenic, cadmium, and mercury crab BAFs were approximately one-fiftieth the corresponding LDW BSAFs; copper and zinc BSAFs were approximately one-tenth the corresponding LDW BSAFs.

To model clam tissue of metals, EPA used data collected from the three subtidal samples and the single intertidal sample of clam tissue at the Lockheed West Site to calculate

BSAFs. Clam data were collected as single composite samples of *Macoma* species at each location. The literature values of BSAFs for arsenic, chromium, and copper that were used in the Lockheed West HHRA were lower than the BSAFs derived from site-wide Lockheed West clam data, whereas literature BSAFs for other metals were higher than those derived with site data. Note that this comparison differs from the comparison in Section 6.2.2 of Lockheed West clam concentrations that is based on intertidal data only.

EPA used the results of the BSAFs that were developed from LDW site data for fish and crab, and from the Lockheed West site-wide data for clams, in a recalculation of seafood ingestion risks for the adult tribal RME scenario using Tulalip survey data. Increases in cancer risk were deemed to be significant if the cancer risks increased by an order of magnitude using field-derived BSAFs (LDW for fish and crab, Lockheed West for clam). Increases in HQ were deemed to be significant if HQs did not exceed 1.0 using the literature BSAFs but did exceed 1.0 using field-derived BSAFs. There were two significant changes in seafood consumption HQs and cancer risks evaluated for tribal adults using Tulalip data: 1) The chromium HQ using the LDW fish and crab BSAF and the Lockheed West site-wide clam BSAF was found to increase over 1.0. 2) Arsenic cancer risk increased from the 10^{-3} range to the 10^{-2} range. This increase also reflects the assumption that inorganic arsenic in clam tissue was 40 percent of total arsenic, which was taken from the *Mya arenaria* data from the LDW site. As pointed out above, arsenic risks for clam consumption using 10 percent as a more likely proportion of inorganic arsenic in total modeled arsenic would be one-quarter those estimated using the percent found in *M. arenaria.* Following from this, the size of the increase in arsenic risks related to clam ingestion based on the field-derived BSAF is somewhat uncertain.

A similar evaluation of the adult tribal seafood scenario based on the Suquamish consumption survey would also result in increases in cancer risk estimates and HQs for the same metals as found with the adult tribal RME scenario. If needed in the future, risk estimates could be calculated using the high-end Suquamish exposures. With the alternative BSAFs, the cancer risk estimate for arsenic in the Suquamish seafood scenario would increase about 3-fold above the present value of 3×10^{-2}, and the HQ for chromium would increase above 1.0; HQs for all other COPC metals are already above 1.0 (see Table 5-14).

For tribal children, there were three significant changes in seafood consumption HQs and cancer risks: arsenic cancer risk increased from the 10^{-4} range to the 10^{-3} range, and the chromium and mercury HQs based on LDW fish and crab BSAFs and Lockheed West site-wide clam BSAFs increased to exceed 1.0. Arsenic is already identified as a COC and a risk driver for tribal seafood ingestion, and chromium and mercury are considered COCs based on this analysis.

6.3 LEAD MODELING

The results of modeling lead exposures for both the child and the developing fetus are driven by the exposure assumptions of the seafood consumption scenarios. Resultant lead modeling results suggested high risks. The exposure scenario parameters for both the direct contact pathways and seafood consumption that were used in the lead modeling are taken directly from the LDW HHRA, and the concentrations of lead in the various seafood categories are based on modeling from sediment using a lead BSAF. The BSAF for lead uptake into clams is 2.54, which results in a modeled mean lead tissue concentration of 140 mg/kg wet wt. In Table 6-1 of Section 6.2.2 above, the modeled mean lead concentration in clam tissue (933 mg/kg dw) was approximately 34-times the actual measured concentration in intertidal clams collected from the site. Alternative values for lead BSAFs are discussed above in Section 6.2. The actual lead concentrations in all seafood tissues that are related to the Site sediment concentrations of lead in the full intertidal or subtidal data sets are not known. Because of the use of BSAF modeling and exposure parameters on seafood consumption taken from the LDW site HHRA, the resultant risk estimates for lead are health protective and over-estimate actual or potential children's exposures at the Lockheed West Site.

6.4 ORGANOCHLORINE PESTICIDES

All detected results for organochlorine pesticide analyses in sediment samples in the 2007 data set were qualified JN, which indicates "the presence of an analyte that has been 'tentatively identified' and the associated numerical value represents its approximate concentration" (EPA 1999). These data were qualified based on the probable interference in the analysis from PCB congeners. Risk estimates for the JN-qualified organochlorine pesticides are presented in the Risk Characterization.

The JN-qualified results in the 2007 sediment data set are highly uncertain and are considered to be biased high. The following comparative analysis of similarly qualified data at the nearby LDW site is presented as support for the likely high bias concentrations in the Lockheed West Site data. At the LDW site, the high bias for DDTs was confirmed by reanalyzing six sediment samples co-located with benthic invertebrate tissue samples, and eight fish and crab tissue samples that had high PCB and DDT concentrations, using a gas chromatography/mass spectrometry (GC/MS) method that is not susceptible to analytical interference by PCBs. The GC/MS method is less sensitive than EPA Method 8081, and, therefore, could not be used for the original analyses of low level organochlorine pesticides and could only be used for confirmation in the high concentration samples. The confirmation analytical results for the LDW samples confirmed the JN-qualification of the original sample results. Specifically, all the results (i.e., concentration data) from the confirmation analyses were less than the original results. The total DDT concentrations in the confirmation analyses for the LDW ranged from 4 to 60 percent of the original sediment results (Windward 2007a). Thus, the original reported concentrations of DDT compounds reflected the presence of both PCB congeners and DDT isomers in the sample, and were elevated because of analytical interference. Based on this evaluation, the risk estimates for organochlorine pesticides for the Lockheed West Site are likely biased high.

6.5 DIOXINS AND PCB DIOXIN-LIKE CONGENERS

Data on dioxins, furans, or PCB congeners with dioxin like toxicity were not collected during the 2007 sediment data collection at Lockheed West. Total excess cancer risks related to Site chemicals in sediment, therefore, do not include risk estimates from these chemicals. For PCB dioxin-like congeners, however, the excess cancer risks are addressed in the Aroclor cancer risk estimates, with some uncertainty. The HHRA performed for the LDW site showed that Aroclor-based PCB cancer risks were generally similar to cancer risks estimated using the toxic equivalent (TEQ) approach applied to dioxin-like PCB congeners. The TEQ method for evaluating cancer risks from PCBs is considered to be an alternative to the method using total Aroclors, i.e., the cancer risk estimates are not additive. The finding of similar cancer risks at the LDW site using either method supports use of the Aroclor method as sufficiently health protective for evaluating cancer risks from total PCBs at Lockheed West. However, it is unknown whether PCB congener enrichment in biota at the Lockheed West Site may differ from the enrichment found with biota at the LDW site. Although the same aquatic organisms may be present at both sites, the sources of PCBs to each site may differ, and consequently the weathering and enrichment of dioxin-like PCB congeners may differ between the sites.

Although the cancer risks associated with dioxins/furans and PCB TEQs are unknown, the current plans to remediate the entire Lockheed West Site will mitigate health risks associated with those chemicals. Cleanup decisions and identification of cleanup levels and remediation performance criteria are expected to be driven by the risk driver chemicals from the HHRA and ERA; these chemicals are the same risk drivers that were identified for the LDW site: arsenic, cPAHs, and total PCBs, with the addition of lead and TBT (see Section 7.2). In addition, dioxins and furans are identified as COCs and risk drivers for the direct contact and seafood ingestion pathways, based on their assumed likely presence in site sediment and seafood from the site (as has been documented in the upstream LDW), and the likelihood of corresponding estimates of cancer risk based on their presence. Cleanup levels and performance criteria for the Site remediation are intended to be consistent with those developed for the LDW site, and will likely be related to background concentrations of risk driver chemicals.

6.6 DERMAL ABSORPTION FOR METALS

Dermal exposure to COPC metals other than arsenic was not evaluated in this HHRA because the metals lacked dermal absorption factors. EPA (2004) guidance states that "for inorganics, the speciation of the compound is critical to the dermal absorption and there are too little data to extrapolate a reasonable default value". In following the LDW HHRA, only incidental ingestion for these metals was considered in the risk characterization. Windward (2007a) provided an analysis of the effects of using alternative absorption factors by applying them to quantify dermal exposures and risks for example metals that are missing absorption factors in EPA (2004). By applying an absorption factor of 0.01 to vanadium, the most toxic of the metal COPCs for the LDW HHRA, Windward (2007a) demonstrated that resultant contribution to the HQ for the child beach scenario from dermal absorption would be approximately equal to the contribution from incidental sediment ingestion.

For the Lockheed West HHRA, the uncertainties in the metals absorption factors were analyzed by calculating dermal absorption HQs for the child beach play scenario and comparing them with the sediment ingestion HQs that were presented previously in Table 5-2. For the child beach play scenario, cancer risks and non-caner HQs for arsenic were evaluated for both sediment ingestion and dermal absorption. Cancer risks are not affected by the exclusion of absorption factors for the other metals since none of them exhibit carcinogenic endpoints via ingestion or dermal absorption. Non-cancer HQs for beach play at the Lockheed West Site were greater than 1 for arsenic and less than 1 for the remaining COPCs (Table 5-2). The contribution to dermal risks from antimony, chromium, copper, and vanadium were not accounted for because of the lack of dermal absorption factors.

Analysis of the impact of dermal absorption for the metals other than arsenic was performed by calculating HQs for the child beach play scenario using absorption factors presented by Cal/EPA (2005). These factors were previously recommended in the EPA dermal guidance prior to the current guidance. Exposure via incidental sediment ingestion was also included so that total risks associated with direct sediment exposure could be compared. As can be seen in Table 6-2, at assumed dermal absorption factors of 0.01 for all metals except arsenic, the dermal absorption contribution to the HQs were far less than the contribution from incidental sediment ingestion. Based on this analysis, the uncertainty associated with metals that lack absorption factors is low for the child beach play direct sediment contact scenario, and the inclusion of absorption factors for all metals would not change total HQs to children exposed to sediment at the Lockheed West Site.

Table 6-2. Non-cancer Hazards for Beach Play Scenario Using Alternative Dermal Absorption Factors for Metals

COPC	EPC (mg/kg dw)[1/]	Dermal Absorption Factor[2/]	Non-Cancer CDI (mg/kg-day) Incidental Ingestion	Non-Cancer CDI (mg/kg-day) Dermal Absorption	Hazard Quotient Incidental Ingestion	Hazard Quotient Dermal Absorption	Hazard Quotient Total
Antimony	81.7	0.01	2.2E-04	4.5E-06	0.5	0.01	0.5
Arsenic	192	0.03	5.1E-04	3.1E-05	1.7	0.10	1.8
Chromium	198	0.01	5.3E-04	1.0E-05	0.2	0.003	0.2
Copper	840	0.01	2.2E-03	4.4E-05	0.1	0.001	0.1
Vanadium	51.8	0.01	1.4E-04	2.7E-06	0.03	0.001	0.03
Total hazard index across both exposure routes							**2.6**

[1/] All EPCs are medium-specific, rather than route-specific (i.e., the same EPC was used for the dermal absorption and incidental sediment ingestion exposure routes).

[2/] Absorptions factor for arsenic from EPA (2004), and for remaining metals from Table C-2 of CalEPA (2005).

CDI – chronic daily intake
COPC – chemical of potential concern for intertidal sediments
dw – dry weight
EPC – exposure point concentration

6.7 SCREENING OF CHEMICALS WITH LOW DETECTION FREQUENCY

In Section 3.2.1, chemicals detected in sediment at a frequency less than 5 percent were screened out from further evaluation in the risk assessment, as per EPA (1989) guidance. The health risks that infrequently detected chemicals may pose is uncertain. In the following subsection, chemicals that were never detected are evaluated to determine that their detection limits were above levels that relate to acceptable risk-based concentrations. The chemicals that were screened as below 5 percent detection frequency were only found in subtidal sediments and are listed in Table 6-3. Comparison of the maximum concentration with the RBC shows that the maximum concentrations of N-nitrosodimethylamine and gamma-BHC exceeded their lowest RBC. Although they were only detected in one sample each, the maximum detection limit for non-detected samples was 220 µg/kg dw for N-nitrosodimethylamine and 5.8 µg/kg dw for gamma-BHC. These detection limits exceed the lowest RBCs for both chemicals, which are for the consumption of seafood. Because of these exceedances by both detected and undetected samples, the potential risks associated with these chemicals are uncertain.

Table 6-3. Chemicals Excluded from Evaluation Based on Low Detection Frequency

Exposure Point	Chemical	Units	Detection Frequency	Sediment RBC for Seafood Consumption	Sediment RBC for Netfishing or Clamming	Max. Conc.	Max. EF
Intertidal-Subtidal							
Seafood and Netfishing							
	1,2-Dichlorobenzene	µg/kg	1/51	9,960	28,000	2.7	0.0003
	2-Methylphenol	µg/kg	1/51	310,000	3,400,000	16	0.0001
	4-Nitroaniline	µg/kg	2/51	NA	NA	55	NA
	Aniline	µg/kg	1/51	85,000	NA	13	0.0002
	Diethylphthalate	µg/kg	1/51	88,600	4,900,000	12	0.0001
	Dimethyl phthalate	µg/kg	2/51	100,000,000	100,000,000	11	1.1E-07
	Di-n-octyl phthalate	µg/kg	1/51	240,000	6,800,000	2600	0.01
	Hexachlorobenzene	µg/kg	2/51	300	1,200	2.9	0.01
	N-Nitrosodimethyl-amine	µg/kg	1/51	9.5	38	38	**4**
	Endosulfan I	µg/kg	1/51	410	410,400	16	0.04
	gamma-BHC	µg/kg	1/51	1	399	25	**25**
	Heptachlor epoxide	µg/kg	1/51	53	210	0.5	0.01
	Nonachlor (cis)	µg/kg	1/51	NA	NA	15	NA
	Nonachlor (trans)	µg/kg	1/51	NA	NA	7.5	NA
	p,p-DDE	µg/kg	1/51	2	7,800	1.8	0.9
Intertidal							
	NONE						

Subtidal chemistry data consisted of 51 samples; those chemicals that were detected in only one or two samples are identified as screened out from evaluation.
EF – Exceedance Factor (maximum detected concentration/lowest RBC)
Max. Conc. – maximum concentration
RBC – risk-based concentration

6.8 UNDETECTED CHEMICALS

Chemicals that were never detected in sediment samples at the Lockheed West Site are listed in Appendix B to this HHRA. Appendix B also presents the RBCs that the reported detection limits for each sample were compared with during selection of COPCs. The chemicals with reported DLs that exceeded their respective RBCs are summarized in Table 6-4. Un-detected chemicals with DLs that exceed RBCs could occur at concentrations below the detection limit yet greater than a concentration that might present a risk to humans who are exposed to site sediment. Table 6-4 lists the level of exceedance (Exceedance Factor, EF) of the DL over the RBC for each chemical. The EFs for five of the eight undetected chemicals are below 10, whereas the EFs for two organochlorine pesticides are between 10 and 30, and the EF for one pesticide (dieldrin) is 847.

The last column in Table 6-4 presents the percent of the undetected samples where the DL exceeded the RBC. As can be seen, exceedance of the RBCs for the two SVOCs were found in only two and four percent of the samples. This low rate of DL exceedance of the RBC suggests that it is unlikely that actual concentrations expressed as the 95 UCL on the mean concentration would pose a risk to human health at the Site. All of the remaining undetected chemicals are organochlorine pesticides (Table 6-4). The detected organochlorine pesticides have been “N” qualified due to interferences with PCB congener peaks in the analytical chromatography (N-qualifier indicates “tentatively identified pending confirmation,” which was not performed). An analysis that was performed of the “N”-qualified organochlorine pesticides in the LDW HHRA indicated that the actual measured concentrations in sediment and tissue were fractions or even orders of magnitude lower than the original concentrations that were flagged with the “N” qualifier. Because of the likely interference by PCB congeners in sediment samples from the Lockheed West Site, and based on the analysis of N-qualified data at the LDW site, whether actual concentrations of undetected organochlorine pesticides would occur above their respective RBCs is highly uncertain. Nonetheless, the finding that the maximum DL exceeded the RBC by orders of magnitude for some pesticides that were never detected suggests uncertainty as to whether risks may be associated with those chemicals.

Table 6-4. Undetected Chemicals with Detection Limit > Risk-Based Concentrations

Exposure Point	Chemical	Units	Sediment RBC for Seafood Consumption	Sediment RBC for Netfishing or Clamming	Max. Detection Limit[1/]	Max. EF	Percent Exceeding RBC (%)
Intertidal-Subtidal							
Seafood and Netfishing							
SVOCs	Hexachlorobutadiene	µg/kg	17	25,000	19	1	4
	N-Nitroso-di-n-propylamine	µg/kg	69	270	220	3	2
Pesticides	Aldrin	µg/kg	1.98	100	5.9	3	82
	alpha-Chlordane	µg/kg	1.31	6,500	9	7	82
	beta-BHC	µg/kg	0.47	960	12	26	82
	Dieldrin	µg/kg	0.02	110	21	847	100
	Heptachlor	µg/kg	0.19	380	3.2	17	82
	Toxaphene	µg/kg	440	1,600	970	2	10
Intertidal							
Clamming/ Beach Play	NONE						

[1/] Maximum detection limit for those chemicals that were never detected in any sediment sample.
For all chemicals except dieldrin, all samples with detection limits exceeding RBCs were in subtidal sediments.
EF – Exceedance Factor (detection limit/lowest RBC)
Max – maximum
RBC – risk-based concentration

Some of the undetected chemicals in Appendix B to this HHRA do not have RBCs for comparison. Undetected chemicals missing RBCs are shown in Table 6-5. Because of the lack of RBCs, it is unknown whether the detection limits for these undetected chemicals may be above a level that could pose a risk, and hence whether risks may be associated with any actual concentrations that are at or just below the detection limit. The lack of RBCs for these chemicals presents uncertainty as to their potential contribution to site-related risks.

Table 6-5. Undetected Chemicals Missing Risk-Based Concentrations

Exposure Point	Compound	Units	Sediment RBC for Seafood Consumption	RBC Netfishing or Clamming	Max. Detection Limit[1/]
Intertidal-Subtidal					
Seafood and Netfishing					
SVOCs	2-Nitrophenol	µg/kg	NO BSAF	NA	94
	4-Bromophenyl phenyl ether	µg/kg	NO BSAF	NA	51
	4-Chloro-3-methylphenol	µg/kg	NO BSAF	NA	76
	4-Chlorophenyl phenyl ether	µg/kg	NO BSAF	NA	72
Pesticides	delta-BHC	µg/kg	NA	NA	3.6
	o,p-DDE	µg/kg	NO BSAF	NA	27
	Oxychlordane	µg/kg	NO BSAF	NA	15
Intertidal					
Clamming/Beach Play					
SVOCS	2-Nitrophenol	µg/kg	NA	NA	3.5
	4-Bromophenyl phenyl ether	µg/kg	NA	NA	1.9
	4-Chloro-3-methylphenol	µg/kg	NA	NA	2.9
	4-Chlorophenyl phenyl ether	µg/kg	NA	NA	2.7
	4-Nitrophenol	µg/kg	NA	NA	41
Pesticides	delta-BHC	µg/kg	NA	NA	0.17
	Endosulfan sulfate	µg/kg	NA	NA	0.11
	Nonachlor (cis)	µg/kg	NA	NA	0.5
	Nonachlor (trans)	µg/kg	NA	NA	0.92
	o,p-DDE	µg/kg	NA	NA	1.2
	Oxychlordane	µg/kg	NA	NA	0.5

[1/] Maximum detection limit for those chemicals that were never detected in any sediment sample.
BSAF – Biota-Sediment Accumulation Factor
Max – maximum
RBC – Risk Based Concentration

6.9 ANALYSIS OF POTENTIAL HEALTH RISKS FROM CONTACT WITH SURFACE WATER

As described in Section 3.1.1, exposures and risks related to direct contact with surface water in the West Waterway or Elliott Bay sections of the Site were not quantified. A previous risk assessment of risks from direct contact with surface water in Elliott Bay and the lower Duwamish River was performed by King County (1999a), and the results used in the LDW HHRA to demonstrate that risk estimates would be much lower than those associated with exposures to sediments. The lower risk estimates were used as the basis for eliminating exposures to surface water as an exposure pathway for sediment-related chemicals. The following presents a summary of the King County risk assessment, as described in the LDW HHRA.

The King County water quality assessment (WQA) evaluated potential noncancer and cancer risks associated with swimming in the LDW and in Elliott Bay near the LDW. The sites selected for determining exposures were the Duwamish River at Duwamish Park, which is located within the area of the LDW site, and Duwamish Head in Elliott Bay, which is located about 2 km to the west of the Lockheed West Site, along the shoreline of Elliott Bay. Exposure point concentrations in water and sediment at these two locations were estimated using the results of a water and sediment quality model developed by King County and used in the King County risk assessments and in the subsequent LDW HHRA after some modifications, including additional calibration. The model was calibrated to the results of the sampling and analysis program, which included the collection of about 2,000 samples and about 13,000 chemical analyses. The model divided the river (north of the Interstate 405 Bridge) and Elliott Bay into 512 cells, which were then divided into 10 layers resulting in 5,120 cell-layers. Sediments were also modeled for each cell. Chemical inputs from the Green River upstream of the study area, the Puget Sound boundary, combined sewer overflows (CSOs), sediments, and other sources were accounted for within the model.

For non-carcinogenic risks, no HQs exceeding 1.0 were predicted for any of the direct contact exposure scenarios for either adults or children at any exposure level. Results indicated negligible non-carcinogenic health effects by direct exposure to sediment or water to swimmers, SCUBA divers or windsurfers at either the LDW or the Elliott Bay site.

Cancer risk estimates for each chemical were less than 1×10^{-6} (one in one million) for swimmers, windsurfers, and SCUBA divers. Total incremental carcinogenic risks across all COPCs were also predicted to be less than 1×10^{-6} for these scenarios at both locations. Risks exceeding 1×10^{-6} were estimated for people swimming at Duwamish Head in Elliott Bay or in the Duwamish River at Duwamish Park only at high exposure levels, which were defined as swimming 24 days per year for 2.6 hours per day with a 90th percentile estimate of a child's body surface area exposed to sediments while swimming. Excess cancer risks were highest for arsenic and total PCBs; risks from other COPCs (not shown) were several orders of magnitude less. Tables 6-6 and 6-7 show the risk estimates for arsenic and PCBs for the LDW and for Elliott Bay, respectively.

Table 6-6. Predicted Incremental Cancer Risks (x 10^{-6}) from Arsenic and PCBs to Highly Exposed Adult and Child Swimmers at Duwamish Park in the Duwamish River

		Water		Sediment		
COPC	**Age Group**	**Ingestion**	**Dermal**	**Ingestion**	**Dermal**	**Total**
Arsenic	1 to 6	0.08	0.009	0.4	4.0	4.4
	7 to 12	0.04	0.006	0.2	3.1	3.3
	13 to 18	0.02	0.005	0.1	2.3	2.4
	Adult	0.2	0.07	0.4	0.7	1.1
PCBs	1 to 6	0.0004	0.08	0.01	0.9	0.9
	7 to 12	0.0002	0.006	0.004	0.7	0.7
	13 to 18	0.0001	0.05	0.002	0.5	0.5
	Adult	0.001	0.7	0.01	0.2	0.2

Table 6-7. Predicted Incremental Cancer Risks (x 10^{-6}) from Arsenic and PCBs to Highly Exposed Adult and Child Swimmers at Duwamish Head in Elliott Bay

		Water		Sediment		
COPC	**Age Group**	**Ingestion**	**Dermal**	**Ingestion**	**Dermal**	**Total**
Arsenic	1 to 6	0.1	0.01	0.7	7.0	7.6
	7 to 12	0.006	0.001	0.3	5.4	5.7
	13 to 18	0.04	0.008	0.2	4.1	4.2
	Adult	0.4	0.1	0.8	1.2	1.9
PCBs	1 to 6	0.0003	0.07	0.02	1.8	1.8
	7 to 12	0.0002	0.05	0.009	1.4	1.4
	13 to 18	<0.0001	0.04	0.005	1.0	1.0
	Adult	0.001	0.5	0.02	0.3	0.2

The results shown in Tables 6-6 and 6-7 indicate that the contribution to the combined risk estimate from the water pathway is insignificant compared to the sediment pathway for direct contact exposure scenarios at both the LDW and Elliott Bay locations..

Based on the risk characterization presented above, the HHRA for the Lockheed West Site does not include direct contact to surface water as a pathway for exposure quantitation or risk estimation. The scenarios that are evaluated in the Lockheed West HHRA consist of direct contact with sediment chemicals as part of beach play and clamming scenarios. Based on the above analysis showing substantially higher risks associated with direct contact with sediments, these scenarios should be protective of current and future uses of the site.

Note also that the exposure parameters for the RME beach play scenario in both the Lockheed West HHRA and the LDW HHRA are more health protective than the exposure parameters for the high-level swimming scenario that was used in the King County HHRA, as shown in Table 6-8.

Table 6-8. Comparison of Key Exposure Parameters for the Lockheed West Beach Play Scenario and King County Swimming Scenario

Exposure Parameter	Lockheed West HHRA (RME scenario)	LDW HHRA (RME scenario)	King County HHRA (Duwamish Park, LDW)	King County HHRA (Duwamish Head, Elliott Bay)
Exposure frequency	65 days/yr	65 days/yr	24 days/yr	24 days/yr
Incidental sediment ingestion rate	200 mg dw/day	200 mg dw/day	53 mg dw/day [a]	53 mg dw/day [a]
EPC (arsenic)	192 mg/kg dw	9.4 - 11 mg/kg dw	5.1 mg/kg dw [a]	9.0 mg/kg dw [a]
EPC (PCBs)	0.50 mg/kg dw (combined subtidal and intertidal)	0.15 – 1.3 mg/kg dw	0.087 mg/kg dw [a]	0.17 mg/kg dw [a]

[a] Incidental sediment ingestion rates and EPCs presented by King County were in wet weight. The values presented in this table are taken from the Phase I HHRA for the LDW site (Windward 2003), and have been converted to dry weight units to facilitate comparison with the Lockheed West and LDW HHRA data, assuming the King County sediment was 70% solids.

7. RISK ESTIMATES SUMMARY AND CONCLUSIONS

The following summarizes the results of the risk estimates developed above in Section 6. Risk estimates are summarized for cancer risks and non-cancer hazards for all of the direct sediment contact exposure scenarios and the seafood consumption scenarios.

The approach to the HHRA at the Lockheed West Site was to use exposure information from the nearby LDW site in combination with sediment concentration data from the Lockheed West Site. This approach was adopted to expedite implementation of active remedial measures and to maintain consistency in the HHRA with the LDW site. The use of the LDW exposure scenarios and inherent assumptions and exposure parameters for evaluating risks at the Lockheed West Site entail a level of uncertainty, which is discussed in Section 6.1 of the Uncertainty Assessment. The approach is sufficient to estimate human health risks at the Lockheed West Site and to support the RI/FS process.

7.1 SUMMARY OF RISK ESTIMATES

Estimated excess cancer risks were higher for the seafood consumption scenarios than the direct sediment exposure scenarios. Estimated cancer risks for seafood consumption scenarios are summarized in Table 7-1. For the adult tribal RME seafood consumption scenario based on Tulalip data, the cumulative risk for all carcinogenic chemicals was 9×10^{-3}, with equal contributions to the risk estimates from inorganic arsenic, PCBs, and cPAH (each at 3×10^{-3}). For the Suquamish adult tribal seafood consumption scenario, the cumulative risk for all carcinogenic chemicals was 5×10^{-2}, and the tribal child cumulative risk for all carcinogenic chemicals was 4×10^{-3}.

The excess cancer risks from inorganic arsenic are largely attributable to the inorganic arsenic concentrations that were modeled in clams. The modeling assumed that 40 percent of total arsenic in clams was the inorganic form, based on data collected in the LDW. Cumulative excess cancer risks for the child seafood consumption scenarios were lower than those for adults (about 44 percent of adult risks), although the excess cancer risks associated with cPAHs were about the same because of the greater sensitivity of children to cancer from cPAHs. The excess cancer risks for the adult tribal scenario based on Suquamish data were more than five times higher than risks for the adult tribal RME scenario based on Tulalip data, which reflects the much higher seafood consumption rate (almost three meals per day) used in the adult tribal scenario based on Suquamish data.

In the evaluation of non-cancer hazards, total PCBs and TBT concentrations modeled into seafood accounted for greater than 90 percent of the non-cancer hazards for both the adult tribal RME and the child tribal seafood consumption scenarios. Hazard quotients for total PCBs and TBT were much greater than 1. For the adult tribal scenario based on Suquamish data, PCBs and TBT accounted for 76 percent of the non-cancer hazards, and arsenic contributed 14 percent. Risks to the child from exposure to lead in seafood were deemed high, based on the modeled exceedance of risk threshold levels in blood.

Excess cancer risks for the direct sediment exposure scenarios were much lower than those for the seafood consumption scenarios (Table 7-2). With the exception of the tribal clamming 183-day-per-year scenario, all excess cancer risk estimates for RME direct sediment exposure scenarios were less than or equal to 1×10^{-4}. Total excess cancer risk from the tribal clamming 183-day-per-year scenario was 2×10^{-4}. The hazard index (which is the sum of the individual chemical hazard quotients) for the child beach play scenario was 2.6, with the arsenic hazard quotient at 1.8; hazard indices for the remaining direct sediment exposure scenarios were less than 1.

Table 7-1. Summary of Risks for Seafood Ingestion Scenarios

	Ingestion Rate (g/day)								
Scenario Name	**Pelagic Fish**	**Benthic Fish**[1/]	**Crab**[2/]	**Mussel**	**Clam**	**Total**	**Meals per Month**[3/]	**Excess Cancer Risk**	**Non-Cancer Hazard Index**[4/]
Adult tribal RME (Tulalip data)[5/]	8.1	7.5	43.4	0.82	37.7	97.5	13.1	9×10^{-3}	173
Child tribal RME (Tulalip data)[6/]	3.24	3	17.4	0.33	15.1	39.0	5.2	4×10^{-3}	372
Adult tribal[7/] (Suquamish data)	56	29.1	54.8	5	438.6	583.5	78	5×10^{-2}	478

[1/] Includes fillet and whole-body consumption.
[2/] Includes edible-meat and whole-body consumption.
[3/] It is assumed that one meal is equal to 227 g. This assumption was applied to both adult and child scenarios, although a child's meal size may be considerably smaller.
[4/] Total across all chemicals. The values indicate that the HQ exceeds 1 for individual endpoints.
[5/] Exposure duration of 70 years, body weight 81.8 kg.
[6/] Exposure duration of 6 years, body weight 15.2 kg.
[7/] Exposure duration of 70 years, body weight 79 kg.
Hazard Index = sum of the HQs for individual chemicals
RME – reasonable maximum exposure
Adapted from Windward (2007a)

Table 7-2. Summary of Risks for Direct Sediment Exposure Scenarios

Scenario Name	Exposure Area	Age Class	Incidental Sediment Ingestion Rate (g/day)	Exposure Frequency (days/yr)	Exposure Duration (years)	Skin Surface Area Exposed (cm^2)	Excess Cancer Risk	Non-Cancer Hazard Index[4/]
Beach play	all intertidal area	0 to 6 yrs	0.20	65	6	varies by age[2/] (1,330 to 2,751)	7×10^{-5}	2.6
Tribal clamming RME scenario	all intertidal area	adult	0.1	120	64	6,040[3/]	1×10^{-4}	0.5
Tribal clamming 183 days per year	all intertidal area	adult	0.1	183	70	6,040[3/]	2×10^{-4}	0.7
Netfishing	all subtidal and intertidal	adult	0.050	119	44	3,600[1/]	3×10^{-5}	0.1

1/ Recommended surface area for commercial/industrial worker. Assumes that head, hands, and forearms are exposed.
2/ Assumes that 35% of the total child body surface area is exposed, roughly corresponding to an individual wearing a short-sleeve shirt and short pants but no shoes.
3/ Assumes that 39% of the total adult body surface area is exposed, roughly corresponding to a barefoot individual wearing a short-sleeve shirt and short pants.
4/ Total across all chemicals. This total is not directly interpretable for risk assessment, but a value greater than 1 suggests that an HQ may exceed 1 for individual endpoints.
Hazard Index = sum of the HQs for individual chemicals
RME – reasonable maximum exposure
Adapted from Windward (2007a)

7.2 IDENTIFICATION OF RISK DRIVERS

The final step of the risk characterization is to identify risk drivers for the Lockheed West Site HHRA. Risk drivers are defined as chemicals contributing the majority of the site risks. The procedure for designating risk drivers was to first identify COCs, which are defined as chemicals with excess cancer risk estimates greater than 1×10^{-6} or an HQ greater than 1 for any RME exposure scenario. Risk drivers were then designated from the COC list based on the risk magnitude. In addition, dioxins and furans are identified as risk drivers for the direct contact and tribal seafood ingestion pathways, based on their assumed likely presence in site sediment and seafood from the Site, and the potential for associated cancer risks above regulatory thresholds.

The RME scenario with the highest excess cancer risks was the tribal adult seafood consumption based on Tulalip data. Of the ten chemicals identified as COCs (including lead), five are identified as risk drivers for seafood consumption: PCBs, arsenic, lead, cPAHs, and TBT; dioxins/furans are also identified as additional risk drivers. For direct sediment exposures, the RME scenario with the highest risk estimates was the tribal RME (i.e., 120-day-per-year) clamming scenario. Two chemicals were identified as COCs for tribal RME clamming and are thereby identified as risk drivers: arsenic and cPAHs; dioxins/furans are also identified as additional risk drivers.

As part of the characterization of risks for the Lockheed West Site, numerous uncertainties were examined that could affect interpretation of risks or the management of risks. One source of uncertainty was that all exposure scenarios that were considered relevant to the site conditions, and their inherent exposure parameters, were borrowed directly from the LDW site HHRA. The use of exposure parameters that are not site-specific and the use of modeling to determine the concentrations of chemicals in seafood is a source of uncertainty. The use of the LDW exposure scenarios was intended to be health protective and to provide consistency between the two sites in the identification of risk drivers and in future cleanup and remediation criteria. The health-protective approach to the HHRA resulted in risk estimates that justify the existing remediation plans for the Lockheed West Site.

8. REFERENCES

Note: Many of the references are taken directly from the HHRA for the LDW site (Windward 2007a).

American Cancer Society. 2007. Who gets cancer? (http://www.cancer.org/docroot/CRI/content/CRI_2_4_1x_Who_gets_cancer.asp?sitearea=).

ATSDR. 1995. Toxicological profile for vanadium and compounds. Agency for Toxic Substances and Disease Registry, Atlanta, GA.

ATSDR. 2000. Toxicological profile for polychlorinated biphenyls (PCBs). Agency for Toxic Substances and Disease Registry, Atlanta, GA.

ATSDR. 2004. Toxicological profile for copper. Agency for Toxic Substances and Disease Registry, Atlanta, GA. CalEPA. 1994. Health effects of benzo(a)pyrene. Office of Environmental Health Hazard Assessment, California Environmental Protection Agency, Berkeley, CA.

CalEPA. 1994. Health effects of benzo(a)pyrene. Office of Environmental Health Hazard Assessment, California Environmental Protection Agency, Berkeley, CA.

CalEPA. 2005. Human-exposure-based screening numbers developed to aid estimation of cleanup costs for contaminated soil. November 2004; January 2005 revision. Office of Environmental Health Hazard Assessment, California Environmental Protection Agency, Berkeley, CA.

Clarke, J.U., and V.A. McFarland. 2000. Uncertainty analysis for an equilibrium partitioning-based estimator of polynuclear aromatic hydrocarbon bioaccumulation potential in sediments. Environ Toxicol Chem 19:360-367.

CRITFC. 1994. A fish consumption survey of the Umatilla, Nez Perce, Yakama, and Warm Springs tribes of the Columbia River basin. Technical report 94-3. Columbia River Inter-Tribal Fish Commission, Portland, OR.

Duff, R.M., and J.C. Kissel. 1996. Effect of soil loading on dermal absorption efficiency from contaminated soils. J Toxicol Env Health 48(11):93-106.

Ecology. 2000. Sediment quality in Puget Sound. Year 2 - central Puget Sound. No. 00-03-055. Washington Department of Ecology, Olympia, WA.

EPA. 1989. Risk Assessment Guidance for Superfund, Volume 1: Human Health Evaluation Manual, Part A. EPA/540/1-89/002. Office of Emergency and Remedial Response, US Environmental Protection Agency, Washington, DC.

EPA. 1991a. Role of the baseline risk assessment in Superfund remedy selection decisions. OSWER Directive 9355.0-30. Office of Solid Waste and Emergency Response, US Environmental Protection Agency, Washington, DC.

EPA. 1991b. Risk assessment guidance for Superfund, human health evaluation manual, supplemental guidance: standard default exposure factors. Directive No. 9285.6-03. Office of Emergency and Remedial Response, US Environmental Protection Agency, Washington, DC.

EPA. 1992. Dermal exposure assessment: principles and applications. Interim report. EPA-600/8-91/011-B. Office of Health and Environmental Assessment, Exposure Assessment Group, US Environmental Protection Agency, Washington, DC.

EPA. 1994. Guidance manual for the Integrated Exposure Uptake Biokinetic Model for lead in children. EPA 540-R-93-081. Technical Review Workgroup for Lead, US Environmental Protection Agency, Washington, DC.

EPA. 1996. EPA Region 10 supplemental risk assessment guidance for Superfund. Draft. Office of Environmental Assessment, Risk Evaluation Unit, US Environmental Protection Agency, Region 10, Seattle, WA.

EPA. 1997a. Exposure factors handbook. EPA/600/P-95/002Fa. Office of Research and Development, National Center for Environmental Assessment, US Environmental Protection Agency, Washington, DC.

EPA. 1997b. The incidence and severity of sediment contamination in surface waters of the United States. Volume 1: National Sediment Quality Survey. EPA 823-R-97-006. US Environmental Protection Agency, Office of Science and Technology, Washington, DC.

EPA. 1997c. Ecological risk assessment guidance for Superfund: Process for designing and conducting ecological risk assessments. EPA/540/R-97/006. Interim final. Environmental Response Team, US Environmental Protection Agency, Edison, NJ.

EPA. 1998a. Risk assessment guidance for Superfund. Volume 1. Human health evaluation manual. Part D, Standardized planning, reporting, and review of Superfund risk assessments. Interim Publication No. 9825.7-01D. Office of Emergency and Remedial Response, US Environmental Protection Agency, Washington, DC.

EPA. 1998b. Guidelines for Ecological Risk Assessment. Text Box 4-10. EPA/630/R-95/002F. Risk Assessment Forum, US Environmental Protection Agency, Washington, DC. April.

EPA. 1999. USEPA contract laboratory program national functional guidelines for organic data review. EPA-540/R-99/008. Office of Emergency and Remedial Response, US Environmental Protection Agency, Washington, DC.

EPA. 2000a. Bioaccumulation testing and interpretation for the purpose of sediment quality assessment: status and needs. EPA-823-R-00-001. Bioaccumulation Analysis Workgroup, US Environmental Protection Agency, Washington, DC.

EPA. 2000b. Guidance for assessing chemical contaminant data for use in fish advisories. Volume 2: Risk assessment and fish consumption limits. Third ed. EPA 823-B-00-008. US Environmental Protection Agency, Washington, DC.

EPA. 2001. Risk Assessment Guidance for Superfund: Volume III - Part A, Process for Conducting Probabilistic Risk Assessment. OSWER 9285.7-45. www.epa.gov/superfund/RAGS3A/index.htm. Office of Emergency and Remedial Response, US Environmental Protection Agency Washington, DC. December.

EPA. 2002a. Blood lead concentrations of US adult females: Summary statistics from Phases 1 and 2 of the National Health and Nutrition Evaluation Survey (NHANES III). Technical Review Workgroup for Lead, US Environmental Protection Agency, Washington, DC.

EPA. 2002b. Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites. EPA 540-R-01-003. US Environmental Protection Agency, Washington, DC. September.

EPA. 2002c. Role of Background in the CERCLA Cleanup Program. OSWER 9285.6-07P. Office of Solid Waste and Emergency Response, US Environmental Protection Agency, Washington, DC. April 26.

EPA. 2002d. Estimated per capita fish consumption in the United States. EPA-821-C-02-003. US Environmental Protection Agency, Washington, DC.

EPA. 2002e. Users guide for the integrated exposure uptake biokinetic model for lead in children (IEUBK). EPA-540-K-01-005. OSWER #9285.7-42. Office of Solid Waste and Emergency Response, US Environmental Protection Agency, Washington, DC.

EPA. 2003a. Human health toxicity values in Superfund risk assessments. OSWER Directive 9285.7-53. Office of Solid Waste and Emergency Response, US Environmental Protection Agency, Washington, DC.

EPA. 2003b. Recommendations of the technical review workgroup for lead for an approach to assessing risks associated with adult exposures to lead in soil. EPA-540-R-03-001. Technical Review Workgroup for Lead, US Environmental Protection Agency, Washington, DC.

EPA. 2003c. Wildlife Exposure Factors Handbook. EPA/600/R-93/187a. Office of Research and Development, US Environmental Protection Agency, Washington, DC. December.

EPA. 2004. Risk assessment guidance for Superfund, Volume 1: Human health evaluation manual (Part E, supplemental guidance for dermal risk assessment). Final, July 2004. EPA/540/R/99/005. Office of Emergency and Remedial Response, US Environmental Protection Agency, Washington, DC.

EPA. 2005a. Application of the draft framework for selecting and using tribal fish and shellfish consumption rates for risk-based decision making at CERCLA and RCRA cleanup sites in Puget Sound and the Strait of Georgia to the Lower Duwamish Waterway sediment cleanup action - June 16, 2005. US Environmental Protection Agency, Region 10, Seattle, WA.

EPA. 2005b. Guidelines for carcinogen risk assessment. EPA/630/P-03/001F. Risk Assessment Forum, US Environmental Protection Agency, Washington, DC.

EPA. 2005c. Guidance for Developing Ecological Soil Screening Levels. OSWER Directive 9285.7-55. US Environmental Protection Agency, Office of Solid Waste and Emergency Response. Washington, DC. November 2003, Revised February 2005.

EPA. 2006a. Child-specific exposure factors handbook (external review draft). EPA/600/R/06/096A. US Environmental Protection Agency, Washington, DC.

EPA. 2006b. Guidance on Systematic Planning Using the Data Quality Objectives Process. EPA QA/G-4. United States Environmental Protection Agency. Office of Environmental Information. EPA/240/B-06/001. Washington D.C. 100pp.

EPA. 2007a. USEPA Region 3 risk-based concentration table [online]. U.S. Environmental Protection Agency Region 3, Philadelphia, PA. Updated October 2007. Available from: http://www.epa.gov/reg3hwmd/risk/human/index.htm.

EPA. 2007b. Framework for selecting and using tribal fish and shellfish consumption rates for risk-based decision making at CERCLA and RCRA cleanup sites in Puget Sound and the Strait of Georgia – Working Document, August 2007. U.S. Environmental Protection Agency, Region 10, Seattle, WA.

EPA. 2007c. ProUCL Version 4.0. User Guide. Statistical software to compute Upper Confidence Limits of the unknown population mean [online]. EPA/600/R-07/038. Technical Support Center for Monitoring and Site Characterization US Environmental Protection Agency. Updated 5/6/2004. Available from: http://www.epa.gov/nerlesd1/tsc/download.htm.

EPA. 2008. USEPA Region 6 Human Health Medium-Specific Screening Levels 2008. U.S. Environmental Protection Agency Region 6. Updated March, 2008. http://www.epa.gov/earth1r6/6pd/rcra_c/pd-n/screenvalues.pdf

ESG. 1999. Waterway Sediment Operable Unit, Harbor Island Superfund Site. Assessing Human Health Risks from the Consumption of Seafood: Human Health Risk Assessment Report. Prepared for Port of Seattle, Lockheed Martin, Todd Pacific Shipyards. Environmental Solutions Group, Seattle, WA. September.

Hiltner, A. 2007. Personal communication (e-mail to Tad Deshler and Nancy Judd, Windward Environmental, regarding Beach Plan and CT scenarios). U.S. Environmental Protection Agency Region 10, Seattle, WA. January 18, 2007. As cited in Windward (2007a).

King County. 1999a. King County combined sewer overflow water quality assessment for the Duwamish River and Elliott Bay. Vol 1, Appendix B2, B3, & B4: human health, wildlife, and aquatic life risk assessments. King County Department of Natural Resources, Seattle, WA.

King County. 1999b. King County combined sewer overflow water quality assessment for the Duwamish River and Elliott Bay. Vol 1, Appendix C: Issue papers. King County Department of Natural Resources, Seattle, WA.

Kissel, J.C., K.Y. Richter, and R.A. Fenske. 1996. Field measurement of dermal soil loading attributable to various activities: implications for exposure assessment. Risk Anal 16:115-125.

Kissinger, L. 2002. Personal communication (email to Tad Deshler, Windward Environmental, Seattle, WA, regarding parameterization of Adult Lead Model, as cited in Windward 2007a). US Environmental Protection Agency, Region 10, Seattle, WA. October 17, 2002.

Kissinger, L. 2007. Personal communication (e-mail and attached Word file to Nancy Judd, Windward Environmental, regarding memo, 8-31-07: LDW HHRA clamming exposure duration and frequency). Toxicologist, Office of Environmental Assessment, US Environmental Protection Agency Region 10, Seattle, WA. September 4, 2007. As cited in Windward (2007a).

NOAA and Ecology. 2000. Sediment quality in Puget Sound. Year 2 - Central Puget Sound. Ecology publication no. 00-03-055. National Oceanic and Atmospheric Administration, Silver Spring, MD and Washington Department of Ecology, Olympia, WA.

O'Neill S.M., J.E. West, and J.C. Hoeman. 1998. Spatial trends in the concentration of polychlorinated biphenyls (PCBs) in chinook (*Oncorhynchus tshawytscha*) and coho salmon (*O. kisutch*) in Puget Sound and factors affecting PCB accumulation: Results from the Puget Sound Ambient Monitoring Program. Puget Sound Research '98:312-328.

ORNL. 2008. Risk Assessment Information System (RAIS). http://rais.ornl.gov/. Accessed October 2008.

Parametrix. 2003. Results of a human use survey for shoreline areas of Lake Union, Lake Washington, and Lake Sammamish. Sammamish-Washington Analysis and Modeling Program (SWAMP). Prepared for King County Department of Natural Resources. Parametrix, Kirkland, WA.

PTI. 1995a. Bioaccumulation Factor Approach Analysis for Metals and Polar Organic Compounds. Prepared for WA Dept Ecology, Environmental Review and Sediment Section. PTI, Bellevue, WA. October.

PTI. 1995b. Analysis of BSAF Values for Nonpolar Organic Compounds in Finfish and Shellfish. Prepared for WA Dept Ecology, Environmental Review and Sediment Section. PTI, Bellevue, WA. November.

Suquamish Tribe. 2000. Fish consumption survey of the Suquamish Indian Tribe of the Port Madison Indian Reservation, Puget Sound region. The Suquamish Tribe, Suquamish, WA.

Tetra Tech. 2008a. Remedial Investigation/Feasibility Study Work Plan for Lockheed West Seattle Superfund Site. Final. Revision 3. Prepared for Lockheed-Martin Corporation. Bothell, WA. June.

Tetra Tech. 2008b. Lockheed West Seattle Superfund Site. Remedial Investigation. Data Report. Prepared for Lockheed-Martin Corporation. Bothell, WA.

Tetra Tech. 2008c. Lockheed West Seattle Superfund Site Clam Tissue and Sediment Data Report Addendum. Prepared for Lockheed Martin Corporation. Tetra Tech, Bothell, WA. November.

Toy, K.A., N.L. Polissar, S. Liao, and G.D. Mittelstaedt. 1996. A fish consumption survey of the Tulalip and Squaxin Island tribes of Puget Sound region. Department of Environment, Tulalip Tribes, Marysville, WA.

Tracey, G.A., and D.J. Hansen. 1996. Use of biota-sediment accumulation factors to assess similarity of nonionic organic chemical exposure to benthically-coupled organisms of differing trophic mode. Arch Environ Contam Toxicol 30:467-475.

USACE. 2003. Environmental Residue-Effects Database. U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS. On-line database - http://el.erdc.usace.army.mil/ered/. Database accessed by Windward (2005a) in November 2003.

USACE. 2008. BSAF Database. US Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS. On-line database, updated January 2008 - http://el.erdc.usace.army.mil/bsaf/BSAF.html. Database accessed September 2008

Varanasi U., E. Casillas, M.R. Arkoosh, T. Hom, D. Misitano, D.W. Brown, S-L. Chan, T.K. Collier, B.B. McCain, and J.E. Stein. 1993. Contaminant exposure and associated biochemical effects in outmigrant juvenile chinook salmon (Onchorynchus tschawytscha) from urban and nonurban estuaries of Puget Sound, Washington. NOAA technical memorandum NMFS-FWFSC-8. Northwest Fisheries Science Center, National Marine Fisheries Service, Seattle, WA.

WDOH. 1995. Development of Sediment Quality Criteria for the Protection of Human Health. Tier I Report. Washington State Department of Health, Office of Toxic Substances. June 1995.

West J.E., S.M. O'Neill, G. Lippert, and S. Quinnell. 2001. Toxic contaminants in marine and anadromous fishes from Puget Sound, Washington. Results of the Puget Sound ambient monitoring program fish component 1989-1999. Washington Department of Fish and Wildlife, Olympia, WA

Weston. 1998b. Appendix K. Technical Memorandum. Ecological and human health risk assessments. Pacific Sound Resources. Marine Sediments Unit. Vol. II. Prepared for USEPA Region 10, Seattle, WA. Roy F. Weston, Inc., Seattle, WA. April.

Windward. 2003. Lower Duwamish Waterway Remedial Investigation, Appendix B. Phase 1 Human Health Risk Assessment. Prepared for the Lower Duwamish Waterway Group. Windward, Seattle, WA

Windward. 2004a. Quality Assurance Project Plan: Fish and crab tissue collection and chemical analyses: Appendix D. Final. Prepared for Lower Duwamish Waterway Group. Windward Environmental LLC, Seattle, WA. August 27.

Windward. 2004b. Quality Assurance Project Plan: Benthic invertebrate sampling of the Lower Duwamish Waterway, Appendix D. Final. Prepared for Lower Duwamish Waterway Group. Windward Environmental LLC, Seattle, WA. July 30.

Windward. 2005. Quality Assurance Project Plan: Surface sediment chemical analyses and toxicity testing of the Lower Duwamish Waterway. Appendix C. Final. Prepared for Lower Duwamish Waterway Group. Windward Environmental LLC, Seattle, WA. January 14.

Windward. 2007a. Lower Duwamish Waterway Remedial Investigation. Baseline Human Health Risk Assessment. Final. Prepared for Lower Duwamish Waterway Group. Windward Environmental LLC, Seattle, WA. November.

Windward. 2007b. Lower Duwamish Waterway Remedial Investigation. Baseline Ecological Risk Assessment. Final. Prepared for Lower Duwamish Waterway Group. Windward Environmental LLC, Seattle, WA. July 31.

Windward. 2007c. Lower Duwamish Waterway Remedial Investigation. Draft. Remedial Investigation Report. Prepared for Lower Duwamish Waterway Group. Windward Environmental LLC, Seattle, WA. November.

Windward. 2008. Lower Duwamish Waterway Remedial Investigation. Draft Final. Remedial Investigation Report. Prepared for Lower Duwamish Waterway Group. Windward Environmental LLC, Seattle, WA. October.

APPENDIX A

OCCURRENCE AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

APPENDIX A

OCCURRENCE AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

This appendix to the Lockheed West baseline HHRA presents the occurrence of chemicals in sediment of the Lockheed West Site and the selection of COPCs using the table format suggested in Risk Assessment Guidance for Superfund Part D (EPA 1998). Details of the COPC selection process are presented in Section 3 of the HHRA; selection is based on a comparison of the maximum concentration of a chemical in the surface sediment sample from the site (or a sample reporting limit for chemicals never detected) with an appropriate risk-based concentration (RBC).

The selection of COPCs for the beach play and clamming scenarios are shown in Table A-1; selection is based on comparisons of intertidal surface sediment chemical concentrations with soil RBCs for a residential exposure scenario from EPA Region 6 (EPA 2008). The selection of COPCs for the netfishing scenario is shown in Table A-2; selection is based on comparisons of both intertidal and subtidal surface sediment chemical concentrations with soil RBCs for an industrial exposure scenario from EPA Region 6 (EPA 2008).

The selection of seafood ingestion COPCs is shown in Table A-3; selection is based on comparisons of chemical concentrations in sediment samples from intertidal and subtidal sediment with sediment RBCs that were modified from RBACGs developed for screening sediment in the benthic sampling QAPP for the LDW site (Windward 2004b). As described in Section 3, the sediment RBACGs for seafood consumption were designed to be protective of seafood consumption by modeling from acceptable tissue concentrations to sediment concentrations using the BSAF method. Acceptable tissue concentrations were calculated to include site-specific conditions for seafood consumption.

Screening criteria also include the frequency of detection of five percent for netfishing and seafood consumption scenarios (Tables A-2 and A-3). Background concentrations of metals are provided for comparison purposes only; no screening of chemicals was performed. In the screening of sediment chemical concentrations for seafood ingestion scenarios (Table A-3), criteria include whether a chemical is identified as a bioaccumulative compound in EPA (2000a).

Table A-1. Intertidal Sediments

Human Health, Lockheed West Site

Exposure Point	CAS Number	Chemical	Mean Conc. (Qualifier) (1)	Minimum Conc. (Qualifier) (1)	Maximum Conc. (Qualifier) (1)	Units	Location of Maximum Conc.	Detection Frequency	Range of Detection Limits	Conc. Used for Screening (2)	Background Value (3)	Screening Value (4)	Basis of Screening Value	COPC Flag (Y/N)	Rationale for Selection or Deletion (5)
Intertidal Sediment	7440-36-0	Antimony	54.7	5.1 [J]	126 [J]	mg/Kg	TT-IT-05	9/9	-	126	0.23 / 0.44	3.1	nc	Y	ASV
	7440-38-2	Arsenic	127	5.9	330	mg/Kg	TT-IT-06	9/9	-	330	5.03 / 10.4	0.39	c	Y	ASV
	7440-43-9	Cadmium	0.33	0.09	0.65	mg/Kg	TT-IT-05	9/9	-	0.65	0.36 / 1.12	3.9	nc	N	BSV
	7440-47-3	Chromium	138	39.2 [J]	289	mg/Kg	TT-IT-07	9/9	-	289	NA	30	c	Y	ASV
	7440-48-4	Cobalt	18	3.91	38.6	mg/Kg	TT-IT-06	9/9	-	38.6	NA	900	c	N	BSV
	7440-50-8	Copper	534	44.6	1,310	mg/Kg	TT-IT-08	9/9	-	1310	21.3 / 50.8	290	nc	Y	ASV
	7439-92-1	Lead	367	91.5	1,420	mg/Kg	TT-IT-02	9/9	-	1420	15 / 45	40	nc	Y	ASV
	7439-97-6	Mercury	0.12	0.02	0.42	mg/Kg	TT-IT-05	9/9	-	0.42	0.0981 / 0.327	2.3	nc	N	BSV
	7439-98-7	Molybdenum	1.0.8	1.54	23.8	mg/Kg	TT-IT-06	9/9	-	23.8	NA	39	nc	N	BSV
	7440-02-0	Nickel	72.2	9.37	151	mg/Kg	TT-IT-08	9/9	-	151	26.8 / 41.7	160	nc	N	BSV
	7782-49-2	Selenium	0.39	0.2 [B]	0.7 [B]	mg/Kg	TT-IT-06	9/9	-	0.7	NA	39	nc	N	BSV
	7440-22-4	Silver	0.4	0.09	0.67	mg/Kg	TT-IT-06	9/9	-	0.67	0.28 / 0.74	39	nc	N	BSV
	7440-28-0	Thallium	0.16	0.06	0.31	mg/Kg	TT-IT-06	9/9	-	0.31	0.252 / 1.79	0.55	nc	N	BSV
	7440-62-2	Vanadium	41	22	68.6	mg/Kg	TT-IT-08	9/9	-	68.6	36 / 59.6	39	nc	Y	ASV
	7440-66-6	Zinc	769	174	1,360	mg/Kg	TT-IT-06	9/9	-	1360	52.6 / 98.5	2,300	nc	N	BSV
	83-32-9	Acenaphthene	38.5	2.8 [J]	280	µg/kg	TT-IT-06	6/9	1.2-1.3	280	NA	370,000	nc	N	BSV
	208-96-8	Acenaphthylene	8.2	3 [J]	21 [J]	µg/kg	TT-IT-06	8/9	1.8	21	NA	370,000	nc	N	BSV
	120-12-7	Anthracene	22.6	3.9 [J]	66	µg/kg	TT-IT-06	8/9	1.8	66	NA	2,200,000	nc	N	BSV
	191-24-2	Benzo(g,h,i)perylene	36.4	4.3 [J]	110	µg/kg	TT-IT-06	9/9	-	110	NA	NA	ntx	N	NSV
	-	Benzofluoranthenes (total)	175	5	460	µg/kg	TT-IT-06	9/9	-	460	NA	NA	ntx	N	NSV
	-	cPAH	109	4.4	344	µg/kg	TT-IT-06	9/9	-	343.82	NA	15	c	Y	ASV (6)
	206-44-0	Fluoranthene	233	4.5 [J]	610	µg/kg	TT-IT-07	9/9	-	610	NA	230,000	nc	N	BSV
	86-73-7	Fluorene	23.9	2.8 [J]	140	µg/kg	TT-IT-06	6/9	2-2.3	140	NA	260,000	nc	N	BSV
	91-20-3	Naphthalene	7.1	2 [J]	41	µg/kg	TT-IT-08	5/9	-	41	NA	12,000	nc	N	BSV
	85-01-8	Phenanthrene	85.6	4.5 [J]	240	µg/kg	TT-IT-06	8/9	1.7	240	NA	NA	ntx	N	NSV
	129-00-0	Pyrene	160	3.8 [J]	520	µg/kg	TT-IT-07	9/9	-	520	NA	230,000	nc	N	BSV
	-	Total HPAH	899	28.8	2,008	µg/kg	TT-IT-07	9/9	-	2008	NA	NA	ntx	N	PAH
	-	Total LPAH	183	12.9	751	µg/kg	TT-IT-06	8/9	2.2	751.2	NA	NA	ntx	N	PAH
	-	Total PAH	1081	28.8	2,461	µg/kg	TT-IT-06	9/9	-	2461.2	NA	NA	ntx	N	PAH
	-	Butyltin	2.8	0.96 [J]	6 [J]	µg/kg	TT-IT-05	8/9	0.72	6	NA	NA	ntx	N	NSV
	-	Dibutyltin	12.8	4.7	34	µg/kg	TT-IT-05	9/9	-	34	NA	NA	ntx	N	NSV

Table A-1. Intertidal Sediments (continued)

Exposure Point	CAS Number	Chemical	Mean Conc. (Qualifier) (1)	Minimum Conc. (Qualifier) (1)	Maximum Conc. (Qualifier) (1)	Units	Location of Maximum Conc.	Detection Frequency	Range of Detection Limits	Conc. Used for Screening (2)	Background Value (3)	Screening Value (4)	Basis of Screening Value	COPC Flag (Y/N)	Rationale for Selection or Deletion (5)
	1191-48-7	Tetrabutyltin	0.58	0.51 [J]	0.94 [J]	µg/kg	TT-IT-07	4/9	0.081-0.095	0.94	NA	NA	ntx	N	NSV
	-	Tributyltin	22	0.81	57	µg/kg	TT-IT-07	9/9	-	57	NA	1800	nc	N	BSV
	95-48-7	1-Methylnapthalene	7.5	3.3 [J]	40	µg/kg	TT-IT-06	3/9	2.6-3	40	NA	NA	ntx	N	NSV
	131-11-3	2-Methylnaphthene	1.9	1.6 [J]	4.5 [J]	µg/kg	TT-IT-08	2/9	1.4-1.7	4.5	NA	NA	ntx	N	NSV
	53-19-0	bis(2-ethylhexyl)phthalate	108	35 [J]	670	µg/kg	TT-IT-08	3/9	3.2-16	670	NA	35,000	c	N	BSV
	72-55-9	Dibenzofuran	12.7	2.2 [J]	67	µg/kg	TT-IT-06	6/9	1.5-1.8	67	NA	15000	nc	N	BSV
	84-74-2	Di-n-butyl phthalate	5	3.5	6.4	µg/kg	TT-IT-02	9/9		6.4	NA	610,000	nc	N	BSV
	117-84-0	Di-n-octyl phthalate	2600 [D]	2600 [D]	2600 [D]	µg/kg	TT-IT-08	1/9	1.4-1.7	2600	Na	NA	ntx	N	NSV
	118-74-1	Hexachlorobenzene	2 [JN]	2 [JN]	2 [JN]	µg/kg	TT-IT-04	1/9	.091-1.8	2	NA	300	c	N	BSV
	108-95-2	Phenol	12	9.7 [J]	21 [J]	µg/kg	TT-IT-09	4/9	2.2-2.5	21	NA	1,800,000	nc	N	BSV
	11097-69-1	Aroclor-1254	23.1	4.2	77	µg/kg	TT-IT-02	9/9		77	NA	220	c	N	PCB
	-	Aroclor -1260	9.8	7.6	20	µg/kg	TT-IT-03	3/9	2.2-15	20	NA	NA	c	N	PCB
	-	PCBs (total)	27.8	12	77	µg/kg	TT-IT-02	9/9		77	NA	220	c	N	BSV
	7421-93-4	Endrin Aldehyde	0.82	0.82 [JN]	0.82 [JN]	µg/kg	TT-IT-02	1/9	0.062-0.5	0.82	NA	1800	nc	N	BSV
	-	gamma-Chlordane	0.37	0.14 [JN]	1.1 [JN]	µg/kg	TT-IT-02	4/9	0.075-0.39	1.1	NA	1600	c	N	CLR
	2385-85-5	Mirex	0.2	0.2 [JN]	0.2 [JN]	µg/kg	TT-IT-03	1/9	0.12-0.5	0.2	NA	270	c	N	BSV
	53-19-0	o,p-DDD	1.1	1.1 [JN]	1.4 [JN]	µg/kg	TT-IT-08	2/9	0.25-2.1	1.4	NA	2400	c	N	DDT
	789-02-6	o,p-DDT	1.2	0.36[JN]	4.2 [JN]	µg/kg	TT-IT-02	8/9	0.17	4.2	NA	1700	c	N	DDT
	50-29-3	p,p'-DDT	1.7	0.28 [JN]	5.2 [JN]	µg/kg	TT-IT-02	9/9	-	5.2	NA	1700	c	N	DDT
	-	Total DDT	1.7	0.28 [JN]	9.4 [JN]	µg/kg	TT-IT-02	9/9	-	9.4	NA	1700	c	N	BSV
	-	Total chlordanes	1.1	0.67 [JN]	1.1 [JN]	µg/kg	TT-IT-02	4/9	0.44-0.5	1.1	NA	1600	c	N	BSV

Footnotes:

- = Not applicable or not available

nc - non-carcinogenicity; c - carcinogenicity; ntx - no toxicity data

(1) Qualifier Definitions: B - compound also detected in a blank sample; D - Diluted; J - Estimated; N - tentatively identified compound, pending confirmation

(2) The maximum detected concentration is the concentration used for screening. Screening was performed against the Screening Toxicity Value only - background values are shown for discussion purposes only.

(3) Background concentrations obtained from joint Ecology/PSAMP 1998 study entitled "Sediment Quality in Puget Sound. Year 2- Central Puget Sound" (Ecology 2000). Reported sediment samples collected from the following areas: South Port Townsend, Port Townsend, North Admiralty Inlet, South Admiralty Inlet, Possession Sound, Central Basin, Port Madison, West Point, East Passage, Liberty Bay, Keyport, Northwest Bainbridge Island, Southwest Bainbridge Island, Rich Passage, Port Orchard, and Port Washington Narrows.

Table A-1. Intertidal Sediments (continued)

(4) RBCs for direct sediment contact are residential-based criteria for soil exposures that are applied to the child beach play and clamming exposures, as per the LDW HHRA. Direct exposure screening criteria are updated with Region 6 values for residential exposures to soil; the lower of criteria for carcinogenic or noncarcinogenic effects are shown, with criteria for noncarcinogenic effects modified by a factor of 0.1 as per Region 10 guidance.

(5) Rationale Codes for COPC screening:

- ASV - Above Screening Value
- BSV - Below Screening Value
- CLR - All chlordane compounds are represented by the summed compound Total chlordanes (see Section 2.2.4 of the text for further clarification).
- DDT - All DDT isomers and breakdown products are represented by the summed compound Total DDTs (see Section 2.2.4 of the text for further clarification).
- NSV - No Screening Value. Discussed in the uncertainty analysis.
- PAH - Not toxicity data; carcinogenic PAHs are represented by the summed compound cPAH (see Section 2.2.4 of the text for further clarification).
- PCB - All Aroclor compounds are represented by the summed compound Total PCBs (see Section 2.2.4 of the text for further clarification).

(6) The compound cPAH is a summation of the following PAHs after conversion to a benzo(a)pyrene equivalent using the potency equivalent factors (PEF) as defined by the California Environmental Protection Agency, Office of Environmental Health Hazard Assessment (California EPA 1994): benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene. The Screening Toxicity factor is for benzo(a)pyrene.

Conc. = concentration

COPC = chemical of potential concern

Table A-2. Intertidal-Subtidal Sediments – Netfishing

Human Health, Lockheed West Site

Exposure Point	CAS Number	Chemical	Mean Conc. (Qualifier) (1)	Minimum Conc. (Qualifier) (1)	Maximum Conc. (Qualifier) (1)	Units	Location of Maximum Conc.	Detection Frequency	Range of Detection Limits	Conc. Used for Screening (2)	Background Value (3)	Screening Value (4)	Basis of Screening Value	COPC Flag (Y/N)	Rationale for Selection or Deletion (5)
Intertidal and Subtidal Sediment	7440-36-0	Antimony	20.3	0.43 [J]	194 [J]	mg/Kg	TT11-SS	51/51	-	194	0.23 / 0.44	45	nc	Y	ASV
	7440-38-2	Arsenic	47.5	4.56	330	mg/Kg	TT-IT-06	51/51	-	330	5.03 / 10.4	1.8	c	Y	ASV
	7440-43-9	Cadmium	0.31	0.04 [B]	0.73	mg/Kg	TT09-SS	51/51	-	0.73	0.36 / 1.12	56	nc	N	BSV
	7440-47-3	Chromium	73.2	14.4	504	mg/Kg	TT18-SS	51/51	-	504	NA	71	c	Y	ASV
	7440-48-4	Cobalt	9.5	3.18 [J]	38.6	mg/Kg	TT-IT-06	51/51	-	38.6	NA	2,100	c	N	BSV
	7440-50-8	Copper	282	28.2	1,900	mg/Kg	TT15-SS	51/51	-	1900	21.3 / 50.8	4,200	nc	N	BSV
	7439-92-1	Lead	146	15.9	1,420	mg/Kg	TT-IT-02	51/51	-	1420	15 / 45	80	nc	Y	ASV
	7439-97-6	Mercury	0.48	0.021*	2.94	mg/Kg	TT17-SS	51/51	-	2.94	0.0981 / 0.327	34	nc	N	BSV
	7439-98-7	Molybdenum	4	0.36	23.8	mg/Kg	TT-IT-06	51/51	-	23.8	NA	570	nc	N	BSV
	7440-02-0	Nickel	28.5	7.29 [J]	151	mg/Kg	TT-IT-08	51/51	-	151	26.8 / 41.7	2,300	nc	N	BSV
	7782-49-2	Selenium	0.58	0.2 [B]	1.2	mg/Kg	TT14-SS, TT15-SS	35/51	0.4-0.5	1.2	NA	570	nc	N	BSV
	7440-22-4	Silver	0.29	0.071	0.703	mg/Kg	TT10-SS	51/51	-	0.703	0.28 / 0.74	570	nc	N	BSV
	7440-28-0	Thallium	0.12	0.033	0.314	mg/Kg	TT-IT-06	51/51	-	0.314	0.252 / 1.79	7.9	nc	N	BSV
	7440-62-2	Vanadium	49.5	22	95.6	mg/Kg	TT18-SS	51/51	-	95.6	36 / 59.6	570	nc	N	BSV
	7440-66-6	Zinc	343	47.5	1,430	mg/Kg	TT11-SS	51/51	-	1430	52.6 / 98.5	100,000	max	N	BSV
	83-32-9	Acenaphthene	75.7	2.8 [J]	450 [D]	µg/kg	TT25-SS	48/51	1.2-1.4	450	NA	3,300,000	nc	N	BSV
	208-96-8	Acenaphthylene	81.9	3 [J]	650 [D]	µg/kg	TT14-SS	50/51	-	650	NA	3,300,000	nc	N	BSV
	120-12-7	Anthracene	282	3.9 [J]	2500 [D]	µg/kg	TT26-SS	50/51	1.8	2500	NA	1.00E+07	max	N	BSV
	191-24-2	Benzo(g,h,i)perylene	290	4.3 [J]	1300 [D]	µg/kg	TT17-SS	51/51	-	1300	NA	NO RBC	ntx	N	NSV
	-	Benzofluoranthenes (total)	1170	5	4,600	µg/kg	TT14-SS	51/51	-	4600	NA	NO RBC	ntx	N	NSV
	-	cPAH	729	4.4	2,911	µg/kg	TT17-SS	51/51	-	2,911	NA	234	c	Y	ASV (6)
	206-44-0	Fluoranthene	1699	4.5 [J]	33000 [D]	µg/kg	TT14-SS	51/51	-	33000	NA	2,400,000	nc	N	BSV
	86-73-7	Fluorene	92.8	2.8 [J]	470 [D]	µg/kg	TT25-SS	48/51	2-2.3	470	NA	2,600,000	nc	N	BSV
	91-20-3	Naphthalene	64.4	2 [J]	610 [D]	µg/kg	TT25-SS	46/51	1.5-47	610	NA	21,000	nc	N	BSV
	85-01-8	Phenanthrene	579	4.5 [J]	3200 [D]	µg/kg	TT17-SS	50/51	1.7	3200	NA	NO RBC	ntx	N	NSV
	129-00-0	Pyrene	1469	3.8 [J]	23000 [D]	µg/kg	TT14-SS	51/51	-	23000	NA	3,200,000	nc	N	BSV
	-	Total HPAH	6921	28.8	70,740	µg/kg	TT14-SS	51/51	-	70740	NA	NO RBC	ntx	N	NSV
	-	Total LPAH	1175	12.9	4,765	µg/kg	TT17-SS	50/51	2.2	4765	NA	NO RBC	ntx	N	NSV
	-	Total PAH	8095	28.8	72,924	µg/kg	TT14-SS	51/51	-	72924	NA	NO RBC	ntx	N	NSV
	-	Butyltin	21.9	0.54	200	µg/kg	TT31-SS	49/51	0.2-0.72	200	NA	NO RBC	ntx	N	NSV

Table A-2. Intertidal-Subtidal Sediments – Netfishing (continued)

Exposure Point	CAS Number	Chemical	Mean Conc. (Qualifier) (1)	Minimum Conc. (Qualifier) (1)	Maximum Conc. (Qualifier) (1)	Units	Location of Maximum Conc.	Detection Frequency	Range of Detection Limits	Conc. Used for Screening (2)	Background Value (3)	Screening Value (4)	Basis of Screening Value	COPC Flag (Y/N)	Rationale for Selection or Deletion (5)
	-	Dibutyltin	202	3.1	1400 [D]	µg/kg	TT31-SS	51/51	-	1400	NA	NO RBC	ntx	N	NSV
	1191-48-7	Tetrabutyltin	15.2	0.31 [J]	120	µg/kg	TT09-SS	43/51	0.081-0.46	120	NA	NO RBC	ntx	N	NSV
	-	Tributyltin	665	0.81 [J]	4500 [D]	µg/kg	TT30-SS	51/51	-	4500	NA	21,000	nc	N	BSV
	95-50-1	1,2-Dichlorobenzene	2.7 [J]	2.7 [J]	2.7 [J]	µg/kg	TT15-SS	1/51	1.5-47	2.7	NA	37,000	sat	N	BDF
	106-46-7	1,4-Dichlorobenzene	3.8	3.5 [J]	9.9 [J]	µg/kg	TT15-SS	5/51	2.2-69	9.9	NA	8,100	c	N	BSV
	90-12-0	1-Methylnapthalene	10.4	3.3 [J]	160 [J]	µg/kg	TT25-SS	8/51	2.6-360	160	NA	NO RBC	ntx	N	NSV
	91-57-6	2-Methylnaphthene	27.5	1.6 [J]	190 [D]	µg/kg	TT25-SS	42/51	1.4-44	190	NA	NO RBC	ntx	N	NSV
	95-48-7	2-Methylphenol	16	16	16	µg/kg	TT15-SS	1/51	4-130	16	NA	3,400,000	nc	N	BDF
	106-44-5	4-Methylphenol	11.9	4.1 [J]	83	µg/kg	TT13-SS	20/51	3.4-110	83	NA	340,000	ntx	N	BSV
	-	4-Nitroaniline	40.5	26 [JD]	55 [JD]	µg/kg	TT40-SS	2/51	4-130	55	NA	200,000	nc	N	BDF
	62-53-3	Aniline	13 [JD]	13 [JD]	13 [JD]	µg/kg	TT06-SS	1/51	1.8-54	13	NA	NO RBC	ntx	N	BDF
	100-51-6	Benzyl alcohol	6.6	6.3 [J]	14 [J]	µg/kg	TT15-SS	6/51	4.3-140	14	NA	1.00E+07	max	N	BSV
	117-81-7	bis(2-ethylhexyl)phthalate	199	28 [J]	740 [D]	µg/kg	TT08-SS	43/51	3.2-230	740	NA	140,000	c	N	BSV
	-	Butyl benzyl phthalate	16.8	3.3 [J]	96 [JD]	µg/kg	TT17-SS	30/51	1.8-96	96	NA	24,000	sat	N	BSV
	132-64-9	Dibenzofuran	49.1	2.2 [J]	400 [D]	µg/kg	TT25-SS	47/51	1.5-47	400	NA	170,000	nc	N	BSV
	84-66-2	Diethylphthalate	12	12	12	µg/kg	TT12-SS	1/51	4.1-130	12	NA	1.00E+07	max	N	BDF
	131-11-3	Dimethyl phthalate	4.3	5.3 [J]	11 [JD]	µg/kg	TT06-SS	2/51	2.1-65	11	NA	1.00E+07	max	N	BDF
	84-74-2	Di-n-butyl phthalate	18.6	3.5 [J]	69 [JD]	µg/kg	TT17-SS	47/51	20-94	69	NA	6,800,000	nc	N	BSV
	117-84-0	Di-n-octyl phthalate	2600 [D]	2600 [D]	2600 [D]	µg/kg	TT-IT-08	1/51	1.4-44	2600	NA	NO RBC	ntx	N	BDF
	118-74-1	Hexachlorobenzene	2.5	2 [JN]	2.9 [JN]	µg/kg	TT18-SS	2/51	0.091-3.1	2.9	NA	1,200	c	N	BDF
	62-75-9	N-Nitrosodimethylamine	38 [J]	38 [J]	38 [J]	µg/kg	TT15-SS	1/51	7.1-220	38	NA	38	c	N	BDF
	87-86-5	Pentachlorophenol	82.9	16	570 [JD]	µg/kg	TT30-SS	21/51	9.8-78	570	NA	10,000	c	N	BSV
	108-95-2	Phenol	33.4	5.4 [J]	130	µg/kg	TT13-SS	44/51	2.2-69	130	NA	1.00E+07	max	N	BSV
	11097-69-1	Aroclor -1254	211	4.2	1400 [D]	µg/kg	TT40-SS	51/51	-	1400	NA	740	c	Y	PCB
	-	Aroclor -1260	151	7.6	900 [J]	µg/kg	TT17-SS	46/51	2.2-15	900	NA	740	c	Y	PCB
	-	Aroclor -1268	29.7	23	160 [D]	µg/kg	TT22-SS	7/51	2.0-33	160	NA	NO RBC	ntx	N	PCB
	-	PCBs (total)	370	4.2	2,240	µg/kg	TT17-SS	51/51	-	2240	NA	860	c	Y	ASV
	959-98-8	Endosulfan I	16 [JN]	16 [JN]	16 [JN]	µg/kg	TT40-SS	1/51	0.2-8	16	NA	410,400	nc	N	BDF

Table A-2. Intertidal-Subtidal Sediments – Netfishing (continued)

Exposure Point	CAS Number	Chemical	Mean Conc. (Qualifier) (1)	Minimum Conc. (Qualifier) (1)	Maximum Conc. (Qualifier) (1)	Units	Location of Maximum Conc.	Detection Frequency	Range of Detection Limits	Conc. Used for Screening (2)	Background Value (3)	Screening Value (4)	Basis of Screening Value	COPC Flag (Y/N)	Rationale for Selection or Deletion (5)
	7421-93-4	Endrin Aldehyde	2.2	0.82 [JN]	17 [JN]	µg/kg	TT40-SS	12/51	0.062-10	17	NA	21,000	nc	N	BSV
	-	gamma-BHC	25 [JN]	25 [JN]	25 [JN]	µg/kg	TT17-SS	1/51	0.18-5.8	25	NA	399	c	N	BDF
	57-74-9	gamma-Chlordane	5.5	0.14 [JN]	46 [JN]	µg/kg	TT17-SS	29/51	0.075-5	46	NA	7,200	c	N	CLR
	1024-57-3	Heptachlor epoxide	0.5 [JN]	0.5 [JN]	0.5 [JN]	µg/kg	TT-IT-07	1/51	0.15-10	0.5	NA	210	c	N	BDF
	72-43-5	Methoxychlor	7.8	11 [JN]	15 [JN]	µg/kg	TT30-SS	4/51	0.12-6.3	15	NA	340,000	nc	N	BSV
	2385-85-5	Mirex	0.45	0.2 [JN]	3 [JN]	µg/kg	TT30-SS	5/51	0.12-10	3	NA	1,100	c	N	BSV
	3734-49-4	Nonachlor (cis)	15 [JN]	15 [JN]	15 [JN]	µg/kg	TT08-SS	1/51	0.096-10	15	NA	NO RBC	ntx	N	BDF
	3734-49-4	Nonachlor (trans)	6.5	5.5 [JN]	7.5 [JN]	µg/kg	TT04-SS	2/51	0.11-10	7.5	NA	NO RBC	ntx	N	BDF
	53-19-0	o,p-DDD	13.3	1.1 [JN]	110 [JN]	µg/kg	TT17-SS	28/51	0.25-29	110	NA	11,000	c	N	DDT
	789-02-6	o,p-DDT	14	0.36 [JN]	90 [JN]	µg/kg	TT40-SS	42/51	0.17-4.6	90	NA	7,800	c	N	DDT
	72-54-8	p,p-DDD	3.8	3.1 [JN]	14 [JN]	µg/kg	TT17-SS	12/51	0.14-4.7	14	NA	11,000	c	N	DDT
	72-55-9	p,p-DDE	1.8 [JN]	1.8 [JN]	1.8 [JN]	µg/kg	TT05-SS	1/51	0.12-10	1.8	NA	7,800	c	N	BDF
	50-29-3	p,p'-DDT	15.11	0.28 [JN]	97 [JN]	µg/kg	TT17-SS	41/51	0.67-120	97	NA	7,800	c	N	DDT
	-	Total DDT	16.3	28 [JN]	294 [JN]	µg/kg	TT17-SS	49/51	6.5-6.7	295	NA	7,800	c	N	BSV
	-	Total Chlordanes	3.8	0.14 [JN]	46 [JN]	µg/kg	TT17-SS	29/51	0.44-14	46	NA	7200	c	N	BSV

Footnotes:

- = Not applicable or not available
nc - non-carcinogenicity; c - carcinogenicity; max - ceiling limit; ntx - no toxicity data
(1) Qualifier Definitions: B - compound also detected in a blank sample; D - Diluted; J - Estimated; N - tentatively identified compound, pending confirmation
(2) The maximum detected concentration is the concentration used for screening. Screening was performed against the Screening Toxicity Value only - background values are shown for discussion purpose only.
(3) Background concentrations obtained from joint Ecology/PSAMP 1998 study entitled "Sediment Quality in Puget Sound. Year 2- Central Puget Sound" (Ecology 2000). Reported concentrations are mean and maximum from 52 sediment samples collected from the following areas: South Port Townsend, Port Townsend, North Admiralty Inlet, South Admiralty Inlet, Possession Sound, Central Basin, Port Madison, West Point, East Passage, Liberty Bay, Keyport, Northwest Bainbridge Island, Southwest Bainbridge Island, Rich Passage, Port Orchard, and Port Washington Narrows.
(4) RBCs for direct sediment contact are industrial-based criteria for soil exposures that are applied to the netfishing exposures. Direct exposure screening criteria are updated with Region 6 values for industrial exposures to soil; the lower of criteria for carcinogenic or noncarcinogenic effects are shown, with criteria for noncarcinogenic effects modified by a factor of 0.1 as per Region 10 guidance.
(5) Rationale Codes:
ASV - Above Screening Value
BDF - Below 5% Detection Frequency
BSV - Below Screening Value
CLR - All chlordane compounds are represented by the summed compound Total chlordanes (see Section 2.2.3 of the text for further clarification).
DDT - All DDT isomers and breakdown products are represented by the summed compound Total DDTs (see Section 2.2.3 of the text for further clarification).
NSV - No Screening Value. To be discussed in the uncertainty analysis.
PAH - Carcinogenic PAHs are represented by the summed compound cPAH (see Section 2.2.3 of the text for further clarification).
PCB - All Aroclor compounds are represented by the summed compound Total PCBs (see Section 2.2.3 of the text for further clarification).
(6) The compound cPAH is a summation of the following PAHs after conversion to a benzo(a)pyrene equivalent using the potency equivalent factors (PEF) as defined by the California Environmental Protection Agency, Office of Environmental Health Hazard Assessment (California EPA 1994): benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene. The Screening Toxicity factor is for benzo(a)pyrene.
Conc. = concentration
COPC = chemical of potential concern
RBC = risk-based concentration

Table A-3. Intertidal-Subtidal Sediments - Seafood Consumption

Human Health, Lockheed West Site

Exposure Point	CAS Number	Chemical	Mean Conc. (Qualifier) (1)	Minimum Conc. (Qualifier) (1)	Maximum Conc. (Qualifier) (1)	Units	Location of Maximum Conc.	Detection Frequency	Range of Detection Limits	Conc. Used for Screening (2)	Background Value (3)	Sediment Screening Value (4)	COPC Flag (Y/N)	Rationale for Selection or Deletion (5)
Sediment; screening toxicity value modeled from risk-based concentration s in seafood tissue.	**Metals**													
	7440-36-0	Antimony	20.3	0.43 [J]	194 [J]	mg/Kg	TT11-SS	51/51	-	194	0.23 / 0.44	3.1	N	NBC
	7440-38-2	Arsenic	47.5	4.56	330	mg/Kg	TT-IT-06	51/51	-	330	5.03 / 10.4	0.004	Y	ASV
	7440-43-9	Cadmium	0.31	0.04 [B]	0.73	mg/Kg	TT09-SS	51/51	-	0.73	0.36 / 1.12	0.001	Y	ASV
	7440-47-3	Chromium	73.2	14.4	504	mg/Kg	TT18-SS	51/51	-	504	NA	77.2	Y	ASV
	7440-48-4	Cobalt	9.5	3.18 [J]	38.6	mg/Kg	TT-IT-06	51/51	-	38.6	NA	900	N	BSV
	7440-50-8	Copper	282	28.2	1,900	mg/Kg	TT15-SS	51/51	-	1900	21.3 / 50.8	9.8	Y	ASV
	7439-92-1	Lead	146	15.9	1,420	mg/Kg	TT-IT-02	51/51	-	1420	15 / 45	40	Y	ASV
	7439-97-6	Mercury	0.48	0.021	2.94	mg/Kg	TT17-SS	51/51	-	2.94	0.0981 / 0.327	0.036	Y	ASV
	7439-98-7	Molybdenum	4	0.36	23.8	mg/Kg	TT-IT-06	51/51	-	23.8	NA	39	N	BSV
	7440-02-0	Nickel	28.5	7.29 [J]	151	mg/Kg	TT-IT-08	51/51	-	151	26.8 / 41.7	160	N	BSV
	7782-49-2	Selenium	0.58	0.2 [B]	1.2	mg/Kg	TT14-SS, TT15-SS	35/51	0.4-0.5	1.2	NA	39	N	BSV
	7440-22-4	Silver	0.29	0.071	0.703	mg/Kg	TT10-SS	51/51	-	0.703	0.28 / 0.74	39	N	BSV
	7440-28-0	Thallium	0.12	0.033	0.314	mg/Kg	TT-IT-06	51/51	-	0.314	0.252 / 1.79	0.52	N	BSV
	7440-62-2	Vanadium	49.5	22	95.6	mg/Kg	TT18-SS	51/51	-	95.6	36 / 59.6	55	N	NBC
	7440-66-6	Zinc	343	47.5	1,430	mg/Kg	TT11-SS	51/51	-	1430	52.6 / 98.5	12.1	Y	ASV
	PAHs													
	83-32-9	Acenaphthene	75.7	2.8 [J]	450 [D]	µg/kg	TT25-SS	48/51	1.2-1.4	450	NA	443000	N	BSV
	208-96-8	Acenaphthylene	81.9	3 [J]	650 [D]	µg/kg	TT14-SS	50/51	-	650	NA	443000	N	BSV
	120-12-7	Anthracene	282	3.9 [J]	2500 [D]	µg/kg	TT26-SS	50/51	1.8	2500	NA	692000	N	BSV
	191-24-2	Benzo(g,h,i)perylen e	290	4.3 [J]	1300 [D]	µg/kg	TT17-SS	51/51	-	1300	NA	3321	N	BSV
	-	Benzofluoranthenes (total)	1170	5	4,600	µg/kg	TT14-SS	51/51	-	4600	NA	29	N	PAH
	-	cPAH	729	4.4	2,911	µg/kg	TT17-SS	51/51	-	2911	NA	0.47	Y	ASV (6)
	206-44-0	Fluoranthene	1699	4.5 [J]	33000 [D]	µg/kg	TT14-SS	51/51	-	33000	NA	1703	Y	ASV
	86-73-7	Fluorene	92.8	2.8 [J]	470 [D]	µg/kg	TT25-SS	48/51	2-2.3	470	NA	692000	N	BSV
	91-20-3	Naphthalene	64.4	2 [J]	610 [D]	µg/kg	TT25-SS	46/51	1.5-47	610	NA	3410	N	BSV
	85-01-8	Phenanthrene	579	4.5 [J]	3200 [D]	µg/kg	TT17-SS	50/51	1.7	3200	NA	3320	N	BSV
	129-00-0	Pyrene	1469	3.8 [J]	23000 [D]	µg/kg	TT14-SS	51/51	-	23000	NA	3320	Y	ASV
	-	Total HPAH	6921	28.8	70,740	µg/kg	TT14-SS	51/51	-	70740	NA	NA	N	NSV
	-	Total LPAH	1175	12.9	4,765	µg/kg	TT17-SS	50/51	2.2	4765	NA	NA	N	NSV
	-	Total PAH	8095	28.8	72,924	µg/kg	TT14-SS	51/51	-	72924	NA	NA	N	NSV

Table A-3. Intertidal-Subtidal Sediments - Seafood Consumption (continued)

Exposure Point	CAS Number	Chemical	Mean Conc. (Qualifier) (1)	Minimum Conc. (Qualifier) (1)	Maximum Conc. (Qualifier) (1)	Units	Location of Maximum Conc.	Detection Frequency	Range of Detection Limits	Conc. Used for Screening (2)	Background Value (3)	Sediment Screening Value (4)	COPC Flag (Y/N)	Rationale for Selection or Deletion (5)
Organometals														
	-	Butyltin	21.9	0.54	200	µg/kg	TT31-SS	49/51	0.2-0.72	200	NA	NA	N	NSV
	-	Dibutyltin	202	3.1	1400 [D]	µg/kg	TT31-SS	51/51	-	1400	NA	NA	N	NSV
	1191-48-7	Tetrabutyltin	15.2	0.31 [J]	120	µg/kg	TT09-SS	43/51	0.081-0.46	120	NA	NA	N	NSV
	-	Tributyltin	665	0.81 [J]	4500 [D]	µg/kg	TT30-SS	51/51	-	4500	NA	0.4	Y	ASV
	SVOCs													
	95-50-1	1,2-Dichlorobenzene	2.7 [J]	2.7 [J]	2.7 [J]	µg/kg	TT15-SS	1/51	1.5-47	2.7	-	9960	N	BDF
	106-46-7	1,4-Dichlorobenzene	3.8	3.5 [J]	9.9 [J]	µg/kg	TT15-SS	5/51	2.2-69	9.9	NA	3320	N	BSV
	90-12-0	1-Methylnapthalene	10.4	3.3 [J]	160 [J]	µg/kg	TT25-SS	8/51	2.6-360	160	NA	NA	N	NSV
	91-57-6	2-Methylnaphthene	27.5	1.6 [J]	190 [D]	µg/kg	TT25-SS	42/51	1.4-44	190	NA	259	N	BSV
	95-48-7	2-Methylphenol	16	16	16	µg/kg	TT15-SS	1/51	4-130	16	-	310,000	N	BDF
	106-44-5	4-Methylphenol	11.9	4.1 [J]	83	µg/kg	TT13-SS	20/51	3.4-110	83	NA	852	N	BSV
	-	4-Nitroaniline	40.5	26 [JD]	55 [JD]	µg/kg	TT40-SS	2/51	4-130	55	-	NA	N	BDF
	62-53-3	Aniline µg/kg	13 [JD]	13 [JD]	13 [JD]	µg/kg	TT06-SS	1/51	1.8-54	13	-	85,000	N	BDF
	100-51-6	Benzyl alcohol	6.6	6.3 [J]	14 [J]	µg/kg	TT15-SS	6/51	4.3-140	14	NA	1,800,000	N	BSV
	117-81-7	bis(2-ethylhexyl)phthalate	199	28 [J]	740 [D]	µg/kg	TT08-SS	43/51	3.2-230	740	NA	79	N	NBC
	-	Butyl benzyl phthalate	16.8	3.3 [J]	96 [JD]	µg/kg	TT17-SS	30/51	1.8-96	96	NA	22100	N	BSV
	132-64-9	Dibenzofuran	49.1	2.2 [J]	400 [D]	µg/kg	TT25-SS	47/51	1.5-47	400	NA	111	N	NBC
	84-66-2	Diethylphthalate	12	12	12	µg/kg	TT12-SS	1/51	4.1-130	12	-	88,600	N	BDF
	131-11-3	Dimethyl phthalate	4.3	5.3 [J]	11 [JD]	µg/kg	TT06-SS	2/51	2.1-65	11	NA	100,000,000	N	BDF
	84-74-2	Di-n-butyl phthalate	18.6	3.5 [J]	69 [JD]	µg/kg	TT17-SS	47/51	20-94	69	NA	11,100	N	BSV
	117-84-0	Di-n-octyl phthalate	2600 [D]	2600 [D]	2600 [D]	µg/kg	TT-IT-08	1/51	1.4-44	2600	-	240,000	N	BDF
	118-74-1	Hexachlorobenzene	2.5	2 [JN]	2.9 [JN]	µg/kg	TT18-SS	2/51	0.091-3.1	2.9	NA	300	N	BDF
	62-75-9	N-Nitrosodimethylamine	38 [J]	38 [J]	38 [J]	µg/kg	TT15-SS	1/51	7.1-220	38	-	9.5	N	BDF
	87-86-5	Pentachlorophenol	82.9	16	570 [JD]	µg/kg	TT30-SS	21/51	9.8-78	570	NA	14	Y	ASV
	108-95-2	Phenol	33.4	5.4 [J]	130	µg/kg	TT13-SS	44/51	2.2-69	130	NA	9	N	NBC

Table A-3. Intertidal-Subtidal Sediments - Seafood Consumption (continued)

Exposure Point	CAS Number	Chemical	Mean Conc. (Qualifier) (1)	Minimum Conc. (Qualifier) (1)	Maximum Conc. (Qualifier) (1)	Units	Location of Maximum Conc.	Detection Frequency	Range of Detection Limits	Conc. Used for Screening (2)	Background Value (3)	Sediment Screening Value (4)	COPC Flag (Y/N)	Rationale for Selection or Deletion (5)
	PCBs													
	11097-69-1	Aroclor -1254	211	4.2	1400 [D]	µg/kg	TT40-SS	51/51	-	1400	NA	0.1	N	PCB
	-	Aroclor -1260	151	7.6	900 [J]	µg/kg	TT17-SS	46/51	2.2-15	900	NA	0.1	N	PCB
	-	Aroclor -1268	29.7	23	160 [D]	µg/kg	TT22-SS	7/51	2.0-33	160	NA	0.1	N	PCB
	-	PCBs (total)	370	4.2	2,240	µg/kg	TT17-SS	51/51	-	2240	NA	0.1	Y	ASV
	Pesticides													
	959-98-8	Endosulfan I	16 [JN]	16 [JN]	16 [JN]	µg/kg	TT40-SS	1/51	0.2-8	16	-	410	N	BDF
	7421-93-4	Endrin Aldehyde	2.2	0.82 [JN]	17 [JN]	µg/kg	TT40-SS	12/51	0.062-10	17	NA	NA	N	NSV
	-	gamma-BHC	25 [JN]	25 [JN]	25 [JN]	µg/kg	TT17-SS	1/51	0.18-5.8	25	-	1	N	BDF
	57-74-9	gamma-Chlordane	5.5	0.14 [JN]	46 [JN]	µg/kg	TT17-SS	29/51	0.075-5	46	NA	1	N	CLR
	1024-57-3	Heptachlor epoxide	0.5 [JN]	0.5 [JN]	0.5 [JN]	µg/kg	TT-IT-07	1/51	0.15-10	0.5	-	53	N	BDF
	72-43-5	Methoxychlor	7.8	11 [JN]	15 [JN]	µg/kg	TT30-SS	4/51	0.12-6.3	15	NA	342	N	BSV
	2385-85-5	Mirex	0.45	0.2 [JN]	3 [JN]	µg/kg	TT30-SS	5/51	0.12-10	3	NA	270	N	BSV
	3734-49-4	Nonachlor (cis)	15 [JN]	15 [JN]	15 [JN]	µg/kg	TT08-SS	1/51	0.096-10	15	-	NA	N	BDF
	3734-49-4	Nonachlor (trans)	6.5	5.5 [JN]	7.5 [JN]	µg/kg	TT04-SS	2/51	0.11-10	7.5	-	NA	N	BDF
	53-19-0	o,p-DDD	13.3	1.1 [JN]	110 [JN]	µg/kg	TT17-SS	28/51	0.25-29	110	NA	NA	N	DDT
	789-02-6	o,p-DDT	14	0.36 [JN]	90 [JN]	µg/kg	TT40-SS	42/51	0.17-4.6	90	NA	NA	N	DDT
	72-54-8	p,p-DDD	3.8	3.1 [JN]	14 [JN]	µg/kg	TT17-SS	12/51	0.14-4.7	14	NA	5	N	DDT
	72-55-9	p,p-DDE	1.8 [JN]	1.8 [JN]	1.8 [JN]	µg/kg	TT05-SS	1/51	0.12-10	1.8	-	2	N	BDF
	50-29-3	p,p'-DDT	15.11	0.28 [JN]	97 [JN]	µg/kg	TT17-SS	41/51	0.67-120	97	NA	1	N	DDT
	-	Total DDT	16.3	28 [JN]	294 [JN]	µg/kg	TT17-SS	49/51	6.5-6.7	295	NA	1	Y	ASV
	-	Total Chlordanes	3.8	0.14 [JN]	46 [JN]	µg/kg	TT17-SS	29/51	0.44-14	46	-	1	Y	ASV

Footnotes:

- = Not applicable or not available

(1) Qualifier Definitions: B - compound also detected in a blank sample; D - Diluted; J - Estimated; N - tentatively identified compound, pending confirmation

(2) The maximum detected concentration is the concentration used for screening. Screening was performed against the Screening Toxicity Value only - background values are shown for discussion purpose only.

(3) Background concentrations obtained from joint Ecology/PSAMP 1998 study entitled “Sediment Quality in Puget Sound. Year 2- Central Puget Sound” (Ecology 2000). Reported concentrations are mean and maximum from 52 sediment samples collected from the following areas: South Port Townsend, Port Townsend, North Admiralty Inlet, South Admiralty Inlet, Possession Sound, Central Basin, Port Madison, West Point, East Passage, Liberty Bay, Keyport, Northwest Bainbridge Island, Southwest Bainbridge Island, Rich Passage, Port Orchard, and Port Washington Narrows.

(4) Screening values are developed in Table A-4. Sediment screening values are based on back-calculation from acceptable risk threshold and tissue concentrations using BSAFs, as described in text. BSAFs for the screening exercise were taken from Appendix D-1, QAPP for benthic invertebrate sampling in the LDW (Windward 2004b).

NA=Toxicity data not available or not applicable (if not a bioaccumulative chemical for seafood consumption exposures).

NO BSAF=this chemical was identified as an important bioaccumulative chemical by EPA (2000a), but no BSAF is available, so no RBC for indirect exposure was calculated.

Table A-3. Intertidal-Subtidal Sediments - Seafood Consumption (continued)

(5) Rationale Codes:

ASV - Above Screening Value

BDF - Below 5% Detection Frequency

BSV - Below Screening Value

CLR - All chlordane compounds are represented by the surrogate compound Total chlordanes (see Section 2.2.3 of the text for further clarification).

DDT - All DDT isomers and breakdown products are represented by the surrogate compound Total DDTs (see Section 2.2.3 of the text for further clarification).

NBC - Not on EPA's Bioaccumulative Compound list.

NSV - No Screening Value. To be discussed in the uncertainty analysis.

PAH - All PAHs are represented by the surrogate compound cPAH (see Section 2.2.3 of the text for further clarification).

(6) The compound cPAH is a summation of the following PAH's after conversion to a benzo(a)pyrene equivalent using the potency equivalent factors (PEF) as defined by the California Environmental Protection Agency, Office of Environmental Health Hazard Assessment (California EPA 1994): benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene. The Screening Toxicity factor is for benzo(a)pyrene.

Conc. = concentration

COPC = chemical of potential concern

RBC = risk-based concentration

BSAF = biota-sediment accumulation factor

Table A-4. Development of Sediment Screening Values for Seafood Consumption

	Sediment Screening Concentration (mg/kg dw)[1]	Basis	Cancer Slope Factor (CSF)	Reference Dose (RfD)	Modeled Tissue Concentration (mg/kg ww)[2]	F_L	F_{oc}	BSAF[8]	BSAF Reference
Metals									
Antimony	3.1	(8)		0.0004	0.033	0.0095	0.0126	na	na
Arsenic	0.004	c	1.5	0.0003	0.006	0.0095	0.0126	0.2	2
Cadmium	0.001	nc	-	0.001	0.083	0.0095	0.0126	77	2
Chromium	77.2	nc	-	0.003	0.250	0.0095	0.0126	0.0043	3
Cobalt	900	(8)	na	na	Na	0.0095	0.0126	na	na
Copper	9.84	nc	-	0.04	3.339	0.0095	0.0126	0.45	3
Lead	40	(8)	na	na	Na	0.0095	0.0126	1.3	3
Mercury	0.036	nc	-	0.0003	0.025	0.0095	0.0126	0.92	3
Molybdenum	39	nc	-	0.005	0.417	0.0095	0.0126	na	na
Nickel	160	nc	-	0.02	1.669	0.0095	0.0126	na	na
Selenium	39	nc	-	0.005	0.417	0.0095	0.0126	na	na
Silver	39	nc	-	0.005	0.417	0.0095	0.0126	na	na
Thallium	0.52	nc	-	0.00007	0.006	0.0095	0.0126	na	na
Tri-n-butyltin	0.0004	nc	-	0.0003	0.025	0.0095	0.0126	75	3
Vanadium	55	nc	-	0.001	0.083	0.0095	0.0126	na	na
Zinc	12.1	nc	-	0.3	25.041	0.0095	0.0126	2.75	3
PAHs									
Acenaphthene	443	nc	-	0.06	5.01	0.0095	0.0126	0.015	3
Acenaphthylene[6]	443	ntx	na	na	Na	0.0095	0.0126	na	na
Anthracene	692	nc	-	0.3	25.04	0.0095	0.0126	0.048	3
Benzo(a)anthracene	0.003	c	0.73	-	0.0011	0.0095	0.0126	0.47	3
Benzo(a)pyrene	0.00047	c	7.3	-	0.0001	0.0095	0.0126	0.32	3
Benzo(b)fluoranthene	0.003	c	0.73	-	0.0011	0.0095	0.0126	0.52	3
Benzo(g,h,i)perylene[4]	3.3	ntx	na	na	Na	0.0095	0.0126	na	na
Benzo(k)fluoranthene	0.029	c	0.073	-	0.0114	0.0095	0.0126	0.52	3
Benzofluoranthenes (total)[5]	0.029	-	na	na		0.0095	0.0126	na	na
Chrysene	0.297	c	0.0073	-	0.1143	0.0095	0.0126	0.51	3
Dibenzo(a,h)anthracene[4]	3.3	c	7.3	-	0.0001	0.0095	0.0126	na	na

Table A-4. Development of Sediment Screening Values for Seafood Consumption (continued)

	Sediment Screening Concentration (mg/kg dw)[1]	Basis	Cancer Slope Factor (CSF)	Reference Dose (RfD)	Modeled Tissue Concentration (mg/kg ww)[2]	F_L	F_{oc}	BSAF[8]	BSAF Reference
Fluoranthene	1.703	nc	-	0.04	3.34	0.0095	0.0126	2.6	3
Fluorene[6]	692	nc	-	0.04	3.34	0.0095	0.0126	na	na
Indeno(1,2,3-cd)pyrene	0.002	c	0.73	-	0.0011	0.0095	0.0126	0.83	3
2-Methylnaphthalene	0.259	nc	-	0.004	0.33	0.0095	0.0126	1.71	1
Naphthalene	3.41	nc	-	0.02	1.67	0.0095	0.0126	0.65	3
Phenanthrene[4]	3.32	nc	na	na	Na	0.0095	0.0126	na	na
Pyrene	3.32	nc	-	0.03	2.504	0.0095	0.0126	0.49	3
Dibenzofuran	0.111	nc	-	0.001	0.083	0.0095	0.0126	1	1
Total LPAHs	na	ntx	na	na	na	0.0095	0.0126	na	na
Total HPAHs	na	ntx	na	na	na	0.0095	0.0126	na	na
Total PAHs	na	ntx	na	na	na	0.0095	0.0126	na	na
Other SVOCs									
1,2,4-Trichlorobenzene	65	(8)	-	0.01	0.835	0.0095	0.0126	na	na
1,2-Dichlorobenzene	9.96	nc	-	0.09	7.512	0.0095	0.0126	1	1
1,3-Dichlorobenzene	1.6	(8)	-	0.003	0.250	0.0095	0.0126	na	na
1,4-Dichlorobenzene	3.32	nc	-	0.03	2.504	0.0095	0.0126	1	1
2,4,5-Trichlorophenol	28.4	nc	-	0.1	8.347	0.0095	0.0126	0.39	2
2,4,6-Trichlorophenol	0.61	(8)	-	0.001	0.083	0.0095	0.0126	na	na
2,4-Dichlorophenol	0.85	nc	-	0.003	0.250	0.0095	0.0126	0.39	2
2,4-Dimethylphenol	120	(8)	-	0.02	1.669	0.0095	0.0126	na	na
2,4-Dinitrophenol	12	(8)	-	0.002	0.167	0.0095	0.0126	na	na
2,4-Dinitrotoluene	12	(8)	-	0.002	0.167	0.0095	0.0126	na	na
2,6-Dinitrotoluene	6.1	(8)	-	0.001	0.083	0.0095	0.0126	na	na
2-Chloronaphthalene	490	(8)	-	0.08	6.678	0.0095	0.0126	na	na
2-Chlorophenol	1.42	nc	-	0.005	0.417	0.0095	0.0126	0.39	2
2-Methylphenol	310	(8)	-	0.05	4.173	0.0095	0.0126	na	na
3,3'-Dichlorobenzidine	1.1	(8)	0.45	-	0.0019	0.0095	0.0126	na	na
4-Chloroaniline	24	(8)	-	0.004	0.334	0.0095	0.0126	na	na
4-Methylphenol	0.852	nc	-	0.003	0.250	0.0095	0.0126	0.39	2
4-Nitrophenol	Na	ntx	na	na	na	0.0095	0.0126	na	na
Aniline	85	(8)	0.0057	0.007	0.1464	0.0095	0.0126	na	na
Benzidine	Na	ntx	na	na	na	0.0095	0.0126	na	na
Benzoic acid	100,000	(8)	-	4	333.9	0.0095	0.0126	na	na

Table A-4. Development of Sediment Screening Values for Seafood Consumption (continued)

	Sediment Screening Concentration (mg/kg dw)[1]	Basis	Cancer Slope Factor (CSF)	Reference Dose (RfD)	Modeled Tissue Concentration (mg/kg ww)2	FL	Foc	BSAF8	BSAF Reference
Benzyl alcohol	1,800	(8)	-	0.5	41.7	0.0095	0.0126	na	na
Bis(2-chloroethyl)ether	0.210	(8)	1.1	-	0.0008	0.0095	0.0126	na	na
Bis(2-chloroisopropyl)ether	2.9	(8)	0.07	0.04	0.0119	0.0095	0.0126	na	na
Bis(2-ethylhexyl)phthalate	0.079	c	0.014	0.02	0.0596	0.0095	0.0126	1	1
Butyl benzyl phthalate	22.1	nc	-	0.2	16.7	0.0095	0.0126	1	1
Di-ethyl phthalate	88.6	nc	-	0.8	66.8	0.0095	0.0126	1	1
Dimethyl phthalate	100,000	(8)	na	na	na	0.0095	0.0126	1	1
Di-n-butyl phthalate	11.1	nc	-	0.1	8.347	0.0095	0.0126	1	1
Di-n-octyl phthalate	240	(8)	na	na	na	0.0095	0.0126	1	1
Hexachlorobenzene	0.3	(8)	1.6	0.0008	0.0005	0.0095	0.0126	na	na
Hexachlorobutadiene	0.014	c	0.078	0.001	0.0107	0.0095	0.0126	1	1
Hexachloroethane	0.079	c	0.014	0.001	0.0596	0.0095	0.0126	1	1
Isophorone	510	(8)	0.00095	0.2	0.8786	0.0095	0.0126	na	na
Nitrobenzene	2.0	(8)	-	0.0005	0.042	0.0095	0.0126	na	na
N-Nitrosodimethylamine	0.0095	(8)	51	0.000008	0.00002	0.0095	0.0126	na	na
N-Nitrosodi-n-propylamine	0.069	(8)	7	-	0.0001	0.0095	0.0126	na	na
N-Nitrosodiphenylamine	99	(8)	0.0049	-	0.1703	0.0095	0.0126	na	na
Pentachlorophenol	0.014	c	0.12	0.03	0.0070	0.0095	0.0126	0.68	2
Phenol	0.009	c	0.3	-	0.0028	0.0095	0.0126	0.39	2
PCBs									
Aroclor 1016	0.0018	nc	0.07	0.00007	0.006	0.0095	0.0126	4.26	3
Aroclor 1221	0.0001	c	2	-	0.0004	0.0095	0.0126	4.26	3
Aroclor 1232	0.0001	c	2	-	0.0004	0.0095	0.0126	4.26	3
Aroclor 1242	0.0001	c	2	-	0.0004	0.0095	0.0126	4.26	3
Aroclor 1248	0.0001	c	2	-	0.0004	0.0095	0.0126	4.26	3
Aroclor 1254	0.0001	c	2	0.00002	0.0004	0.0095	0.0126	4.26	3
Aroclor 1260	0.0001	c	2	-	0.0004	0.0095	0.0126	4.26	3
Total PCBs	0.0001	c	2	-	0.0004	0.0095	0.0126	4.26	3
Pesticides									
4,4'-DDD	0.005	c	0.24	-	0.0035	0.0095	0.0126	0.88	3
4,4'-DDE	0.002	c	0.34	-	0.0025	0.0095	0.0126	2.03	3
4,4'-DDT	0.001	c	0.34	-	0.0025	0.0095	0.0126	5.69	3
Total DDT	0.001	c	0.34	-	0.0025	0.0095	0.0126	5.69	3

Table A-4. Development of Sediment Screening Values for Seafood Consumption (continued)

	Sediment Screening Concentration (mg/kg dw)1	Basis	Cancer Slope Factor (CSF)	Reference Dose (RfD)	Modeled Tissue Concentration (mg/kg ww)2	FL	Foc	BSAF8	BSAF Reference
Aldrin	0.002	nc	17	0.00003	0.003	0.0095	0.0126	1.62	4
alpha-BHC	0.090	(8)	6.3	-	0.0001	0.0095	0.0126	na	na
beta-BHC	0.0004	c	1.8	-	0.0005	0.0095	0.0126	1.62	4
alpha-Chlordane	0.001	c	0.35	0.0005	0.0024	0.0095	0.0126	2.97	3
Chlordane[7]	0.001	c	0.35	0.0005	0.0024	0.0095	0.0126	2.97	3
Dieldrin	0.00002	c	16	0.00005	0.0001	0.0095	0.0126	3.43	4
Endosulfan	0.410	nc	-	0.006	0.501	0.0095	0.0126	1.62	4
Endrin	0.021	nc	-	0.0003	0.025	0.0095	0.0126	1.62	4
gamma-BHC (Lindane)	0.001	c	1.3	0.0003	0.0006	0.0095	0.0126	1.62	4
Heptachlor	0.0002	c	4.5	0.0005	0.0002	0.0095	0.0126	1.62	4
Heptachlor epoxide	0.053	c	9.1	0.000013	0.0001	0.0095	0.0126	na	na
Methoxychlor	0.342	nc	-	0.005	0.417	0.0095	0.0126	1.62	4
Mirex	0.270	nc	-	0.0002	0.017	0.0095	0.0126	na	na
Toxaphene	0.440	c	1.1	-	0.0008	0.0095	0.0126	na	na

na – toxicity data not available or not applicable if not a bioaccumulative chemical for seafood consumption exposures.
1. The RBC for a given chemical may be derived from either carcinogenic or non-carcinogenic endpoints. For chemicals with both endpoints, the lower RBC is shown. RBCs for indirect exposures to sediment via seafood consumption are based on the clam RBC, shown as the modeled tissue concentration. See text for more information and for the model algorithm.
2. Tissue concentrations are RBCs modeled from acceptable risk levels for consumption of fish, at 98 g/day, body weight of 79 kg, and the highest clam BSAF. See text for the model algorithm.
3. This chemical was identified as an important bioaccumulative chemical by EPA (2000a), but no BSAF is available, so no RBC for indirect exposure was calculated.
4. Reference dose and BSAF for pyrene used as a surrogate
5. Reference dose and BSAF for benzo(k)fluoranthene used as a surrogate
6. BSAF used from anthracene as a surrogate
7. RBCs for chlordane for human health are based on toxicity of mixtures of chlordane-related compounds (e.g., alpha- and gamma-chlordane, cis- and trans-nonachlor).
8. BSAFs from Table D-1 of the QAPP for benthic invertebrate sampling of the LDW (Windward 2004b).
Foc = fraction of organic carbon in Lockheed West sediment; average organic carbon for 51 subtidal plus intertidal sediment stations is 1.26%, from the 2007 data set for the Lockheed West Data Report.
Fl = fraction lipid in organisms; average lipid content from Puget Sound clams (Tetra Tech 1994), as cited in Windward (2004b)
BSAF references (Windward (2004b):

1 EPA. 1997. The incidence and severity of sediment contamination in surface waters of the United States. Volume 1: national sediment quality survey. EPA 823-R-97-006. US Environmental Protection Agency, Office of Science and Technology, Washington, DC.
2 Washington State Department of Health. 1995. Tier I report, development of sediment quality criteria for the protection of human health. Washington State Department of Health, Olympia, WA.
3 Environmental Residue-Effects Database – bivalve mollusks only
4 Tracey GA, Hansen DJ. 1996. Use of biota-sediment accumulation factors to assess similarity of nonionic organic chemical exposure to benthically-coupled organisms of differing trophic mode. Arch Environ Contam Toxicol 30:467-475.

RBC = risk-based concentration
BSAF = biota-sediment accumulation factor
F_L = fraction of lipid in tissue
F_{OC} = fraction of organic carbon in sediment

APPENDIX B

ANALYSIS OF NON-DETECTED CHEMICALS IN LOCKHEED WEST SEDIMENT

Table B-1. Comparison of Detection Limits with Risk-Based Concentrations

Exposure Point	Compound	Units	Sediment RBC for Seafood Consumption	RBC Netfishing or Clamming	Max. Detection Limit (1)	Discussed in Uncertainty Analysis?
Intertidal-Subtidal	1,2,4-Trichlorobenzene	µg/kg	65,000	26,000	54	NO
Seafood and Netfishing	1,3-Dichlorobenzene	µg/kg	1,600	14,000	58	NO
SVOCs	2,4,5-Trichlorophenol	µg/kg	27,415	680,000	110	NO
	2,4,6-Trichlorophenol	µg/kg	610	170,000	65	NO
	2,4-Dichlorophenol	µg/kg	822	210,000	65	NO
	2,4-Dimethylphenol	µg/kg	120,000	1,400,000	200	NO
	2,4-Dinitrophenol	µg/kg	12,000	140,000	1300	NO
	2,4-Dinitrotoluene	µg/kg	12,000	140,000	110	NO
	2,6-Dinitrotoluene	µg/kg	6,100	68,000	100	NO
	2-Chloronaphthalene	µg/kg	490,000	2,600,000	130	NO
	2-Chlorophenol	µg/kg	1,371	26,000	61	NO
	2-Nitroaniline	µg/kg	NO BSAF	200,000	97	NO
	2-Nitrophenol	µg/kg	NO BSAF	NA	94	No RBC
	3,3-Dichlorobenzidine	µg/kg	1,100	4,300	140	NO
	3-Nitroaniline	µg/kg	NO BSAF	82,000	94	NO
	4,6-Dinitro-o-cresol	µg/kg	NO BSAF	6,200	61	NO
	4-Bromophenyl phenyl ether	µg/kg	NO BSAF	NA	51	No RBC
	4-Chloro-3-methylphenol	µg/kg	NO BSAF	NA	76	No RBC
	4-Chloroaniline	µg/kg	24,000	270,000	76	NO
	4-Chlorophenyl phenyl ether	µg/kg	NO BSAF	NA	72	No RBC
	4-Nitroaniline	µg/kg	NO BSAF	23,000	97	NO
	4-Nitrophenol	µg/kg	NO BSAF	550,000	1100	NO
	Benzoic acid	µg/kg	100,000,000	100,000,000	3500	NO
	bis(2-chloroethoxy)methane	µg/kg	NO BSAF	180,000	47	NO
	bis(2-chloroethyl)ether	µg/kg	210	620	87	NO
	bis(2-chloroisopropyl)ether	µg/kg	2,900	8,200	44	NO
	Hexachlorobutadiene	µg/kg	17	25,000	**19**	YES
	Hexachlorocyclopentadiene	µg/kg	NO BSAF	410,000	540	NO
	Hexachloroethane	µg/kg	97	140,000	79	NO
	Isophorone	µg/kg	510,000	2,000,000	58	NO
	Nitrobenzene	µg/kg	2,000	11,000	72	NO
	N-Nitroso-di-n-propylamine	µg/kg	69	270	**220**	YES
	N-Nitrosodiphenylamine	µg/kg	99,000	390,000	120	NO
	PCB-1016	µg/kg	4,260	24,000	33	NO
	PCB-1221	µg/kg	4,260	830	33	NO
	PCB-1232	µg/kg	4,260	830	33	NO
	PCB-1242	µg/kg	4,260	830	37	NO
	PCB-1248	µg/kg	4,260	830	50	NO
	PCB-1262	µg/kg	NO BSAF	830	33	NO
Pesticides	Aldrin	µg/kg	1.98	100	**5.9**	YES
	alpha-BHC	µg/kg	90	270	11	NO
	alpha-Chlordane	µg/kg	1.31	6,500	**9**	YES
	beta-BHC	µg/kg	0.47	960	**12**	YES

Table B-1. Comparison of Detection Limits with Risk-Based Concentrations (continued)

Exposure Point	Compound	Units	Sediment RBC for Seafood Consumption	RBC Netfishing or Clamming	Max. Detection Limit (1)	Discussed in Uncertainty Analysis?
	delta-BHC	µg/kg	NA	NA	3.6	No RBC
	Dieldrin	µg/kg	0.02	110	**21**	YES
	Endosulfan II	µg/kg	396	370,000	8	NO
	Endosulfan sulfate	µg/kg	1,620	NA	24	NO
	Endrin	µg/kg	20	18,000	7.8	NO
	Heptachlor	µg/kg	0.19	380	**3.2**	YES
	o,p-DDE	µg/kg	NO BSAF	NA	27	No RBC
	Oxychlordane	µg/kg	NO BSAF	NA	15	No RBC
	Toxaphene	µg/kg	440	1,600	**970**	YES
Intertidal	1,2,4-Trichlorobenzene	µg/kg	NA	14,000	2.1	NO
Clamming/Beach Play	1,2-Dichlorobenzene	µg/kg	NA	28,000	1.8	NO
SVOCS	1,3-Dichlorobenzene	µg/kg	NA	6,900	2.2	NO
	1,4-Dichlorobenzene	µg/kg	NA	3,200	2.6	NO
	2,4,5-Trichlorophenol	µg/kg	NA	610,000	4.1	NO
	2,4,6-Trichlorophenol	µg/kg	NA	44,000	2.5	NO
	2,4-Dichlorophenol	µg/kg	NA	18,000	2.5	NO
	2,4-Dimethylphenol	µg/kg	NA	120,000	7.5	NO
	2,4-Dinitrophenol	µg/kg	NA	12,000	49	NO
	2,4-Dinitrotoluene	µg/kg	NA	12,000	3.8	NO
	2,6-Dinitrotoluene	µg/kg	NA	6,100	3.8	NO
	2-Chloronaphthalene	µg/kg	NA	390,000	4.9	NO
	2-Chlorophenol	µg/kg	NA	6,400	2.3	NO
	2-Methylphenol	µg/kg	NA	310,000	4.5	NO
	2-Nitroaniline	µg/kg	NA	NA	3.7	No RBC
	2-Nitrophenol	µg/kg	NA	NA	3.5	No RBC
	3,3-Dichlorobenzidine	µg/kg	NA	1,100	5	NO
	3-Nitroaniline	µg/kg	NA	1,800	3.5	NO
	4,6-Dinitro-o-cresol	µg/kg	NA	610	2.3	NO
	4-Bromophenyl phenyl ether	µg/kg	NA	NA	1.9	No RBC
	4-Chloro-3-methylphenol	µg/kg	NA	NA	2.9	No RBC
	4-Chloroaniline	µg/kg	NA	24,000	2.9	NO
	4-Chlorophenyl phenyl ether	µg/kg	NA	NA	2.7	No RBC
	4-Methylphenol	µg/kg	NA	31,000	4	NO
	4-Nitroaniline	µg/kg	NA	23,000	4.6	NO
	4-Nitrophenol	µg/kg	NA	NA	41	No RBC
	Aniline	µg/kg	NA	85,000	2.1	NO
	Benzoic acid	µg/kg	NA	100,000,000	130	NO
	Benzyl alcohol	µg/kg	NA	1,800,000	5	NO
	bis(2-chloroethoxy)methane	µg/kg	NA	18,000	1.8	NO
	bis(2-chloroethyl)ether	µg/kg	NA	210	3.3	NO
	bis(2-chloroisopropyl)ether	µg/kg	NA	2900	1.7	NO
	Butyl benzyl phthalate	µg/kg	NA	240,000	2.1	NO
	Diethylphthalate	µg/kg	NA	4,900,000	4.8	NO
	Dimethyl phthalate	µg/kg	NA	100,000,000	2.5	NO
	Hexachlorobutadiene	µg/kg	NA	6,200	0.66	NO

Table B-1. Comparison of Detection Limits with Risk-Based Concentrations (continued)

Exposure Point	Compound	Units	Sediment RBC for Seafood Consumption	RBC Netfishing or Clamming	Max. Detection Limit (1)	Discussed in Uncertainty Analysis?
	Hexachlorocyclopentadiene	µg/kg	NA	37,000	21	NO
	Hexachloroethane	µg/kg	NA	35,000	3	NO
	Isophorone	µg/kg	NA	510,000	2.2	NO
	Nitrobenzene	µg/kg	NA	2,000	2.7	NO
	N-Nitrosodimethylamine	µg/kg	NA	2.3	8.3	NO
	N-Nitroso-di-n-propylamine	µg/kg	NA	69	4.4	NO
	N-Nitrosodiphenylamine	µg/kg	NA	99,000	3	NO
	Pentachlorophenol	µg/kg	NA	3,000	12	NO
	PCB-1016	µg/kg	NA	390	2.3	NO
	PCB-1221	µg/kg	NA	220	2.3	NO
	PCB-1232	µg/kg	NA	220	2.3	NO
	PCB-1242	µg/kg	NA	220	2.3	NO
	PCB-1248	µg/kg	NA	220	2.3	NO
	PCB-1262	µg/kg	NA	220	2.3	NO
	PCB-1268	µg/kg	NA	220	2.3	NO
Pesticides	Aldrin	µg/kg	NA	29	0.19	NO
	alpha-BHC	µg/kg	NA	90	0.35	NO
	alpha-Chlordane	µg/kg	NA	1,600	0.31	NO
	beta-BHC	µg/kg	NA	320	0.41	NO
	delta-BHC	µg/kg	NA	NA	0.17	No RBC
	Dieldrin	µg/kg	NA	30	0.64	NO
	Endosulfan I	µg/kg	NA	37000	0.86	NO
	Endosulfan II	µg/kg	NA	37000	0.44	NO
	Endosulfan sulfate	µg/kg	NA	NA	0.11	No RBC
	Endrin	µg/kg	NA	1,800	0.5	NO
	gamma-BHC	µg/kg	NA	440	0.55	NO
	Heptachlor epoxide	µg/kg	NA	53	0.5	NO
	Heptachlor	µg/kg	NA	110	0.11	NO
	Methoxychor	µg/kg	NA	31,000	0.59	NO
	Nonachlor (cis)	µg/kg	NA	NA	0.5	No RBC
	Nonachlor (trans)	µg/kg	NA	NA	0.92	No RBC
	o,p-DDE	µg/kg	NA	NA	1.2	No RBC
	Oxychlordane	µg/kg	NA	NA	0.5	No RBC
	p,p-DDD	µg/kg	NA	2,400	0.5	NO
	p,p-DDE	µg/kg	NA	1,700	0.14	NO

1. Maximum detection limit for those chemicals that were never detected in any sample. Bold value exceeds one of the RBCs.

NA = not applicable, seafood consumption screened against the maximum concentration of both intertidal and subtidal sediment.

YES = Discussed in uncertainty analysis because the reported highest detection limit exceeded an RBC.

APPENDIX C

TOXICITY PROFILES

The following are profiles of the toxicology of the chemicals identified as COPCs in the Lockheed West HHRA. Primary focus is placed on the information basis of the reference doses (RfDs) and cancer slope factors (CSFs) that are used as toxicity values in the estimation of health risk. Toxicity values used to quantify health risks in this HHRA are the RfD and CSF, which were obtained from the EPA IRIS database (EPA 2008), unless otherwise noted. Toxicity information is summarized from multiple sources, primarily the EPA IRIS database, the Risk Assessment Information System (ORNL 2008), and the toxicity profiles provided in the LDW HHRA (Windward 2007), which obtained information from the IRIS database, Agency for Toxic Substances and Disease Registry (ATSDR), ATSDR Tox FAQs (ATSDR 2006a), the Hazardous Substances Data Bank (HSDB) (TOXNET 2006), the Health Effects Assessment Summary Tables (HEAST) (EPA 1997b) as cited by EPA Regions 3 and 6, EPA reviews of toxicity through groundwater drinking (EPA 2006a), and reviews of fish consumption toxicity (EPA 2000).

Toxicity information is provided on the following COPCs.

Primary risk drivers:

Arsenic
Carcinogenic Polycyclic Aromatic Hydrocarbons (cPAHs)
Polychlorinated Biphenyls (PCBs)

Remaining COPCs:

Antimony
Cadmium
Chlordane
Chromium
Copper
DDT and metabolites
Lead
Mercury
Pentachlorophenol
Tributyltin
Vanadium
Zinc

GLOSSARY

Aplastic anemia	A condition whereby the capacity of bone marrow to generate red blood cells is defective.
Chloracne	A rare acne-like skin condition caused by certain toxic chemicals.
Coma	A state of unconsciousness in which a person is unable to respond to stimuli.
Contact dermatitis	An inflammation of the skin caused by direct contact with an irritating or allergy-causing substance.
Conjunctivitis	An inflammation of the clear membrane that covers the white part of the eye and lines the inner surface of the eyelids, commonly known as pinkeye.
Defoliant	Any substance designed to destroy or remove foliage.
Dyspnea	Difficulty breathing or shortness of breath.
Edema	Swelling or enlargement of organs, skin, or other parts of the body caused by the excessive buildup of fluid in tissue.
Erythrocyte	Red blood cell.
Fungicide	Any substance used to kill fungus.
Hemoglobin	The red substance in blood that carries oxygen to cells throughout the body.
Hemolysis	The premature breakdown and destruction of red blood cells, which results in an inadequate number of red blood cells for the transport of oxygen.
Herbicide	Any substance used to kill plants.
Jaundice	A condition, characterized by a yellow color in the skin, the mucous membranes, or the eyes, in which bilirubin, a byproduct of old red blood cells, is not adequately eliminated from the body.
Lethargy	A feeling of fatigue, tiredness, or general lack of energy.
Leukocyte	White blood cell.
Leukemia	A type of cancer that targets bone marrow and causes an uncontrolled increase in the production of white blood cells.
LOAEL	Lowest-observed-adverse-effect level. The lowest dose at which an adverse reaction to a chemical or substance was observed.

LD50	Lethal dose at 50 percent. The amount of a chemical or other toxic substance that is sufficient to kill 50 percent of a population of test animals.
Lymphocyte	The nearly colorless cells formed in lymphatic tissue (lymph nodes, spleen, thymus, and tonsils) that constitute nearly a third of all white blood cells in the blood.
Lymphoma	Malignancy (cancer) of lymph tissue found in the lymph nodes, spleen, liver, and bone marrow.
Necrosis	Death of cells or tissue caused by injury or disease, especially in a localized area of the body.
NOAEL	No-observed-adverse-effect level. The highest dose at which no effect was observed from exposure to a certain chemical or toxic agent.
Pulmonary edema	Fluid accumulation and swelling in the lungs.
Proteinuria	The presence of protein in urine.
Tachycardia	Irregular heartbeat or palpitations, often accompanied by sensations of heart pounding or racing.
Vertigo	A sudden sensation of spinning or dizziness, typically provoked by head movement.

Source: Windward (2007a)

TOXICOLOGICAL PROFILES FOR PRINCIPAL RISK DRIVERS

Arsenic

Arsenic is a naturally occurring element in the earth's crust that is usually found combined with other elements. Arsenic combined with elements such as oxygen, chlorine, and sulfur is referred to as inorganic arsenic; arsenic combined with carbon and hydrogen is referred to as organic arsenic. Arsenic in seafood is more commonly found in the organic form (EPA 1997a). Most of the common organic forms, such as arsenobetaine and arsenocholine, have very low toxicity, but other forms that may also occur to some extent, such as dimethylated and monomethylated arsenic acids, are more toxic (EPA 1997a). Some seafood may also contain arseno-sugars, which may be metabolized to dimethyl arsenic (Chew 1996).

Pharmacokinetics

Pharmacokinetic studies show that water-soluble arsenic compounds are well absorbed across the gastrointestinal tract. They appear to be transported throughout the body; analysis of tissues taken at autopsy from people who were exposed to arsenic found arsenic present in all tissues of the body. The arsenic levels in hair and nails were the highest, with somewhat lower levels in internal organs (ATSDR 2005a).

The metabolism of arsenic consists mainly of a reduction reaction, which converts pentavalent arsenic to trivalent arsenic, and methylation reactions, which convert arsenite to monomethylarsonic acid and dimethylarsenic acid (EPA 2000). Recent research suggests that trivalent forms of methylated arsenic generated during methylation may be more toxic than inorganic arsenic (Petrick et al. 2000; Petrick et al. 2001; Thomas et al. 2001). The primary excretion route for arsenic and metabolites is in the urine, with human studies showing that 45 to 85 percent is excreted in the urine within 1 to 3 days. Very little is excreted in the feces (ATSDR 2005a).

Acute toxicity

Symptoms of acute inorganic arsenic poisoning in humans are effects on the gastrointestinal system (nausea, anorexia, vomiting, abdominal pain); central nervous system (headaches, weakness, delirium); motor function (peripheral neuropathy, paresthesia); cardiovascular system (hypotension, shock); and the liver, kidney, and blood (anemia, leucopoenia). Oral doses as low as 20 to 60 µg/kg/day have been reported to cause toxic effects in some individuals (ATSDR 2005a). Severe exposures can result in acute encephalopathy, congestive heart failure, stupor, convulsions, paralysis, coma, and death. The acute lethal dose to humans has been estimated to be about 0.6 mg/kg/day (ATSDR 2005a).

Chronic toxicity

General symptoms of chronic arsenic poisoning in humans are weakness, general debility and lassitude, loss of appetite and energy, loss of hair, hoarseness of voice, loss of weight, and mental disorders. Primary target organs are the skin (hyperpigmentation and hyperkeratosis), nervous system (peripheral neuropathy), and vascular system. Skin effects include the formations of warts or corns on the palms and soles, along with areas of darkened skin on the face, neck, and back (EPA 2000). Blackfoot disease, a disease characterized by a progressive loss of circulation in the hands and feet, leading ultimately to necrosis and gangrene, is associated with arsenic (ATSDR 2005a). Anemia, leukopenia, hepatomegaly, and portal hypertension have also been reported. In addition, possible reproductive effects include a high male to female birth ratio.

The RfD for chronic oral exposures, 0.0003 mg/kg/day, is based on a NOAEL of 0.0008 mg/kg/day and a LOAEL of 0.014 mg/kg/day for hyperpigmentation, keratosis, and possible vascular complications in two studies of a human population consuming arsenic-contaminated drinking water. Because of uncertainties in the data, the EPA IRIS file has stated that "strong scientific arguments can be made for various values within a factor of 2 or 3 of the currently recommended RfD value."

Carcinogenicity

There is clear evidence that chronic exposure of humans to inorganic arsenic increases the risk of cancer. Epidemiological studies have revealed an association between arsenic concentrations in drinking water and increased incidences of skin cancers (including squamous cell carcinomas and multiple basal cell carcinomas), as well as cancers of the liver, bladder, respiratory and gastrointestinal tracts. Occupational exposure studies have shown a clear correlation between exposure to arsenic and lung cancer mortality. Inhalation of arsenic results in an increased risk of lung cancer (EPA 2000). Dimethyl arsenic may be a promoter of various forms of cancer in rats and mice (Kenyon and Hughes 2001). EPA (2005a) has placed inorganic arsenic in weight-of-evidence group A, human carcinogen.

The oral cancer slope factor for arsenic is 1.5 per mg/kg-day. The slope factor is derived from studies in Taiwan concerning skin cancer incidence, age, and level of exposure via drinking water. In 37 villages that had obtained drinking water for 45 years from artesian wells with various elevated levels of arsenic, 40,421 individuals were examined for hyperpigmentation, keratosis, skin cancer, and blackfoot disease. The local well waters were analyzed for arsenic, and the age-specific cancer prevalence rates were correlated with both local arsenic concentrations and duration of exposure.

Carcinogenic Polycyclic Aromatic Hydrocarbons

PAHs are a group of organic chemicals that have a fused ring structure of two or more benzene rings, and are formed during the incomplete combustion of organic materials. Industrial activities which produce PAHs include: coal coking, production of carbon blacks, creosote, coal tar, petroleum refining, synfuel production from coal, and the use of Soderberg electrodes in aluminum smelters and ferrosilicum and iron works (EPA 2000). Domestic activities which produce PAHs include: cigarette smoke, burning of wood and fossil fuels, waste incineration, broiling and smoking foods, and the use of combustion engines. Benzo(a)pyrene is the PAH with the most available health effects data.

Pharmacokinetics

PAHs can be absorbed through the lungs, the stomach, or the skin. Oral absorption increases with more lipophilic PAHs or in the presence of oil in the gastrointestinal tract. Upon inhalation, oral or dermal exposure of animals, the highest levels of PAHs were found in highly perfused tissues, such as the lung, liver, gastrointestinal tract and kidneys. It has been demonstrated that PAHs metabolize to reactive intermediates by enzyme systems, which then covalently bind to cellular macromolecules leading to mutation and tumor development (EPA 2000).

Acute toxicity

There are little data describing acute toxicity of PAHs after inhalation, oral, or dermal exposure in humans or animals. However, benzo(a)pyrene is fatal to mice following ingestion, and the liver and the skin have been identified as target organs in animals after oral or dermal exposure, respectively (ATSDR 1995). The intraperitoneal LD50 values (injected dose which kills half of the animals being tested) in mice for pyrene, anthracene, and benzo(a)pyrene are 514, >430, and 232 mg/kg, respectively.

Chronic toxicity

PAHs have a high chronic exposure toxicity characterized by chronic dermatitis and hyperkeratosis (ATSDR 1995). Chronic studies in animals exposed to PAHs via ingestion, intratracheal installation, or skin-painting have not as yet identified adverse health effects other than cancer. RfDs have not been developed for any of the carcinogenic PAHs being evaluated in this Phase 1 HHRA.

Carcinogenicity

Occupational studies of workers exposed to mixtures containing PAHs have shown that mixtures of PAHs are carcinogenic to humans. Cancer associated with exposure to PAH containing mixtures in humans occurs mainly in the lung and skin following inhalation and dermal exposure.

The EPA and California EPA describe the cancer causing ability of individual cPAHs relative to the cancer causing ability of a reference compound, benzo(a)pyrene (EPA 1993; California EPA 1994). The oral cancer slope factor developed by EPA for carcinogenicity of benzo(a)pyrene is 7.3 per mg/kg-day (IRIS). EPA has classified benzo(a)pyrene as a probable human carcinogen (B2) based on observations of significant dose-related increases in multiple studies of rats and mice of both sexes (IRIS). The oral cancer potency factor was applied to the sum of cPAHs, using the CalEPA PEFs described in Section 4 of the HHRA.

Polychlorinated Biphenyls

Although the production and use of PCBs were banned in this country in 1979, this chemical group is extremely persistent in the environment and bioaccumulates through the food chain (EPA 2000). There is evidence that some dioxin-like PCB congeners, which are assumed to be the most toxic, preferentially accumulate in organisms higher on the food chain, including humans. As a result, the composition of PCB mixtures in fish tissue may differ significantly from the environmental PCB source. Often the mixtures of interest are not those that have been used in studies of laboratory animals to determine toxicity (EPA 2000).

Pharmacokinetics

PCBs are absorbed through the gastrointestinal tract and distributed throughout the body, although the highest accumulation is typically in lipid-rich tissues. Human milk may contain relatively elevated PCB concentrations due to its high fat content (ATSDR 2000b).

The retention of PCBs in fatty tissues is linked to the degree of chlorination and also to the position of the chlorine atoms in the biphenyl ring. In general, more chlorinated congeners persist for longer periods of time. In occupationally exposed individuals, less chlorinated congeners had half-lives between 1 and 6 years, while more chlorinated congeners had half-lives ranging from 8 to 24 years (ATSDR 2000b). In subjects who consumed PCB-contaminated rice in Taiwan, the half-lives of several PCBs ranged from 3 to 24 months (EPA 2000).

Acute toxicity

Studies in animals have shown that exposure to very high doses of PCBs can cause death. However, doses of such magnitude are unlikely in environmental exposures and current industrial settings. There have been no reports of deaths in humans after exposure to PCBs even where exposures were much higher than those typically identified with environmental exposures (ATSDR 2000b).

Chronic toxicity

Numerous effects have been documented in animal studies including hepatic, gastrointestinal, hematological, dermal, body weight, endocrine, immunological, neurological, reproductive, developmental, and liver cancer (ATSDR 2000b). One of the most distinct effects associated with PCB exposure is the skin condition chloracne, which is generally associated with high levels of exposure (ATSDR 2000b). Evidence of other chronic effects in humans is not nearly as definitive. Several studies in humans have suggested that PCB exposure, particularly via in utero exposure through maternal fish consumption, may cause adverse effects in children and in developing fetuses (ATSDR 2000b). Neurobehavioral effects have been documented in children exposed in utero. A review of exposure evaluations in 10 recent studies associating neurodevelopmental effects with PCBs is available (Longnecker et al. 2003). This will facilitate future comparisons across studies and future updates to neurodevelopmental toxicity metrics. PCBs have also been associated with immunological effects in several epidemiological studies (Dallaire et al. 2006).

Over intermediate durations (i.e., less than 10 percent of an organism's lifetime), learning problems have been noted in monkeys fed PCB mixtures similar in composition to human breast milk (ATSDR 2000b). Some studies also indicate a possible connection between PCB exposure and cardiovascular effects; although this has been better demonstrated in assessments of dioxins, which share a similar chemical structure to PCBs (see structure activity relationships at the end of the PCB section).

EPA has derived an RfD of 0.00002 mg/kg-day for Aroclor 1254 (IRIS). The RfD was based on a LOAEL of 0.005 mg/kg-day for ocular and immunological effects in monkeys. This RfD is considered to be protective of developmental effects as well, and is used for total PCBs in this HHRA.

Carcinogenicity

PCBs are classified by EPA as Class B2, probable human carcinogens. This designation is based on studies that have found liver tumors in rats exposed to Aroclors 1260, 1254, 1242, and 1016. Occupational mortality data indicate that exposures to PCBs during capacitor manufacturing and repairing were associated with cancer of the liver, biliary tract and/or gall bladder, intestinal cancer, and skin melanoma; however, previous reviews of human epidemiological studies of PCBs have not yielded conclusive results (Silberhorn et al. 1990). Some more recent studies have indicated an increase in melanoma, brain, prostate, or liver cancer mortality in populations occupationally exposed to PCBs (Prince et al. 2006a; Prince et al. 2006b; Ruder et al. 2006). Elevated risk of non-Hodgkin lymphoma has been associated with detection of PCBs in carpet dust (Colt et al. 2005) and in elevated PCB concentrations in blood (De Roos et al. 2005).

EPA has developed a range of slope factors for PCBs (EPA 1996). Using information on environmental processes, they have provided guidance for choosing an appropriate slope factor based on the class of the mixture and the exposure pathway. Because bioaccumulated PCBs appear to be more toxic and more persistent in the body than commercial PCBs, the upper bound slope factor associated with high risk and persistence (2.0 per mg/kg-day) was used in this HHRA (IRIS).

Both dioxin-like and non-dioxin-like modes of action contribute to overall PCB toxicity. When congener concentrations are available, the mixture-based approach based on Aroclor analyses can be supplemented by analysis of dioxin TEQs to evaluate the PCB congeners with dioxin-like toxicity. In the TEQ approach, all PCB congeners with dioxin-like properties are analyzed in order to assess their impact on the overall risk from PCBs. For the Lockheed West HHRA, PCB congener concentration data were not collected. Further details on the toxicological basis of PCB congeners can be found in the summary provided in the LDW HHRA (Windward 2007).

TOXICOLOGY PROFILES OF CHEMICALS OF POTENTIAL CONCERNT

Antimony

Antimony is naturally present in the earth's crust. The release of antimony into the environment occurs primarily through anthropogenic sources like non-ferrous metal mining, smelting, refining, and production, the use and disposal of antimony alloys and compounds, coal combustion, and refuse and sludge combustion. Antimony exposure occurs through inhalation, ingestion of food containing antimony, and through dermal contact (IRIS).

Pharmacokinetics

Antimony is absorbed by erythrocytes and distributed to other tissues such as liver, adrenals, spleen, and thyroid. Much of the absorbed antimony is excreted via urine and feces. Of the antimony that is not excreted, the longest biological half-life is believed to occur in the lungs. The highest concentrations of antimony after acute or chronic exposure have been found in the thyroid, adrenals, liver, and kidney (HSDB).

Acute toxicity

Violent vomiting, diarrhea, lowered respiratory rate, myocardial edema, hyperemia, and capillary engorgement are major results of acute exposure to antimony. Seventy people became acutely ill after ingesting lemonade containing 0.013 percent antimony. Fifty-six of the victims were treated for burning stomach pains, colic, nausea, and vomiting. Most recovered after approximately three hours, while some required hospitalization for a few days (IRIS).

Chronic toxicity

Dyspnea, weight and hair loss, popular eruptions on the skin, jaundice, damage to the heart and liver, and spleen, kidney damage, abnormal increase in erythrocytes, and a decrease in leukocytes are reported from long-term exposure to antimony. Chronic inhalation results in damage to the lungs, liver and heart (HSDB). EPA developed an RfD for antimony of 0.0004 mg/kg-day based on a study in which rats were exposed to potassium antimony tartrate (IRIS).

Carcinogenicity

EPA has not conducted a complete evaluation and determination of the carcinogenicity of antimony (IRIS).

Cadmium

Cadmium is a heavy metal that is released through a wide variety of industrial and agricultural activities. The accumulation of cadmium in human and other biological tissue has been evaluated in both epidemiological and toxicological studies. ATSDR (1999c) has determined that exposure conditions of most concern are long-term exposure to elevated levels in the diet.

Pharmacokinetics

Cadmium is not readily absorbed when exposure occurs via ingestion. Absorption may be much higher in iron-deficient individuals. Evaluations of the impact of cadmium complexation indicate that cadmium absorption from food is not dependent upon chemical complexation. Some populations with high dietary cadmium intakes have elevated blood cadmium levels, which could be due to the particular forms of cadmium in their food (ATSDR 1999c).

Cadmium is not directly metabolized, but absorption appears to involve sequestering by metallothionein, and plasma cadmium is found primarily bound to this protein. This type of binding appears to protect the kidney. It is thought that kidney damage by cadmium occurs primarily due to unbound cadmium (ATSDR 1999c). Once cadmium is absorbed, it is eliminated slowly; the biological half-life has been estimated at 10 to 30 years (FDA 1993).

Acute toxicity

Effects of acute oral exposure to cadmium include gastrointestinal irritation, nausea, vomiting, abdominal pain, cramps, salivation, and diarrhea. Lethal doses in humans caused massive fluid loss, edema, and widespread organ destruction. The ingested doses were 25 and 1,500 mg/kg (ATSDR 1999c; FDA 1993).

Chronic toxicity

Kidney toxicity is the main concern with cadmium exposure, with the critical effect being significant proteinuria (an indicator of kidney toxicity). The RfD for cadmium in food was calculated to be 0.001 mg/kg-day (IRIS). The RfD was calculated using a toxicokinetic model to determine the highest level of cadmium in the human renal cortex not associated with significant proteinuria (EPA 2000).

Cadmium causes many other types of toxic effects in addition to kidney toxicity, such as reducing the gastrointestinal uptake of iron, bone disorders, and increased calcium excretion. Some human studies have shown cardiovascular toxicity and elevated blood pressure, but the results are conflicting (ATSDR 1999c). In addition, animal studies indicate that cadmium causes a wide variety of alterations in the function of the immune system.

Carcinogenicity

No animal or human oral exposure studies suggest that cadmium is carcinogenic via the oral exposure route, although cadmium is classified as a probable human carcinogen (B1) by EPA based on inhalation studies in humans (EPA 2000). ATSDR has concluded that there is minimal evidence of an association between cadmium exposure and increased cancer risk in humans but that the statistical power of the studies examined to detect an effect was not high. They determined that neither the human nor the animal studies provided enough evidence to agree on the carcinogenic status of cadmium by the oral route (ATSDR 1999c).

Chlordane

Chlordane is an organochlorine insecticide comprised of the sum of cis- and trans-chlordane and trans-nonachlor and oxychlordane for purposes of health advisory development. First introduced in 1947, it was used extensively on agricultural crops, livestock, lawns, and for termite control. Because of concern over cancer risk, human exposure, and effects on wildlife, most uses were banned in 1978, and all uses were banned by 1988. Due to its long half-life and ability to concentrate in biological materials, it is still widely distributed in fish in the United States (EPA 2000).

Pharmacokinetics

Chlordane is extremely lipid soluble, and lipid partitioning of chlordane and its metabolites has been documented in both humans and animals. Chlordane is metabolized via oxidation, which results in a number of metabolites that are very persistent in body fat. Human studies have found chlordane in pesticide applicators, residents of homes treated for termites, and those with no known exposures other than background (EPA 2000).

Acute toxicity

Chlordane is moderately to highly toxic with an estimated lethal dose to humans of 6 to 60 g (IRIS). Effects reported in humans after acute exposure include headaches, irritability, excitability, confusion, loss of coordination, seizures, and convulsions. There is also some evidence that acute exposures to chlordane may be associated with impaired immune function and aplastic anemia in humans (EPA 2000).

Chronic toxicity

IRIS provides an RfD of 0.0005 mg/kg-day based on a NOAEL of 0.15 mg/kg-day for hepatic necrosis in a 2-yr feeding study in mice (IRIS). The LOAEL in the principal study was 0.75 mg/kg-day.

Carcinogenicity

Chlordane is classified as a probable human carcinogen (B2) by EPA based on oral studies in animals. An increased incidence of hepatocellular carcinoma was observed in both sexes in mice in two separate studies using different strains. Hepatocellular carcinomas were also observed in another study in male mice using a third strain. The oral cancer slope factor of 0.35 per mg/kg-day is the geometric mean of the cancer potencies calculated from five data sets (IRIS).

Chromium

Trivalent chromium is a naturally occurring chemical with low toxicity. Hexavalent chromium, however, is released into the environment through industrial emissions and is highly toxic due to its strong oxidation characteristics and membrane permeability. Hexavalent chromium is used in chromate manufacturing, ferrochromium industries, and in metal alloys (HSDB).

Pharmacokinetics

Trivalent chromium is an essential ion required for lipid, protein, and fat metabolism and to maintain normal glucose metabolism. The most common routes of exposure to toxic levels of chromium are through inhalation and ingestion (ToxFAQs).

Acute toxicity

The acute toxic effects of hexavalent chromium were studied in 1965 when 155 people were exposed to 20 milligrams per liter (mg/L) hexavalent chromium in their drinking water. The victims suffered from mouth sores, diarrhea, stomachaches, indigestion, vomiting, increased white blood cell counts, and a higher per capita cancer rate. Acute exposure to hexavalent chromium may also affect fetal development. Dermal exposure to hexavalent chromium can cause skin irritation and allergic contact dermatitis (IRIS).

Chronic toxicity

Chronic exposure to chromium can cause damage to the liver, kidney, and circulatory system, as well as cause nerve tissue damage and dermatitis. EPA has developed RfDs of 1.5 and 0.003 mg/kg-day for trivalent and hexavalent chromium, respectively (IRIS). The

RfD for hexavalent chromium will be applied to all chromium data in this HHRA since the proportion of trivalent chromium in the total chromium measurements is not known.

Carcinogenicity

EPA has classified trivalent chromium as Group D, not classifiable as to human carcinogenicity. Hexavalent chromium is a Group A known human carcinogen via the inhalation pathway (IRIS). EPA has not developed an oral cancer potency factor for hexavalent chromium.

Copper

Copper occurs naturally in elemental form and as a component of many minerals. Because of its high electrical and thermal conductivity, it is widely used in the manufacture of electrical equipment. Common copper salts, such as the sulfate, carbonate, cyanide, oxide, and sulfide are used as fungicides, as components of ceramics and pyrotechnics, for electroplating, and for numerous other industrial applications (Faust 1992). Copper can be absorbed by the oral, inhalation, and dermal routes of exposure.

Pharmacokinetics

Copper is an essential nutrient that is normally present in a wide variety of human tissues (Faust 1992). Copper is incorporated into more than a dozen specific copper proteins. Copper is essential for hemoglobin formation, carbohydrate metabolism, catecholamine biosynthesis, and cross-linking of collagen, elastin, and hair keratin (EPA 1987).

Acute toxicity

In humans, ingestion of gram quantities of copper salts may cause gastrointestinal, hepatic, and renal effects with symptoms such as severe abdominal pain, vomiting, diarrhea, hemolysis, hepatic necrosis, hematuria, proteinuria, hypotension, tachycardia, convulsions, coma, and death (Faust 1992). Acute inhalation exposure to copper dust or fumes at concentrations of 0.075 to 0.12 mg Cu/m3 may cause metal fume fever with symptoms such as cough, chills, and muscle ache (Faust 1992). Among the reported effects in workers exposed to copper dust are gastrointestinal disturbances, headache, vertigo, drowsiness, and increase in liver size.

Chronic toxicity

Gastrointestinal disturbances and liver toxicity have resulted from long-term exposure to drinking water containing 2.2 to 7.8 mg Cu/L (Faust 1992). The chronic toxicity of copper has been characterized in patients with Wilson's disease, a genetic disorder causing copper accumulation in tissues. Vineyard workers chronically exposed to Bordeaux mixture (copper sulfate and lime) exhibit degenerative changes of the lungs and liver. Dermal exposure to copper may cause contact dermatitis in some individuals (ATSDR 2004). Additionally, high levels of copper are known to cause kidney and liver damage (ATSDR 2004).

EPA has not developed an oral RfD for elemental copper. The HEAST database proposed a provisional value of 0.04 mg/kg-day (EPA 2005). Provisional RfDs have greater uncertainty than RfDs certified by EPA.

Carcinogenicity

No suitable bioassays or epidemiological studies are available to assess the carcinogenicity of copper (Faust 1992). EPA has placed copper in weight-of-evidence group D, not classifiable as to human carcinogenicity.

DDT and Metabolites

DDT is an organochlorine pesticide that has not been marketed in the United States since 1972 but is ubiquitous due to its widespread use in previous decades and its relatively long half-life. DDT's close structural analogs, DDE and DDD, are metabolites of DDT and have also been formulated as pesticides in the past (EPA 2000). DDT is very widely distributed; it has been found in wildlife all over the world and in many human samples as well.

Although some use of DDT continues throughout the tropics, it remains of human health concern in the United States primarily due to its presence in water, soil, and food. Because individuals are typically exposed to a mixture of DDE, DDT, and DDD and their degradation and metabolic products, the sum of the 4,4' and 2,4' isomers of DDT, DDE, and DDD will be evaluated together in this HHRA.

Pharmacokinetics

DDT and its analogs are stored in fat, liver, kidney, and brain tissue; trace amounts can be found in all tissues (EPA 2000). DDE is stored more readily than DDT. DDT is eliminated through first-order reduction to DDD and, to a lesser extent, to DDE. The DDD is converted to more water-soluble bis(p-chlorophenyl)acetic acid, with a biological half-life of 1 year. DDE is eliminated much more slowly, with a biological half-life of 8 years. Because elimination occurs slowly, ongoing exposure may lead to an increase in the body burden over time.

Acute toxicity

The low effect dose for severe effects (acute pulmonary edema) in infants has been reported to be 150 mg/kg. In adults, behavioral effects were noted at 5 to 6 mg/kg and seizures at 16 mg/kg (HSDB). Evidence from acute exposure studies of dogs indicates that DDT may sensitize the myocardium to epinephrine. This was observed for both injected epinephrine and epinephrine released by the adrenal glands during a seizure and resulted in ventricular fibrillation. DDT may concurrently act on the CNS, in a manner similar to that of other halogenated hydrocarbons, to increase the likelihood of fibrillation. Chronic exposure to 10 mg/kg-day did not produce increased incidence of arrhythmias in rats or rabbits (EPA 2000).

DDD is considered less toxic than DDT in animals. Symptoms develop more slowly and have a longer duration with DDD than with DDT exposure. Lethargy is more significant and convulsions are less common than with DDT exposure (HSDB).

Chronic toxicity

Extensive research has been conducted on chronic and sub-chronic exposure effects of DDT in animals and in humans working with DDT. These studies have primarily focused on carcinogenic effects, which are discussed in the following section. Studies have also identified liver damage, and there is limited evidence that DDT may cause an increase in the number of white blood cells and decreased hemoglobin level (EPA 2000). Immunological effects have been associated with exposure to DDT.

IRIS lists an oral RfD of 0.0005 mg/kg-day for DDT based on liver effects with a NOAEL of 0.05 mg/kg-day from a 27-week rat feeding study conducted in 1950 (IRIS).

Carcinogenicity

DDE, DDT, and DDD are all considered probable human carcinogens (category B2) based on animal studies, with oral cancer slope factors of 0.24, 0.34, and 0.34 per mg/kg-day, respectively (IRIS). Liver tumors were associated with each chemical. The occupational studies of workers exposed to DDT are of insufficient duration to assess carcinogenicity (IRIS). Elevated leukemia incidence, particularly chronic lymphocytic leukemia, was noted in two studies of workers. Lung cancer has also been implicated in one study. Bone marrow cells in experimental animals have also been affected by exposure, including an increase in chromosomal fragments in the cells (HSDB). The oral cancer slope factor for DDT (0.34) is used for total DDTs in this HHRA, in accordance with EPA (2000) recommendations.

Lead

Lead is a naturally occurring bluish-gray metal found in small amounts in the earth's crust. Lead’s most important industrial use is in the production of some types of batteries. It is also used in the production of ammunition, in some kinds of metal products (such as sheet lead, solder, some brass and bronze products, and pipes), and in ceramic glazes. Human activities (such as the former use of "leaded" gasoline) have spread lead and substances that contain lead to all parts of the environment. Before the use of leaded gasoline was banned, most of the lead released into the US environment came from car exhaust. Other sources of lead released to the air include burning fuel, such as coal or oil, industrial processes, and burning solid waste.

Sources of lead in dust and soil include lead that falls to the ground from the air, and weathering and chipping of lead-based paint from buildings and other structures. Lead in dust may also come from windblown soil. Disposal of lead in municipal and hazardous waste dump sites may also add lead to soil. Mining wastes that have been used for sandlots, driveways, and roadbeds can also be sources of lead (ATSDR 1999d).

People living near hazardous waste sites may be exposed to lead and chemicals that contain lead by breathing air, drinking water, eating foods, or swallowing or touching dust or dirt that contains lead. For people who do not live near hazardous waste sites, exposure to lead may occur in several ways: 1) by eating foods or drinking water that contain lead, 2) by spending time in areas where leaded paints have been used and are deteriorating, 3) by working in jobs where lead is used, 4) by using health-care products or folk remedies that contain lead, and 5) by having hobbies in which lead may be used such as sculpturing (lead solder) and staining glass.

Pharmacokinetics

Absorbed lead is distributed in various tissue compartments.

Acute toxicity

Lead can affect almost every organ and system in your body. The most sensitive is the central nervous system, particularly in children. Studies have shown that children exposed to low levels of lead have lower IQs, reduced motor skills, developmental problems, hyperactivity, and increased aggression (Canfield et al. 2003; Pattee and Pain 2003).

Lead also damages kidneys and the reproductive system. The toxic effects of lead are the same regardless of the route of entry into the body, and they are correlated with internal exposure as blood lead level.

Chronic toxicity

At high levels over long periods of time, lead may decrease reaction time, cause weakness in fingers, wrists, or ankles, and possibly affect the memory. Lead may cause anemia, a disorder of the blood. It can also damage the male reproductive system. Even low levels of exposure to lead may have significant effects.

Since most of the toxicity data for lead is based on an internal dose, an RfD, which is based on an external dose (i.e., mg/kg-day) has not been developed. Data on external exposure (i.e., mg/kg-day) are available from animal studies, but these data are generally not used to assess human health impacts because of the large database available using blood levels. Risks from lead exposure were evaluated using the IEUBK model for young children and the Adult Lead Model (ALM) for risks to fetal development, as described in Section B.3.4.4. EPA and the Centers for Disease Control and Prevention have determined that child or fetal blood lead concentrations at or above 10 µg/dL present risks to children's health.

Carcinogenicity

The Department of Health and Human Services has determined that lead acetate and lead phosphate may reasonably be anticipated to be carcinogens based on studies in animals. There is inadequate information to clearly determine lead’s carcinogenicity in people (ToxFAQs).

Mercury

Mercury is widely distributed in the environment due to both natural and anthropogenic processes. It is released generally as elemental mercury (Hg0) or divalent mercury (Hg2+). It can be converted between these forms and may form mercury compounds by chemical processes in air, water, and soil. Biological processes in other media, primarily soil and sediment, can convert inorganic mercury into organic mercury, primarily methylmercury. In fish tissue, the majority of mercury is in the form of methylmercury (EPA 2000).

Pharmacokinetics

Methylmercury is rapidly and nearly completely absorbed; estimates of absorption efficiency are 90 percent or greater (ATSDR 1999e; EPA 1997c; WHO 1990). Methylmercury is readily distributed to all tissues following absorption from the gastrointestinal tract. Methylmercury in the body is considered to be relatively stable and is only slowly demethylated to form mercuric mercury. Estimates for the half-life of methylmercury in the body range from 44 to 80 days (EPA 1997c).

Methylmercury binds readily to protein and can be found throughout fish tissue. A substantial portion of the mercury in fish can be found in trimmed filets, making it difficult to reduce exposure by trimming fat and skin prior to cooking (EPA 2000).

Acute toxicity

Acute high-level exposures to methylmercury may result in kidney damage and failure, gastrointestinal damage, cardiovascular collapse, shock, and death. The estimated lethal dose is 10 to 60 mg/kg-day (ATSDR 1999e).

Chronic toxicity

Neurotoxicity is the chronic effect of greatest concern, both to the developing embryo or fetus and to adults and children (EPA 2000). Neurotoxicological effects include tremors, decreased IQ, and decreased motor function. In addition, damage to the liver and kidney can occur with chronic exposure (ATSDR 1999e). Effects to humans from consumption of contaminated food have been documented in Japan and Iraq.

The current IRIS RfD for methylmercury of 0.0001 mg/kg-day was originally based on data on neurological changes in 81 Iraqi children who had been exposed in utero. This value was subsequently updated using data from a population in the Faroe Islands who were exposed to methylmercury and PCBs through consumption of fish and pilot whale. In deriving the RfD, EPA used a benchmark dose (BMD) approach to quantify a dose-effect relationship between methylmercury in cord blood and a neurological endpoint. A BMD limit of 58 micrograms per liter (µg/L) cord blood was estimated based on findings from the Boston Naming Test, a neuropsychological evaluation. A methylmercury intake level associated with a blood level of 58 µg/L was then calculated to be 1.0 µg/kg-day. The current RfD of 0.1 µg/kg-day (i.e., 0.0001 mg/kg-day) derived from the Faroe Islands data, is thus unchanged from the previous RfD derived from the Iraqi data. The RfD for methylmercury is used for mercury in this HHRA.

Carcinogenicity

Methylmercury is currently a Class C chemical, a possible carcinogen based on inadequate data in humans and limited evidence in animals. Dietary exposure of mice to methylmercury resulted in significant increases in the incidences of kidney tumors in males but not in females (EPA 1997c). Evidence points to a mode of action for methylmercury carcinogenicity that operates at high doses certain to produce other types of toxicity in humans. Given the relatively low levels of exposure, even among consumers of highly contaminated fish, methylmercury is not likely to present a carcinogenic risk to the US population (EPA 2000). An oral slope factor is currently not available for methylmercury.

Pentachlorophenol

Pentachlorophenol is a man-made substance that does not occur naturally in the environment. At one time, it was one of the most widely used biocides in the United States. Now the purchase and use of pentachlorophenol are restricted to certified applicators. It is no longer available to the general public. Application of pentachlorophenol in the home as an herbicide and pesticide accounted for only 3 percent of its consumption. Before use restrictions, pentachlorophenol was widely used as a wood preservative. It is now used industrially as a wood preservative for power line poles, cross arms, and fence posts (ToxFAQs).

Pharmacokinetics

The most common exposure routes for pentachlorophenol are inhalation and dermal contact. Human studies have estimated half lives of less than 33 hours. Bioaccumulation appears to be minor; most absorbed pentachlorophenol does not break down, but instead leaves in urine. Much smaller amounts leave in feces (ToxFAQs).

Acute toxicity

Many, but not all, the harmful effects associated with exposure to pentachlorophenol may be due to impurities present in commercial pentachlorophenol. Short exposures to large amounts of pentachlorophenol in the workplace or through the misuse of products that contain it can cause harmful effects on the liver, kidneys, blood, lungs, nervous system, immune system, and gastrointestinal tract. Contact with pentachlorophenol (particularly in the form of a hot vapor) can irritate the skin, eyes, and mouth. If large enough amounts enter the body, heat is produced causing an increase in body temperature. The body temperature can increase to dangerous levels, causing injury to various organs and tissues and even death (ToxFAQs).

Chronic toxicity

Long-term exposure to low levels such as those that occur in the workplace can cause damage to the liver, kidneys, blood, and nervous system. The major organs or systems affected by long-term exposure to low levels in animals are the liver, kidney, nervous system, and immune system. All these effects get worse as the level of exposure increases (ToxFAQs).

EPA has established an RfD for pentachlorophenol of 0.03 mg/kg-day based on a rat chronic oral study that documented liver and kidney pathology (IRIS).

Carcinogenicity

EPA's IRIS database classifies pentachlorophenol as a probable human carcinogen (B2) and provides an oral cancer slope factor of 0.12 per mg/kg-day based on statistically significant increases in the incidences of multiple biologically significant tumor types in mice. In addition, a high incidence of two uncommon tumors was also observed.

Tributyltin

TBT is one of several organotin compounds that have been used as biocides, disinfectants, and antifoulants. This overview focuses primarily on bis(tri-n-butyltin) oxide (TBTO) because this is the only TBT compound for which the EPA has established an RfD for assessing chronic toxicity to humans and because more toxicological information is available for this compound than for other organotin compounds.

Pharmacokinetics

No studies are available regarding the distribution of tin in human tissues following oral exposure (ATSDR 2005d). Laboratory studies with mammals have shown that organotin compounds are absorbed; studies with rats detected tin compounds in the gastrointestinal tract, kidney, and liver. Rats that orally ingested tin compounds showed the highest concentrations in the liver and kidneys; concentrations in the brain and adipose tissue were 10 to 20 percent of those found in the kidneys and liver (Krajnc et al. 1984). Studies involving trialkyltin compounds show that absorbed compounds are metabolized, with the data suggesting that the liver is the active site and dealkylation the principle metabolic pathway (ATSDR 2005d).

Acute toxicity

There are no controlled studies on the effects of TBTO in humans. The available data demonstrate that TBT is toxic to animals, with LD50 values ranging from 122 to 194 mg/kg-day in rats.

Chronic toxicity

There are no studies on the effects of TBTO in humans. Animal studies have shown effects on the blood and liver, and immunological effects, including thymus atrophy and depletion of T-lymphocytes in the spleen and lymph nodes (ATSDR 2005d).

EPA's IRIS database provides an RfD for TBTO of 0.0003 mg/kg-day, based on a NOAEL of 0.025 mg/kg-day. This was based on a chronic feeding study of rats in which immunologic function analyses for specific and nonspecific resistance were performed after

4 to 6 or 15 to 17 months of exposure to test doses of TBTO ranging from 0.025 to 2.5 mg/kg-day (Vos et al. 1990). The RfD for TBTO can be converted to TBT ion units by multiplying it by the ratio (0.49) of the molecular weights for the two substances. The resulting RfD for the TBT ion is 0.00015 mg/kg-day.

Carcinogenicity

TBTO is currently Class D, which is defined as a chemical not classifiable with respect to human carcinogenicity. There are no data documenting the development of cancer in humans following exposure to TBTO. A large number of studies show that TBTO is not genotoxic, and there are no structure-activity relationships suggesting that TBTO might be a carcinogen.

Vanadium

Vanadium compounds are widely distributed in the earth's crust. Elemental vanadium does not occur in nature, but its compounds exist in over 50 different mineral ores and in association with fossil fuels (HSDB). The route of entry of vanadium compounds most commonly seen in industrial exposures is through the respiratory system. Exposures are usually limited to areas where vanadium pentoxide is produced, in steel mills where vanadium pentoxide is used, and in cleaning boilers fired by oil containing vanadium (HSDB).

Pharmacokinetics

Vanadium compounds and metallic vanadium, when absorbed, are rapidly excreted and exhibit low degrees of toxicity, as indicated by minor irritation and lack of systemic effects. Absorbed vanadium is widely distributed in the body. In animals, the highest values are found in bone, kidney, liver, spleen and lung. Bone maintains essentially unchanged levels for several weeks. The lowest values are found in the brain, but in human autopsy material, brain concentrations of vanadium are more or less the same as those found in other organs (HSDB).

Acute toxicity

Vanadium and its compounds are principally eye and respiratory tract irritants that result in conjunctivitis, coughing, wheezing, difficulty in breathing, and industrial bronchitis. A metallic taste and throat irritation may occur. Greenish discoloration of the fingers, scrotum, and upper legs may also be present. A greenish black discoloration of the tongue indicates heavy exposure (HSDB).

Chronic toxicity

Some studies suggest exposure to vanadium may impair the lung resistance to respiratory infection, although the available data on chronic respiratory effects of vanadium are inconclusive. NCEA provides an RfD of 0.001 mg/kg-day for vanadium (EPA 2004).

Carcinogenicity

At this time, there is no information regarding the carcinogenicity of vanadium to humans or animals.

Zinc

Zinc is an essential trace element that plays a necessary role in enzymatic functions, protein synthesis, and carbohydrate metabolism. Small doses of zinc are necessary for normal growth and development in birds and mammals. Zinc also has many industrial uses. It is used as a galvanizing agent, component in brass, bronze alloys, light metal alloys, and in wet batteries (HSDB). The most common route of high-level exposure to zinc is through consumption of liquid contained in galvanized metal containers or by water contaminated with industrial zinc waste (ToxFAQs).

Pharmacokinetics

Absorption of zinc occurs in the intestine when ingested or through the lung when zinc dust or fumes are inhaled. Zinc is mainly stored in skeletal muscle, but significant concentrations can also occur in the pancreas, prostate, liver, and retina. Zinc has a biological half-life of 162 to 500 days (HSDB).

Acute toxicity

In humans, ingestion of gram quantities of zinc may cause pancreatic derangement, light-headedness, and mild derangement of cerebellar function. Acute exposure to zinc can also cause dizziness, nausea, tightness in the throat, diarrhea, and vomiting. Metal fume fever has been observed after inhalation of zinc oxide fumes (HSDB).

Chronic toxicity

Prolonged exposure to drinking water that contained 40 mg/L of zinc triggered symptoms such as irritability, muscular stiffness and pain, loss of appetite, and nausea (HSDB). EPA has established an RfD of 0.3 mg/kg-day for zinc based on a human diet supplement study in which adult females experienced a 47 percent decline in erythrocyte superoxide dismutase after 10 weeks of exposure (IRIS).

Carcinogenicity

EPA has placed zinc in Class D, not classifiable as to human carcinogenicity (IRIS).

TOXICOLOGY REFERENCES

ATSDR. 1995. Toxicological profile for polycyclic aromatic hydrocarbons (PAHs). Agency for Toxic Substances and Disease Registry, Atlanta, GA.

ATSDR. 1999c. Toxicological profile for cadmium. Agency for Toxic Substances and Disease Registry, Atlanta, GA.

ATSDR. 1999d. Toxicological profile for lead (update). Agency for Toxic Substances and Disease Registry, Atlanta, GA.

ATSDR. 1999e. Toxicological profile for mercury. Agency for Toxic Substances and Disease Registry, Atlanta, GA.

ATSDR. 2000b. Toxicological profile for polychlorinated biphenyls (PCBs). Agency for Toxic Substances and Disease Registry, Atlanta, GA.

ATSDR. 2004. Toxicological profile for copper. Agency for Toxic Substances and Disease Registry, Atlanta, GA.

ATSDR. 2005a. Toxicological profile for arsenic (update). Agency for Toxic Substances and Disease Registry, Atlanta, GA.

ATSDR. 2005d. Toxicological profile for tin. Agency for Toxic Substances and Disease Registry, Atlanta, GA.

ATSDR. 2006a. ToxFAQs™: Frequently Asked Questions about contaminants found at hazardous waste sites Agency for Toxic Substances and Disease Registry, US Department of Health and Human Services, Atlanta, GA.

California EPA. 1994. Health effects of benzo(a)pyrene. Office of Environmental Health Hazard Assessment, California Environmental Protection Agency, Berkeley, CA.

Canfield, R.L., C.R.J. Henderson, D.A. Cory-Slechta, C. Cox, T.A. Jusko, and B.P. Lanphear. 2003. Intellectual impairment in children with blood lead concentrations below 10 ug per deciliter. N Engl J Med 348(16):1517-1526.

Chew, C. 1996. Toxicity and exposure concerns related to arsenic in seafoods: an arsenic literature review for risk assessments. Prepared for US Environmental Protection Agency, Region 10. ICF Kaiser, Inc., Bellevue, WA.

Colt, J.S., R.K. Severson, J.H. Lubin, N. Rothman, D. Camann, S. Davis, J.R. Cerhan, W. Cozen, and P. Hartge. 2005. Organochlorines in carpet dust and non-Hodgkin lymphoma. Epidemiology 16:516-525.

Dallaire, F., E. Dewailly, C. Vézina, G. Muckle, J-P. Weber, S. Bruneau, and P. Ayotte. 2006. Effect of prenatal exposure to polychlorinated biphenyls on incidence of acute respiratory infections in preschool Inuit children. Environ Health Persp 114(8):1301-1305.

De Roos, A.J., P. Hartge, J.H. Lubin, J.S. Colt, S. Davis, J.R. Cerhan, R.K. Severson, W. Cozen, D.G. Patterson, Jr, L.L. Needham, and N. Rothman. 2005. Persistent organochlorine chemicals in plasma and risk of non-Hodgkin's lymphoma. Cancer Res 2005 65(23):11214-11226.

EPA. 1987. Summary review of the health effects associated with copper. Health issue assessment. EPA/600/8-87/001. Office of Health and Environmental Assessment, US Environmental Protection Agency, Washington, DC.

EPA. 1993. Provisional guidance for quantitative risk assessment of polycyclic aromatic hydrocarbons. EPA-600/R-93/089. Environmental Criteria and Assessment Office, Office of Health and Environmental Assessment, US Environmental Protection Agency, Cincinnati, OH.

EPA. 1996. PCBs: Cancer dose-response assessment and application to environmental mixtures. EPA/600/P-96/001F. Office of Pollution Prevention and Toxics, US Environmental Protection Agency, Washington, DC.

EPA. 1997a. Arsenic and fish consumption. EPA-822-R-97-003. Health and Ecological Criteria Division, US Environmental Protection Agency, Washington DC.

EPA. 1997b. Health Effects Assessment summary tables. FY 1997 update. EPA-540-R-97-036. Office of Research and Development and Office of Emergency and Remedial Response, US Environmental Protection Agency, Washington, DC.

EPA. 1997c. Mercury study report to Congress. EPA/452/R-97-003. Health and Ecological Criteria Division, Office of Research and Development and Office of Air Quality Planning and Standards, US Environmental Protection Agency, Washington, DC.

EPA. 2000. Guidance for assessing chemical contaminant data for use in fish advisories. Volume 2: Risk assessment and fish consumption limits. Third ed. EPA 823-B-00-008. US Environmental Protection Agency, Washington, DC.

EPA. 2004. EPA Region IX preliminary remediation goals: 2004 PRG table [online]. US Environmental Protection Agency Region IX, San Francisco, CA. Updated October 2004. Available from: http://www.epa.gov/region09/waste/sfund/prg/index.html.

EPA. 2005. EPA Region III risk-based concentration table [online]. US Environmental Protection Agency Region III, Philadelphia, PA. Updated October 2005. Available from: http://www.epa.gov/reg3hwmd/risk/human/index.htm.

EPA. 2006a. Ground water and drinking water: Drinking water contaminants [online]. Office of Ground Water and Drinking Water (OGWDW), US Environmental Protection Agency, Washington, DC. Updated 2/28/2006. Available from: http://www.epa.gov/OGWDW/hfacts.html.

EPA. 2008. Integrated Risk Information System (IRIS) database [online]. US Environmental Protection Agency, Washington, DC. [Cited 1/2006]. Available from: http://www.epa.gov/iris/.

Faust, R.A. 1992. Toxicity summary for copper. Health and Research Safety Division, Biomedical and Environmental Information Analysis Section, Chemical Hazard Evaluation and Communication Group, Oak Ridge National Laboratory, Oak Ridge, TN.

FDA. 1993. Guidance document for cadmium in shellfish. Center for Food Safety and Applied Nutrition, US Food and Drug Administration, Washington, DC.

Kenyon, E.M., and M.F. Hughes. 2001. A concise review of the toxicity and carcinogenicity of dimethylarsinic acid. Toxicology 160(1-3):227-236.

Krajnc, E., P.W. Webster, and J.G. Loeber. 1984. Toxicity of bis(tri-*n*-butyltin) oxide in the rat. I: Short-term effects of general parameters and on the endocrine and lymphoid systems. Toxicol Appl Pharmacol 75(363-386).

Longnecker, M.P., M.S. Wolff, B.C. Gladen, J.W.G. Brock, J.L. Jacobson, S.A. Korrick, W.J. Rogan, N. Weisglas-Kuperus, I. Hertz-Picciotto, P. Ayotte, P. Stewart, G. Winneke, M.J. Charles, S.W. Jacobson, E. Dewailly, E.R. Boersma, L.M. Altshul, B. Heinzow, J.J. Pagano, and A.A. Jensen. 2003. Comparison of polychlorinated biphenyl levels across studies of human neurodevelopment. Environ Health Persp 111(1):65-70.

ORNL. 2008. Risk Assessment Information System (RAIS). http://rais.ornl.gov/. Accessed October 2008.

Pattee, O.H., and D. J. Pain. 2003. Lead in the environment. In: Hoffman DJ, Rattner BA, Burton GA, Jr, Cairns J, Jr, eds, Handbook of ecotoxicology. Second ed. Lewis Publishers, Boca Raton, FL, pp 373-408.

Petrick, J.S., A. Ayala-Fierro, W.R. Cullen, D.E. Carter, and H.V. Aposhian. 2000. Monomethylarsonous acid (MMAIII) is more toxic than arsenite in Chang human hepatocytes. Toxicol Appl Pharmacol 163:203-207.

Petrick, J.S., J. Jagadish, E.A. Mash, and H.V. Aposhian. 2001. Monomethylarsonous acid (MMAIII) and arsenite: LD50 in hamsters and in vitro inhibition of pyruvate dehydrogenase. Chem Res Toxicol 14:651-656.

Prince, M.M., A.M. Ruder, M.J. Hein, M.A. Waters, E.A. Whelan, N. Nilsen, E.M. Ward, T.M. Schnorr, P.A. Laber, and K.E. Davis-King. 2006a. Mortality and exposure response among 14,458 electrical capacitor manufacturing workers exposed to polychlorinated biphenyls (PCBs). Environ Health Persp 114(10):1508-1514.

Prince, M.M., M.J. Hein, A.M. Ruder, M.A. Waters, P.A. Laber, and E.A. Whelan. 2006b. Update: cohort mortality study of workers highly exposed to polychlorinated biphenyls (PCBs) during the manufacture of electrical capacitors, 1940-1998. Environ Health Glob Access 5(13):10 pp.

Ruder, A.M., M.J. Hein, N. Nilsen, M.A. Waters, P.A. Laber, K. Davis-King, M.M. Prince, and E.A. Whelan. 2006. Mortality among workers exposed to polychlorinated biphenyls (PCBs) in an electrical capacitor manufacturing plant in Indiana: an update. Environ Health Persp 114(1):18-23.

Rushneck, D.R., A. Beliveau, B. Fowler, C. Hamilton, D. Hoover, K. Kaye, M. Berg, T. Smith, W.A. Telliard, H. Roman, E. Ruder, and L. Ryan. 2004. Concentrations of dioxin-like PCB congeners in unweathered Aroclors by HRGC/HRMS using EPA method 1668A. Chemosphere 54:79-87.

Safe, S.H. 1994. Polychlorinated biphenyls (PCBs): environmental impact, biochemical and toxic responses, and implications for risk assessment. Crit Rev Toxicol 24(2):87–149.

Silberhorn, E.M., H.P. Glauert, and L.W. Robertson. 1990. Carcinogenicity of polyhalogenated biphenyls: PCBs and PBBs. Crit Rev Toxicol 20(6):397-426.

Thomas, D.J., M. Styblo, and S. Lin. 2001. The cellular metabolism and systemic toxicity of arsenic. Toxicol Appl Pharmacol 176:127-144.

TOXNET. 2006. Hazardous substances data bank (HSDB) [online]. TOXNET Toxicology Data Network, US National Library of Medicine, Bethesda, MD. Available from: http://toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?HSDB.

Van den Berg, M., L.S. Birnbaum, M. Denison, M. De Vito, W. Farland, M. Feeley, H. Fiedler, H. Hakansson, A. Hanberg, L. Haws, M. Rose, S. Safe, D. Schrenk, C. Tohyama, A. Tritscher, J. Tuomisto, M. Tysklind, N. Walker, and R.E. Peterson. 2006. The 2005 World Health Organization reevaluation of human and mammalian toxic equivalency factors for dioxins and dioxin-like compounds. Tox Sci 93(2):223-241.

Vos, J., A. Deklerk, E. Krajnc, L. Van Loveren, and J. Rozing. 1990. Immunotoxicity of bis(tri-butyltin) oxide in the rat: effects on thymus-dependent immunity and on nonspecific resistance following long-term exposure in young versus aged rats. Toxicol Appl Pharmacol 105:144-155.

WHO. 1990. Environmental health criteria 101: Methylmercury [online]. World Health Organization, Geneva, Switzerland. Available from: http://www.inchem.org/documents/ehc/ehc/ehc101.htm.

Windward. 2007. Lower Duwamish Waterway Remedial Investigation. Baseline Human Health Risk Assessment. Final. Prepared for Lower Duwamish Waterway Group. Windward Environmental LLC, Seattle, WA. November.

APPENDIX D

SEAFOOD INGESTION RISKS RE-CALCULATED WITH ALTERNATIVE BSAFS

NOVEMBER 13, 2008

LOCKHEED WEST SITE

HUMAN HEALTH RISK ASSESSMENT

RE-CALCULATED SEAFOOD INGESTION HEALTH RISKS WITH ALTERNATIVE BSAFS

SUMMARY

The following presents a comparison of the excess cancer risks and non-cancer hazards from the draft human health risk assessment (HHRA) for the Lockheed West CERCLA site (Tetra Tech 2008a) with risks re-calculated using alternative biota-sediment accumulation factors (BSAFs) for modeling tissue concentrations in seafood. This comparison of risk estimates was performed for the risk driver chemicals of concern (COC) in the adult tribal reasonable maximum exposure (RME) seafood consumption scenario. Methods for exposure and risk calculations using alternative tissue modeling methods were the same as used in the draft HHRA. A summary of the total excess cancer risks and non-cancer hazards from the draft HHRA and those using alternative BSAFs for tissue modeling is presented in Table 1.

Table 1. Summary of Risk Comparison for Risk Driver Chemicals of Concern

Scenario	Source	Cancer Risks	Non-Cancer Hazard Index
Tribal RME Seafood Consumption	Draft HHRA[a]	8×10^{-3}	167
	Alternative BSAFs[b]	8×10^{-3}	205

Risk driver chemicals of concern = arsenic (inorganic), carcinogenic PAHs, total PCBs, tributyltin

a. Tissue modeling is based on literature BSAFs and regression equations from LDW site data, as per the RI/FS work plan.

b. Tissue modeling uses alternative BSAFs developed from sources identified in Attachment 1: 90 percent upper confidence limits (90 UCL) on regressions with log K_{ow}, 90 UCLs on database values, 75th percentiles on database values, or sources from the draft HHRA where alternatives are unavailable.

This comparison suggests that use of alternative BSAFs for modeling tissue concentrations of risk driver COCs would result in no change in excess cancer risk estimates and a 23 percent increase in non-cancer hazards, from a hazard index of 167 to 205, for the adult tribal RME seafood consumption scenario. Given that both the total excess cancer risk estimate and non-cancer hazards in the draft HHRA exceed EPA risk thresholds of 10^{-4} and 1, respectively, the use of alternative methods for tissue modeling in the HHRA will not impact risk management decisions for the site.

ANALYSIS

The Remedial Investigation/Feasibility Study (RI/FS) work plan for the Lockheed West Site (Tetra Tech 2008b) proposed a process for using modeling to estimate tissue concentrations of chemicals of potential concern (COPCs) in the baseline HHRA. The estimated tissue concentrations were to be used for the seafood consumption scenarios that estimated excess cancer risks and non-cancer hazards from ingesting various types of seafood from the Site. The modeling described in the work plan was based on applying BSAFs or regression equations on tissue and sediment relationships to the sediment exposure point concentrations (EPCs) for the COPCs identified for seafood tissue. The work plan identified various literature sources for the BSAFs, and the regression equations from the ecological risk assessment (ERA) and draft final RI report for the Lower Duwamish Waterway (LDW) CERCLA site, located upstream of the Lockheed West Site.

EPA approved the RI/FS work plan and a subsequent list of BSAFs and regression equations submitted by Lockheed Martin Corporation for use in the tissue modeling of the HHRA. Prior to submission of the draft HHRA to EPA, EPA requested during the project meeting of October 21, 2008, that alternative BSAFs also be considered in the tissue modeling, with a re-calculation of risk estimates for risk driver chemicals and the risk driver exposure scenario, and results conveyed in a separate memorandum. EPA expressed interest in the effects of alternative tissue modeling on the risk estimates. This memo presents the results of the re-calculation of excess cancer risk estimates and non-cancer hazards for the adult tribal RME seafood consumption scenario using alternative BSAFs, and compares them with risk estimates from the draft HHRA for the Lockheed West Site. The re-calculated risk estimates are based on the alternative sources of BSAFs for modeling tissue concentrations in seafood that were recommended by EPA, and uses the same exposure parameters and calculation procedures as used in the draft HHRA.

Risk estimates are re-calculated for four risk driver COCs that have been identified in the draft HHRA for the tribal RME seafood consumption scenario (COCs are defined as those COPCs with exceedance of 10^{-6} excess cancer risk or hazard quotient of 1; risk drivers are those COCs that account for the majority of the risks):

- arsenic (modeled as inorganic arsenic in all seafood types)
- carcinogenic polycyclic aromatic hydrocarbons (cPAHs)
- tributyltin (TBT)
- total polychlorinated biphenyls (PCBs, as total Aroclors)

Details on the tissue modeling and risk calculations can be found in the draft HHRA report (Tetra Tech 2008a).

In the exposure assessment of the draft HHRA, tissue concentrations of COPCs are modeled from the EPCs in sediment for seven categories of seafood tissue: benthic fish fillet, benthic fish whole body, pelagic fish, clam, mussel, crab whole body, and crab edible meat, consistent with the RI/FS work plan (Tetra Tech 2008b) and the LDW HHRA (Windward 2007a). EPCs in sediment are the 95 percent upper confidence limit (UCL) on the mean sediment concentration, as determined by ProUCL 4.0. EPCs in intertidal sediment are used for modeling tissue concentrations of clams; EPCs in subtidal plus intertidal sediments are used for modeling tissue concentrations of fish and crab. BSAF modeling was performed with sediment normalized to organic carbon fraction, and tissue to lipid fraction, for cPAHs, PCBs, and TBT. The EPC for cPAHs in sediment was used to model cPAH concentrations in tissues using BSAFs for benzo(a)pyrene. Arsenic was modeled as total arsenic in all tissues, and then converted to inorganic arsenic in each tissue based on percentages from the LDW RI (e.g., clam inorganic arsenic was assumed to be 40% of total arsenic)

BSAF SOURCES

The tissue modeling for the draft HHRA used the literature BSAFs from sources identified in the RI/FS work plan (Tetra Tech 2008b) and the regression equations on tissue and sediment relationships taken from the LDW ERA (Appendix A, Windward 2007b) and the draft final RI report (Appendix D, food web model, Windward 2008). The values and sources of the BSAFs and equations used for the modeling of the four risk driver COCs in the draft HHRA are summarized in Table 2.

For the alternative BSAFs, EPA (2008) provided a list of sources for different chemical classes at the October 21, 2008, project meeting, which is reproduced as Attachment 1 to this memo. The sources for the four COCs consist of (1) Ecology (PTI 1995b) 90 UCLs on the regression with log K_{ow} for PCBs in fish and PCBs and PAHs in shellfish, (2) 90 UCLs calculated from individual BSAF values in databases (e.g., USACE 2008, PTI 1995a) for the remaining chemical classes, and (3) the 75th percentile values recommended by WDOH (1995) as alternatives for PAHs in fish. EPA also requested inclusion of the 90th percentile value for the BSAF for PAHs in fish provided in WDOH (1995). The 75th percentile value for the BSAF for PAHs in fish was used in the draft HHRA, based on the recommendation in WDOH (1995). For COCs or tissue types with no BSAF values in any of the sources listed in the table of Attachment 1, the sources from the draft HHRA were used, consisting of either a 90th percentile BSAF value from the ERED database or a regression equation.

Table 2 presents the BSAFs and regression equations approved by EPA for use in the draft HHRA and the alternative BSAF values for each of the four COCs.

The BSAF sources are summarized as the following:

- Proposed in the RI/FS work plan and used in the draft HHRA for the four COCs:
    - Regression equations from LDW ERA and RI reports – arsenic, TBT, and PCBs in clams; PCBs in fish and crabs.
    - Army Corps of Engineers (USACE 2008) BSAF database (also referred to as the ERED database) – 90^{th} percentile values for cPAHs (benzo[a]pyrene) in clams; and cPAHs (benzo[a]pyrene) and TBT in crab.
    - PTI 1995a - single values for arsenic in fish and crab
    - WDOH 1995 – 75^{th} percentile value for cPAHs (benzo[a]pyrene) in fish.
- Alternative sources (Attachment 1, and including 90^{th} percentile values per EPA request):
    1. PTI 1995b – 90 UCL on the regression of BSAF values against log K_{ow} – PAHs and PCBs in clams, PCBs in fish.
    2. PTI 1995a:
        a. 90 UCL on the mean of BSAF values –arsenic in clams
        b. 90^{th} percentile value for arsenic in clams
        c. single values for arsenic in fish and crab
    3. Army Corps of Engineers (USACE 2008) BSAF database (ERED)
        a. 90 UCL on the mean of values – cPAHs (benzo[a]pyrene), TBT, and PCBs in clams, cPAHs (benzo[a]pyrene) in crab
        b. 90^{th} percentile values – cPAHs (benzo[a]pyrene), TBT, and PCBs in clams; and cPAHs (benzo[a]pyrene) and TBT in crab
    4. WDOH 1995 – 75^{th} and 90^{th} percentile values for PAHs and PCBs in fish, taken from chemical groupings based on log K_{ow}.

RESULTS OF COMPARISON

The excess cancer risk and non-cancer risk estimates for the tribal RME seafood consumption scenario from the draft HHRA and as re-calculated using each of the alternative BSAFs for the four COCs are presented in Table 3. At the bottom of Table 3 are presented total excess cancer risks and hazard index (sum of hazard quotients) for the four COCs in the tribal RME scenario as calculated in the draft HHRA and using the alternative BSAFs. The summed risk estimates indicate that the use of alternative BSAFs for tissue modeling would result in an increase in excess cancer risk estimates from 8.1 x 10^{-3} to 8.4 x 10^{-3}, and non-cancer hazards from 167 to 205 (23 percent increase). Because total excess cancer risks are presented with one significant digit, as per EPA guidance on HHRA, the total cancer risk estimates can be considered unchanged with the use of alternative BSAFs.

The changes in risk estimates for each COC using the alternative BSAFs are summarized as the following:

Arsenic:

- Cancer risks from arsenic in seafood using the 90 UCL value on the PTI (1995a) data for clams would decrease from 2.6 x 10^{-3} to 1.7 x 10^{-3}.
- The hazard quotient would decrease from 6 to 4 using the 90 UCL BSAF for clams.

cPAHs:

- Cancer risk estimates would decrease from 2.6 x 10^{-3} to 2.3 x 10^{-3} using the 90 UCL on the regression with log K_{ow} for clams.
- Cancer risk estimates would increase from 2.6 x 10^{-3} to 5.8 x 10^{-3} using the 90th percentile values for clams, fish, and crab.

PCBs:

- Cancer risk estimates would increase from 2.9 x 10^{-3} to 4.4 x 10^{-3} using the 90 UCL on the log K_{ow} regression values for PCBs in clams and fish.
- Cancer risk estimates would increase to 1.1 x 10^{-2} when using the ERED 90th percentile BSAF for PCBs in clams and the WDOH 90th percentile BSAFs for PCBs in fish.
- Hazard quotients increase from 72 to 110 when using the 90 UCL on the log K_{ow} regression values for PCBs in fish and clams.

TBT – Non-cancer risks increase slightly from hazard quotient of 89 to 91 when using alternative BSAF sources. Note that an alternative BSAF for TBT was only available for clams in the ERED database (Table 2).

In summary, excess cancer risks decrease for cPAHs, and increase for PCBs, from the risk estimates in the draft HHRA when using 90 UCL regressions on log K_{ow}; and decrease for arsenic but increase for PCBs and cPAHs when using 90 UCL values from databases. The use of 90th percentile values from available databases also results in a decrease for arsenic cancer risks, but an increase in cancer and non-cancer risks for cPAHs, PCBs, and TBT. The highest increase in cancer risk estimates results from the use of 90th percentile BSAF values for PCBs from the ERED (clams) and WDOH (fish) databases.

In comparing the risk estimates re-calculated using alternative BSAFs with risk estimates in the draft HHRA, total excess cancer risks for the tribal RME seafood consumption scenario are unchanged, and non-cancer hazards increase 23 percent for the sums of risk driver COCs (Table 3). The total excess cancer risk estimates and non-cancer hazards in the draft HHRA for the tribal RME seafood consumption scenario exceed the EPA risk thresholds of 10^{-4} and 1, respectively, which are sufficient to warrant site cleanup. Use of alternative BSAF sources in the tissue modeling would not affect remediation decisions at the Lockheed West Site at this time.

Table 2. Summary of Tissue Modeling Methods used in the Draft HHRA and Alternative BSAF Sources

	Chemical of Concern	Draft HHRA BSAF	Draft HHRA BSAF Reference[c]	90% UCL on Regression with K_{ow} BSAF	90% UCL on Regression with K_{ow} BSAF Reference[c]	90% UCL[a] BSAF	90% UCL[a] BSAF Reference[c]	90th Percentile[b] BSAF	90th Percentile[b] BSAF Reference[c]
Clam									
	Arsenic	Regression	1	NA	-	0.198	PTI 1995a LogN	0.204	PTI 1995a
	cPAHs	0.59	ERED ME	0.38	PTI 1995b	0.653	ERED ME LogN (Chebyshev)	0.59	ERED ME
	Tributyltin	Regression	1	NA		6.16	ERED ME N	7.88	ERED ME
	PCBs (total)	Regression	2	2.55	PTI 1995b	1.21	ERED ME LogN	1.29	ERED ME
Fish									
	Arsenic	0.12 n=1	PTI 1995a	NA	-	NA	-	NA	-
	cPAHs	0.105	WDOH 75th Percentile	NA	-	NA	-	0.66	WDOH
	Tributyltin	0.23	3	NA	-	NA	-	NA	-
	PCBs (total)	Regression	2	3.04	PTI 1995b	NA	-	11.08	WDOH
								3.962	WDOH 75th Percentile
Crab									
	Arsenic	0.022 n=1	PTI 1995a	NA	-	NA	-		
	cPAHs	0.14 n=3	ERED CM	NA	-	0.153	ERED CM N	0.14 n=3	ERED CM
	Tributyltin	4.18 n=2	ERED CM	NA	-	NA	-	4.18 n=2	ERED CM
	PCBs (total)	-	2	NA	-	NA	-	NA	-

a. BSAFs were calculated as the 90 percent upper confidence limits (UCL) on the mean value in a database (ERED, PTI 1995a), using ProUCL.
LogN: Log normal distribution; Chebyshev = 90 UCL basis
N: Normal distribution
b. BSAFs are 90th percentiles of values calculated from a database (ERED, PTI 1995a) or taken from a source (WDOH).
c. BSAF Sources:
1. Based on regression equations in the LDW ERA (Windward 2007b), Attachment 11. Equation for arsenic: tissue concentration = 5.1 x (sediment concentration^0.47); units in mg/kg dw. Equation for TBT: tissue concentration = sediment concentration^0.1801 x 145.4; units calculated as µg/kg dw sediment, and µg/kg dw tissue, converted to mg/kg ww.
2. Based on regression equations from the LDW food web model, Appendix D, draft final RI (Windward 2008).
PCBs in clams: tissue concentration = 0.2879 x sediment concentration + 9.4827; units in µg/kg dw.
PCBs in fish: tissue concentration = 6.2255 x sediment concentration + 118.05; units in µg/kg dw.
PCBs in crab: tissue concentration = 2.779 x sediment concentration + 145.28; units in µg/kg dw.
3. Derived from mean TBT data in site-wide sediment and whole body pelagic fish in the LDW ERA (Windward 2007b).

ERED: Environmental Residue-Effects Database, http://el.erdc.usace.army.mil/bsaf/BSAF.html – *Macoma nasuta*, 90th percentile value for cPAHs in clams.
CM: Crustacean, marine: 90th percentile values for marine crustaceans for cPAHs (benzo[a]pyrene BSAF, n=3) and TBT (n=2).
ME: Mollusk, estuarine: 90th percentile values for estuarine clams (deposit feeders, or filter feeders if deposit feeder data unavailable)

WDOH: Washington State Department of Health. 1995. Tier I report, development of sediment quality criteria for the protection of human health. Washington State Department of Health, Olympia, WA. Used as 75th percentile values in the draft HHRA and Work Plan proposed values. Taken as 90th percentile values as an alternative source. BSAFs are developed for upper trophic level fish (species not identified), and grouped into chemical classes based on K_{ow}.

PTI 1995a: Bioaccumulation Factor Approach Analysis for Metals and Polar Compounds. Washington Department of Ecology. Developed 90th percentile values for fish; fish species not identified but stated as high trophic species. Crab: single BSAF value.

PTI 1995b: Analysis of BSAF Values for Nonpolar Organic Compounds in Finfish and Shellfish. 90 UCL on regressions of BSAFs with log K_{ow}.

Table 3. Comparison of Risk Estimates in the Draft HHRA with Risks using Alternative BSAF Modeling

Exposure Scenario	Chemical of Concern	Source of BSAF[a]	Daily Intake (ug/day)	Cancer Risk Calculations: Intake (mg/kg-day)	Cancer Risk Calculations: CSF $(mg/kg\text{-}day)^{-1}$	Cancer Risk Calculations: Cancer Risk	Non-Cancer Hazard Calculations: Intake (mg/kg-day)	Non-Cancer Hazard Calculations: RfD (mg/kg-day)	Non-Cancer Hazard Calculations: Hazard Quotient
Tribal RME Consumption of Seafood; fish, crab, clam, mussel tissue	Arsenic (inorganic)	Draft HHRA; Proposed in work plan	141.6	1.73E-03	1.5	2.6E-03	1.73E-03	3.0E-04	6
		90 UCL on database values - clam	90.0	1.10E-03	1.5	1.7E-03	1.10E-03	3.0E-04	4
		90th Percentile on database values – clam	92.7	1.13E-03	1.5	1.7E-03	1.13E-03	3.0E-04	4
	cPAH	Draft HHRA; Proposed in work plan	28.7	3.50E-04	7.3	2.6E-03	3.50E-04	-	-
		90 UCL of regression with log K_{ow} - clam	26.1	3.19E-04	7.3	2.3E-03	3.19E-04	-	-
		90 UCL on database values - clam & crab	30.4	3.72E-04	7.3	2.7E-03	3.72E-04	-	-
		75th Percentile on database values –fish (WDOH)	26.1	3.19E-04	7.3	2.3E-03	3.19E-04	-	-
		90th Percentile on database values – clam (ERED), fish (WDOH), crab (ERED)	64.9	7.93E-04	7.3	5.8E-03	7.93E-04	-	-
	Tributyltin	Draft HHRA; Proposed in work plan	1098	1.34E-02	-	-	1.34E-02	1.5E-04	89
		90 UCL on ERED database values - clam	1117	1.37E-02	-	-	1.37E-02	1.5E-04	91
		90th Percentile on ERED database values - clam & crab	1123	1.37E-02	-	-	1.37E-02	1.5E-04	91
	PCBs (total)	Draft HHRA; Proposed in work plan	117.5	1.44E-03	2	2.9E-03	1.44E-03	2.0E-05	72
		90 UCL of regression with log K_{ow} - clam & fish	179.3	2.19E-03	2	4.4E-03	2.19E-03	2.0E-05	110
		90 UCL on ERED database values - clam	174.2	2.13E-03	2	4.3E-03	2.13E-03	2.0E-05	106
		75th Percentile from WDOH database - fish	210.6	2.57E-03	2	5.1E-03	2.57E-03	2.0E-05	129

Table 3. Comparison of Risk Estimates in the Draft HHRA with Risks using Alternative BSAF Modeling (continued)

Exposure Scenario	Chemical of Concern	Source of BSAF[a]	Daily Intake (ug/day)	Cancer Risk Calculations			Non-Cancer Hazard Calculations		
		90th Percentile on database values – clam (ERED) & fish (WDOH)	447.3	5.47E-03	2	1.1E-02	5.47E-03	2.0E-05	273
	Risk Sums	Draft HHRA; Proposed in Work Plan			**Total Excess Cancer Risks:**	8.1E-03		**Hazard Index:**	167
		Alternative BSAF Sources[b]			**Total Excess Cancer Risks:**	8.4E-03		**Hazard Index:**	205

a. Listed in order of draft HHRA followed by alternative sources of BSAFs for each COC.

b. Sum of risk estimates using alternative BSAF sources in Attachment 1 (EPA 2008), supplemented with values from draft HHRA where alternatives are unavailable:

Arsenic – 90 UCL on PTI (1995a) database (clam); single values for fish and crab (PTI 1995a), as used in draft HHRA

cPAHs - 90 UCL of regression with log K_{ow} (clam); 75th percentile of WDOH database (fish); 90 UCL of ERED database (crab)

PCBs - 90 UCL of regression with log K_{ow} (clams, fish); regression equation from LDW for crab, as used in draft HHRA

TBT - 90 UCL on ERED database (clams); LDW RI data for fish, as used in draft HHRA; 90th percentile of ERED database for crab, as used in draft HHRA.

REFERENCES

EPA. 2008. Developing BSAFs for sites from literature values. US Environmental Protection Agency, Region 10 (received from L. Kissinger, October 21, 2008).

PTI. 1995a. Bioaccumulation Factor Approach Analysis for Metals and Polar Organic Compounds. Prepared for WA Dept Ecology, Environmental Review and Sediment Section. PTI, Bellevue, WA. October.

PTI. 1995b. Analysis of BSAF Values for Nonpolar Organic Compounds in Finfish and Shellfish. Prepared for WA Dept Ecology, Environmental Review and Sediment Section. PTI, Bellevue, WA. November.

Tetra Tech. 2008a. Draft Baseline Human Health Risk Assessment. Lockheed West Seattle Superfund Site. Prepared for Lockheed-Martin Corporation. Bothell, WA. November 10.

Tetra Tech. 2008b. Remedial Investigation/Feasibility Study Work Plan for Lockheed West Seattle Superfund Site. Final. Revision 3. Prepared for Lockheed-Martin Corporation. Bothell, WA. June.

USACE. 2008. BSAF Database. US Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS. On-line database, updated January 2008 - http://el.erdc.usace.army.mil/bsaf/BSAF.html. Database accessed September 2008

WDOH. 1995. Development of Sediment Quality Criteria for the Protection of Human Health. Tier I Report. Washington State Department of Health, Office of Toxic Substances. June.

Windward. 2007a. Lower Duwamish Waterway Remedial Investigation. Baseline Human Health Risk Assessment. Final. Prepared for Lower Duwamish Waterway Group. Windward Environmental LLC, Seattle, WA. November.

Windward. 2007b. Lower Duwamish Waterway Remedial Investigation. Baseline Ecological Risk Assessment. Final. Prepared for Lower Duwamish Waterway Group. Windward Environmental LLC, Seattle, WA. July 31.

Windward. 2008. Lower Duwamish Waterway Remedial Investigation. Draft Final. Remedial Investigation Report. Prepared for Lower Duwamish Waterway Group. Windward Environmental LLC, Seattle, WA. October.

ATTACHMENT 1

Approaches and Sources for Alternative BSAFs

Approach for Developing BSAFs		
Chemical Class	**Organism**	**Approach**
PCBs	Fish	Ecology regression 90% UCL equation
Dioxins/Furans	Fish	Ecology regression 90% UCL equation
Pesticides	Fish	90% UCL using BSAF data on individual pesticide or 75th percentile WADOH recommendation
PAH	Fish	90% UCL using BSAF data on individual pesticide or 75th percentile WADOH recommendation
Metals	Fish	90% UCL using BSAF data on individual metal
All other classes	Fish	90% UCL from data on individual chemicals
PCBs	Shellfish	Ecology regression 90% UCL equation
Dioxins/Furans	Shellfish	?
Pesticides	Shellfish	?
PAH	Shellfish	Ecology regression 90% UCL
Metals	Shellfish	90% UCL using BSAF data on individual metal
All other classes	Shellfish	90% UCL from data on individual chemicals

Source: Reproduced from EPA (2008), Region 10, October 21, 2008

APPENDIX E

COMPARATIVE ANALYSIS OF METALS BIOACCUMULATION AND SEAFOOD CONSUMPTION RISKS

DRAFT

Comparative Analysis of Metals Bioaccumulation and Tribal RME Seafood Consumption Risks and Hazards for Lockheed West Literature Value BAFs vs. Lower Duwamish Waterway Site Specific BAFs, Lon Kissinger DRAFT 3/6/09

1. Introduction

Metals bioaccumulation may be affected by sediment metal concentration, environmental temperature and oxygen content, hardness, presence of organic compounds, pH, general physiologic behavior, life cycle and life history, seasonal variations, species-specific and individual variability, contamination in food and an organism's intestinal contents. Failure to consider any single factor can lead to serious misinterpretations of metals bioaccumulation (Prossi 1983 as cited in Ecology 1995).

The Lockheed West Site risk assessment utilized an Ecology 1995 technical publication discussing metals bioaccumulation to estimate tissue metal concentrations from Lockheed West Site sediment concentrations. The Ecology technical report proposes use of the 90th percentile of available literature metals BAFs to evaluate site specific metals bioaccumulation. Given the multitude of factors that can affect metals bioaccumulation, site specific data are preferred to use of literature values. The Lockheed West Site is immediately adjacent to the Lower Duwamish Waterway (LDW) Superfund Site. Similar species and environmental conditions are expected for the LDW and Lockheed West sites, though the upstream portion of the LDW has lower salinity than the Lockheed West Site. The LDW site has undergone extensive characterization of contaminants in aquatic organisms and sediments. Given the proximity of the LDW and Lockheed West sites, metals bioaccumulation factor (BAF) determinations using LDW data may be applicable to the Lockheed West Site.

Additionally, limited *Macoma* bioaccumulation for the Lockheed West Site may be used to evaluate metals bioaccumulation in bivalves as opposed to literature values. Many of the clams from the LDW site were *Mya arenaria*. *Mya arenaria* are filter feeders as opposed to *Macoma* species which are deposit feeders. Because of this difference in feeding strategy, Macoma sp. should hence be expected to have a more direct association with sediment contamination than *Mya arenaria*. *Macoma* data are thus to be preferred in characterizing bioaccumulation over *Mya arenaria*.

2. Objective

The objective of this report is to evaluate LDW metals bioaccumulation, to compare this information along with Lockheed West *Macoma* BAFs to metals BAFs selected for the Lockheed West Site, and to compare hazard quotients (HQs) and risks resulting from use of Lockheed West Site vs. LDW and Lockheed West *Macoma* BAFs.

3. Methodology

Surficial sediment metals concentration data were obtained from the April 26, 2006, Microsoft Access database used for the LDW human health risk assessment. Aquatic biota tissue data were taken from the fish and crab data report for the LDW (LDWG 2005).

BAFs were developed for the following organism/tissue types: benthic whole body (i.e. English Sole and Starry Flounder), pelagic (i.e., Shiner Surfperch) whole body, crab (i.e. Dungeness and Slender) edible meat, and crab (i.e., Dungeness and Slender) hepatopancreas. Data were available to compute benthic fillet BAFs, but given that metals may accumulate in a variety of tissues, BAFs were based on whole body tissue results. An exception was made for crab, as no whole body data were available. Consequently crab edible tissue and hepatopancreas results were used to develop crab BAFs based on the relative weight of these two tissue types. LDW tissue samples were collected on an area specific basis in four areas that represented different salinity regimes and PCB concentrations. BAFs were computed for data from these individual sampling areas as well as the entire LDW to evaluate potential differences in bioaccumulation that might result from changes in environmental conditions (e.g., salinity, metals concentrations), the feeding areas of different species, or other factors.

To compute the LDW wide BAF for each metal, LDW wide concentration data for each species tissue type were used to compute an average concentration. The average tissue concentration was then divided by the LDW wide spatially weighted average concentration (SWAC) for that metal in surficial sediments. For fish/crab sampling area specific BAFs, tissue data for a specific area were paired with the appropriate surface sediment metal SWAC for that area.

BAFs were computed using wet weight tissue concentrations and dry weight sediment concentrations.

SWACs were used to correct for potential bias introduced by higher sampling density in contaminated areas. The SWAC approach assigns an area of influence (in this case determined using Thiessen Polygons, TP) for each sampling result. In high density sampling areas, individual samples have a lower area of influence than lower density sampling areas. The lower the area associated with an individual sample, the less that result affects a SWAC (the formula describing this relationship is given below).

The steps taken to derive surficial area weighted sediment concentrations were as follows (SEE Figure 1 for a graphical description of the process):

1) Surficial sediment data from the LDWG Baseline RA Access database were imported into ArcMap Version 9.2.
2) The event data were converted into a shape file.
3) Sediment data within the boundaries of the LDW site were selected.
4) The Thiessen Polygon (TP) generator within the ArcToolbox application was used to generate TPs for each sediment sampling location.
5) The TPs were clipped to fit within the boundary of the LDW shore line and TP areas were computed.
6) For individual fish/crab sampling areas, the TPs generated in step 4 were clipped to fit the shape of that fish/crab sampling area and TP areas were re-computed.
7) The dbf files for relevant data were imported into Microsoft Excel.
8) Average metals concentrations were calculated as Σ (TP $area_i$ x $concentration_i$) / Σ TP $area_i$
   a) For LDW wide samples, TPs throughout the LDW were used.
   b) For fish/crab area specific results, only TPs within an individual fish/crab area were used.

The impact of using all sediment metal data, detected and non-detected, vs. only detected data was also evaluated. Separate sets of TPs were generated using detected values vs. the total surficial sediment data set. If tissue data sets consisted of a high fraction of detections, then averages were computed for that species tissue type. There were a large number of non-detects for chromium in crab edible meat, and hepatopancreas samples. BAFs were not computed in these cases.

4. Results

4.1. Sediments

Most metals were detected in all LDW sediment samples (See Table 1). Three metals had frequencies of detection (FOD) that were less than 100%: arsenic, FOD = 93%; cadmium, FOD = 71%, and mercury, FOD = 86%. Generally, SWACs computed using all vs. detected data only did not vary substantially. The degree by which $SWAC_{detected\ data}$ exceeded $SWAC_{all\ data}$ for LDW wide SWACs was: As = 1%, Cd = 16%, and Hg =7%. The degree by which $SWAC_{detected\ data}$ exceeded $SWAC_{all\ data}$ for specific fish/crab sampling areas was 11% or less with the exception of cadmium in area 4, which had a value of 37%. Generally, it was felt that the uncertainty in SWACs caused by incorporating non-detect values was low. In computing BAFs, a health protective decision was made to use metal SWACs that included non-detect results. Use of a lower sediment concentration caused by incorporating non-detects would result in a higher, more protective BAF.

The ratio of a specific metal's concentration for an area to the minimum metal concentration for all areas was used to evaluate the magnitude and variation of metal concentrations (SEE Table 2).

Generally area 4 had the lowest sediment metals levels. Cadmium and lead showed the greatest variation in SWACs across fish/crab sampling areas. Cadmium and lead SWACs for area 1 were approximately three fold higher than their respective SWACs for area 4.

4.2. Tissues

Metals were generally detected in all tissue types (See Tables 3 through 6). Chromium was infrequently detected in crab edible meat and hepatopancreas samples.

4.2.1. Tissue Metals by Area

The ratio of a specific metal's concentration for an area to the minimum metal concentration for all areas was used to evaluate the magnitude and variation of metal concentrations across areas (See Table 7). Generally, fish tissue metals concentrations were lowest in upstream fish/crab sampling areas 3 and 4. There were a few exceptions to a trend towards lower metals concentrations in upstream areas. Chromium benthic fish whole body and pelagic fish whole body concentrations were highest in area 4. Copper benthic fish whole body concentrations were highest in area 3. All mercury fish results were highest in area 4.

The lowest crab edible meat and hepatopancreas sample metals concentrations were uniformly found in area 3. Crab edible meat arsenic concentrations were highest in area 4. Crab hepatopancreas copper concentrations were highest in area 4.

The most variable tissue metal concentrations between areas were as follows: chromium benthic whole body, lead crab hepatopancreas, copper benthic whole body, and cadmium crab hepatopancreas.

4.2.2. Tissue Metals as a Function of Sediment Concentration

Tissue metal concentrations vs. sediment concentrations are plotted in Figures 2 through 7. Generally there did not appear to be an association between sediment and tissue metal concentrations. Failure to detect a relationship may be due to the fact that a wide range of sediment concentrations was not available to evaluate the presence of a relationship. Further, it is unclear as to whether SWACs for fish/crab sampling areas were the appropriate sediment metal concentration metric to associate with tissue metal concentrations.

4.3. LDW Bioaccumulation Factors and Recommended LDW BAFs for Use at Lockheed West

Given that tissue – sediment metal concentration relationships were not discernable; it is recommended that LDW wide BAFs be used to evaluate Lockheed West Site HQs and risks. Since only one fish tissue BAF is used for the Lockheed West Site HHRA, it is recommended that the maximum BAF obtained for either LDW pelagic or benthic fish species be used. A whole crab BAF was computed by assuming that 69% of crab tissue was edible meat and 31% was hepatopancreas by weight. LDW BAFs as well as the BAFs used in the Lockheed West Site HHRA are provided in Table 8. Table cells containing the recommended LDW fish BAF are shaded.

5. Comparison of BAFs Used for the Lockheed West Project with LDW BAFs

BAFs for LDW whole body benthic and pelagic fish samples are plotted along with Lockheed West Site fish BAFs in Figure 9. BAFs for LDW crab and Lockheed West Site crab BAFs are plotted in Figure 10. Numeric values are provided in Table 8. Ratios of Lockheed West Site to LDW BAFs are provided in Table 11. All BAFs are expressed in terms of (mg/kg tissue wet weight) / (mg/kg sediment dry weight). Lockheed West dry weight BAFs were converted to the desired units (i.e., wet weight tissue to dry weight sediment) by multiplying the dry weight BAF by the percent solids for each tissue type derived from Table 3-25 of the Lockheed West Site HHRA.

Most of the fish BAFs employed by the Lockheed West Site are several fold greater than those computed from LDW data. However, Lockheed West Site fish BAFs for arsenic, chromium and mercury are less than LDW fish BAFs.

Lockheed West Site crab BAFs were generally lower than the corresponding blended LDW BAFs. Lockheed West Site arsenic, cadmium, and mercury crab BAFs were 50 fold lower than the corresponding LDW BAFs. Lockheed West Site copper and zinc BAFs were approximately 10 fold lower than the corresponding LDW BAFs.

6. Comparison of Lockheed West Macoma BAFs with Literature Values Used in the Lockheed West HHRA

Gary Braun in an email from October 1, 2008, provided information on site specific *Macoma* BAFs and compared them to literature values used in the Lockheed West Site HHRA. This information is provided in Table 12. Lockheed West Site-specific BAFs for arsenic, chromium, and copper were greater than the literature values used.

7. Impact of Using LDW vs. Lockheed West Metals BAFs on Risk and Hazard Quotient Estimates

Chronic daily intake for contaminants via adult tribal seafood consumption parameterized based on Tulalip Tribes' data was provided in Table 3-7 of the Lockheed West Site HHRA. Child tribal seafood consumption parameterized using Tulalip data was provided in Table 3-8 of the Lockheed West Site HHRA. This information is repeated here. Exposure point concentrations derived using EPCs derived using Lockheed West Site and LDW BAFs are provided in Table 13.

Chronic daily intake (CDI) mg/kg-day) = [(EPC-p x IR-p) + (EPC-b x IR-b) + (EPC-bwb x IR-bwb) + (EPC-c x IR-c) + (EPC-cwb x IR-cwb) + (EPC-m x IR-m) + (EPC-cl x IR-cl)] x FI x EF x ED-a x CF x 1/BW-a x 1/AT

Where:

EPC-p	Exposure point concentration in pelagic fish, mg/kg ww
EPC-b	Exposure point concentration in benthic fish fillet, mg/kg ww
EPC-bwb	Exposure point concentration in benthic fish whole body, mg/kg ww
EPC-c	Exposure point concentration in crab edible meat, mg/kg ww
EPC-cwb	Exposure point concentration in crab whole body, mg/kg ww
EPC-m	Exposure point concentration in mussels, mg/kg ww
EPC-cl	Exposure point concentration in clams, mg/kg ww
IR-p	Ingestion rate for pelagic fish, 8.1 g/day adult, 3.2 g/day child
IR-b	Ingestion rate for benthic fish, 7.5 g/day adult, 3.0 g/day child
IR-bwb	Ingestion rate for benthic fish whole body, 0 g/day adult and child.
IR-c	Ingestion rate for crab edible meat, 28.0 g/day adult, 11.5 g/day child[3]
IR-cwb	Ingestion rate for crab whole body, 8.8 g/day adult, 3.6 g/day child[1]
IR-m	Ingestion rate for mussels, 0.8 g/day adult, 0.33 g/day child
IR-cl	Ingestion rate for clams, 43.4 g/day adult, 17.4 g/day child[1]
FI	Fractional intake from source, 1 unitless
ED-a	Exposure duration - 70 years adult, 6 years child
CF	Conversion factor, 0.001 g fish/kilogram fish
BW-a	Body weight - 81.8 kg adult, 15.2 kg child
AT-c	Averaging time - cancer, 25,550 days
AT – n	Averaging time – non cancer, 25,550 days adult, 2190 days child

Toxicity values (i.e. reference doses and cancer slope factors) used for the metals of concern are provided in Table 14.

Since a chromium BAF was not available for crab using LDW data, the Lockheed West Site BAF was used in the LDW based analysis of chromium's HQ.

Chronic daily intakes, hazard quotients and risks are provided in Table 15. In Table 15, the column headed "Lockheed West-old" provides chronic daily intakes (CDI) based on the

[3] Note that an error was made in the percentage of shellfish consumption attributed to clams and crab in the LDW HHRA. In the LDW HHRA, the percentage of shellfish consumption attributed to crab was set at 53% while the percentage of shellfish associated with bivalves was set at 46%. These values were reversed. The current analysis uses the correct fractions for consumption of various types of shellfish.

percentage attribution of clam vs. crab consumption used in the LDW and Lockheed West HHRAs. As was noted previously, these percentages were reversed in the LDW HHRA. The column "Lockheed West-new" provides CDIs based on the corrected percentage attribution of clam vs. crab consumption. The column "Lockheed West-new / Lockheed West-old" shows the difference in CDI resulting from the shift in percent attribution. Generally this effect is quite small, CDIs using the corrected percentages exceeded old values by a maximum of 15 percent.

The columns under the "HQ" and "Risk" heading provide hazard quotients and risks for different treatments of crab/clam consumption and Lockheed West vs. LDW BAFs. Increases in risk were deemed to be significant if the risks increased by an order of magnitude using LDW BAFs. Increases in HQ were deemed to be significant if HQs did not exceed 1.0 using Lockheed West BAFs but did exceed 1.0 using LDW BAFs. There were two significant changes in seafood consumption HQs and risks evaluated for tribal adults using Tulalip data. Arsenic risk increased from the 10^{-3} range to the 10^{-2} range. The chromium HQ using LDW BAFs was greater than 1.0. There were three significant changes in seafood consumption HQs and risks evaluated for tribal children assuming Tulalip child seafood consumption rates were 40 percent of adult rates. Arsenic risk increased from the 10^{-4} range to the 10^{-3} range. The chromium and mercury HQs based on LDW BAFs exceeded 1.0.

The implications of this analysis for revisions to the Lockheed West Site HHRA will require discussion between Lockheed and EPA.

Table 1. Spatially Weighted Average Concentrations of Metals in Various Areas of the LDW Using Either All Data or Detected Data Only

		LDW Wide			Area 1			Area 2			Area 3			Area 4		
Metal	LDW Wide FOD	Including ND	D Only	D/ND	Including ND	D Only	D/ND	Including ND	D Only	D/ND	Including ND	D Only	D/ND	Including ND	D Only	D/ND
Arsenic	93%	15.31	15.50	1%	15.50	15.63	1%	11.72	11.72	0%	9.18	10.45	14%	9.92	10.03	1%
Cadmium	71%	0.47	0.54	16%	0.65	0.71	10%	0.39	0.44	11%	0.57	0.63	9%	0.21	0.29	37%
Chromium	100%	29.42			32.91			28.77			34.45			22.04		
Copper	100%	60.93			73.76			59.15			53.83			32.04		
Lead	100%	47.65			61.79			47.78			59.80			20.28		
Mercury	86%	0.17	0.18	7%	0.22	0.22	3%	0.18	0.18	1%	0.15	0.16	5%	0.10	0.10	0%
Zinc	100%	124.81			155.10			117.09			123.90			77.84		

Table 2. Comparison of Sediment Metals SWACs for the Entire LDW and various Fish Crab Sampling Areas

Metal	SWAC LDW Wide	LDW wide SWAC / minimum SWAC	SWAC Area 1	Area 1 SWAC / minimum SWAC	SWAC Area 2	Area 2 SWAC / minimum SWAC	SWAC Area 3	Area 3 SWAC / minimum SWAC	SWAC Area 4	Area 4 SWAC / minimum SWAC
Arsenic	15.31	1.67	15.50	1.69	11.72	1.28	9.18	1.00	9.92	1.08
Cadmium	0.47	2.21	0.65	3.06	0.39	1.86	0.57	2.70	0.21	1.00
Chromium	29.42	1.34	32.91	1.49	28.77	1.31	34.45	1.56	22.04	1.00
Copper	60.93	1.90	73.76	2.30	59.15	1.85	53.83	1.68	32.04	1.00
Lead	47.65	2.35	61.79	3.05	47.78	2.36	59.80	2.95	20.28	1.00
Mercury	0.17	1.69	0.22	2.15	0.15	1.51	0.15	1.51	0.10	1.00
Zinc	124.81	1.60	155.10	1.99	117.09	1.50	123.90	1.59	77.84	1.00

Table 3. Average Tissue Metals Concentrations and Frequency of Detection (FOD) in LDW Benthic Fish Samples

	LDW Wide (n = 6)		Area 1 (n = 6)		Area 2 (n = 6)		Area 3 (n = 6)		Area 4 (n = 6)	
Metal	**mg/kg ww**	**FOD**	**mg/kg ww**	**FOD**	**mg/kg ww**	**FOD**	**mg/kg ww**	**FOD**	**mg/kg ww**	**FOD**
Arsenic	2.975	100%	3.596	100%	3.296	100%	3.165	100%	1.844	100%
Cadmium	0.007	100%	0.009	100%	0.009	100%	0.006	100%	0.006	100%
Copper	0.375	88%	0.293	100%	0.202	83%	0.182	83%	0.825	83%
Chromium	1.734	100%	0.762	100%	1.880	100%	2.657	100%	1.638	100%
Lead	0.348	100%	0.261	100%	0.453	100%	0.459	100%	0.221	100%
Mercury	0.014	100%	0.016	100%	0.011	100%	0.011	100%	0.019	100%
Zinc	12.946	100%	12.200	100%	13.050	100%	12.683	100%	13.850	100%

Table 4. Average Tissue Metals Concentrations and Frequency of Detection (FOD) in LDW Pelagic Fish Samples

	LDW Wide (n = 6)		Area 1 (n = 6)		Area 2 (n = 6)		Area 3 (n = 6)		Area 4 (n = 6)	
Metal	**mg/kg ww**	**FOD**	**mg/kg ww**	**FOD**	**mg/kg ww**	**FOD**	**mg/kg ww**	**FOD**	**mg/kg ww**	**FOD**
Arsenic	0.955	100%	0.949	100%	1.118	100%	0.881	100%	0.874	100%
Cadmium	0.014	100%	0.018	100%	0.016	100%	0.015	100%	0.012	100%
Chromium	0.200	96%	0.123	83%	0.123	100%	0.203	100%	0.212	100%
Copper	1.600	100%	1.738	100%	1.620	100%	1.890	100%	1.185	100%
Lead	0.110	100%	0.130	100%	0.114	100%	0.144	100%	0.055	100%
Mercury	0.033	100%	0.023	100%	0.027	100%	0.028	100%	0.031	100%
Zinc	21.000	100%	22.083	100%	23.653	100%	21.583	100%	20.350	100%

Table 5. Average Tissue Metals Concentrations and Frequency of Detection (FOD) in LDW Crab Edible Meat Samples

	LDW Wide (n = 6)		Area 1 (n = 6)		Area 2 (n = 6)		Area 3 (n = 6)		Area 4 (n = 1)	
Metal	mg/kg ww	FOD	mg/kg ww	FOD	mg/kg ww	FOD	mg/kg ww	FOD	mg/kg ww	FOD
Arsenic	3.224	100%	3.840	100%	2.693	100%	2.545	100%	6.780	100%
Cadmium	0.024	100%	0.026	100%	0.029	100%	0.015	100%	0.030	100%
Chromium	NA	0%	0.088	0%	0.092	0%	0.088	0%	0.110	0%
Copper	6.782	100%	7.200	100%	6.587	100%	6.232	100%	8.740	100%
Lead	0.024	100%	0.036	100%	0.024	100%	0.014	100%	0.018	100%
Mercury	0.049	100%	0.048	100%	0.052	100%	0.047	100%	0.045	100%
Zinc	34.037	100%	34.433	100%	35.200	100%	32.000	100%	36.900	100%

Table 6. Average Tissue Metals Concentrations and Frequency of Detection (FOD) in LDW Crab Hepatopancreas Samples

	LDW Wide (n = 2)		Area 1 (n = 2)		Area 2 (n = 2)		Area 3 (n = 2)		Area 4 (n = 1)	
Metal	mg/kg ww	FOD	mg/kg ww	FOD	mg/kg ww	FOD	mg/kg ww	FOD	mg/kg ww	FOD
Arsenic	3.119	100%	3.670	100%	2.520	100%	2.655	100%	4.140	100%
Cadmium	0.536	100%	0.789	100%	0.406	100%	0.286	100%	0.788	100%
Chromium	NA	29%	0.060	50%	0.065	0%	0.035	0%	0.160	100%
Copper	25.643	100%	41.550	100%	22.400	100%	17.050	100%	17.500	100%
Lead	0.105	100%	0.182	100%	0.102	100%	0.054	100%	0.059	100%
Mercury	0.025	100%	0.025	100%	0.023	100%	0.024	100%	0.036	100%
Zinc	23.586	100%	24.200	100%	26.700	100%	20.300	100%	22.700	100%

Table 7. Ratio of Metal Tissue Concentration Value for an Area to the Minimum Metal Concentration for all Areas by Tissue Type

Benthic Fish				
Metal	Area 1	Area 2	Area 3	Area 4
Arsenic	1.95	1.79	1.72	1.00
Cadmium	1.59	1.60	1.04	1.00
Chromium	1.61	1.11	1.00	4.54
Copper	1.00	2.47	3.48	2.15
Lead	1.18	2.05	2.08	1.00
Mercury	1.48	1.00	1.08	1.79
Zinc	1.00	1.07	1.04	1.14
Pelagic Fish				
Metal	Area 1	Area 2	Area 3	Area 4
Arsenic	1.09	1.28	1.01	1.00
Cadmium	1.56	1.37	1.26	1.00
Chromium	1.00	1.00	1.65	1.72
Copper	1.47	1.37	1.59	1.00
Lead	2.35	2.05	2.61	1.00
Mercury	1.00	1.20	1.23	1.36
Zinc	1.09	1.16	1.06	1.00
Crab Edible Meat				
Metal	Area 1	Area 2	Area 3	Area 4
Arsenic	1.51	1.06	1.00	2.66
Cadmium	1.75	1.91	1.00	1.95
Chromium	NA	NA	NA	NA
Copper	1.16	1.06	1.00	1.40
Lead	2.56	1.71	1.00	1.30
Mercury	1.06	1.15	1.04	1.00
Zinc	1.08	1.10	1.00	1.15
Crab Hepatopancreas				
Metal	Area 1	Area 2	Area 3	Area 4
Arsenic	1.46	1.00	1.05	1.64
Cadmium	2.76	1.42	1.00	2.76
Chromium	NA	NA	NA	NA
Copper	2.44	1.31	1.00	1.03
Lead	3.34	1.88	1.00	1.09
Mercury	1.09	1.00	1.04	1.60
Zinc	1.19	1.32	1.00	1.12

Table 8. Bioaccumulation Factors for Various Tissue Types Obtained from the Lower Duwamish Waterway (mg/kg$_{tissue}$ ww / mg/kg$_{sediment}$ dw)

Organism/Tissue	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Zinc
Lockheed West Fish	0.03	0.5	0.01075	0.113	0.0525	0.13375	1.16
Benthic Fish	0.1943	0.0160	0.0589	0.0285	0.0073	0.0823	0.1037
Pelagic Fish	0.0624	0.0299	0.0068	0.0263	0.0023	0.1933	0.1683
Lockheed West Crab	0.004	0.009		0.025	0.023	0.004	0.0288
Crab Edible Meat	0.2105	0.0508	NA	0.1113	0.0005	0.2855	0.2727
Crab Hepatopancreas	0.2037	1.1448	NA	0.4209	0.0022	0.1481	0.1890
"Blended" LDW Hepatopancreas - Edible meat	0.2084	0.3899	NA	0.2073	0.0010	0.2429	0.2468

Note: Recommended LDW fish BAFs are shaded.

Table 11. Comparison of Lockheed West and Lower Duwamish BAFs

Ratio: Lockheed West BAF to LDW BAF for:	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Zinc
Fish	0.15	16.72	0.18	3.96	7.19	0.69	6.89
Blended crab	0.02	0.02	NA	0.12	23.00	0.02	0.12

Note: Shaded cells indicate where Lockheed West BAFs are less than LDW BAFs.

Table 12. Comparison of Lockheed West Site Specific Macoma and Literature BAFs

Metal	Mean Lockheed West Site BSAF	Literature Value	Ratio Site/Literature
Arsenic (total)	1.02	0.314[a]	0.3
Cadmium	1.21	26.9	22
Chromium	0.14	0.0043	0.03
Copper	2.94	0.45	0.2
Lead	0.28	2.54	9.1
Mercury	0.44	0.92	2.1
Selenium	6.71	na	Na
Zinc	1.81	3.62	2.0

Note: Shaded cells indicate where Lockheed West BAFs are less than LDW BAFs.

Table 13. Exposure Point Concentrations Derived using Lockheed West vs. Lower Duwamish Waterway BAFs

		Exposure Point Concentration mg/kg ww		Fraction	Inorganic Arsenic Concentration	
Metal	**Tissue Class**	**Lockheed West**	**LDW or Lockheed West Macoma**	**Inorganic Arsenic**	**Lockheed West**	**LDW or Lockheed West Macoma**
Arsenic	fish	3.270	21.179	0.06	0.196	1.271
	fish fillet	3.270	21.179	0.0075	0.025	0.159
	crab whole body	0.432	22.716	0.025	0.011	0.568
	crab edible meat	0.432	22.716	0.005	0.002	0.114
	bivalve	9.053	29.376	0.4	3.621	11.750
Cadmium	fish	0.180	0.011			
	crab	0.003	0.140			
	bivalve	1.812	0.081			
Chromium	fish	0.968	5.305			
	crab	0.070				
	bivalve	0.128	4.158			
Copper	fish	69.834	17.592			
	crab	15.574	128.093			
	bivalve	56.952	370.440			
Lead	fish	7.665	1.067			
	crab	0.613	0.151			
	bivalve	139.827	15.414			
Mercury	fish	0.082	0.118			
	crab	0.014	0.148			
	bivalve	0.035	0.017			
Zinc	fish	548.680	79.587			
	crab	13.622	116.716			
	bivalve	543.000	271.500			

Table 14. Toxicity Values for Metals of Concern

Metal	RfD (mg/(kg day)	CSF (mg/(kg day))$^{-1}$
Arsenic	0.0003	1.5
Cadmium	0.001	NA
Chromium	0.003	NA
Copper	0.04	NA
Mercury (methyl)	0.0001	NA
Zinc	0.3	NA

Table 15. Comparison of Hazard Quotient and Risk Resulting from Use of Lockheed and Lower Duwamish BAFs

Metal	CDI, mg/kg/day				HQ			Risk		
	LW-new	LW-old	LW-new / LW-old	LDW	LW-new	LW-old	LDW	LW-new	LW-old	LDW
Adult Tribal Tulalip										
Arsenic	1.980E-03	1.729E-03	1.15	6.590E-03	6.60	5.76	21.97	3.0E-03	2.6E-03	9.9E-03
Cadmium	1.015E-03	8.892E-04	1.14	1.092E-04	1.01	0.89	0.11			
Chromium	2.849E-04	2.816E-04	1.01	3.290E-03	0.09	0.09	1.10			
Copper	5.110E-02	4.840E-02	1.06	2.611E-01	1.28	1.21	6.53			
Lead	7.729E-02	6.763E-02	1.14	8.600E-03						
Mercury	4.107E-05	3.977E-05	1.03	9.828E-05	0.41	0.40	0.98			
Zinc	4.042E-01	3.676E-01	1.10	2.144E-01	1.35	1.23	0.71			
Child Tribal Tulalip										
Arsenic	4.263E-03	3.752E-03	1.14	1.423E-02	14.21	12.51	47.42	5.5E-04	4.8E-04	1.8E-03
Cadmium	2.184E-03	1.942E-03	1.12	2.389E-04	2.18	1.94	0.24			
Chromium	6.132E-04	6.040E-04	1.02	7.083E-03	0.20	0.20	2.36			
Copper	1.100E-01	1.048E-01	1.05	5.665E-01	2.75	2.62	14.16			
Lead	1.664E-01	1.467E-01	1.13	1.856E-02						
Mercury	8.841E-05	8.605E-05	1.03	2.150E-04	0.88	0.86	2.15			
Zinc	8.700E-01	7.959E-01	1.09	4.651E-01	2.90	2.65	1.55			

Note: Shaded cells indicate where use of LDW BAFs results in a significant increase in HQ or risk for a contaminant.

Figure 1. Developing Surficial LDW Sediment Metals Concentrations

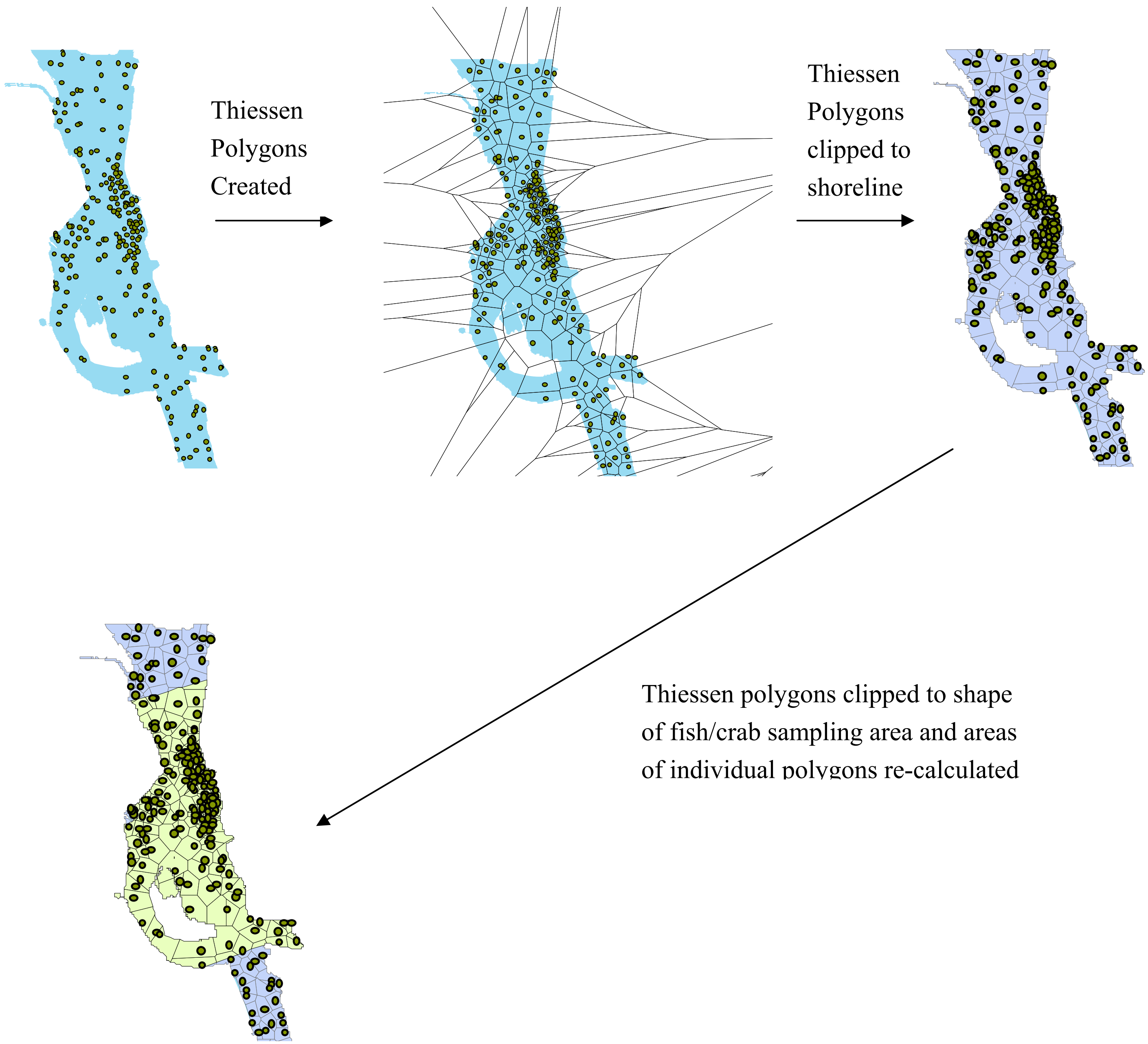


Figure 2. Arsenic Tissue Concentration vs. Sediment Arsenic Concentration (bwb: benthic whole body, p: pelagic, cem: crab edible meat, chp: crab hepatopancreas)

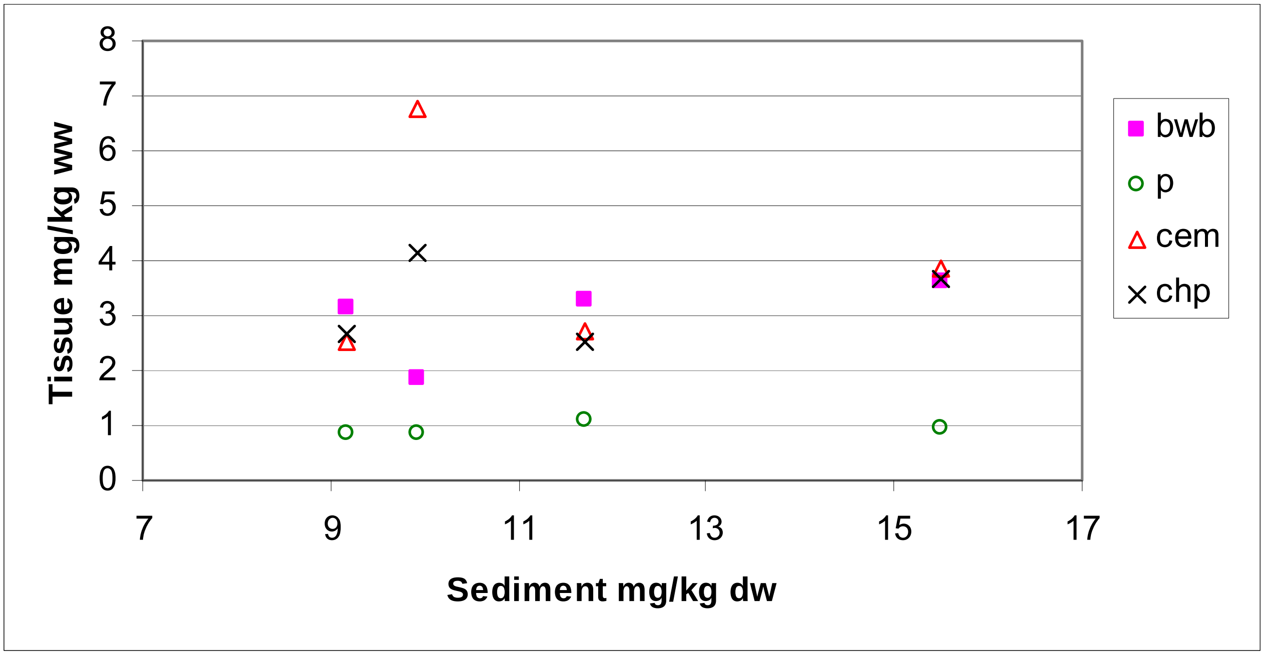


Figure 3. Cadmium Tissue Concentration vs. Sediment Cadmium Concentration (bwb: benthic whole body, p: pelagic, cem: crab edible meat, chp: crab hepatopancreas)

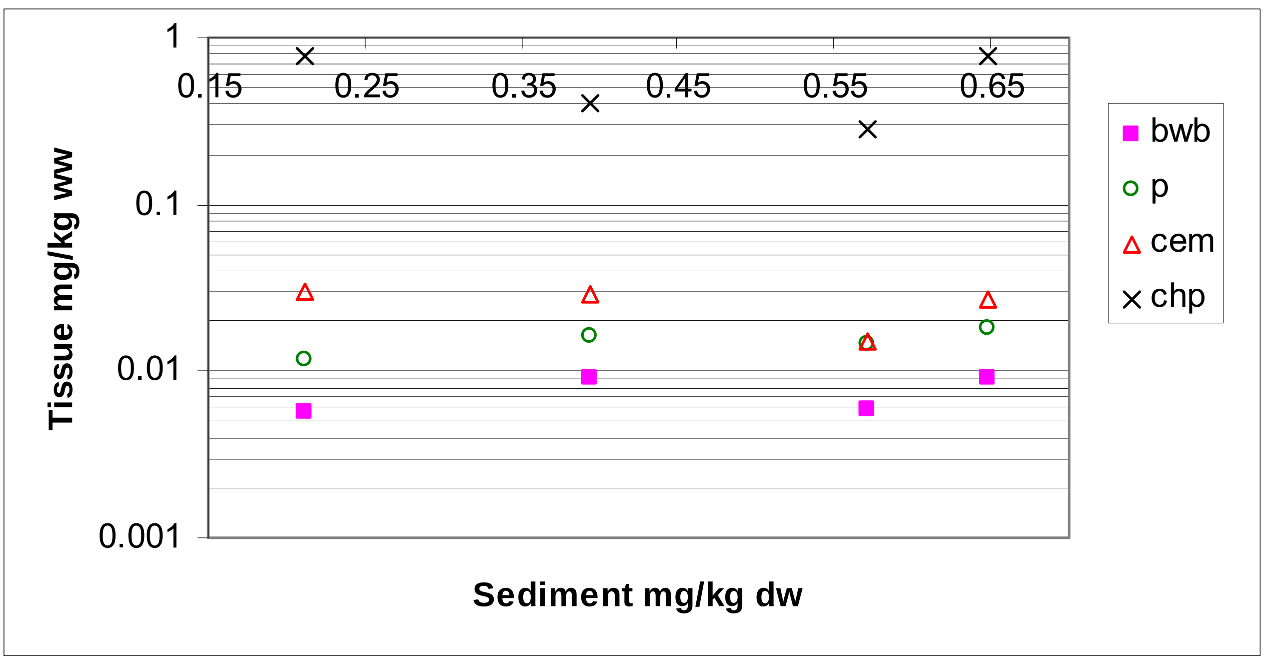


Figure 4. Chromium Tissue Concentration vs. Sediment Chromium Concentration (bwb: benthic whole body, p: pelagic, cem: crab edible meat, chp: crab hepatopancreas)

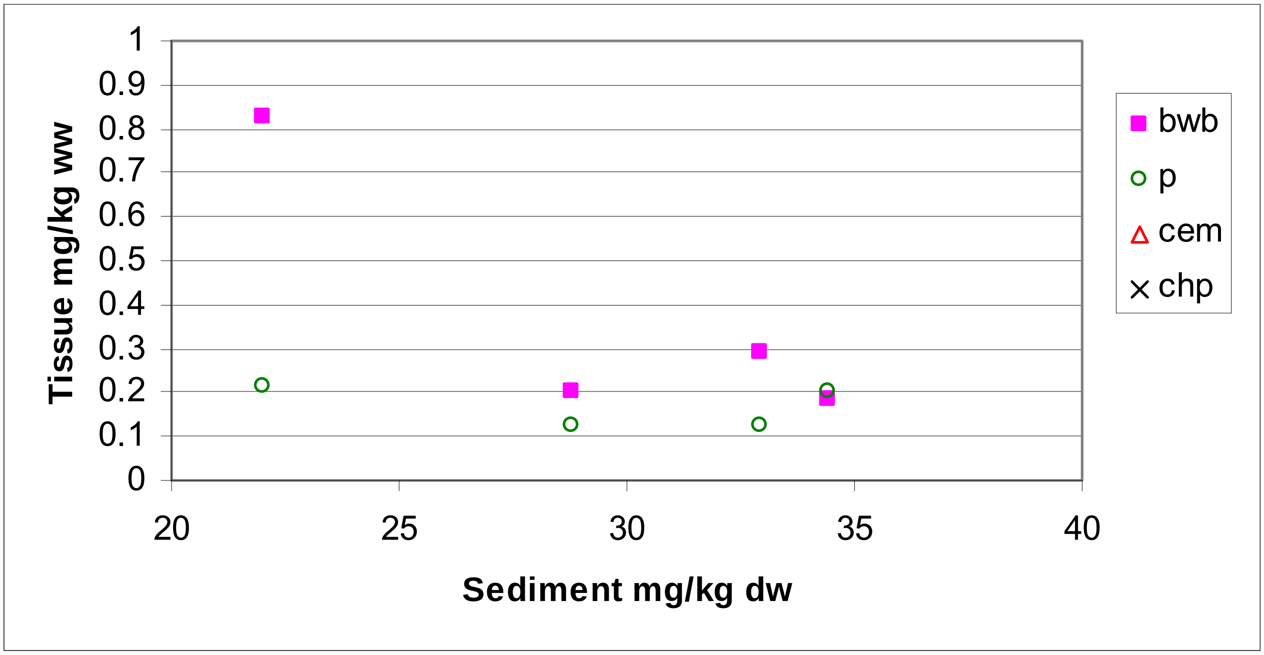


Figure 5. Copper Tissue Concentration vs. Sediment Copper Concentration (bwb: benthic whole body, p: pelagic, cem: crab edible meat, chp: crab hepatopancreas)

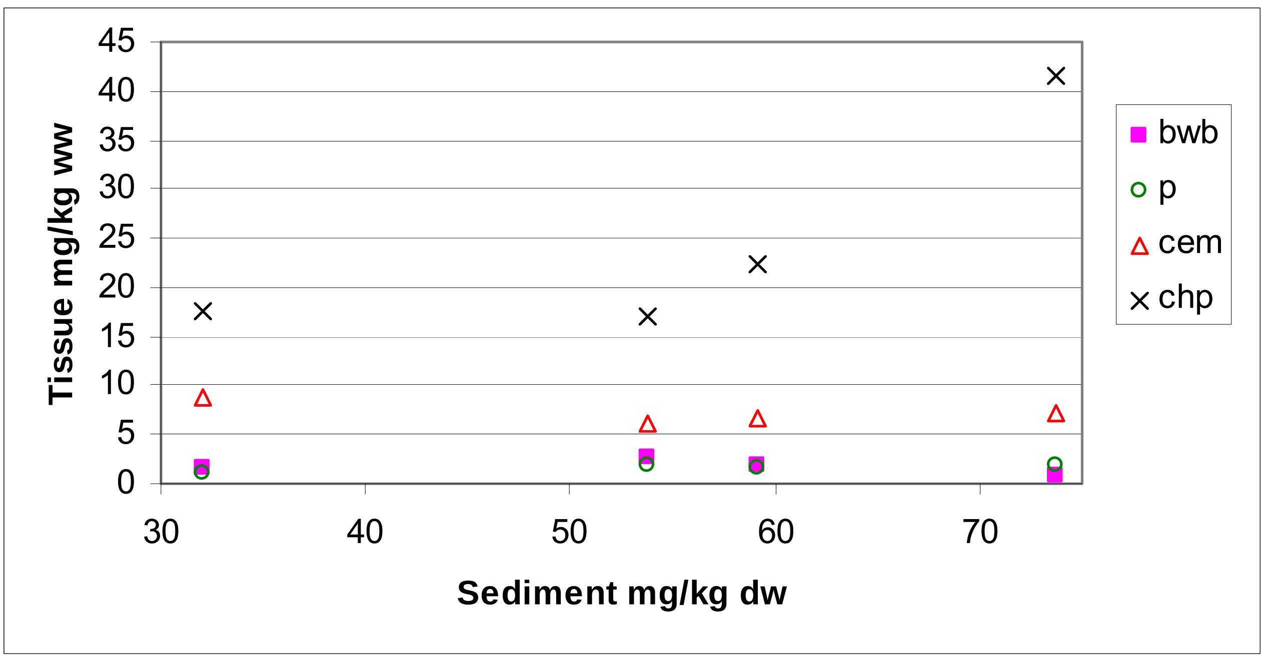


Figure 6. Lead Tissue Concentration vs. Sediment Lead Concentration (bwb: benthic whole body, p: pelagic, cem: crab edible meat, chp: crab hepatopancreas)

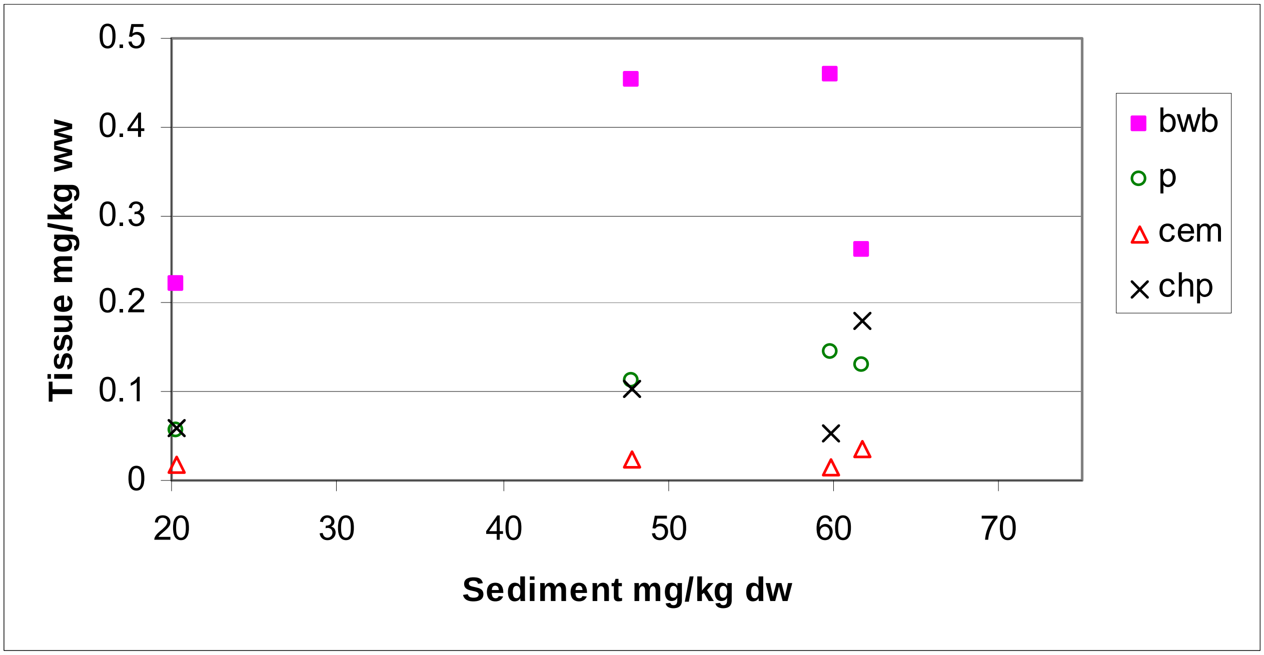


Figure 7. Mercury Tissue Concentration vs. Sediment Mercury Concentration (bwb: benthic whole body, p: pelagic, cem: crab edible meat, chp: crab hepatopancreas)

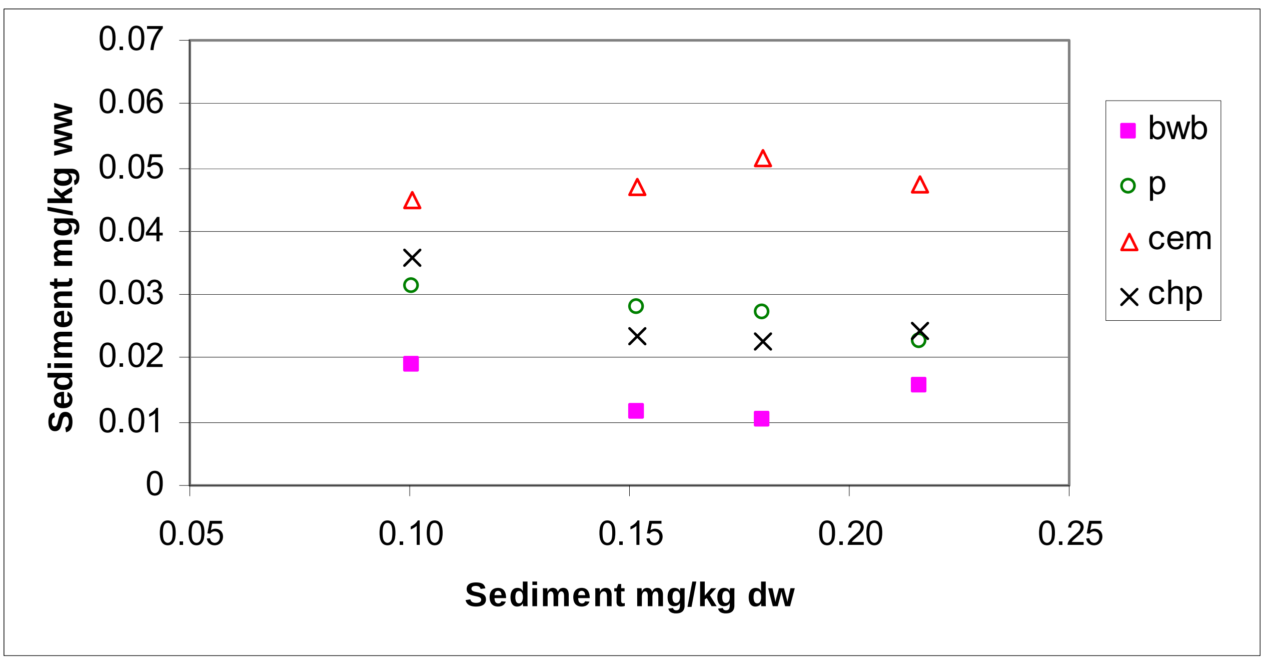


Figure 8. Zinc Tissue Concentration vs. Sediment Zinc Concentration (bwb: benthic whole body, p: pelagic, cem: crab edible meat, chp: crab hepatopancreas)

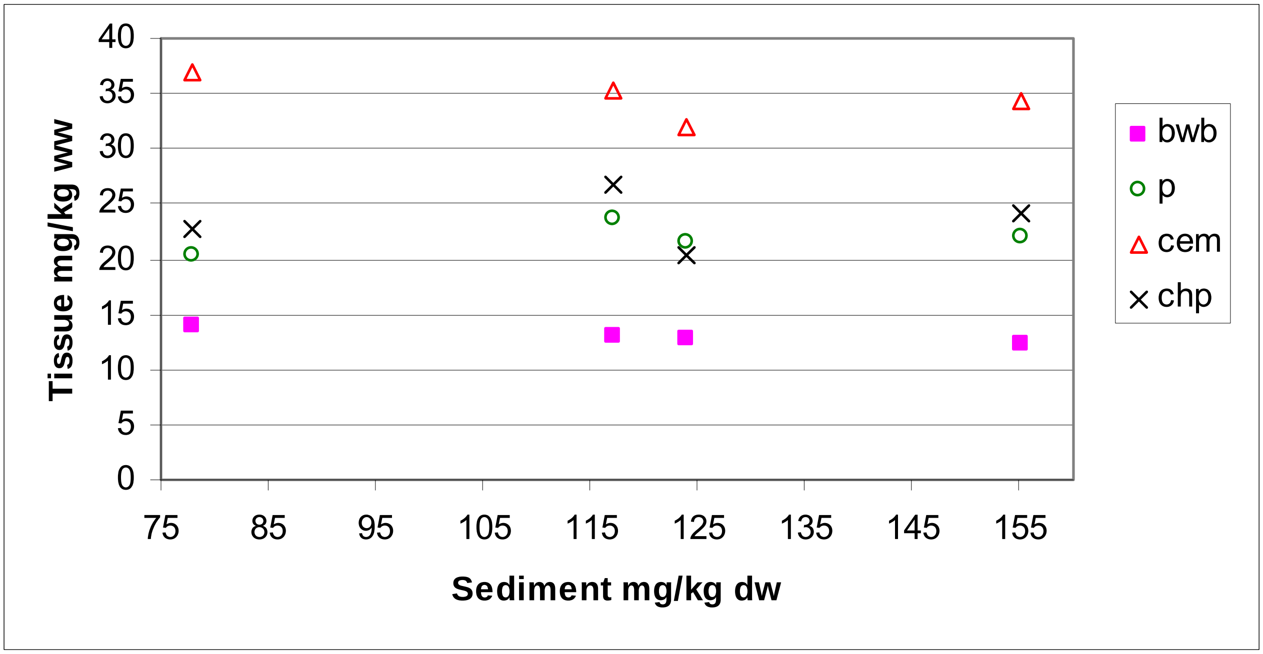


Figure 9. LDW Site Wide Fish BAFs Compared with BAFs chosen for Lockheed West

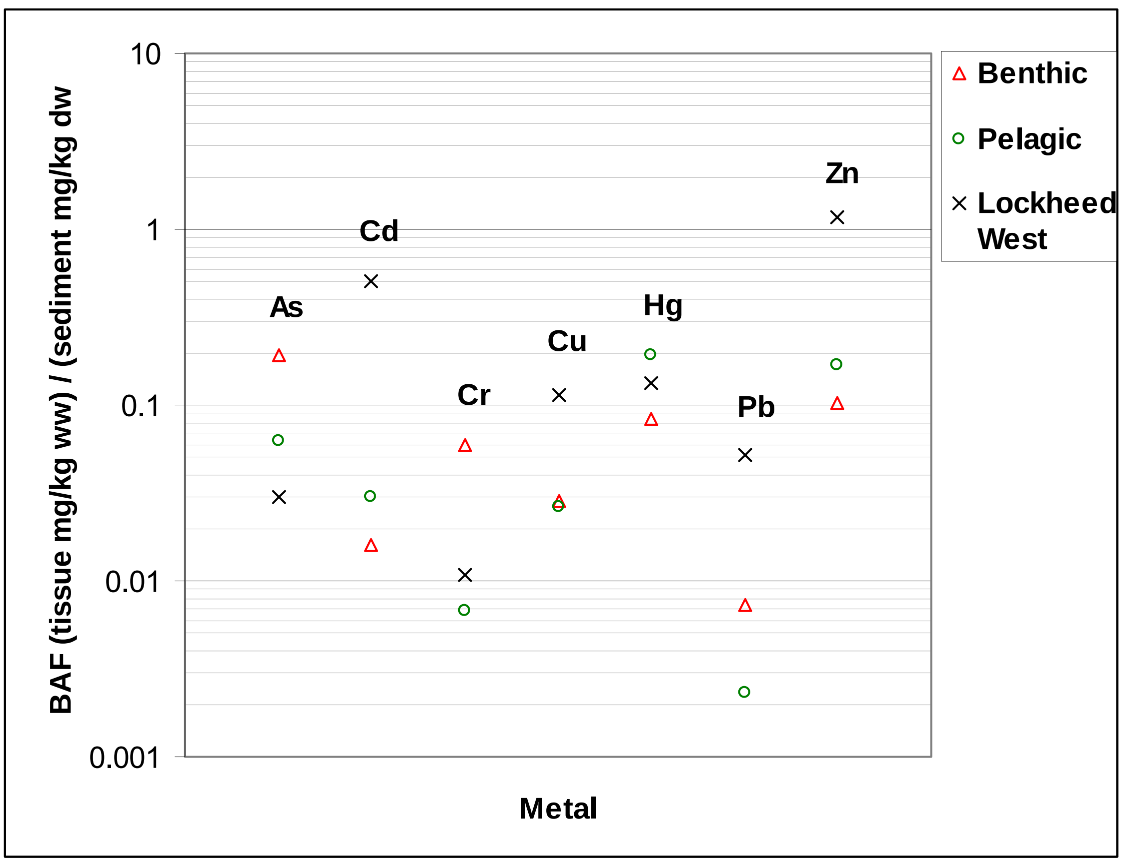
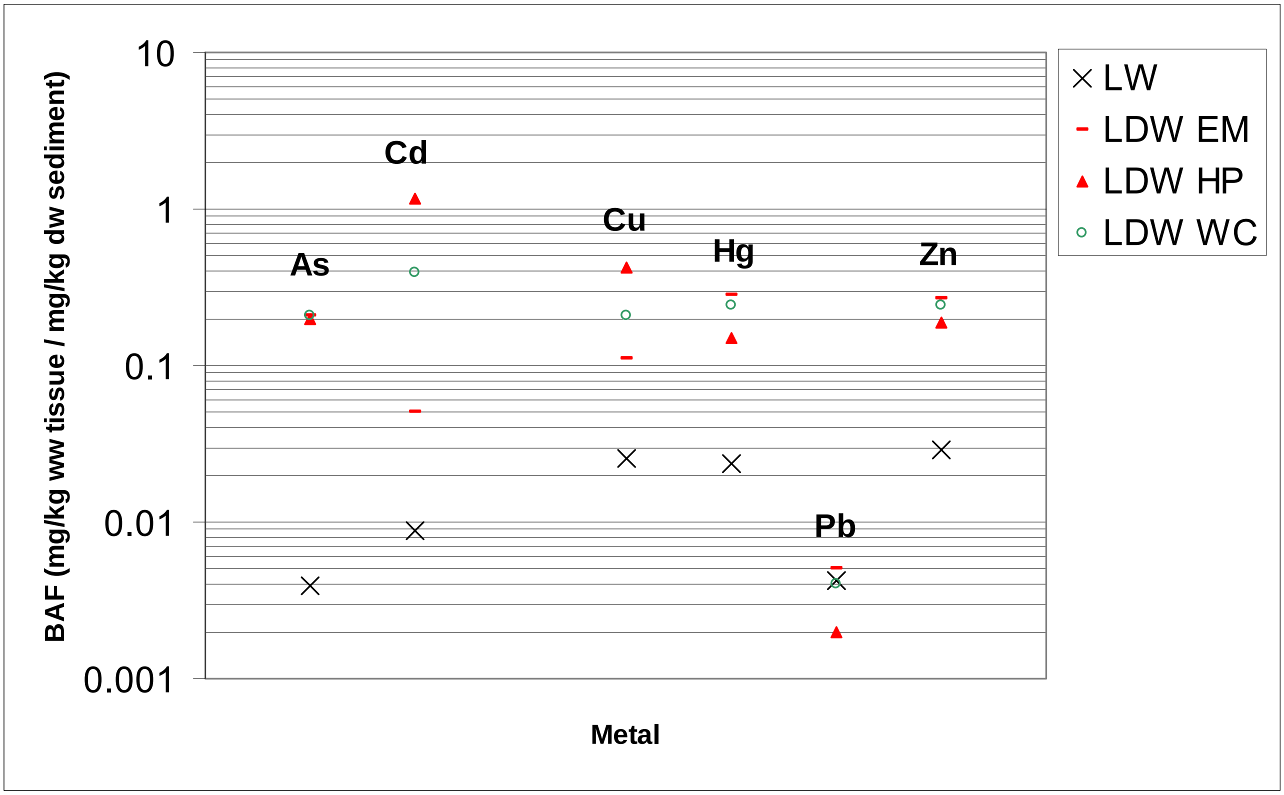


Figure 10. LDW Site Wide Crab BAFs Compared with BAFs chosen for Lockheed West (EM – edible meat, HP – hepatopancreas, WC – whole crab)



References

Lower Duwamish Waterway Group (LDWG). 2005. Lower Duwamish Waterway Remedial Investigation, Data Report: Fish and Crab Tissue Collection and Chemical Analysis.

Washington Dept. of Ecology. 1995. Bioaccumulation Factor Approach Analysis for Metals and Polar Compounds. CAOU-03-03. Prepared by PTI.

APPENDIX F

RESPONSES TO EPA COMMENTS

RESPONSE TO EPA'S OVERALL COMMENTS (dated February 24, 2009) REGARDING THE HUMAN HEATH AND ECOLOGICAL DRAFT RISK ASSESSMENTS FOR THE LOCKHEED WEST SUPERFUND SITE.

1. Revise statements that active remediation will mitigate or eliminate all human health and ecological exposures and risks. It is more accurate to state that active remediation is expected to reduce exposures and risks associated with current site conditions (to acceptable or background levels).

   Response: Statements that active remediation will mitigate or eliminate exposures have been changed to state that active remediation is expected to reduce exposures and risks associated with current site conditions.

2. In the introduction of the Human Health Risk Assessment (HHRA) and the Ecological Risk Assessment (ERA), explain the principles used to develop the HHRA and ERA work plans and how it was determined that appropriate sections/elements/values used in the LDW HHRA and ERA were acceptable to use in the LW HHRA and ERA. Make an affirmative statement that this risk assessment conforms to the work plan. Then, delete all the references throughout the LW HHRA and ERA referring to a streamlined approach and the phrase "as per the approved work plan." Since the LDW HHRA and ERA were used to support the LW HHRA and ERA, the LDW HHRA and ERA will be placed in the Lockheed West administrative record.

   Response: Additional text has been added in the introduction of both ERA and HHRA on how the scope of the work plan was developed and the basis for using information from the LDW risk assessments. The added text focuses on the assumptions of similar ecological habitats and human uses as the LDW site, due to location and proximity of the site downstream of the LDW site within the same water body, and similar subtidal and intertidal resources. A statement is added in the Executive Summary and Introduction section that the risk assessments conform to the work plan. Subsequent references in the text that the risk assessments are consistent with the work plan have been deleted as requested.

3. EPA does not agree with statements that the site poses less risk because it is smaller than the LDW site. Delete such statements from the HHRA and ERA. The site-related risk estimates are based on site contaminant levels, relevant exposure scenarios and toxicity data. The size of the site is not considered in calculating risk estimates. Site specific considerations in relation to determining exposure are discussed in the Framework for Selecting and Using Tribal Fish and Shellfish Consumption Rates (EPA, August 2007) (Framework). In particular, the quality and quantity of current and potential fish and shellfish habitat at the site are factors in consultations with affected tribes in selecting seafood consumption rates to be used for risk assessment.

   Response: As requested, throughout both the HHRA and ERA documents, multiple references to risks being associated with or influenced by the size of the site, or relative to

the size of the LDW site, have been removed. A subsection of the Uncertainty Assessment has been added to discuss uncertainties in the risks estimated for the LW site that may be associated with or influenced by differences in size of the site with the LDW site. The introductory sections of the ERA and HHRA have been edited to include mention of site use factors and fraction contaminated terms, which are set to 1.0 to maintain consistency in estimating cleanup levels with other nearby sites. Consistent cleanup levels among the sites within the Duwamish Waterway/Elliott Bay region are necessary to ensure that cleanups achieve the common goal of health protectiveness for the highest exposed populations that use the resources of the region.

4. The use of LDW exposure scenarios and parameters was meant to allow for a streamlined approach to the baseline risk assessment and to provide consistency in how contiguous sites are addressed. EPA does not agree with statements that the use of the LDW information results in an overestimation of risks related to the Lockheed West site. The uncertainties associated with the LDW HHRA may both over-and under-estimate risks. Delete statements that imply that risk associated with the Lockheed West site are not as significant as those associated with the LDW. Revise and expand the discussion of uncertainties associated with the LDW information in the Uncertainty Sections.

   Response: As described in the response to General Comment 3, multiple references to risks being associated with or influenced by the size of the site, or relative to the size of the LDW site, have been removed. Discussion in the Uncertainty Assessment has been expanded as per response to General Comment 3.

5. In addition to supporting remedy selection, risk assessments provide risk information to affected tribes and the public, and provide context for long-term monitoring and remedy evaluation. This should be clarified in the risk assessments.

   Response: A statement will be added to the introduction section: In addition to supporting remedy selection, risk assessments provide risk information to affected tribes and the public, and provide context for long-term monitoring and remedy evaluation.

6. It is understood that Lockheed is committed to actively remediating the entire Lockheed West site. However, it is premature to assume that at a minimum the entire site will be capped. Please delete all references to specific remedial actions.

   Response: References to capping or other specific remedial actions have been removed; statements have been edited to mention active remediation without specific reference to the type of action.

7. Statements made throughout the Lockheed HHRA that EPA's Framework develops or establishes tribal consumption rates for Lockheed, the LDW or any other site, need to be revised. The underlying basis of the Framework is consultation with potentially impacted tribes. The Suquamish Tribe, in consultation with the Muckleshoot Tribe and EPA, agreed to a risk assessment approach for the Lockheed West site that is consistent with that used for the LDW site. The Tribe specifically requested inclusion of a Suquamish tribal scenario as relevant to Suquamish tribal members and as an estimate of Suquamish consumption and risk. Lockheed should work with the Tribe and EPA to revise statements related to the Framework to more accurately reflect the intent of the document.

Response: Statements in the LW HHRA that the Framework develops the consumption rates have been revised to state that "The EPA Framework document presents a conceptual framework for selecting and using Tribal fish and shellfish consumption rates for purposes of estimating site-related risks hazardous waste cleanup sites in Puget Sound.", and "The Framework provides that EPA will consult with the Tribes on site-specific exposure assumptions and cleanup decisions at each Superfund site within a Tribal fishing area." The following sentences will also be added: "The Suquamish Tribe, in consultation with the Muckleshoot Tribe and EPA, agreed to a risk assessment approach for the Lockheed West site that is consistent with that used for the LDW site. The Tribe specifically requested inclusion of a Suquamish tribal scenario as relevant to Suquamish tribal members and as an estimate of Suquamish consumption and risk."

8. Inclusion of the Suquamish survey data provides risk assessment information that is relevant to Suquamish tribal members and is an estimate of a high end consumption and exposure. Throughout the HHRA, revise statements about the use of Suquamish data, present quantitative risk estimates to Suquamish tribal members (rather than qualitative estimates relative to Tulalip tribal members), and present tribal populations as a range of exposures. As examples:

    a. Page ES-5 -- In the third paragraph of Section ES.4, include statements of quantitative risk based on Suquamish survey information and tribal children's risk after the statement of risk based on Tulalip survey information.

    Response: A statement on the results of the Suquamish survey risk estimates has been added.

    b. Page 3-7 -- Revise the second paragraph of Section 3.1.5 to state "The adult tribal scenario based on Suquamish data is evaluated as a high end exposure scenario to characterize a range of tribal consumption rates."

Response: Suggested edit has been made.

c. Page 7-1 -- In the first paragraph of Section 7.1, include quantitative risk estimates for the Suquamish scenario and tribal children.

Response: A statement on the results of the Suquamish survey risk estimates has been added.

9. Consistent with the LDW HHRA, identify dioxins/furans as COCs and risk drivers for the direct contact and seafood ingestion pathways in the main text of the HHRA. Future remediation plans cannot be used as justification for not identifying and evaluating potential risk drivers.

Response: Statements have been added in Sections ES.4, 5.2.4.1 and 5.2.4.3 (Seafood Consumption Risks), 6.5 (Uncertainty Assessment of Dioxins), and 7.2 (Identification of Risk Drivers) that identify dioxins/furans as COCs and risk drivers for the direct contact and seafood ingestion pathways, based on assumed likely presence in site sediment and seafood from the site (as has been documented in the upstream LDW), and the likelihood of unacceptable risk estimates.

10. EPA does not agree with statements that the site poses less risk than the LDW site because there is limited access to the site. Delete such statements. The Suquamish Tribe has treaty rights to harvest that are not constrained by limited public access. The Tribe also believes that site remediation and potential habitat restoration projects will provide greater opportunities for tribal harvest in the future. Lockheed could include the statement that this site is not currently accessible to the general public.

Response: Statements that the size poses less risk than the LDW site because there is limited access to the site have been edited to state that "…because of presently limited access by the general public to the site, exposures and risks to the general public from contact with intertidal sediments is currently less than assumed in the risk assessment. For tribal exposure scenarios, the Suquamish Tribe has treaty rights to harvest that are not constrained by limited public access, and site remediation and potential habitat restoration projects may provide greater opportunities for tribal harvest in the future."

11. EPA does not agree with statements that the site poses less risk than the LDW site because habitat is not as extensive as the LDW. Delete such statements. Risk assessments do not measure the value of natural resources or habitat and cannot be used to make assumptions about tribal consumption patterns, resource management practices or ecological sustainability.

Response: Similar to the response to General Comment 3, references to risks being influenced by the size of the site, including the size of habitat relative to the LDW site, have been removed.

12. In both the HHRA and ERA, clarify the basis for excluding infrequently detected (detected in <5% of samples) contaminants. Given data gaps related to sources and source control, as well as the approach taken in modeling tissue concentrations rather than analyzing tissue, there is little justification for eliminating contaminants based on a belief that a COPC should not be present.

Response: Clarification has been added that EPA guidance allows for excluding infrequently detected chemicals, in order to focus the risk assessment. In addition, the past industrial uses of the site were considered in identifying chemicals that could be COPCs. Since past historical uses consisted primarily of shipyard activities, various metals are the main historical use-based chemicals identified as COPCs. Of the chemicals lacking toxicity values or for which RBACGs were exceeded by detection limits, none are identified as COPCs based on past activities at the site. The exclusion of infrequently detected chemicals also conforms with the work plan. A new Section 6.7 has been added to the Uncertainty Assessment that lists chemicals that were excluded based on detection frequency and evaluates their exceedances of RBACGs.

13. Uncertainty regarding modeling and lack of site specific data in the ERA must be discussed in more detail in the Uncertainty Section.

Response: More detailed discussion on uncertainty regarding modeling and lack of site specific data has been added to the ERA.

Specific HHRA Comments:

14. **Page ES-1. Executive Summary.** The statement that the HHRA provides support for the decision to remediate the Lockheed West site appears to make the HHRA a justification document, not an evaluation document. This is emphasized by statements regarding the use of LDW exposure scenarios, and their assumptions and exposure parameters, as conservative, based on the inconsequential statements that the Lockheed West site is smaller in size than the LDW site and that the public will have limited access to the LW site. Replace the term "conservative" throughout the document, with "health protective" or something similar with preapproval from EPA in writing. It is not appropriate to consider cleanup alternatives in a risk assessment. Risk assessments inform selection decisions among cleanup alternatives, not vice versa. When Lockheed develops the Feasibility Study, it should consider that much of the Lockheed West site is State Owned Aquatic Land (SOAL) administered by either DNR or the Port of Seattle. In order to limit access to the site, institutional controls (ICs) that would limit public access to public lands would have to be instituted. For SOAL administered by DNR, that would typically require a lease. In any case, ICs could not interfere with tribal treaty rights except on consent and may be difficult to implement for certain exposures. It should be noted that in the original

Southwest Harbor / Terminal 5 plan, one of the alternatives for a portion of the site was a destination public shoreline access and fish and wildlife habitat.

Response: The statement that the HHRA provides support for the decision to remediate the Lockheed West site in the Executive Summary has been deleted. Later text in the Executive Summary has been edited to remove reference to the HHRA providing support for the decision to remediate, and instead states that it provides support for active remediation of the site. As described in the response to General Comment 3, discussion has been added to the Uncertainty Assessment about the role of the site size in estimating exposures and consequent risks. As per the comment, the term "conservative" in describing risk estimates has been replaced throughout with "health protective", which was previously used in some places.

15. **Page ES-1, Executive Summary, paragraph 2.** Add the bolded text. "Use of the LDW exposure assumptions and exposure parameters should be ~~is a very~~ ~~conservative~~ **health protective** for the Lockheed West Site, **However, it is important to recognize that the Lockheed West Site is one of many cleanup sites affecting the larger Elliott Bay/Duwamish environment. It is important to consistently address all sources of contamination in this larger area. Use of LDW exposure assumptions for all sites within Elliott Bay and the LDW will insure that chemical contamination within the Duwamish corridor and Elliott Bay is appropriately addressed.**"

Response: Text has been edited as follows: "Use of the LDW exposure assumptions and exposure parameters is a health protective approach for the Lockheed West Site."and "The Lockheed West Site is one of many cleanup sites affecting the larger Elliott Bay/Duwamish environment, and the use of the LDW exposure assumptions ensures consistency in how the sources of contamination in this larger area are addressed."

16. **Page ES-3, ES.2 Exposure Assessment.** Add the bolded text. "… either by ingestion ~~in~~ **of contaminants in** sediment or seafood or by **dermal** absorption **of contaminants** ~~across the~~ **from contaminated sediment adhering to the** skin…"

Response: Text has been edited as requested.

17. **Page ES-3, ES.2 Exposure Assessment.** Add the bolded text. "The total consumption rate **of non-anadromous seafood** for the adult tribal scenario was 97.5 grams of seafood per day (three meals per week, assuming a meal weighs 227 grams, which is about 8 ounces. **Contaminant exposure associated with consumption of anadromous species (i.e., salmon) were not included in the HHRA because it was assumed that the site-associated salmon body burden (as opposed to body burden from open ocean migration) is not substantial.**"

Response: Text has been edited as requested

18. **Page ES-8, ES.4 Risk Characterization and Uncertainty Analysis.** Add the bolded text, "highlights the ~~conservativeness~~ **health protective nature** of the approach."

    Response: Text has been edited as requested

19. **Page 1-1, 1.1 Purpose of the Streamlined Human Health Assessment.** Discussion of remediation alternatives in this section, especially the emphasis on capping, is premature and inappropriate. The purpose of a risk assessment is to support a decision as to whether remediation is necessary. This comment also applies to the same statement on Page ES-1. See Comment 6 above.

    Response: See response to Comment 6. Text has been edited to state "Although active remediation will reduce exposures of humans to the present sediment contaminants, the presence of Site contamination requires performance of a baseline risk assessment to indicate the potential extent of risk under present site conditions, to provide risk information to affected tribes and the public, to support the remedy selection for the sediments that will mitigate the risk, and to provide context for long-term monitoring and remedy evaluation."

20. **Page 1-3, 1.2 Scope.** The Eastern Softshell Clam, Mya arenaria, seems to prefer a lower salinity environment than other more commonly consumed clam species (e.g., Littleneck and butter clams). Surveys of both the Lockheed West and East Waterway suggest that the Eastern Softshell Clam is not common in the marine environments downstream of the Duwamish estuary. Inorganic arsenic levels in Mya arenaria were much higher than levels found in other clams in the Duwamish corridor. This is an important distinction. The risk assessment must be modified to account for this difference.

    Response: The text has been modified to include discussion on the level of inorganic arsenic that was assumed for clams in the HHRA, the source of the percentage of inorganic arsenic as coming from the Mya studies of the LDW, and that Mya clams are not common at the site due to salinity differences. The assumption of proportional inorganic arsenic concentrations at the LW site is considered to be health protective.

21. **Page 2-2, 2.1.1 Sediment Chemical Data.** Add the bolded text. "The RBACGs are considered to protective of human receptors exposed to chemicals via direct contact ~~or incidental ingestion of~~ **with contaminated** sediment **or by indirect sediment contaminant contact from** ~~and for~~ ingestion of fish and shellfish ~~by human receptors~~ **that have acquired body burdens of contaminants of Site contaminants**.

    Response: Text has been edited as requested

22. **Page 2-2, 2.1.2 Fish and Shellfish Tissue Chemistry.** See comment 20

Response: Text has been edited as requested

23. **Page 2-2, 2.1.2 Fish and Shellfish Tissue Chemistry**. "**Presumably**…aquatic species identified at the LDW Site **could** use the Lockheed West Site sediment areas, since the Site is located just downstream of the LDW Site." Resolve these questions. Do the aquatic species identified use each Site in the same manner? Are the pathways different, similar, or the same? Does the word "could" adequately characterize the species located at the Site for risk assessment—and could a more definitive statement regarding aquatic species that use the Site be made?

Response: Whether aquatic species identified use each Site in the same manner as at the LDW site is unknown. The pathways of exposure are assumed to be the same because the species are identical, the same habitats are present, environmental conditions are similar, and food sources are not known to differ between the sites. Text has been edited to include mention of species that have been documented in the West Waterway.

24. **Page 2-6, 2.2.1 Averaging Duplicate Samples.** The LDW HHRA (See page 22, Section B.2.2.1) used the minimum reporting limit, not half the reporting limit, when all results were non-detects. The same methodology should be used in the LW HHRA.

Response: For the LW HHRA, all chemicals with all results non-detects are eliminated from further evaluation based on the < 5% detection frequency. Therefore, the use of the minimum or half reporting limits in quantifying exposures do not apply to the LW HHRA.

25. **Page 3-1, 3 Exposure Assessment.** The text states "based on assumed similarities in aquatic habitat and future human uses between the Lockheed West and LDW Sites, the exposure pathways and exposed populations for the Lockheed West and the LDW Sites, the exposure and exposed populations for the Lockheed West HHRA are consistent with scenarios developed for the LDW HHRA." This statement appears to be contradicted by a statement within Page 3-4, Section 3.1.1 Water Recreation: "King County concluded that the frequency of recreational activities would be low in the Duwamish River estuaries compared to Elliott Bay." Lockheed West is located on Elliott Bay, in close proximity to the Armani public boat launch. The possibility that public access would be provided at this Site was considered in the Southwest Harbor design phases. Remove the statement (conjecture) attributed to King County in Section 3.1.1.

Response: Statement has been removed, as requested.

26. **Page 3-2, 3 Exposure Assessment**. The statement that risks from direct exposure to surface water are less than risks associated with sediment or fish consumption pathways should not mean that the surface water pathway is non-existent and should not be discussed in a narrative. Add an appropriate surface pathway discussion.

Response: Text has been modified to indicate that the surface water exposure pathway is evaluated qualitatively, based on the previous analysis by King County. Results of the King County assessment have been added to the Exposure Assessment, and an analysis presenting data on exposures and risks from the King County assessment has been added as Section 6.9 of the Uncertainty Assessment.

27. **Page 3-3, Figure 3-1.** Typo ~~comsumtion~~ **consumption**

    Response: Edit has been made.

28. **Page 3-3, 3.1. Conceptual Site Model and Exposure Scenarios.** The rationale for choice of the Tulalip data to parameterize the tribal RME seafood consumption scenario should be presented here. Add the bolded text. "', ~~in compliance with~~ **as suggested by** the EPA Region 10 tribal seafood consumption framework (EPA 2007b). **The Framework includes a policy decision to use Tulalip Tribes' seafood consumption rates to assess tribal seafood consumption risks when current or potential high quality shellfish habitat is limited. Use of Tulalip rates at the Lockheed West Site is consistent with this policy decision."** Add language stating that this choice was allowed by the Suquamish and Muckleshoot Tribes only because the Tribes believe that background concentrations will essentially be the cleanup level for both the LDW and LW Sites.

    Response: Edit has been made as requested.

29. **Page 3-4, 3.1.1 Water Recreation:** Add the bolded text. "…found ~~very low~~ health risks related to water exposures in the LDW **were in the 1 x 10^{-6} range with hazard quotients less than 1**."

    Response: Edit has been made as requested."

30. **Page 3-4, Water Recreation**. This section is confusing. The statement that recreational activities would be less in the Duwamish Waterways than on Elliott Bay because of limited access in the industrial waterways needs to be clarified—a portion of the Lockheed West Site abuts Elliott Bay. Because future development of the Site could include public access, a water recreation scenario should at least be described.

    Response: Text has been edited to remove the statement that recreational activities would be less in the Duwamish Waterways than on Elliott Bay. The quantitative results of the King County risk assessment related to surface water health risks in the Duwamish waterways and Elliott Bay have been added as part of the evaluation of the surface water direct contact pathway. Data and results from the King County direct water contact scenarios have been summarized in Section 6.9 of the Uncertainty Assessment.

31. **Page 3-4, 3.1.2 Beach Play.** "Because of the present lack of public access to the Site, the beach play scenario may greatly overestimate present exposures." Delete this statement in this Section. It would be more appropriate to discuss the impacts of this scenario in the Uncertainty Section.

    Response: As per EPA's follow-up comments at the March 3 meeting, the statement has been edited to refer to the general public, and a sentence has been added: "In addition, the Suquamish Tribe has treaty rights to harvest in intertidal sediments that are not constrained by limited public access."

32. **Page 3-5, 3.1.2. Beach Play**. Provide a reference for the statement that "the frequency and magnitude of this (direct contact with surface water) is likely to be very low when compared with the magnitude and frequency of contact with the intertidal sediment …." And if this is the case, EPA does not believe that it means that the water contact pathway should not be described. Include this pathway.

    Response: Text has been added to provide reference for the statement, and the water contact pathway is now evaluated in Section 6.9 of the Uncertainty Assessment by inclusion of discussion and summary of the quantitative results of the King County risk assessment related to surface water exposures.

33. **Page 3-6, 3.1.3 Clamming.** Add to the end of first text block at top of page. "**As has been generally noted in tribal seafood consumption risk assessments, none of the exposure parameter values selected have any effect on tribal treaty rights.**"

    Response: Text has been edited: "As per the tribal Framework document and the opinion of the tribes, none of the exposure parameter values selected have any effect on tribal treaty rights."

34. **Page 3-6, 3.1.3 Clamming.** Exposure to water is not included. Revise the statement "…while direct contact with surface water may occur, such contact is low compared to the "frequency and magnitude of contact with the intertidal sediment that occurs during clamming activities" to read: "**The contaminant dose and resultant risks associated with clamming sediment exposure are much greater than those associated with surface water exposure.**" Surface water exposure risks from the King County HHRA should be included in the LW risk assessment to clearly identify differences in the magnitude of risk

    Response: Suggested sentence has been added to the existing statement: "The contaminant dose and resultant risks associated with clamming sediment exposure are much greater than those associated with surface water exposure. Therefore, exposure to water is not included in the clamming scenarios; however, a qualitative evaluation of exposure to

surface water from direct contact is included in Section 6.9 of the Uncertainty Assessment." As per response to Comment 30, results of the King County risk assessment on surface water risks and sediment risks are now included as part of the qualitative evaluation of the surface water pathway, and are referred to in discussion of surface water contact risks.

35. **Page 3-6, 3.1.3 Clamming, 2nd paragraph.** In the LDW HHRA 120 day per year tribal clamming scenario, ingestion risks were generally less than dermal risks for bioaccumulative contaminants, however ingestion risks were of the same order of magnitude as dermal contact risks. Arsenic risks were actually higher for ingestion relative to dermal absorption. The difference between ingestion and dermal risks is somewhat overstated. Insert the following language.

"~~Although the primary exposure pathway for t~~**T**he clamming scenarios ~~is~~ **consider** dermal contact **with and incidental ingestion of** ~~with~~ sediment **contaminants.** ~~, exposure through the incidental ingestion of sediment during clamming is included in the risk analysis for these scenarios~~."

Response: Edit has been made as requested.

36. **Page 3-7, 3.1.5 Fishing and Shellfishing for Consumption, final paragraph.** Make the following modifications to this section. "The seafood exposure parameters are consistent with those developed for the LDW HHRA. As a ~~conservative~~ **health protective** measure, the seafood consumption scenarios for the Lockheed West HHRA did not include adjustments to account for differing exposure to Site chemicals than those assumed for the LDW HHRA. ~~Exposures could differ from those assumed in the LDW HHRA due to the much smaller size and quality of habitats of the Lockheed West Site, which could affect the availability of seafood and possibly seafood consumption rates, and the lower relative contributions of the Site sediment contamination to the tissue concentrations in seafood that could be exposed to chemicals in areas outside the Site.~~ **The Lockheed West Site is one of many cleanup sites affecting the larger Elliott Bay and Duwamish environment. It is important to consistently address all sources of contamination in this larger area. The use of consistent exposure assumptions for all sites within the Duwamish corridor and Elliott Bay will insure that chemical contamination within the Duwamish corridor and Elliott Bay is appropriately addressed.**"

Response: Text has been deleted as suggested. See response to General Comment 3 on other text changes. The following text has been added, and is similar to text added to Section 1.2 Scope: "Consistent cleanup levels among the sites within the Duwamish Waterway/Elliott Bay region are necessary to ensure that cleanups achieve the common goal of health protectiveness for the highest exposed populations that use the resources of the region. Use of the LDW exposure scenarios and all inherent assumptions and exposure

parameters is a health protective approach for the Lockheed West Site, and is protective of human populations who might use the site in the future."

37. **Page 3-10, 3.2.1 Screening Procedure.** Add to text in outline item 3 -- "EPA risk assessments compute the risks for contaminants without respect to source (i.e., site or background associated). In characterizing risks, the site and background related components of risk are identified."

Response: Item 3 has been moved from the outline as per Comment 39, and the edit has been made as requested.

38. **Page 3-10, Section 3.2.1, Frequency of Detection screening procedure**. Clarify the basis for excluding infrequently detected (detected in <5% of samples) contaminants. Given data gaps related to sources and source control, as well as the approach taken in modeling tissue concentrations rather than analyzing tissue, there is little justification for eliminating contaminants based on a belief that a COPC should not be present.

Response: See response to Comment 12.

39. **Page 3-11, Section 3.2.1, Comparison with Background screening procedure**. Although it is stated that no chemicals were eliminated based on comparison with background, this should not be included as a screening procedure using LDW background estimations. There has been no agreement regarding background values for the Lockheed West Site (nor have the final background value decisions been made for the LDW). Risk assessments typically carry risks from background through the risk characterization. See EPA policy memo regarding background (OSWER 9285.6-07T, 2000). Step 3, comparison with background, should be removed from the COPC development process. A discussion of how contaminant concentrations compare with background levels may be included for informational purposes if it is clearly labeled as such.

Response: Step 3 has been removed as part of the screening process; the comparison with background is retained and the text has been edited to clarify that use of the background comparison is for informational purposes.

40. **3-14, 3.2.3 Sediment Screening for Seafood Consumption Exposure.** Using the BSAFs presented is appropriate for bioaccumulative organic compounds, but not for metals. This section should be revised to discuss the bioaccumulation of metals. Given the (sufficiently) close proximity of the LDW and LW Sites, and that metals bioaccumulation is Site and organism specific, metals concentrations from organisms and sediment for the LDW are useful to assess metals bioaccumulation for the LW Site. EPA will provide further, more specific, direction for LDW metals BSAFs.

Response: Additional text will be added on metals bioaccumulation taken largely from the Ecology document that provides metals BSAFs. Since this section of the HHRA develops the screening procedure that was taken from the LDW HHRA and was approved in the work plan, and was assumed to be sufficiently health protective in those documents, no changes are made to the metals screening procedure. Text is added that states: "The derivation and use of BSAFs in modeling seafood chemical concentrations for the seafood consumption scenarios in the Lockheed West HHRA, and limitations with BSAF modeling, are described in more detail in Section 3.3.5." Note that the exposure assessment section is revised to include reference to the bioaccumulation factors for metals that EPA developed from LDW site data as mentioned in further comments below.

41. **Page 3-13, 3.2.2 Sediment Direct Contact.** RAGS Part A has some discussion of background considerations in screening out COPCs that have below background concentrations. However, more recent policy guidance on treatment of contaminants with background levels states that risks be computed regardless of the source of the contaminant followed by a separation into background and Site-related components (See http://www.epa.gov/oswer/riskassessment/pdf/bkgpol_jan01.pdf). This section should note that comparison between Site and background concentrations is for informational purposes only.

Response: Text has been added as requested.

42. **Page 3-17, 3.2.3 Sediment Screening for Seafood Consumption Exposure, Outline item 1.** "…(**anadromous,** pelagic…)"

Response: Edit has been made as requested.

43. **Page 3-17, 3.2.3 Sediment Screening for Seafood Consumption Exposure.** "The tribal consumption rate of ~~98~~ **194** g/day…"

Response: Edit has been made as requested.

Using this process, salmon comprised 96.5 g/day of the total consumption rate. EPA (2007b) decided that salmon did not accumulate a significant site-related contaminant body burden from the LDW. **Multiplying a Site related contaminant concentration of zero by the salmon consumption rate results in a contaminant dose of zero for salmon consumption. For all other market basket fractions, the Site related body burden was assumed to be 100% The total consumption rate for all market basket fractions other than salmon was 97.5 g/day** ~~Consequently, the "effective" consumption rate was 194 g/day – 96.5 g/day consumption of species with a site related body burden~~… Note that attributing zero to a "not…significant Site-related contaminant body burden" is not a conservative assumption. See Comment 4 above emphasizing that the uncertainties associated with the LDW HHRA may both over-and under-estimate risks.

Response: Edit has been made as requested, and comment noted.

44. **Page 3-18.** Clarify the basis for the exclusion of salmon and be more descriptive of the rational used in the LDW HHRA. LDW looked at the biomass and contaminant concentrations in juvenile salmon to get the total amount of PCBs in the juveniles. Then they determined the PCB ratio in returning adult salmon. The EPA Framework does not recommend that salmon be excluded for all sites, or when using the Tulalip rate.

Response: The basis for the exclusion of salmon from seafood ingestion pathways, described in the RI/FS work plan, has been clarified by the addition of text edited from the LDW HHRA that provides the rationale based on the analysis of biomass and contaminant concentration in juvenile salmon.

45. **Page 3-18**. It is possible that species at higher trophic levels, with higher lipid content, or longer life cycles, may accumulate or magnify contaminants to a greater degree than clams. Explain how the use of clam RBACGs and BSAFs is designed to be sufficiently protective for consumption of all seafood types. LDW did not use BSAFs with species' with larger home ranges.

Response: The HHRA contains text from the LDW QAPP and HHRA as rationale for the screening process. The use of clam BSAFs was designed to be sufficiently protective by assigning the consumption rate of the total of all species to the clam BSAF rather than only the clam consumption rate. The approved LDW QAPP was assumed to provide sufficiently health protective RBACGs. Use of the LDW QAPP RBACGs, with modifications for updated toxicity values and tribal seafood ingestion rates as described in the risk assessment, conforms to the LW work plan. Note that updated BSAFs were identified for clams, fish, and crab for use in modeling tissue concentrations to quantify exposures and associated risks through seafood ingestion.

46. **Page 3-20, 3.2.4 Undetected Chemicals.** Add these chemicals to the risk assessment.

Response: RBACGs for clamming for these chemicals have been taken from the EPA PRG list for residential soil, with adjustments of 0.1 to those for non-cancer endpoints. No BSAFs are available for these chemicals so sediment RBACGs for seafood ingestion were not calculated. Results of the RBACG determination for these chemicals have been added to Attachment B and the chemicals have been removed from Table 3-4. None of the

reporting limits for these chemicals in sediment exceeded their RBACGs, so no changes were made to Table 3-3.

3-nitroaniline has both a chronic oral RfD of 3E-4 mg/kg-day and a slope factor of 2.1E-2, See: http://hhpprtv.ornl.gov/quickview/pprtv.php?chemical=Nitroaniline%2C+3-#pprtv_roc

4,6-dinitro-o-cresol has a chronic oral RfD of 1E-4 mg/kg-day, See: http://hhpprtv.ornl.gov/quickview/pprtv.php?chemical=Dinitro-o-cresol%2C+4%2C6-#pprtv_roc

Bis(2-chloroethoxy)methane has a chronic oral RfD of 3E-3 mg/kg-day, See: http://hhpprtv.ornl.gov/quickview/pprtv.php?chemical=Bis%282-chloroethoxy%29methane#pprtv_roc

2-nitroaniline has a chronic oral RfD of 3E-3 mg/kg/day, See: http://hhpprtv.ornl.gov/quickview/pprtv.php?chemical=Nitroaniline%2C+2-#pprtv_roc

4-nitroaniline has a chronic oral RfD of 3E-3 mg/kg-day and a slope factor of 2.1E-2, See: http://hhpprtv.ornl.gov/quickview/pprtv.php?chemical=Nitroaniline%2C+4-

47. **Page 3-37, Table 3-19. Adult Tribal Consumption of Shellfish (Crabs, Clams, and Mussels) Based on Tulalip and Suquamish Data.** EPA has been made aware that the percentages of crab and clam consumption derived from the Tulalip data set were reversed. The percentage consumption of clams should be 53% while the consumption of crabs should be 46%. Modify the risk assessment accordingly.

    Response: This finding has been added to Section 6.1 of the Uncertainty Analysis. The consumption of clams would be 15% higher with the higher percentage of clam consumption. The text now notes that the concentrations of PAHs, PCBs, and TBT are higher in crabs than in clam tissue, so resultant risk estimates for those chemicals would decrease proportionately for the Tribal Seafood Consumption scenario, whereas risks from metals, which are higher in clams than crabs, would increase.

48. **Page 3-45, 3.3.5.1 BSAF Modeling 1st paragraph on page.** Describe that metal BSAFs are generally the ratio of the tissue to the sediment concentration.

    Response: Additional text has been added as requested in Comment 40.

49. **Page 3-45, 3.3.5.1 BSAF Modeling 2nd paragraph on page.** Clarify the final sections of the paragraph.

Response: Text has been edited for clarification.

50. **Page 3-46, 3.3.5.1 BSAF Modeling.** To employ OC normalization, the sediment organic carbon fraction should be greater than 0.05.

Response: Use of a 0.5% criterion for organic carbon content has not been previously applied in the regulatory arena to the development of BSAFs for organic chemicals. Also, use of a 0.5% criterion is not mentioned in the literature referenced as BSAF sources for this HHRA. No changes regarding organic carbon normalization have been made to the report.

51. **Page 3-47, Table 3-26, Sources of BSAF Values**. Given that metals bioaccumulation is Site and species specific, sediment and tissue contaminant data from the nearby LDW Site, which has environmental conditions similar to the LW Site, should be considered for evaluating metal bioaccumulation at the LW Site. LW Macoma data should be considered for quantification of metals bioaccumulation in shellfish at the LW Site. Note Comment 40 above, particularly that EPA will soon provide further more specific direction for LDW metals BSAFs.

Response: Section 6.2 of the Uncertainty Analysis now includes text on metals bioaccumulation and the general lack of BSAFs for metals. The text includes discussion of the recent document from EPA that derives BSAFs for metals from the LDW site data, presents alternative metals BSAFs for seafood categories, and recalculates risks for the seafood ingestion pathway using the LW site data and exposure assumptions. Results of that reanalysis are now summarized in Section 6.2. Based on the results, additional COCs are identified as those metals with HQs exceeding 1 when they previously were below 1, and cancer risk estimates that increased by an order of magnitude with the new BSAFs. The EPA document on metals BSAFs is now appended to the HHRA. Note that the method used for modeling, including the use of Department of Ecology BSAFs for metals, conforms to the work plan.

52. **Page 3-50, 3.3.5.2 Regression Models.** Specifically, the benthic invertebrate regression for arsenic is not appropriate to use to model arsenic uptake by clams. As noted in the previous comment, arsenic bioaccumulation should be calculated using arsenic sediment tissue ratios for Macoma taken from the LW Site. Given the changes in aquatic biota PCB concentrations over time, LDW PCB concentration sediment/tissue regressions were not to be used to model bioaccumulation, literature values were used instead.

Response: See response to Comment 51; discussion of the results of the EPA reanalysis of arsenic and metals BSAFs and the recalculation of risks for the LW site has been added to the Uncertainty Assessment, and the EPA report is appended to the HHRA. For PCBs, an analysis was performed that compared results of modeled PCBs into seafood tissue at the LW site using the LDW regressions and those using the literature BSAFs. That analysis showed no differences in the excess cancer risk results for the Tribal seafood ingestion scenario with either the LDW regressions or the literature BSAFs. The analysis provides support that cancer risk estimates are not necessarily more certain using either the literature values or the LDW regression equations. The report comparing the risk results from the two modeling approaches for PCBs had been previously submitted to EPA and is now appended to the HHRA.

53. **Page 3-59, 3.3.6.1 Child Lead Model.** The lead BSAF used should be based on LDW data.

Response: See response to Comment 51; results of the EPA reanalysis of metals BSAFs and the recalculation of risks for the LW site is now mentioned in the Uncertainty Assessment, and the EPA report is appended to the HHRA.

54. **Page 4-3, 4 Toxicity Assessment.** The Provisional Peer Reviewed Toxicity Value database should also be listed as a source of toxicity data. The comment on Page 3-20, 3.2.4, Undetected Chemicals, noting toxicity values for several contaminants should be incorporated here.

Response: The Provisional Peer Reviewed Toxicity Value database was listed as a source of toxicity data in the bulleted list of Page 4-1. The text has been edited to include the database in the list of sources used in the HHRA. The development of RBACGs used for the screening process to select COPCs has been modified to include toxicity values for the additional chemicals in Comment 46.

55. **Page 5-1, 5 Risk Characterization.** The statement that risk estimates are considered to be very conservative for the Site "given its small size, limited access, and uncertain habitat quality and contribution to aquatic organism exposure compared to the LDW Site" is conclusory and subjective. Describe the Site's role in the Elliott Bay ecosystem. Size often does not equate with importance. In addition, statements about limited access do not define what future access will be.

Response: As per the response to General Comment 3, the discussion of risk estimates relative to site size has been deleted. Section 6.1 of the Uncertainty Assessment has been modified to include discussion of the uncertainty in foraging rates and foraging success between the LW and LDW sites. The Risk Characterization text has been edited to clarify

that statements about limited access only apply to present conditions for the general public.

56. **Page 5-1, Risk Characterization, 2nd paragraph**. This discussion may identify factors that could lead to an overestimate of risks, but should also include concerns noted in the comment on ES-1, Executive Summary, paragraph 2. See Comment 4.

Response: Text is edited as follows: "The <u>exposure assumptions used to quantify</u> risk estimates are considered to be ~~very conservative~~ <u>health protective</u> for the Site.~~, given its small size, limited access, and uncertain habitat quality and contribution to aquatic organism exposure compared with the LDW site~~. Uncertainties related to the use of exposure assumptions from the LDW HHRA are discussed in Section 6.1."

57. **Page 6-1, 6. Use of Exposure Scenarios from the LDW Site.** The discussion that follows the statement that LDW exposure scenarios does not take into account any potential differences between the Sites makes a point of describing the small size of the Lockheed West Site subtidal and intertidal areas. A discussion about whether this Site has any importance to the ecosystem of Elliott Bay or the Duwamish system is missing. This section should be consistent with other comments noting inconsequential comparisons between the LDW and LW Sites.

Response: As per the response to Comment 3, discussion of the influence of site size on exposure modeling and exposure estimates has been edited and clarified. Also see response to Comment 55.

58. **Page 6-1, 6.1 Use of Exposure Scenarios from the LDW Site.** See comment on ES-1, Executive Summary, paragraph 2. Sustainability in this context may be affected by many factors subject to change over time, including land uses, societal attitudes, and the size of a population consuming a resource, among other things. The discussion of sustainability issues should be removed; it cannot be resolved toward any useful end and merely generates unproductive controversy.

Response: See the response to Comment 15. The text in question was not meant to address sustainability of the resources over time (i.e., whether the present biomass could be sustained at the consumption rates assumed), but rather to compare the differences in the amount of biomass between the LW and LDW site. Additional discussion has been added to this section of the Uncertainty Assessment.

59. **Page 6-2, 6.2, Modeling of Tissue Exposure Point Concentrations.** An additional uncertainty is the percent inorganic arsenic in shellfish. This value is highly variable and the percent inorganic arsenic value found for Mya arenaria collected from the LDW is high and may not be representative of shellfish that favor higher salinity that are found at LW. See Comment 20.

Response: See response to Comment 20. Text has been modified to note that the differences in inorganic arsenic between the clam species is an uncertainty.

60. **Page 6-5, 6.5 Dioxins and PCB Dioxin Like Congeners.** It is not clear that dioxin- like PCB congeners were not enriched in biota samples from LW. The LDW HHRA could make this statement because PCB tissue congener concentrations were available. The assertion that TEQ and Aroclor PCB risks are similar for the LW must be removed. The discussion of remedial alternatives could be appropriate for the FS, but not for the HHRA. Remove the discussion of total Site remediation.

Response: The text has been edited to indicate that it is unknown whether PCB congener enrichment in biota at the Lockheed West Site may differ from the enrichment found with biota at the LDW site. Although the same aquatic organisms may be present at both sites, the sources of PCBs to each site may differ, and consequently the weathering and enrichment of dioxin-like PCB congeners may differ between the sites.

61. **6-5, 6.6 Dermal Absorption of Metals.** The magnitude of risk from dermal absorption of metal is clearly related to the concentrations of the metals of concern. What is the relative difference in metals concentrations between LDW and the LW Sites? Would risks/hazards be significant given the difference in concentrations?

Response: This section on the uncertainty of dermal absorption of metals has been modified to present more details on the alternative analysis of dermal metals absorption presented in the LDW HHRA.

62. **Page 6-6, Section 6.7.** Compare modeled tissue concentrations with empirical tissue concentration for Lockheed West clam tissue or empirical tissue samples from similar or nearby sites to more fully discuss uncertainties associated with the modeling approach taken at the Site.

Response: Modeled tissue concentrations in clams and tissue concentrations from the clam collection at the site are now discussed and tabulated in Table 6-1 in the Uncertainty Assessment.

63. **Page 6-8, Table 6-2.** Modify Table 6-2 to reflect contaminants for which toxicity values were identified (See comment on page 3-20, 3.2.4 Undetected Chemicals).

Response: Table 6-2 has been modified to remove the chemicals discussed in Comment 46.

64. **Page 7-1**, **Section 7 Risk Estimates Summary and Conclusions.** Remove the reference to Site size.

Response: See response to Comment 3; reference has been removed.

Draft Ecological Risk Assessment Comments, Lockheed West Superfund Site (November 2008)

Specific Comments

65. **Page 1-1, 1.1 Purpose of Ecological Risk Assessment.** "Although placement of a cap will eliminate all exposures…." Delete this statement and provide a more general statement that the remedy will result in a clean surface across the entire Site below risk levels for all contaminants. This outcome can be achieved by dredging, capping, or a combination of both.

    Response: Statement has been reworded as suggested. Also see responses to Comments 1 and 6.

66. **Page 2-1, Section 2, Problem Formulation.** Explicitly identify the problem evaluated in the opening paragraph of this section.

    Response: Text has been modified to include discussion of the site history and to state that the ERA problem is that the presence of contaminants in sediments, related partly to past shipyard activities and other sources, has lead to concerns over potential risks to aquatic receptors.

67. **Page 2-1, 2.1 Aquatic Habitat.** Remove the statement that the use of LDW exposure scenarios is a very conservative approach given the "smaller size of the exposure area at Lockheed West, and limited available ecological habitat under consideration." Other statements regarding the size of the Site and particularly the availability of habitat (page 2-2 for selection of ROCs; page 2-10 for the conceptual model) should be reconciled with Taylor et al (1999, p. 34) concluding that this Site has a wide range of habitat types: sandy pocket beach, cobble beach, boulders, rip rap, microalgae and piling habitats for fish. Appropriately modify or remove these statements. Though the statement is made that the primary habitats at the LW Site include shoreline and subtidal marine environments in Elliott Bay and West Waterway, the use of LDW information appears to emphasize the waterway portion of the Site. A comparison of LW Site habitat with the U.S. Army Corps of Engineers and Environmental Protection Agency *Final Biological Assessment: Pacific Sound Resources Superfund Site* (February 2002) and the Final Monitoring Report for PSR dated August 1, 2008 could be beneficial but is not necessary. A statement regarding the environmental setting as part of the Ecological Risk Model should be included.

    Response: Statement has been removed and replaced with one that states that uncertainty regarding the influence of the size of the site relative to the LDW site from which exposure

parameters are used is discussed in Section 7.2 under risk characterization for fish. The conceptual site model text has been edited to add the description of Taylor et al. and to clarify the environmental setting at the site.

68. **Page 2-5, 2.2.2 Fish**. Information provided by Ted Turk at the September 5, 2008, LDW meeting included recent work by Jeff Cordell that demonstrated that juvenile Chinook diet in the LDW is made up of polychaetes and clam siphons, unlike juvenile Chinook at other sites in Puget Sound. Because juvenile Chinook are a threatened and endangered (T&E) species and found in abundance in the LDW a conservative approach should be taken. Risk conclusions from the LDW should not be used as supporting data to minimize potential risk.

Response: The LDW ERA recognized that there was uncertainty about modeling dietary exposures to juvenile salmon. The LDW ERA included analyses for modeled dietary exposures using both benthic invertebrate tissue data and exposures based on measured chemicals in stomach contents of juvenile salmon collected from the LDW. Comparison of the two sources of dietary exposure data showed that the exposures based on the benthic invertebrate concentrations were higher than based on the stomach contents. Thus, the risk estimates for juvenile salmon in the LDW ERA accounted for their unique diet based on stomach contents. Based on that analysis, risk conclusions from the LDW should be considered appropriately protective of juvenile Chinook salmon that may pass through the LW site.

69. **Page 2-5, 2.2.3 Wildlife**. Herons do not require "larger expanses of shallow water." Herons will forage in backyard goldfish ponds if they can find something to eat. Herons may be present regardless of the size of foraging area. Revise accordingly.

Response: Statement has been reworded to clarify that herons typically forage in shallow water, which is limited at the site.

70. **Page 2-7, 2.2.4 Summary of ROCs**. On June 25, 2001, NMFS sampling caught a very large tadpole in Slip 4 of the LDW. Per WDFW personnel, due to limited information on amphibian populations if their habitat is present we should assume that populations are as well.

Response: Comment acknowledged. Note that amphibians and amphibian habitat have not been documented at the site, due to the armored intertidal areas and open industrial waterway.

71. **Page 2-7, 2.2.4 Summary of ROCs.** The use of LDW receptors is adequate. Provide a summary comparing the ROCs selected at the PSR and West Waterway Sites.

Response: The ROCs selected for the PSR and West Waterway ERAs have been added.

72. **Page 2-7, 2.3 Assessment Endpoints**. Even though the draft ERA states that measurement endpoints are more fully described below, there is no summary identifying the assessment endpoints for the Lockheed West Site in the ERA. Societal values can be a factor in selecting assessment endpoints as well. This section appears to be definitional only and is based on the 1992 guidance. The 1998 guidance supersedes the 1992 guidance (http://www.epa.gov/superfund/programs/nrd/era.htm#pagetop).

Response: Text has been added to indicate the assessment endpoints for the Lockheed West ERA, including societal values. The presentation of assessment endpoints is found in Table 2-2. The guidance specific to performance of ERA for Superfund sites is the EPA 1997 guidance "Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments" (EPA 540-R-97-006, 1997). The text has been clarified that the presentation of assessment endpoints is consistent with the 1997 EPA guidance.

73. **Page 2-9, 2.4 Conceptual Site Model for Ecological Exposures**. The conceptual model describes the relationship between "ecological stressors" and the stressors as pathways from contaminated sediment to specified organisms. Explain why the only stressors at this site are contaminated sediment as surrogates for "ecological" stressors, and why those stressors are the same or comparable at the LDW Site, including erosion, Elliott Bay currents, tidal fluctuations, groundwater inputs. Page 4-33 of the Work Plan states: "The development of baseline ERA and HHRA will include more specific CSMs." This needs to occur.

Response: The text has been edited to clarify that the Superfund guidance focuses on chemical stressors as separate from other non-contaminant stressors.

74. **Page 2-10, 2.4 Conceptual Site Model for Ecological Exposures.** This page describes groundwater and its resulting transition zone water as a possible concern to benthic organisms and states that groundwater will be evaluated in the FS for its potential to impact the Lockheed West Site. Risks from transition zone water to benthos should be predicted in this risk assessment using the available porewater and groundwater data, comparing it to AWQC or other benchmarks. The associated uncertainties should also be discussed. Also, delete the statement that "…the entire contaminated sediment area of the Site will be covered…."

Response: The pathway of groundwater to transition zone has been added to the Section 7.1 of the risk characterization for benthic invertebrates, using available data on groundwater contaminant concentrations from well data and ambient water quality criteria as the effect measure. The groundwater data are from available well data that are over 10 years old, and of a limited analyte list, and hence are evaluated as an uncertainty; additional more recent groundwater data are expected for the FS analysis. . The statement that "...the entire contaminated sediment area of the Site will be covered…" has been deleted.

75. **Page 2-11 2.5.1 Data Selection.** Rewrite the second sentence to state, "Data prior to 2007 environmental investigations are not considered.

    Response: Edit has been made.

76. **Page 2-16, 2.6.1 Criteria #2. See comment numbers 12 and 38.**

    Response: See responses to Comments 12 and 38 regarding infrequently detected chemicals.

77. **Page 2-16, 2.6.1 Criteria #3.** A table of the "available background concentrations" should be provided and noted that these are tentative as EPA has not yet agreed to acceptable background concentrations at this Site.

    Response: See response to Comment 39.

78. **Page 2-17, Third bullet.** Typo. "NOAA" is the National Oceanic and Atmospheric Administration.

    Response: Edit has been made.

79. **Page 3-1, 3.1 Benthic Invertebrate Community Exposure Assessment**. Compare the statement "Modeling is based on a relationship between benthic invertebrate tissue concentrations and sediment characteristics established with data for upstream LDW Site, as per the EPA-approved RI/FS work plan" with Pages 11-32 to 11-4 of the work plan. The rationale for use of LDW technical information for the Lockheed West Site should be explicitly restated in the ERA. This would make the ERA a stand alone document. The differences between the two Sites should also be discussed so that a reviewer could evaluate the conclusions of the ERA. Clarify that the two Sites are different not only because of the LDW's freshwater component, but because of other factors such as tidal and wave energy, among other factors.

    Response: See response to Comment 2 on expanded text on the rationale for using LDW information in the risk assessment, and on the risk assessment conforming to the work plan. Text on the additional differences between the sites has been added.

80. **Page 4-7, 4.1.1.2 Regression Models**. "Details of the food web model (FWM) and its calibration for the LDW Site can be found in Appendix D of the LDW RI Report." Generally describe why and how the LDW FWM should apply to Lockheed West.

    Response: Additional text from the LDW report describing the model has been added, and text has been added on the application of the food web model to the LW site.

81. **Page 5-5, 5.2 Fish Effects Assessment.** The laboratory effects studies included in the total PCBs assessment used unweathered Aroclor mixtures. PCB residues in fish have undergone physico-chemical weathering and differential accumulation in the food web, which may result in PCB mixtures that may be more biologically active than the commercial mixtures (Parkinson and Safe 1987; Smith et al. 1990). This should be included in the Uncertainty Section.

    Response: Text on the uncertainty over the enrichment of PCB congeners in weathered samples has been added to Section 5.2, and includes discussion from the LDW ERA that dioxin-like congeners were not enriched in tissue samples from the nearby LDW.

82. **Page 5-7, Table 5-5, TRVs for Fish COPCs Evaluated Using the Critical Tissue-residue Approach.** Include PCB TRVs derived from the paper by Hugla and Thome (1999) where reduced fecundity in barbel corresponded to a whole body LOAEL concentration of 0.52 ppm wet weight (ww) and NOAEL of 0.2 ppm ww. In addition, based on Fisher et al (1994), the recommend LOAEL should be 1.08 ppm ww, not 4.02 ppm ww. At 176 days post exposure there was a significant reduction in ww of fry in the 0.625 ppm nominal exposure concentration. The mean tissue concentration for this treatment was 1.08 ppm wet weight but it was measured 31 days post exposure. For the 176 day post exposure significant growth response, these tissue concentrations were likely far lower. Correct Table 5-5.

    Response: Table 5-5 has been corrected and risks have been re-calculated for PCB exposures to fish.

83. **Page 6-1, 6.1.1 Approach**. Birds are not completely covered with feathers. Large portions of their heads, legs, feet, and in some birds seasonal brood spots on their chests, are not feathered. Skin absorption of polyaromatic hydrocarbons from Great Lakes sediment shows that in a worst-case scenario dermal contact can be as important as ingestion.

    Response: Comment acknowledged; text has been modified to note areas that may be exposed.

84. **Page 7-32, 7.2.1.3 Risk Conclusions.** In addition to uncertainty related to the TRVs, there is also uncertainty in modeling concentrations in prey items. If tissue concentrations were underestimated, the risk could also be underestimated. This must be clarified.

    Response: Text has been modified to include uncertainties related to tissue modeling of prey in evaluating dietary exposures.

85. **Pages 7-5 and 7-7, Figures 7-1 and 7-2**. Pages 7-6 and 7-8 are missing. The figures are not double sided. Renumber or otherwise fix.

    Response: Edits have been made on the figure pages.

RESPONSE TO EPA COMMENTS (dated March, 2009; received May 11, 2009) ON THE DRAFT FINAL HUMAN HEALTH RISK ASSESSMENT FOR THE LOCKHEED WEST SUPERFUND SITE.

Specific Comments:

ES-4: There ~~was~~ **is** uncertainty associated with the application of the seafood consumption rates **used at the Lockheed West Site**~~to the much larger LDW site~~; ~~it is likely that the current fraction of contaminated seafood consumed from the Lockheed West Site is lower than that assumed for the LDW site, and thereby entails higher uncertainty~~. **The rates employed assume that all Puget Sound harvested seafood consumed by tribal members comes from the Lockheed West Site.** Tribes with treaty rights to obtain seafood from the West Waterway and Elliott Bay areas of the Site may increase their consumption rate in the future as contamination conditions improve in the overall lower Duwamish system and Elliott Bay, including waters of the Lockheed West Site. Any future habitat improvements could also increase the harvestable population of fish and shellfish to some degree.

Response: Edit has been made.

ES-6: What equation was used for Suquamish risks? Given that the risks are in the 10^{-2} range, the one hit model should be used. SEE Risk Assessment Guidance for Superfund, Part A, Page 8-11.

Response: The exponential equation was used for the Suquamish risk estimates, as is described in the main text. This use is now mentioned in the Executive Summary.

Page 1-5: "…will **generally** be present at…"

Response: Edit has been made.

Page 1-7: Add text noting that even if knowledge of movement patterns of organisms may not be appropriate for determining site specific contributions to contaminant body burdens. The important consideration in contaminant accumulation by organisms is where organisms feed, not necessarily their general movement patterns.

Response: Text has been added to reflect comment.

2.1, 2-1 Data Availability and Selection: "…contaminated sediment and **seafood** tissue ~~of seafood~~

Response: Edit has been made.

2-2: "…that have acquired **site related** body burdens of ~~site~~ contaminants…"

Response: Edit has been made.

2-2: "…and would **generally** be expected…"

Response: Edit has been made.

2-6, 2.2.1 Averaging Duplicate Samples: The LDW HHRA (Section B2.2.1) used the minimum reporting limit and that protocol should be used here. I had heard earlier that all results were detected, in which case this concern would not apply. The text revision should be made however.

Response: The text describing the approach has been edited to include use of the minimum reporting limit as used in the LDW HHRA, and deleted mention of one-half the minimum reporting limit which was not used.

3-4, 3.1 Conceptual site Model and Exposure Scenarios: ~~Use of Tulalip rates at the Lockheed West Site is consistent with this policy decision.~~ ~~This choice was agreed upon~~ ~~by~~ ~~t~~**T**he Suquamish and Muckleshoot Tribes ~~because the Tribes~~ recognize that background concentrations will likely be the cleanup levels for both the LDW and LW Sites **and hence decided that use of Tulalip rates to characterize seafood consumption risks for the LW site was tolerable**

Response: Edit has been made.

3-11, Outline Item 3: Provide citation for EPA's bioaccumulative compound list.

Response: Citation has been added.

3-51, Benthic Invertebrate Regression Model: Add the following text:

"The suitability of using benthic invertebrate arsenic bioaccumulation data to characterize sediment/tissue arsenic bioaccumulation relationships in bivalves is highly uncertain. The Lower Duwamish project found it difficult to develop a predictive sediment tissue bioaccumulation relationship for arsenic in bivalves. The uncertainty section discusses comparison arsenic tissue concentrations based on Lockheed West Macoma tissue arsenic concentrations as well as concentrations modeled using the benthic invertebrate sediment/tissue relationship."

Response: Text has been added as requested, with minor edits.

Page 5-10, 5.2.4 Seafood Consumption: Add the following text after the first paragraph: "As has been noted previously, determining the relationship between metal concentrations in sediment and tissues is highly uncertain. The uncertainty section discusses use of data from the nearby Lower Duwamish Site as well as Lockheed West specific bivalve data to characterize metals risks and hazards."

Response: Text has been added as requested.

Page 5-10, 5.2.4.1 Excess Cancer Risk Estimates: Add the following as a footnote to the adult and child tribal seafood consumption risks parameterized using Tulalip data:

"Consideration of alternative methods for computing metals bioaccumulation in the uncertainty analysis (Chapter 6), resulted in significant cancer risk increases for arsenic. The adult tribal RME arsenic risk using Tulalip data increased from 3×10^{-3} to 9.9×10^{-3}. The child tribal RME arsenic risk using Tulalip data increased from 5.5×10^{-4} to 1.8×10^{-3}. Increases in arsenic risk associated with different bioaccumulation assessment approaches may be offset by the fact that the percentage of inorganic arsenic in shellfish is likely lower than assumed."

Response: Text has been added as requested

Page 5-13, 5.2.4.2 Non-cancer Hazard Estimates: Add the following as a footnote to the first paragraph:

"Consideration of alternative methods for computing metals bioaccumulation in the uncertainty analysis (Chapter 6), resulted in significant hazard quotient increases for chromium and mercury. The child tribal RME chromium and mercury HQs using Tulalip data increased from 0.2 to 2 and 0.9 to 2 respectively."

Response: Text has been added as requested

Page 6-6, 6.2.2 Comparison of Modeled Clam Tissue Concentrations with Site Clam Data: This section should be rewritten utilizing all subtidal and intertidal results, not just intertidal. In particular, this section is at odds with EPA's results that included subtidal results.

Response: Text has been added to further explain the reason why the comparison of modeling clam tissue concentrations differs from the evaluation of BSAFs presented by EPA, which is attached to the HHRA. The following text is added to the end of the section:

"The intent of this comparison was to determine whether the modeled chemical concentrations in intertidal clams that were used in the seafood consumption scenarios were verified by the measured site clam data. The modeled clam tissue concentration data were used in the tribal RME seafood consumption scenario and the Suquamish seafood consumption scenario. These scenarios assume that tribal members consume clams from the intertidal areas of the site. Thus, the modeling of chemical concentrations in these clams was based on intertidal sediment data and clam BSAFs, or the LDW regression equations for benthic invertebrates for arsenic and TBT, and the LDW food web model for PCBs. Because the modeled clam tissue concentrations are based on intertidal sediment data, the comparison with measured clam tissue data was made with clams collected from the intertidal area of the Lockheed West Site.

This comparison differs from the analysis of clam BSAFs for metals that was performed by EPA (see Appendix E) and summarized in Section 6.2.5. The EPA analysis was designed to evaluate the health protectiveness of the clam BSAFs that are used to model tissue concentrations in the seafood consumption scenarios. The approach used in the EPA analysis was to calculate site-specific BSAFs for clams using co-located clam tissue data and sediment data collected during the clam study of the Site. EPA used all the Site clam samples, which consist of a single intertidal clam sample and three subtidal clam samples. The EPA analysis of clam BSAFs differs from the above verification of the modeled clam concentrations used in the seafood consumption scenario in that EPA used the full set of intertidal and subtidal sediment and clam data to develop BSAFs whereas the verification study was only for intertidal clam data. The EPA study found that many site-specific BSAFs for metals calculated from the co-located intertidal and subtidal data sets were higher than those used in the modeling of the seafood consumption scenarios. The verification evaluation performed herein found that most of the modeled intertidal clam tissue concentrations of organic chemicals and metals were similar to or higher than the measured intertidal clam tissue concentrations, demonstrating the general health protectiveness of the modeling effort."

<u>Comment on</u> <u>Page 6-6, 6.2.2 Comparison of Modeled Clam Tissue Concentrations with Site Clam Data, received via e-mail from Lon Kissinger, EPA Region 10:</u> The conclusion at the end reinforces that a comparison of metals bioaccumulation modeling with site specific intertidal Macoma BSAFs indicates that modeling was health protective. The conclusion should be tempered somewhat. Please use the following for the conclusion: "The comparison of intertidal Macoma BSAFs with BSAFs used for modeling indicates that modeling is health protective. However, EPA's analysis using all Macoma data suggests that at higher subtidal

metal concentrations, modeling may underestimate actual metals bioaccumulation. Given that tribal members are assumed to be accessing clams in the intertidal zone, metals bioaccumulation for the human health risk analysis was based on intertidal data."

Response: Edit has been made.

<u>Responses to Comments Dated 04/11/09 Inserted Electronically into the Final Human Health Risk Assessment for the Lockheed West Superfund Site (received May 11, 2009).</u>

Comment A1. This is covered on page es-9 re: uncertainties. (Comment is inserted on Page ES-4 and deletes a paragraph in the Executive Summary that discusses the uncertainty in the application of the seafood consumption rate used at the LDW site to the much smaller Lockheed West Site. The topic is also mentioned in the section of the Executive Summary that presents uncertainties in the risk assessment.)

Response: Paragraph has been deleted.

Comment A2. Add discussion re: development of the Suquamish ingestion rate using the market basket approach. (Inserted on Page 3-16, Section 3.2.3. Sediment Screening for Seafood Consumption Exposure.)

Response: This section of the HHRA discusses the method used in the LDW HHRA to derive risk-based concentrations (RBCs) of chemicals in seafood tissue. The seafood tissue RBCs were used in the LDW HHRA to develop risk-based analytical concentration goals (RBACGs) for sediment chemicals based on the tribal RME consumption of seafood scenario, which uses the Tulalip ingestion rates. The method that describes developing the tissue RBCs in the Lockheed West HHRA was taken from the LDW HHRA, as specified in the Lockheed West work plan for the RI/FS and risk assessments. Since the Suquamish seafood consumption scenario was not identified as the RME scenario for seafood consumption, the LDW HHRA did not develop tissue RBCs based on the Suquamish ingestion survey. Hence the LDW HHRA did not describe the derivation of the Suquamish seafood ingestion rates for application to developing tissue RBCs. For that reason, discussion on the derivation of Suquamish ingestion rates has not been added to the Lockheed West HHRA.

Comment A3. RBACGS adjusted for Tulalip may not include all COCs that would be included if adjusted for Suquamish. If not added here, discuss in uncertainty section. (Inserted on Page 3-19, Section 3.2.3. Sediment Screening for Seafood Consumption Exposure.)

Response: Discussion on RBACGs adjusted for the Suquamish ingestion rates will not be added to Section 3.2.3, but the following text will be added to the uncertainty assessment in Section 6.1, which discusses uncertainties in the use of LDW exposure scenarios for the Lockheed West Site: "The method used to identify sediment COPCs for the seafood consumption scenarios is based on the tribal RME scenario developed for the LDW site. As described in Section 3.2.3, sediment COPCs for seafood consumption are identified

through a screening process using risk-based analytical concentration goals (RBACGs) that were originally developed for the LDW site based on the tribal RME scenario. The RBACGs are derived from seafood tissue RBCs, which in turn are derived using the Tulalip survey seafood ingestion rates as the tribal RME seafood consumption scenario. The Suquamish survey seafood ingestion rates are higher than the Tulalip survey ingestion rates. Derivation of tissue RBCs and in turn sediment RBACGs based on the Suquamish survey ingestion rates would result in lower sediment RBACGs than those derived using the Tulalip survey rates. The application of lower RBACGs to the screening process to select COPCs, whereby maximum concentrations of sediment chemicals would be compared against lower Suquamish-based RBACGs, could result in additional chemicals screening above the lower RBACGs. As COPCs, by definition, these additional chemicals would be identified as possibly contributing to risk estimates for the Suquamish seafood consumption scenario. However, they would not necessarily contribute to risk estimates for the tribal RME scenario based on the Tulalip survey, because of the lower seafood ingestion rates used to estimate exposures in that scenario.

The extent of contribution of any additional chemicals to the total health risk in the Suquamish seafood consumption scenario would be so low as to not affect the total cancer risk estimate for that scenario. For example, the total cancer risk estimate for the Suquamish seafood consumption scenario is 5×10^{-2}***, which is driven mostly by arsenic and cPAHs in sediment, each contributing about one-half of the estimated cancer risk. Total PCBs contribute about one-fifth to this risk estimate and pentachlorophenol contributes about 0.02 percent. Any additional COPCs identified by using lower RBACGs would contribute less than 0.02 percent to the total cancer risk. Because these additional COPCs contribute a relatively small amount to the total cancer risk estimates compared to the present risk drivers, they would not add to the list of risk driver chemicals for the Suquamish seafood consumption scenario. In addition, the use of lower RBACGs would not add risk drivers to the tribal RME seafood consumption scenario (because that scenario is based on a lower seafood ingestion rate), and they would not change the identification of chemicals of concern (COCs) for the tribal RME seafood consumption scenario, nor would they change risk-based cleanup levels that may be calculated for RME COCs."***

Comment A4. Also include dioxin/furan COC language here. (Inserted on Page 3-20, Section 3.2.3. Sediment Screening for Seafood Consumption Exposure.)

Response: A sentence stating that dioxins/furans are also identified as COPCs based on their presumed presence in seafood will be added, and will be consistent with language that states that dioxins/furans are identified as COCs.

Comment A5. Include Suquamish scenario. (Inserted in title of Table 5-15, Page 5-18, Section 5.2.5. Cumulative Risks across Clamming Scenarios (Collection and Consumption.)

.

Response: This section and Table 5-15 provide cumulative risks for the RME scenarios of clam collection and clam consumption, which uses the Tulalip survey clam ingestion rate. The intent of the section is to present the cumulative risk estimates specifically for the RME scenarios. The text states that summing the clam collection and consumption risks for the Suquamish scenario would result in higher risk estimates due to the higher clam ingestion rate for the Suquamish survey. However, since the Suquamish seafood consumption scenario is not identified as the RME scenario, those cumulative risks are not calculated and are not presented in the HHRA. Their presentation would necessitate the calculation of risks specifically for clam consumption using the Suquamish ingestion rate. However, the risks estimated for the Suquamish seafood consumption scenario are based on the market basket approach, where clams are consumed as a fraction of the total consumption rate. In other words, risks related specifically to the consumption of clams have not been calculated and are not readily available to include in a discussion of cumulative risks for the Suquamish high-end exposure scenarios. Therefore, additional risk estimates specifically for clam consumption in the Suquamish scenario have not been included.

Revision: The following paragraph is revised in the Final HHRA report, Page 5-18:

5.2.5 Cumulative Risks across Clamming Scenarios (Collection and Consumption)

"Risks associated with both the collection of clams and eating of clams are evaluated in this HHRA. The combined risks from engaging in both of these activities at the Lockheed West Site are presented in Table 5-15. Total risks are calculated as the sum of risks associated with tribal RME clam consumption (seafood exposure) and with tribal 120 days-per-year clamming (sediment exposure). Almost all (i.e., over 95 percent) of the total cancer risk and non-cancer hazard for each chemical is attributed to the consumption of clams. Similar comparison using the Suquamish exposures of higher clam consumption rate (438.6 g/day vs 37.7 g/day for the RME scenario) and 183 days per year clam collection would result in higher cumulative risk estimates than shown for the RME scenarios in Table 5-15. If needed in the future, risk estimates could be calculated using the high-end Suquamish exposures. The risk results for Suquamish exposures would show a greater percentage of total risks due to clam consumption compared with clam collection because of the much higher clam ingestion rate in the Suquamish seafood scenario."

Comment A6. include Suquamish scenario. (Inserted in title of Table 5-17, Page 5-21, Section 5.3.2. Adult lead model for Developing Fetus.)

Response: This section presents the results of the adult lead model for the RME scenarios, which is a combination of tribal RME clamming, netfishing, and tribal RME seafood consumption. The LDW HHRA evaluated these tribal RME scenarios using the adult lead model, and the RI/FS work plan specified that the Lockheed West HHRA would evaluate the same scenario for the adult lead model. In both the LDW HHRA and Lockheed West HHRA modeling for the RME scenario for adult lead exposure, the median ingestion rates for each seafood category from the Tulalip survey data are used to calculate a weighted lead concentration in seafood, as per guidance from EPA. The median ingestion rates for seafood categories from the Tulalip survey are reported in the LDW HHRA and were originally provided by EPA to the LDW project. In order to run the adult lead model using Suquamish survey seafood ingestion rates, as requested in the comment, the median ingestion rates for each seafood category for the Suquamish survey data would need to be acquired from EPA. Because the median ingestion rates are not readily available and since the model cannot be properly run without them, no additional analysis has been performed.

Revision: The following is the revised paragraph in the Final HHRA report, Section 5.3.2 (Developing Fetus), Page 5-21:

"The results of the modeling of exposure of the developing fetus to lead are consistent with the results from the IEUBK model for children. The results of both the child and fetus modeling indicate that lead is considered to be a COC for the HHRA. The results of modeling lead exposures for both the child and fetus are driven by the exposure assumptions of the seafood consumption scenarios. For both the child lead receptor and developing fetus receptor, the incorporation of the seafood consumption pathway results in the estimation of significant risks from lead exposure. Incorporation of the median Suquamish tribal survey seafood ingestion rates into the ALM modeling would result in substantially greater estimated blood lead levels in the developing fetus, due to the much higher seafood ingestion rates than the RME scenario used herein. If needed in the future, the ALM model could be run for the high-end Suquamish exposures if the median seafood ingestion rates are developed from the Suquamish seafood ingestion survey. As described earlier, the direct contact pathways (i.e., beach play, tribal clamming, and tribal netfishing) and the RME seafood consumption pathways are taken directly from the LDW HHRA."

Comment A7. The following paragraphs do a good job of putting the uncertainties in an acceptable context. Any sustainability language should be deleted. (Inserted on Page 6-1, Section 6.1, Use of Exposure Scenarios from the LDW Site.)

Response: This section discusses uncertainties in using the exposure scenarios and parameters from the LDW HHRA in estimating exposures and risks for the Lockheed West Site. The comment deletes a paragraph that points out that using the LDW parameters does not take into account any potential differences between the sites that could affect exposures, specifically the amount of clams and the extent of intertidal area. Although the sizes of the intertidal areas of the two sites are mentioned, any potential differences in clam abundance and sustainability of those clams are not quantified, and for that reason, the paragraph has been deleted.

Comment A8. Include impact re: Suquamish scenario. (Inserted on Page 6-7 in reference to Table 5-9, Section 6.2.2, Comparison of Modeled Clam Tissue Concentrations with Site Clam Data.)

Response: This section describes a comparison of the measured tissue concentrations of chemicals in clams collected from the intertidal sediments of the Site with concentrations that were modeled into clams based on intertidal sediment data for the tribal RME seafood consumption scenario. Because the measured PCB levels were higher than the modeled concentrations, the risks from PCBs in the tribal RME seafood scenario were re-calculated using the measured concentrations. The comment requests that the Suquamish seafood consumption risk estimates for PCBs also be re-calculated using measured clam data in place of the modeled clam data. These risk estimates are re-calculated and mention of the resultant risk estimates is included in this section of the HHRA

Comment A9. Include changes re: Suquamish scenario. (Inserted on Page 6-10, Section 6.2.5, Bioaccumulation of Metals.)

Response: The text on Page 6-10 of this section presents a summary of the analysis presented by EPA on the changes in risk estimates for the tribal RME seafood consumption using alternative BSAFs for metals, as derived from the LDW site and Lockheed West clam data. EPA analyzed the impacts of alternative BSAFs on the tribal

RME scenario using the Tulalip seafood ingestion rates; EPA did not analyze the impacts of alternative BSAFs on the Suquamish seafood consumption scenario. Since this analysis was performed by EPA and is only summarized in this section of the Lockheed West HHRA, no additional analyses have been performed.

Revision: The following paragraph is added to the Final HHRA report, just before the last paragraph of Section 6.2.5, Page 6-12:

"A similar evaluation of the adult tribal seafood scenario based on the Suquamish consumption survey would also result in increases in cancer risk estimates and HQs for the same metals as found with the adult tribal RME scenario. If needed in the future, risk estimates could be calculated using the high-end Suquamish exposures. With the alternative BSAFs, the cancer risk estimate for arsenic in the Suquamish seafood scenario would increase about 3-fold above the present value of 3×10^{-2}, and the HQ for chromium would increase above 1.0; HQs for all other COPC metals are already above 1.0 (see Table 5-14)."

Comment A10. This is not included in the document. (Inserted on Page 8-7 identifying a reference that is not cited in the text)

.

Response: The reference has been deleted.

APPENDIX D— 3-D MODEL SETUP AND SENSITIVITY ANALYSIS

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

APPENDIX D
3-D Model Setup and Sensitivity Analysis

D.1 INTRODUCTION

This appendix describes the setup of the 3-dimensional (3-D) model used to delineate the extent of site contamination in the remedial investigation (RI) and to estimate contaminant masses and sediment volumes used in the feasibility study (FS). The interpolation method used to delineate the extent of sediment contamination at the site is a 3-D kriging model. Kriging models are commonly used to interpolate data in the mining and environmental fields. The basis of the kriging model is described in Section D.2 of this appendix. In addition, as requested by the U.S. Environmental Protection Agency (EPA), an assessment of the model sensitivity was completed to determine if other interpolation methods available in the software or if adjustment to the kriging model setup parameters used for the site data could result in substantially different estimates.

D.2 MODELING METHODOLOGY

The extent of contaminant distribution in the Lockheed West Seattle Superfund Site (Lockheed West) sediments was estimated by using a 3-D kriging model program (Mining Visualization Software [MVS] version 9.13, C Tech). Data from the surface and subsurface sediment samples collected for the RI were used as the basis for the kriging model. In addition to the data collected specifically for the RI (Tetra Tech, 2008), recent surface sediment samples from monitoring locations at surrounding sites (Pacific Sound Resources [PSR] Marine Operable Unit, Todd Shipyard Sediment Operable Unit) and Elliott Bay (Ecology, 2009) were used along with historic core data and surface samples collected in previous investigations at the site (see Section 4 of the RI/FS Report).

Kriging is a statistics-based interpolation method that optimizes the estimation based on a linear combination of the known data. One aspect of the MVS kriging model is that it honors the measured data used in the model. This is slightly different than some kriging methods where statistical functions (e.g., nuggets) are used to smooth the data based on the spatial variability. The MVS kriging model uses a nugget of 0 which results in a calculated value at a point to be equal to the measured value. This difference in the models results in the predicted values in the MVS kriging model matching the measured values whereas for other kriging methods that smooth the data the predicted values may not match the measured data.

The MVS kriging model uses a variogram analysis procerdure to examine the spatial distribution and number of points in the input data set, and calculates a variogram that best fits the data within the constraints applied. Along with the properties of the data set these constraints include some important parameters of the kriging model that can impact the model results. These parameters include the following:

- Density of data points;
- Reach of model points (i.e., how many data points are used and what distance away?); and
- Anisotropy (i.e., difference in the horizontal versus vertical influence on the model points).

The density of the data in the model area is dependent on the amount of data collected. The RI data collected for Lockheed West cover the study area with both surface sediment samples and sediment cores. At only a small number of cores (7 out of 37) did the deepest sample collected and analyzed not have concentrations for the risk-driver chemicals below the Sediment Quality Standards (SQS). Outside of the RI study area, data from other sources were included in the model dataset. Within the study area where the RI cores and surface samples were collected, the density of the data used in the model is such that there is a relatively greater level of confidence in the model outputs. Outside of the Lockheed West study area where data from other sources are used (PSR, Todd Shipyard, Elliot Bay) the data density is lower and the uncertainty associated with the model outputs is greater.

In the model setup, specific parameters are set for the model reach and the anisotropy. The model reach determines how many data points are used in the interpolation at locations with no data and the distance away of a neighboring data point Anisotropy, which determines the relative horizontal and vertical influence that data points have on the model estimation points, is also set for the model reach. For the Lockheed West model estimation, these parameters were set at the default values that include a model reach of up to 20 data points and the anisotropy set to 10. The model reach sets how many data points are used to estimate the values between the measured data. A smaller model reach results in model values being dependent on the closest data points. This parameter setting would be appropriate if the contamination distribution is expected to be relatively localized. A larger model reach would use more data from a greater distance away to estimate the model values. This setting would be appropriate if the contaminant distribution in the system was diffuse. Because shipyard operations occurred in local areas of the site and site activities and physical processes could have distributed contamination a small distance, a default model reach towards the lower end of the model reach range of up to 20 data points was used.

The anisotropy places a greater influence on data points in the horizontal plane compared to those in the vertical plane relative to the point of estimation. If the anisotropy is set to 100, there would be a small vertical influence, which would be most appropriate for a system with a strong horizontal flow controlling transport and deposition with little chance for vertical mixing. If the anisotropy is set to 1, the horizontal influence is equal to the vertical influence, which would potentially overemphasize the vertical influence since vertical mixing is expected to be limited to the top 10 centimeters (cm) and the processes involved in horizontal transport and mixing are likely to be present over a greater range. This asymmetrical relationship assumes that the contamination has been deposited in layers with some horizontal flow influencing distribution. This use of an anisotropy setting of 10 makes an assumption that flow has some influence on the deposition of contaminants at Lockheed West and takes into account some impact of tidal flux and current flows on contaminant transport and deposition at the site, though the exact level of this impact is not known.

The 3-D modeling at the site was done using the risk-driver chemicals (arsenic, copper, lead, mercury, polychlorinated biphenyls [PCBs], carcinogenic polycyclic aromatic hydrocarbons [cPAHs], and tributyltin). The chemical concentrations were modeled within a geological shell, where the top was based on the bathymetry surface (Tetra Tech, 2006) and the bottom was based on the depth of the collected sediment cores with an additional 5 feet added. The model was used to determine the extent of risk-driver chemicals individually and in combination at the site. The extent of chemical concentrations was determined against various threshold levels including the SQS, Elliott Bay levels based on the data collected by the Washington State Department of Ecology (Ecology, 2009), and the "Bold Study" levels for Puget Sound (EPA, 2009). When used in model included all of the risk driver chemicals of concern in combination, the extent of chemical concentrations was based on where any of the risk-driver chemicals that were modeled exceeded the threshold concentration level. Figure D-1 shows the predicted horizontal extent of the sediments with concentrations for the risk-driver chemicals above the SQS for the base kriging model.

D.3 ALTERNATIVE MODELING INTERPOLATION METHODS

One means to test the uncertainty of the kriging model method is to compare the estimations to alternative interpolation methods. In this case, two alternative methods were used to compare against the kriging method. One method involved using the nearest neighbor data point and a second method was using an inverse distance weighted (IDW) averaging method. The nearest neighbor model interpolates values simply based on the value of the closest sampling point. The IDW interpolates the values based on the closest points and weights them according to their distance away. With IDW, as the power parameter (the weighting factor used for estimating the influence of distance) in the model increases (and thus, the stations farthest away have the least influence), the interpolation approaches that of the nearest neighbor methodology. To evaluate these methods, a series of interpolations was done with different powers and search distances to provide a range of outputs for comparison.

A visual comparison of the estimated extent of sediment contamination using the same input dataset as the base kriging model shows that the area estimated using the IDW model (Figure D-2) with a power equal to 2 is much smaller than for the base case kriging model (Figure D-1) or the nearest neighbor model (Figure D-3). The estimated extent of sediment contamination in the IDW model is more localized around the data points whereas the nearest neighbor model has the same general extent of sediment concentrations above the SQS as the base kriging model, with some small local differences. Figures D-4 and D-5 show the extent of sediments with concentrations above the SQS for IDW models using powers of 5 and 10, respectively. The trend is that the higher the power, the greater the extent; therefore, when IDW power is increased to the power of 10, the extent increases, though the changes are relatively small.

Table D-1 shows the differences in the estimated volumes of sediment above the SQS. The IDW model has the lowest estimated volume using a power of 2 and very similar volumes when using powers of 5 or 10, whereas the nearest neighbor model has a much higher estimated sediment volume. The nearest neighbor models and the IDW models both exhibit a large bias at depth extending the vertical extent of contamination to the bottom of the geology model shell. This vertical bias in the models is present in areas where cores have data at deep intervals with concentrations for the risk-driver chemicals below the SQS. This effect is potentially due to collocated surface samples and individually collected surface samples that have SQS exceedances exerting a larger influence at depth because they are physically closer than a core located even a short distance (25 feet) away.

D.4 KRIGING MODEL UNCERTAINTY

As discussed above, the two important parameters that can impact the model results are model reach and anisotropy. To evaluate the influence of these parameters, a series of model runs were performed using extreme ranges of the parameters to evaluate the relative influence of each of them.

The default setting in the base kriging model used a model reach of 20. Figure D-6 shows the horizontal extent of the sediment with concentrations above the SQS for the risk-driver chemicals with the reach set to 5 points. This model setup results in some localization of the horizontal extent of the SQS footprint. Figure D-7 shows the horizontal extent for the SQS exceedance with the reach set to 100. The horizontal extent above the SQS for this model is very similar to the base model with the reach set to 20. The result for the base kriging model compared to model runs with smaller and larger model reaches indicate that the horizontal extent of contamination for the risk-driver chemicals is not underestimated due to a limitation of the model reach.

As discussed above, the base kriging model anisotropy is set to 10. Figure D-8 shows the horizontal extent for the sediment concentrations above the SQS for the risk-driver chemicals with the anisotropy set to 1. This model shows that if the horizontal influence is equal to the vertical influence, the extent of contamination is more localized resulting in a small contaminant footprint. Figure D-9 shows the extent of sediment concentrations for the risk-drivers above the SQS with the anisotropy set to 50. This model has a much higher influence for data points in the horizontal direction than the vertical direction. The horizontal extent for risk-driver chemicals above the SQS is generally the same as in the base case model. Adjustments to the anisotropy used in the base kriging model indicate that the horizontal extent of contamination is not underestimated.

Table D-2 summarizes the sediment volume differences for kriging model setups where the model reach or the anisotropy is adjusted. The volume of sediment with concentrations above the SQS for the risk-driver chemicals ranges from 189,000 cubic yards to 249,500 cubic yards. The base case volume estimate of sediment with concentrations for the risk-driver chemicals above the SQS is 228,000 cubic yards. Differences in the estimated volumes for sediments from the kriging model are not substantial for the range of adjustments made to the kriging model parameters.

D.5 KRIGING MODEL UNCERTAINTY SUMMARY

The uncertainty in the extent of contamination and the sediment volume estimates from the kriging model used for the Lockheed West sediment site were examined by comparing against other model algorithms and by adjustments to the kriging parameters. The comparisons show that the base model used provides a conservative estimate for the extent of sediment where the risk-driver chemicals exceed the SQS. The base model result does not underestimate the horizontal extent due to localizing the influence of data points and provides a similar outer extent as other models. The vertical extent for risk-driver chemicals above the SQS from the base kriging model are truer to the core data for the site than IDW and nearest neighbor models which potentially have an over-influence of the surface sediment data on the extent of subsurface contamination. The results of this uncertainty analysis indicate that different model interpolation methods such as IDW and nearest neighbor do not in general result in a different horizontal extent of sediment concentrations above the SQS levels for the risk-driver chemicals. The sediment volumes estimated from the IDW and nearest neighbor models have a positive bias at depth due to the influence from collocated and separate surface sediment samples where core data are located even a relatively small distance away.

Large adjustments to the model reach and to the model anisotropy also are not found to result in a substantial difference in the horizontal extent of the sediment concentrations above the SQS. The difference in the sediment volumes for the high and low parameter settings is approximately 10 percent or less than the estimated sediment volume for the base kriging model. There is no substantial difference in model results using other interpolation methods or by incorporating particular kriging parameter settings different than those used in the base kriging model based on the available site data.

D.6 REFERENCES

Ecology (Washington State Department of Ecology). 2009. Urban Waters Initiative, 2007. Sediment Quality in Elliott Bay. Publication No. 09-03-014. September.

EPA (U.S. Environmental Protection Agency). 2009. *Data Summaries of Dioxin/Furan Congeners, PCB Aroclors, PCB Congeners, Total Organic Carbon, Grain Size, and Pesticides*. Puget Sound Dioxin/PCB Survey, OSV Bold, 2008. January 21.

Tetra Tech. 2006. High-Resolution Multibeam Sonar Bathymetric Survey conducted for Lockheed Martin Corporation. Prepared by Tetra Tech, Inc., Bothell, WA.

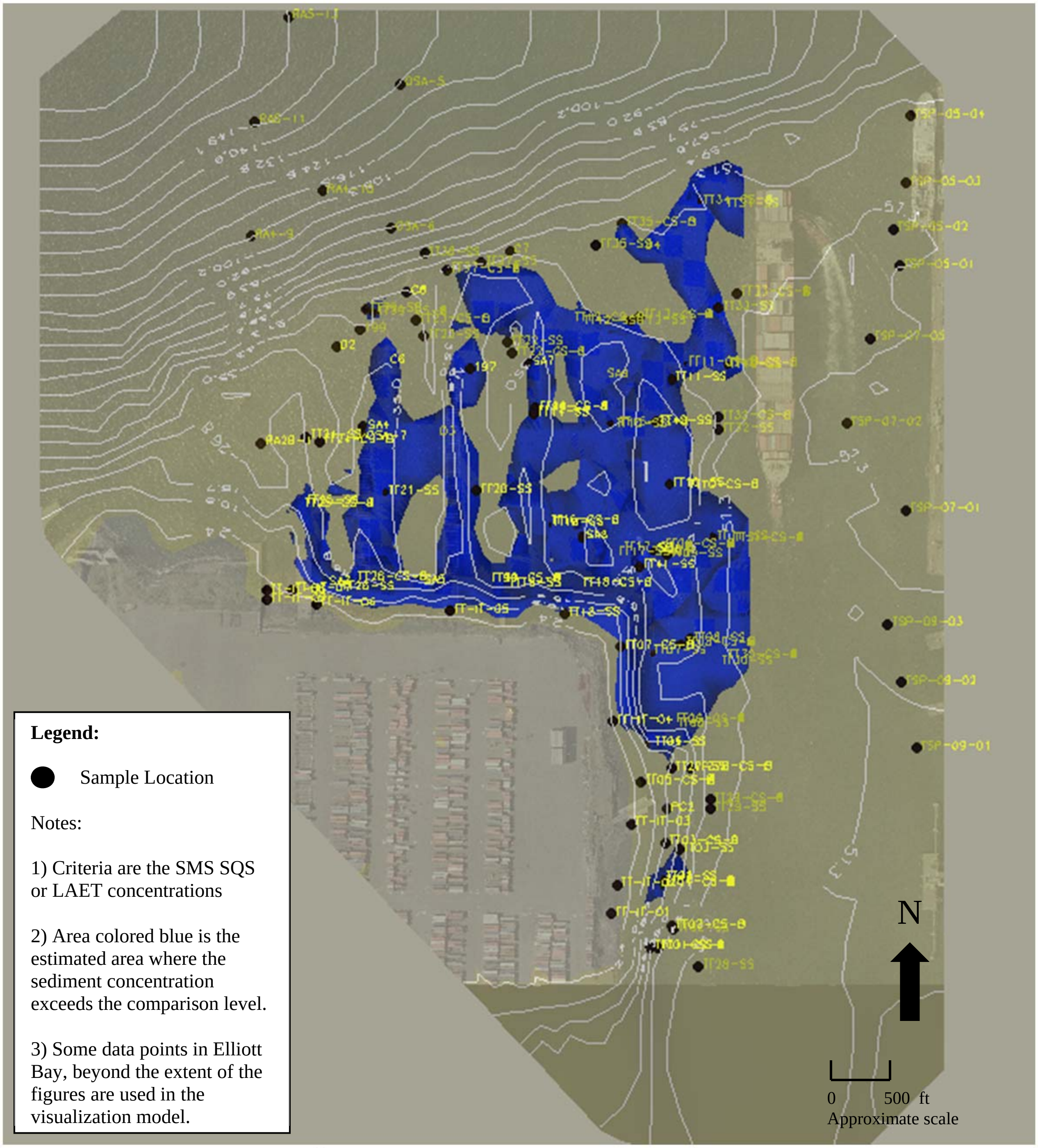
Tetra Tech. 2008. Remedial Investigation Data Report. Prepared for Lockheed Martin Corporation. Revision 1. January.

Table D-1.
Model Interpolation Estimated Sediment Volume for Risk-Driver Chemicals Above SQS

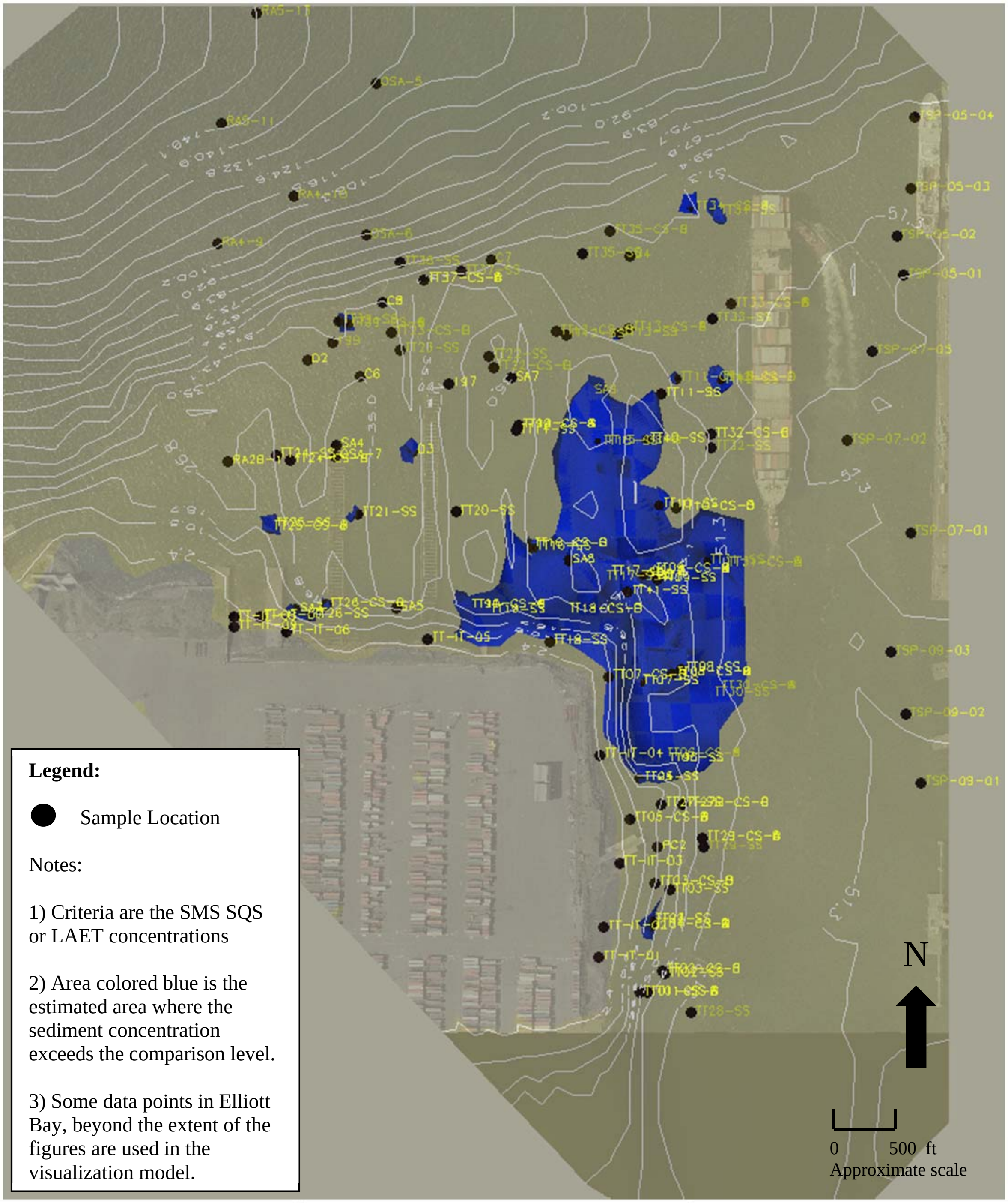
Model	Extent Basis	Sediment Volume (cy)
Kriging – Base Case	Risk-Driver SQS	228,000
Nearest Neighbor	Risk-Driver SQS	323,000
IDW – Shepard (Power =2)	Risk-Driver SQS	195,000
IDW – Shepard (Power =5)	Risk-Driver SQS	240,500
IDW – Shepard (Power =10)	Risk-Driver SQS	277,700
	RSD	19.4 %

Table D-2.
Estimated Sediment Volume for Risk-Driver Chemicals Above SQS for Kriging Model Setups

Model	Extent Basis	Sediment Volume (cy)
Kriging – Base Case	Risk-Driver SQS	228,000
Anisotropy set to 1	Risk-Driver SQS	249,500
Anisotropy set to 50	Risk-Driver SQS	189,000
Reach extent set to 5	Risk-Driver SQS	243,500
Reach extent set to 100	Risk-Driver SQS	210,500
	RSD	11.1 %



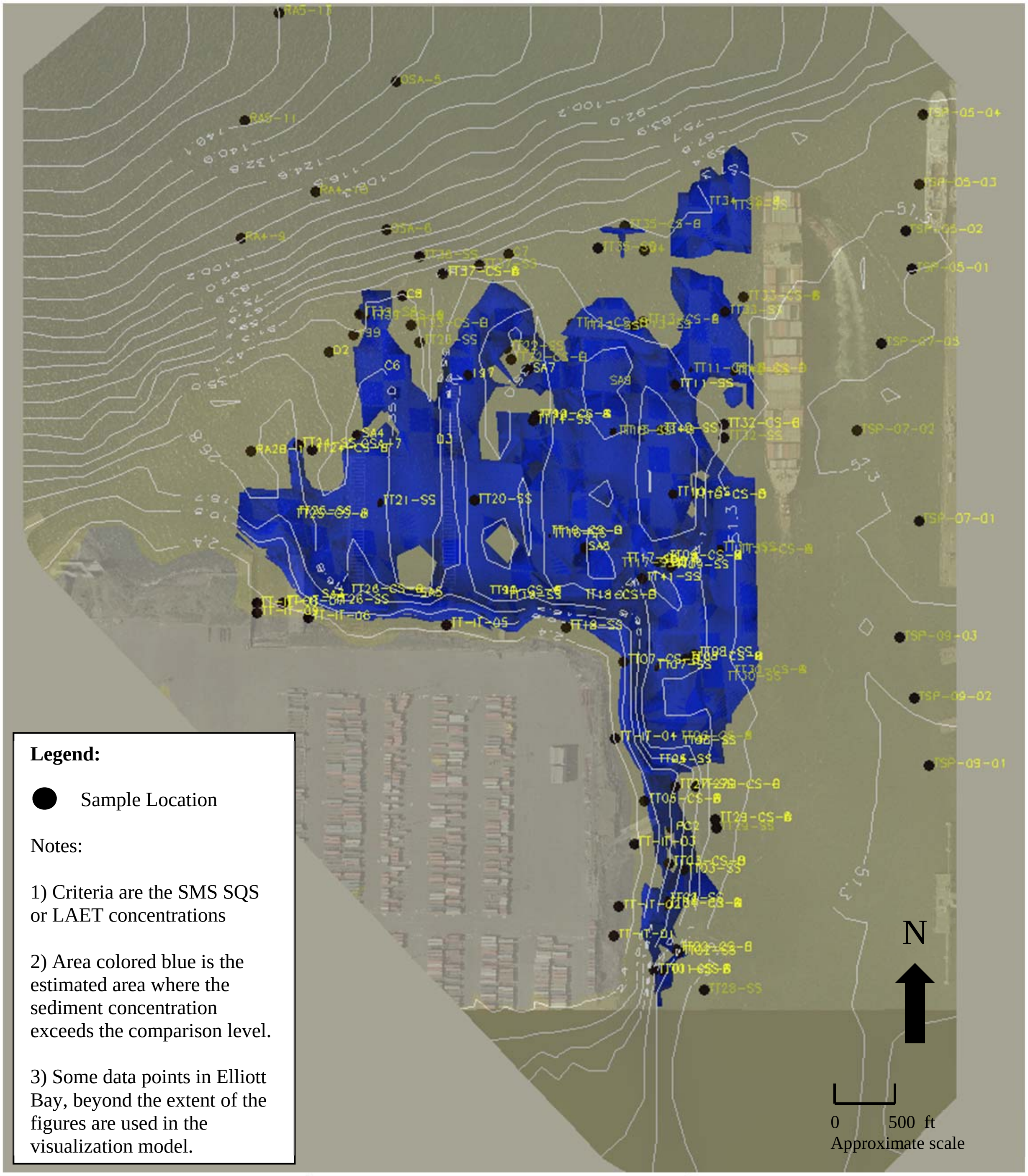
TETRA TECH EC, INC.	Lockheed West Shipyard No. 2 Seattle, WA	**Figure D-1** **Krig Model for Extent Above SQS (Base Model)**



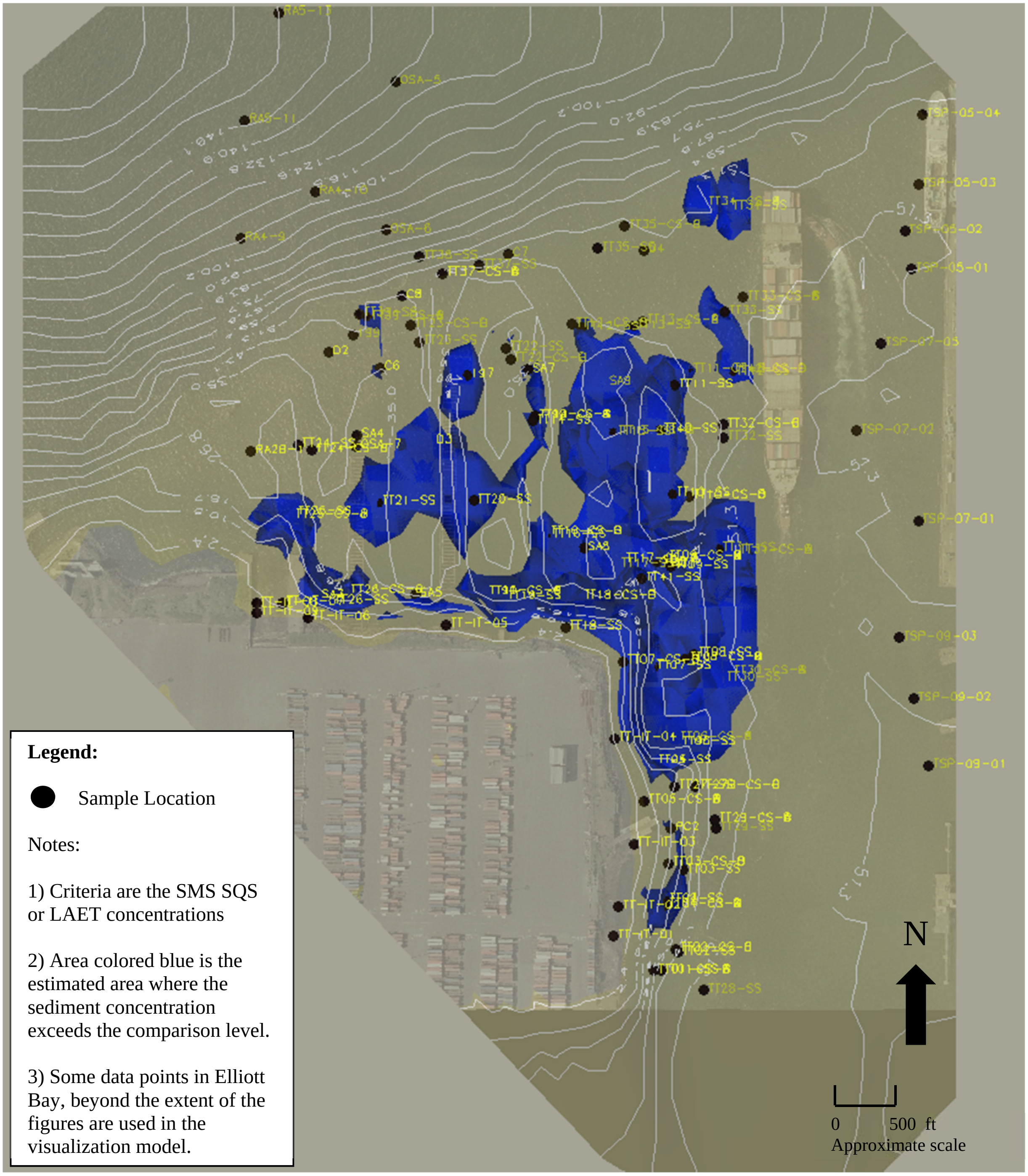
TETRA TECH EC, INC.

Lockheed West
Shipyard No. 2
Seattle, WA

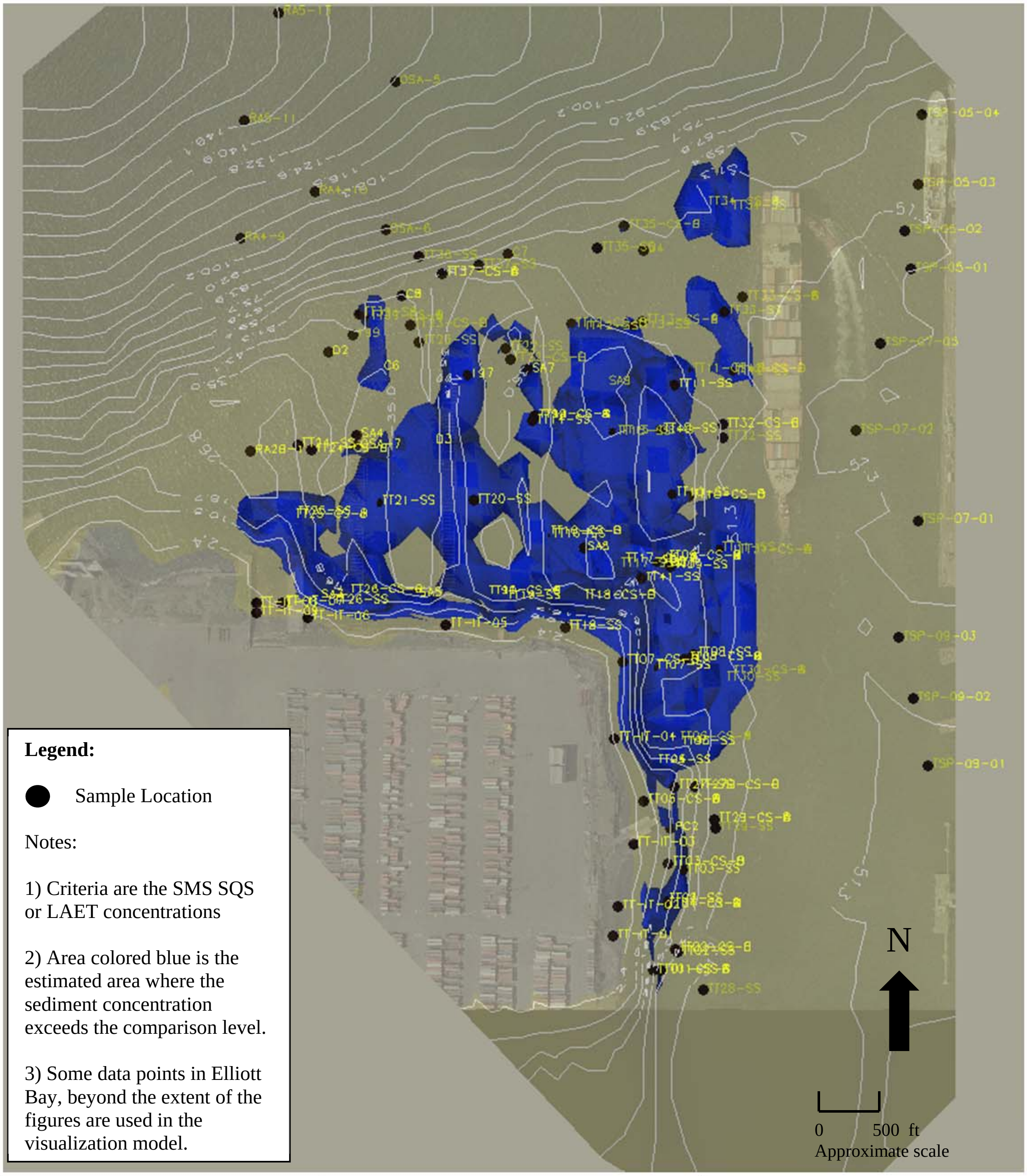
Figure D-2
IDW Model for Extent Above SQS (Power = 2)



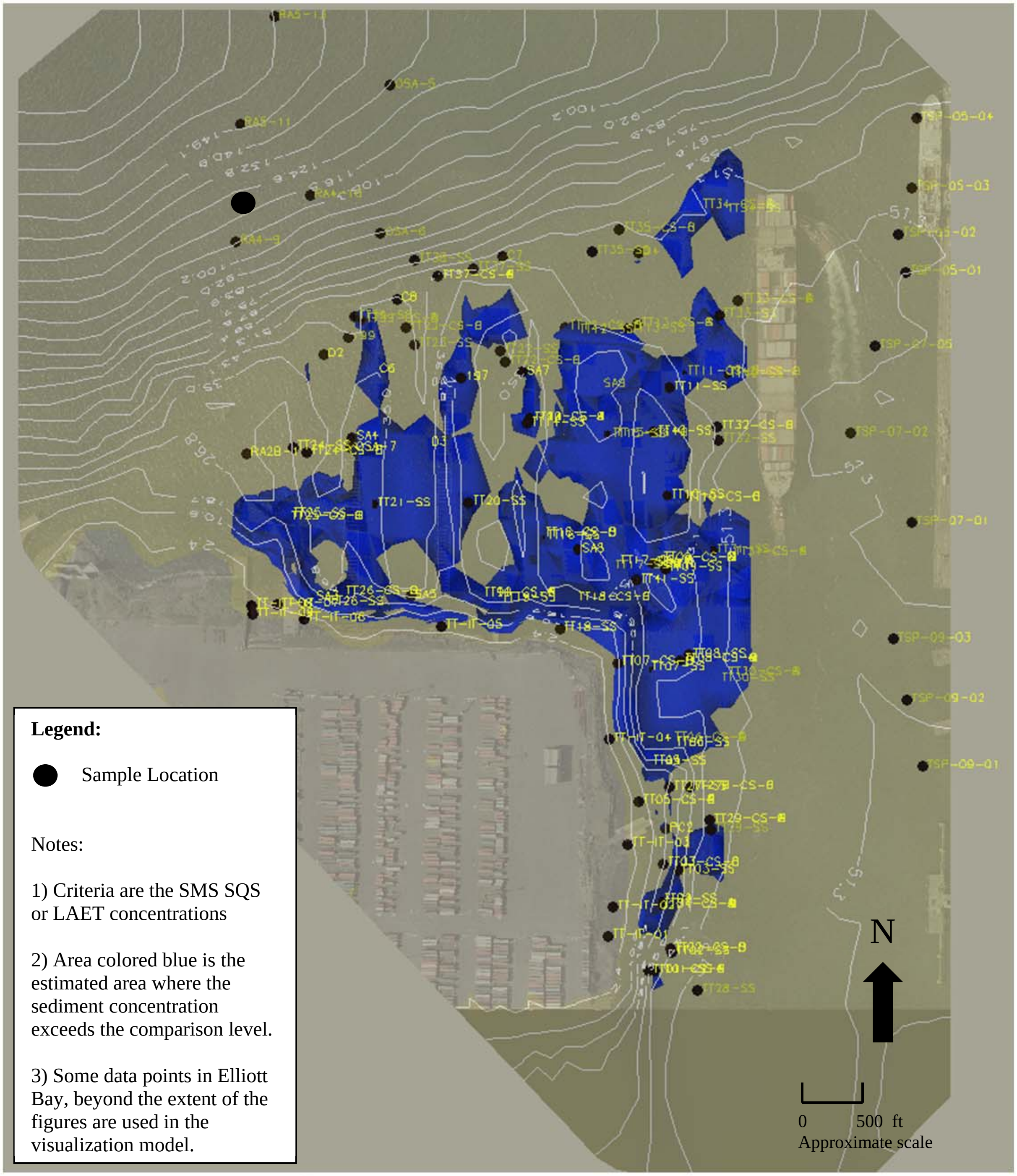
TETRA TECH EC, INC.	Lockheed West Shipyard No. 2 Seattle, WA	**Figure D-3** **Nearest Neighbor Model for Extent Above SQS**



TETRA TECH EC, INC.	Lockheed West Shipyard No. 2 Seattle, WA	**Figure D-4** **IDW Model for Extent Above SQS (Power = 5)**



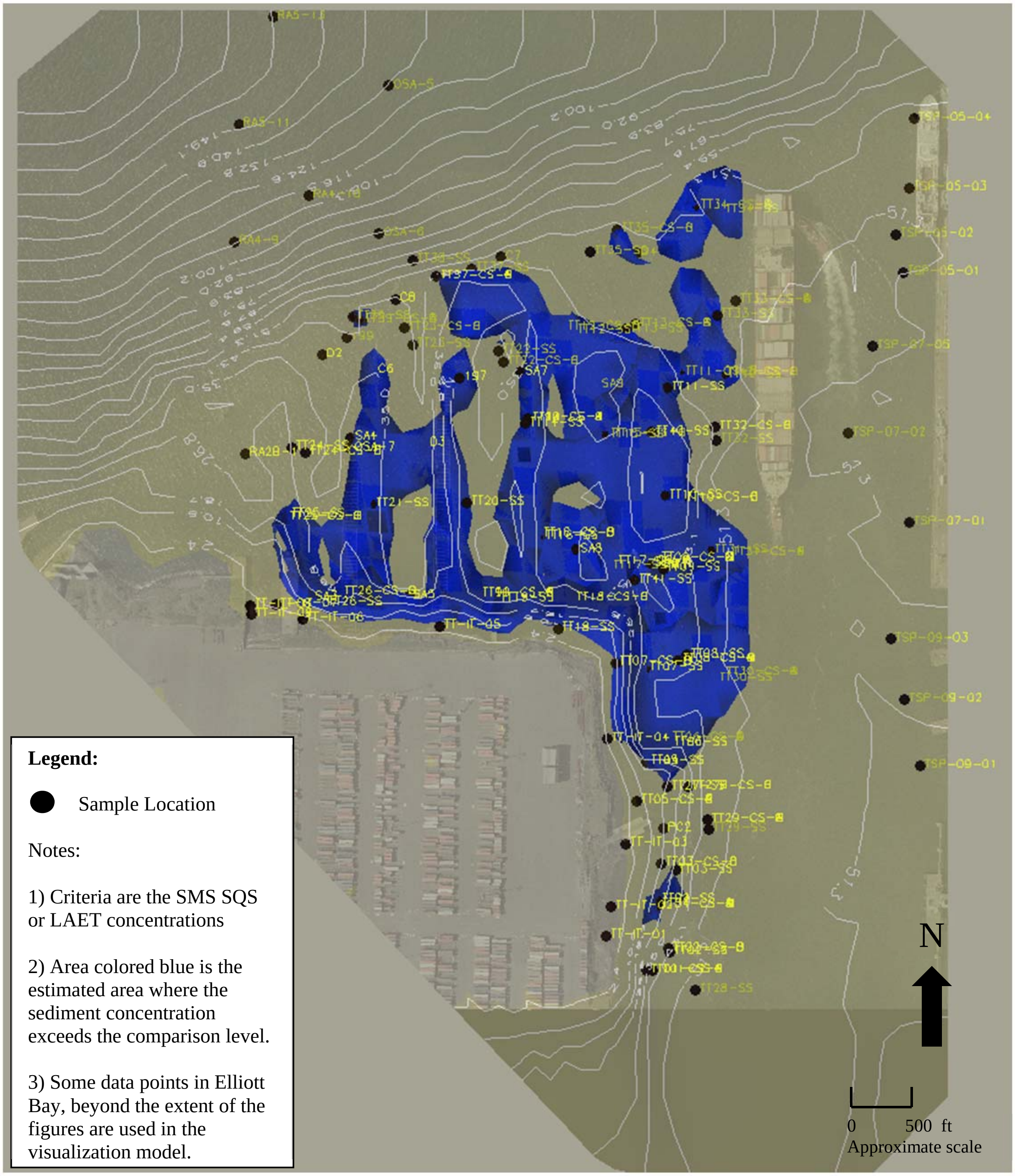
TETRA TECH EC, INC.	Lockheed West Shipyard No. 2 Seattle, WA	**Figure D-5 IDW Model for Extent Above SQS (Power = 10)**



TETRA TECH EC, INC.

Lockheed West
Shipyard No. 2
Seattle, WA

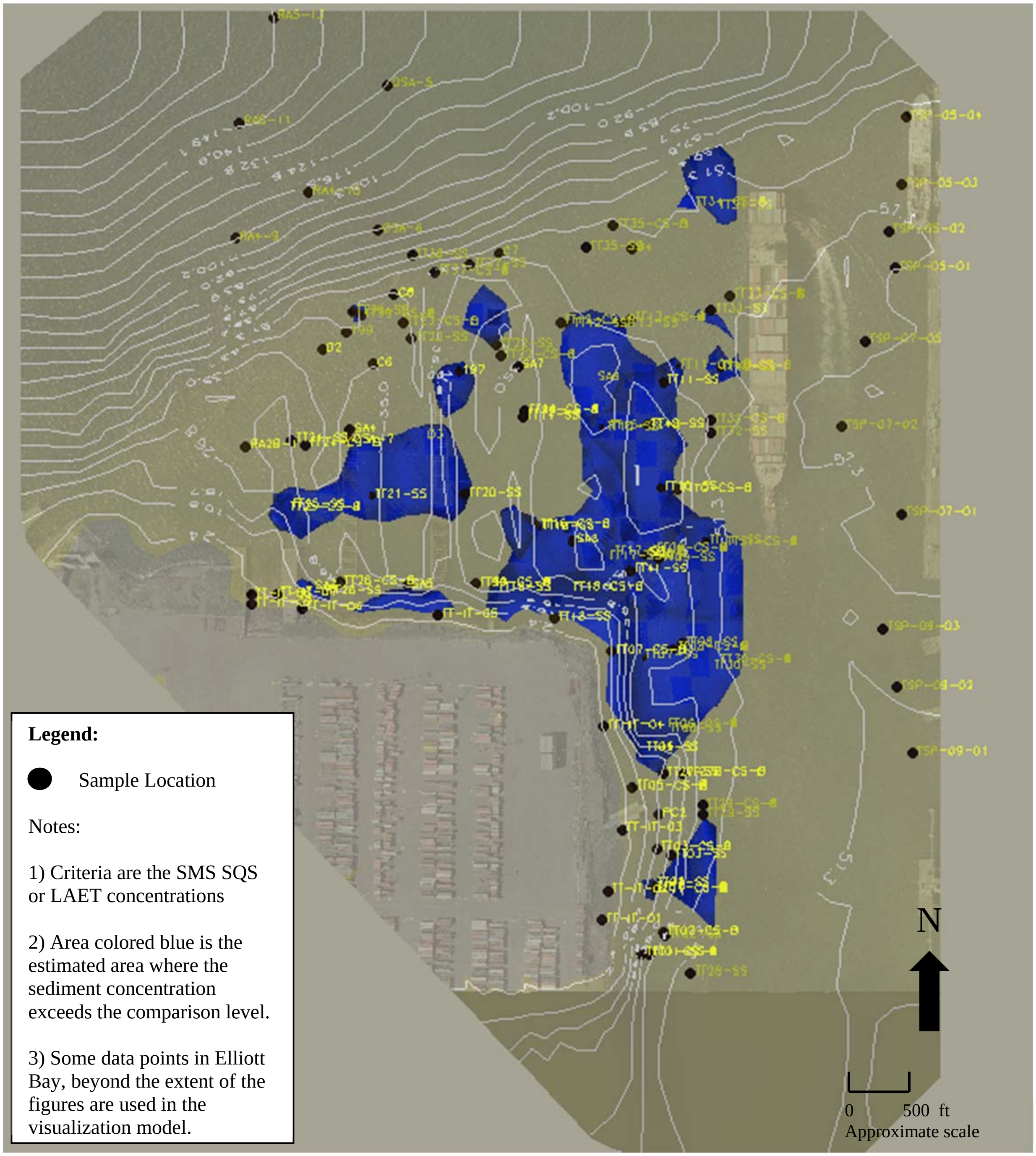
Figure D-6
Krig Model for Extent Above SQS (Reach = 5)



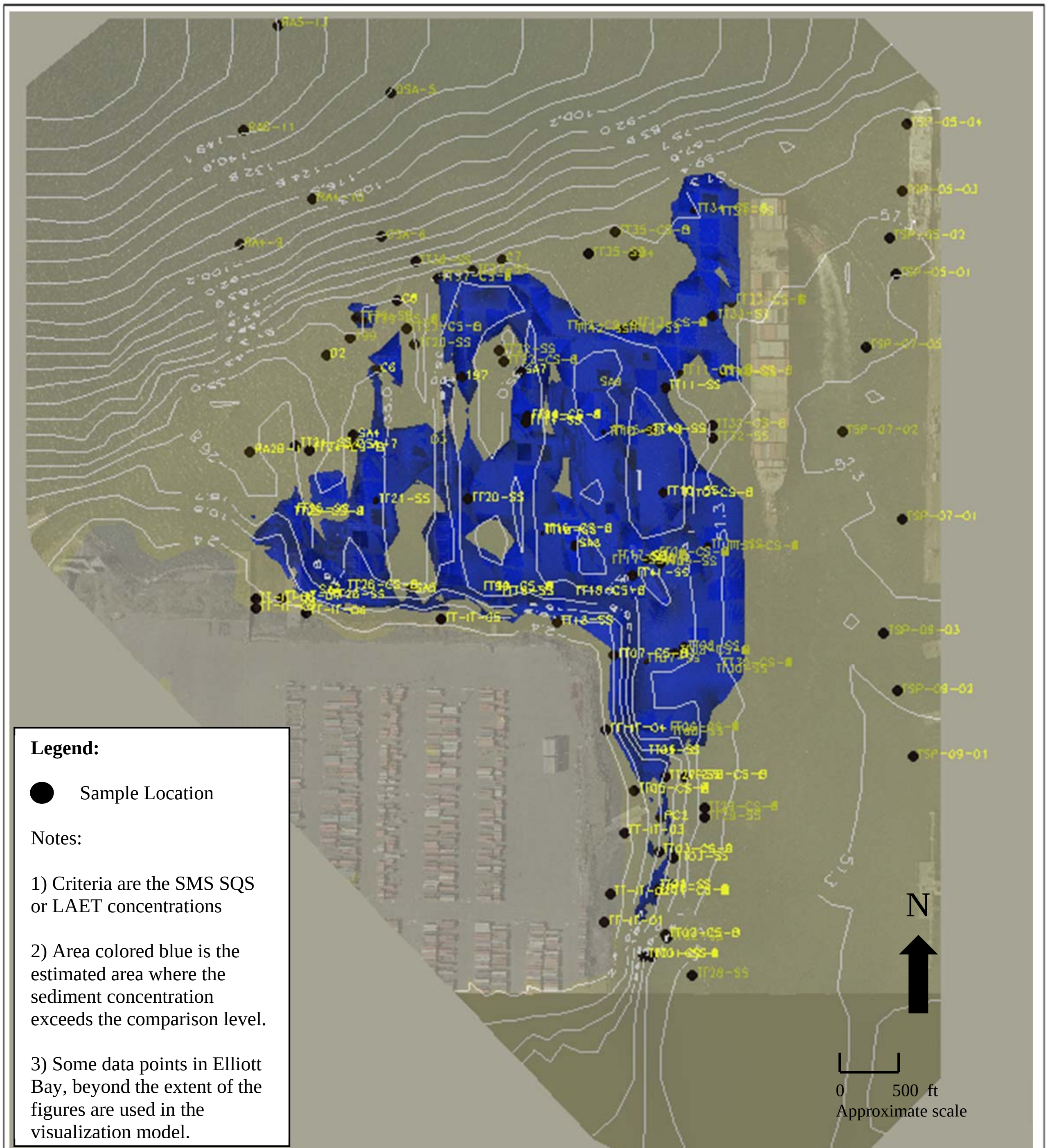
TETRA TECH EC, INC.

Lockheed West
Shipyard No. 2
Seattle, WA

Figure D-7
Krig Model for Extent Above SQS (Reach = 100)



TETRA TECH EC, INC.	Lockheed West Shipyard No. 2 Seattle, WA	**Figure D-8 Krig Model for Extent Above SQS (Anisotropy = 1)**



TETRA TECH EC, INC.

Lockheed West
Shipyard No. 2
Seattle, WA

Figure D-9
Krig Model for Extent Above SQS (Anisotropy = 50)

APPENDIX E— VOLUME ESTIMATES FOR REMEDIAL ALTERNATIVES AND EXISTING SITE PROFILES

TABLE OF CONTENTS

LIST OF FIGURES

APPENDIX E

Volume Estimates for Remedial Alternatives and Existing Site Profiles

E.1 INTRODUCTION

This appendix presents the methods used to estimate the volume of contaminated sediments that will potentially require remediation. This is a key component in developing and evaluating remedial alternatives for the Lockheed West site because the volume of sediment to be removed and disposed of is a major factor in estimating the cost and construction time frame for the remedial alternatives with a dredging component (Alternatives 2B, 3A1, 3A2, 3B, 3C, 4A, 4B, and 4C). The methodology presented here defines the limits of removal (i.e., neat dredge volume) for the purposes of FS-level analyses and estimates the quantity of contaminant mass removals for each risk-driver COC associated with each alternative.

Existing site profiles are also presented here as part of the volume estimates for Alternative 2B that involves removal to fit a conventional cap with the goal of minimizing changes in the existing water depths at the site.

E.2 METHODOLOGY FOR VOLUME ESTIMATES

The three dimensional sediment contamination visualization software (C-Tech MVS) was utilized for volume calculations of contaminated sediments for removal alternatives. In addition to this 3-D model, AutoCAD/Civil3D software is used to compute removal quantities for Alternative 2B. Neat dredge volume and contaminant mass removal quantities calculated by C-Tech MVS and AutoCAD/Civil3D are summarized in Table 11-2. Neat dredge volume for the removal alternatives were then increased by 50% for FS evaluations and cost estimates to account for the various causes of volume creep (e.g., refinement of dredge prisms during design, for dredge operational considerations, overdredging allowance, additional sediment characterization, allowance to account for clean-up passes for residuals management, and dredge cut slope stability issues).

The C-Tech MVS 3-D model uses existing surface and subsurface sediment data for the Lockheed West site as defined in Section 4. The model interpolates the data by kriging to estimate sediment concentrations between the collected data points. The mass of the risk-driver chemicals was estimated based on the sediment mass associated with the removal volume and the average concentrations within the vertical and horizontal extents based on a combination of threshold values. The sediment mass was computed from the removal volume using a density of 1.68 g/cm^3 and a porosity of 0.25 based on the average for data collected from the site.

E.3 VOLUME ESTIMATE FIGURES

Volume estimate figures are compiled in the following order:

E.3.1 Existing Site Profiles

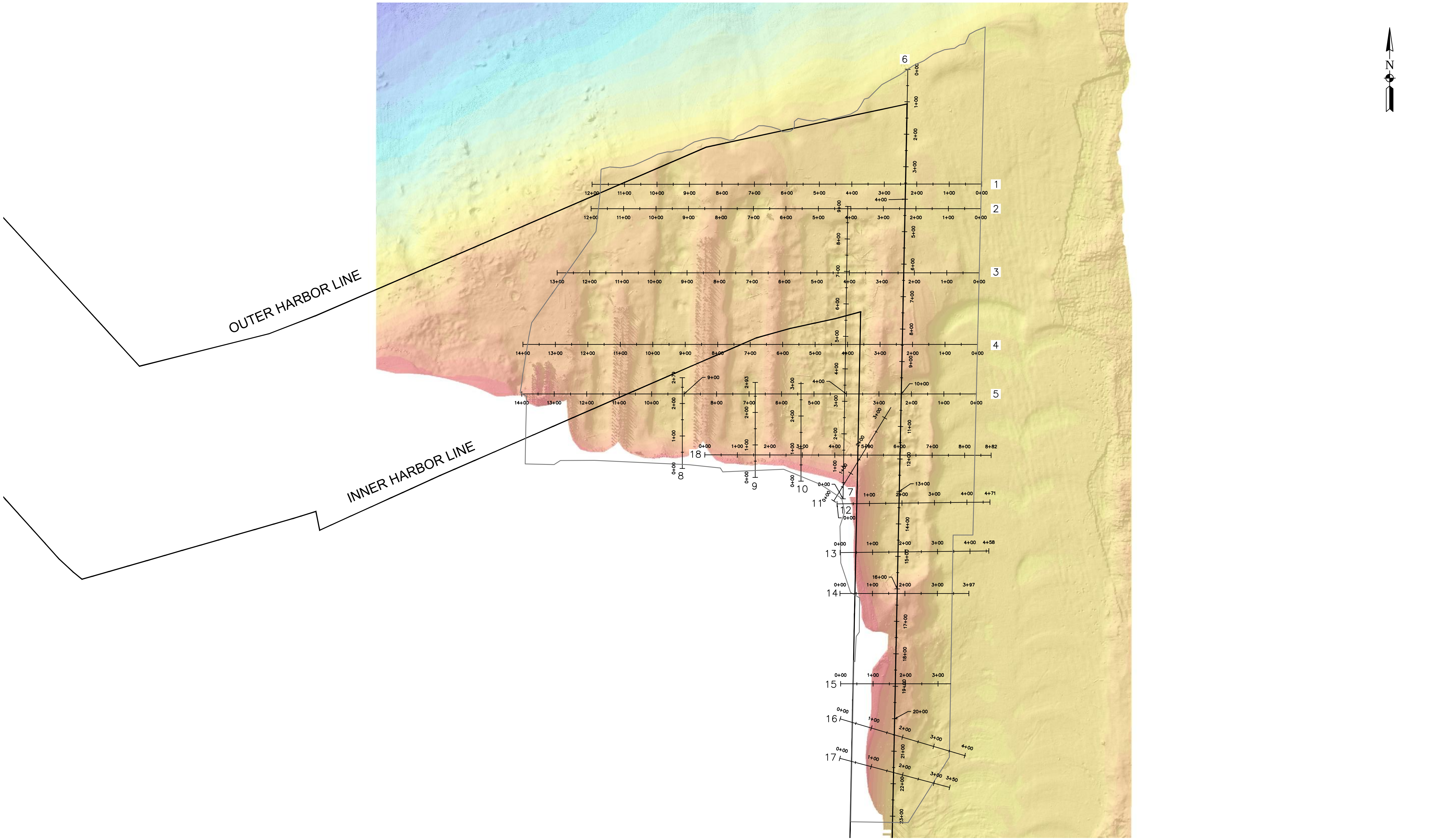
Existing site profiles were developed by AutoCAD/Civil3D software using the high resolution multibeam sonar bathymetric survey data completed for Lockheed by Tetra Tech on May 20, 2006. A plan view site map is shown in Figure E1. The locations of longitudinal and transverse cross-sections and shoreline profiles are marked on Figure E-1 and plotted on Figures E-2 through E-10.

E.3.2 Dredge to Fit Cap Site Profiles

Dredge to fit cap site profiles were generated for Alternative 2B. This alternative would include removal of sediments in the capping footprint to fit the 3-foot conventional cap with the goal of minimizing changes to existing water depths. Alternative 2B dredge lines were conceptually designed on each site profile while minimizing the changes in the existing water depths during placement of a conventional cap. The criteria followed during this conceptual design activity include the following: 1) elevated humps along the former piers were generally dredged greater than or equal to 3 feet; 2) a stable side slope of 1v:3h were assumed along the dredge and cap slopes; 3) sharp dips between the humps were eliminated to the extent possible; and 4) major humps along the dry docks were dredged deeper than 3 feet (-46 ft MMLW) with the intention of maintaining or slightly increasing water depths in front of the Terminal 5 area. This exercise was performed for the whole site. Then the dredge volumes within Alternative 2B area of potential action (AOPA) were computed using AutoCAD/Civil3D tools. Dredge to fit cap site profiles are plotted on Figures E-11 through E-15.

E.3.3 C-Tech MVS Volumetrics

A representative set of dredge volumes and associated contaminant mass removal outputs from C-Tech MVS 3-D model for Alternative 3 and Alternative 4 are presented in Figures E-16 through E-22. The volume of sediment was estimated based on the 3-dimensional extent of contamination above the threshold concentrations for the risk-driver chemicals (e.g., CSL, SQS) associated with each alternative. In addition, representative contaminant mass removal quantities are shown in these figures for arsenic removal. Contaminant mass removal quantities for each risk-driver COC were computed separately for each alternative with removal components and these results are summarized in Section 11, Table 11-5.



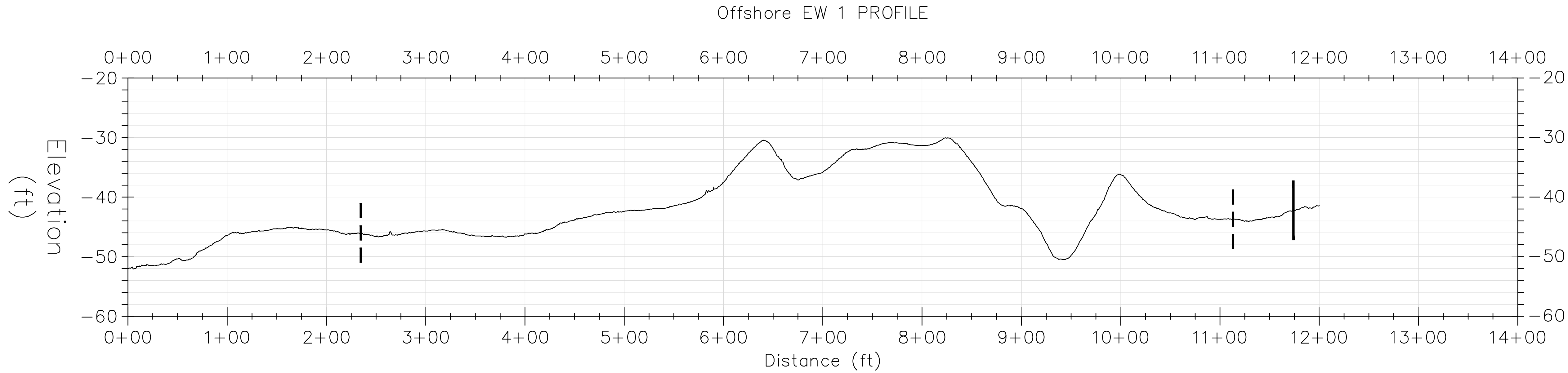
TETRA TECH

0 150 300 450
(Scale in Feet)

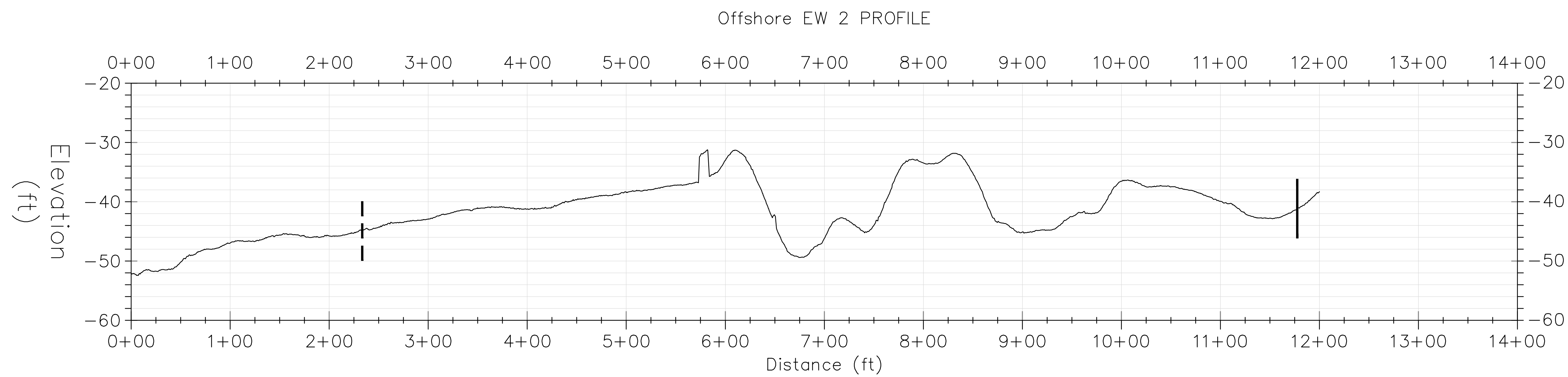
Lockheed West Seattle
Superfund Site
Seattle, WA

FIGURE E1
Site Map

P:\8945_TTDIV-LOCKHEED\YARD 2\RIFS\CAD\KYLE_DREDGE_CALC-FILES\SURFACE AND SECTIONS_ALIGNMENT-MOD02.DWG
PLOT/UPDATE: NOV 12 2010 14:33:51



PROFILE 1



PROFILE 2

LEGEND

STUDY AREA BOUNDARY

INNER HARBOR LINE

OUTER HARBOR LINE

SCALE:
1"=120' HORIZONTAL
1"=20' VERTICAL
(6X VERTICAL
EXAGGERATION)

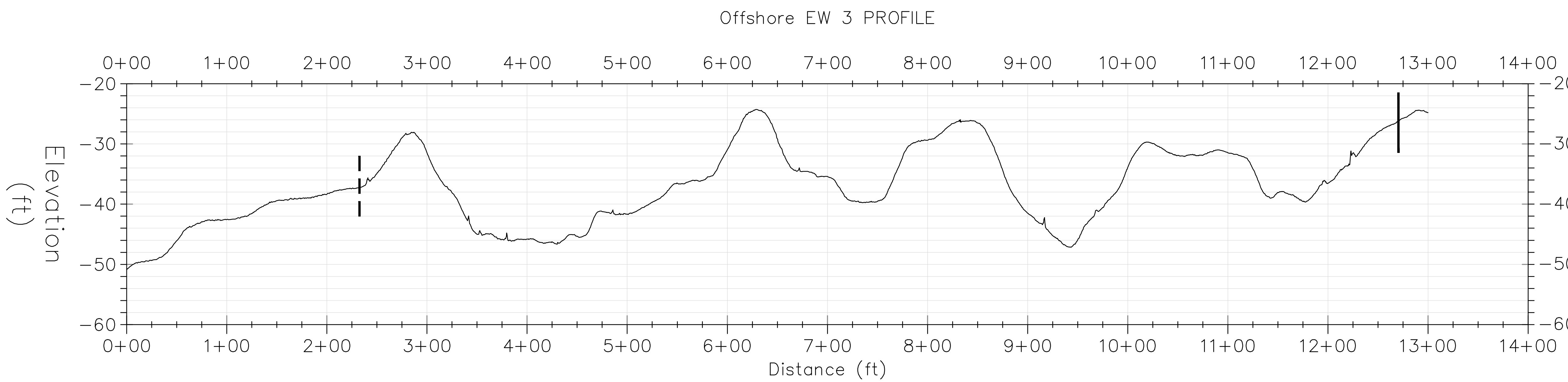
TETRA TECH

0 150 300 450
(Scale in Feet)

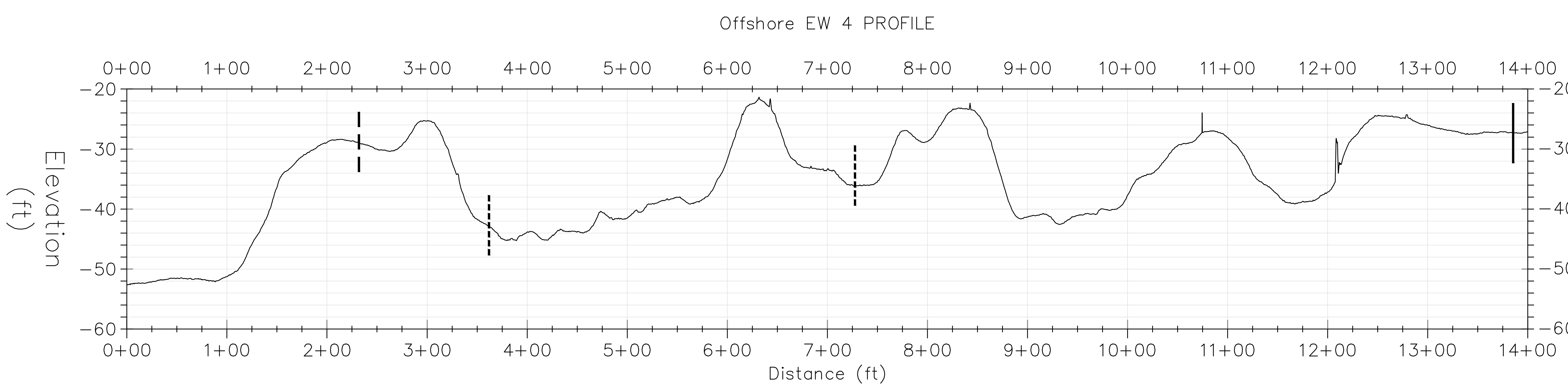
Lockheed West Seattle
Superfund Site
Seattle, WA

FIGURE E2
Existing Site Profiles

C:\USERS\WALTER.BOWLES\DOCUMENTS\PROJECTS\LOCKHEED\SURFACE AND SECTIONS_ALIGNMENT-MOD02.DWG
PLOT/UPDATE: NOV 08 2010 11:28:22



PROFILE 3



PROFILE 4

LEGEND

- STUDY AREA BOUNDARY (solid line)
- INNER HARBOR LINE (short-dashed line)
- OUTER HARBOR LINE (long-dashed line)

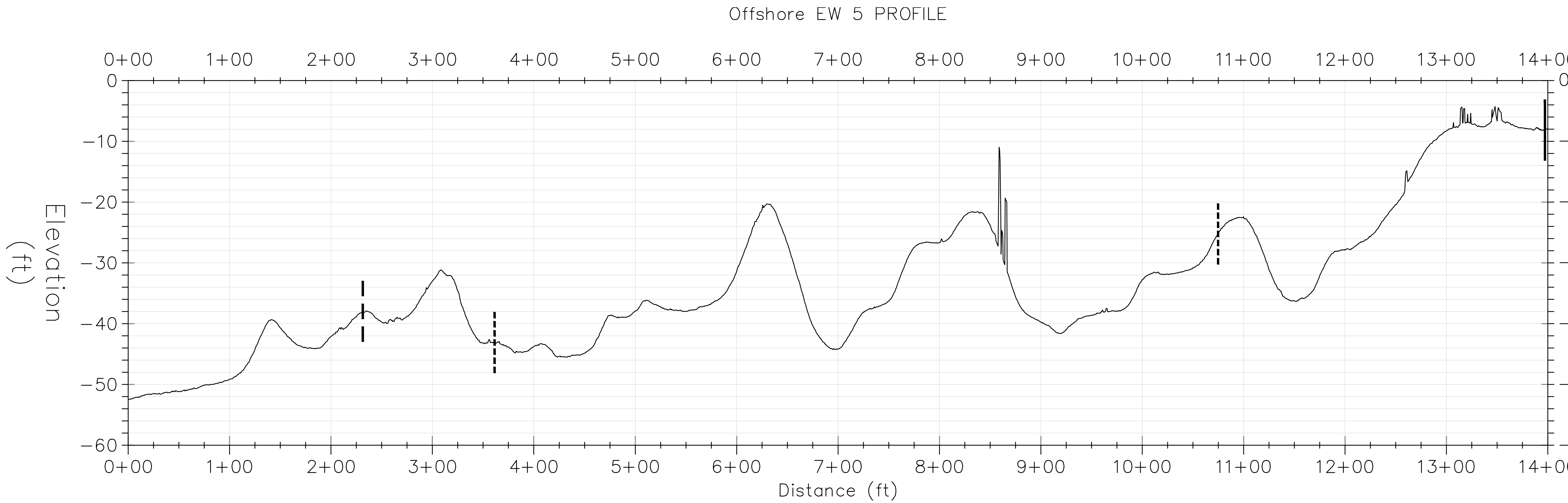
SCALE:
1"=120' HORIZONTAL
1"=20' VERTICAL
(6X VERTICAL EXAGGERATION)

TETRA TECH

Lockheed West Seattle
Superfund Site
Seattle, WA

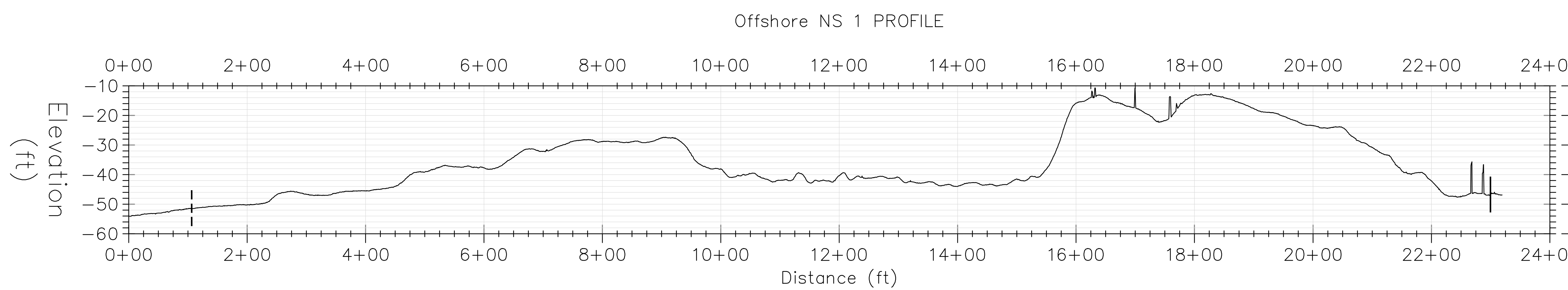
FIGURE E3
Existing Site Profiles

C:\USERS\WALTER.BOWLES\DOCUMENTS\PROJECTS\LOCKHEED\SURFACE AND SECTIONS_ALIGNMENT-MOD02.DWG
PLOT/UPDATE: NOV 08 2010 11:28:22



SCALE:
1"=120' HORIZONTAL
1"=20' VERTICAL
(6X VERTICAL
EXAGGERATION)

PROFILE 5



PROFILE 6

LEGEND

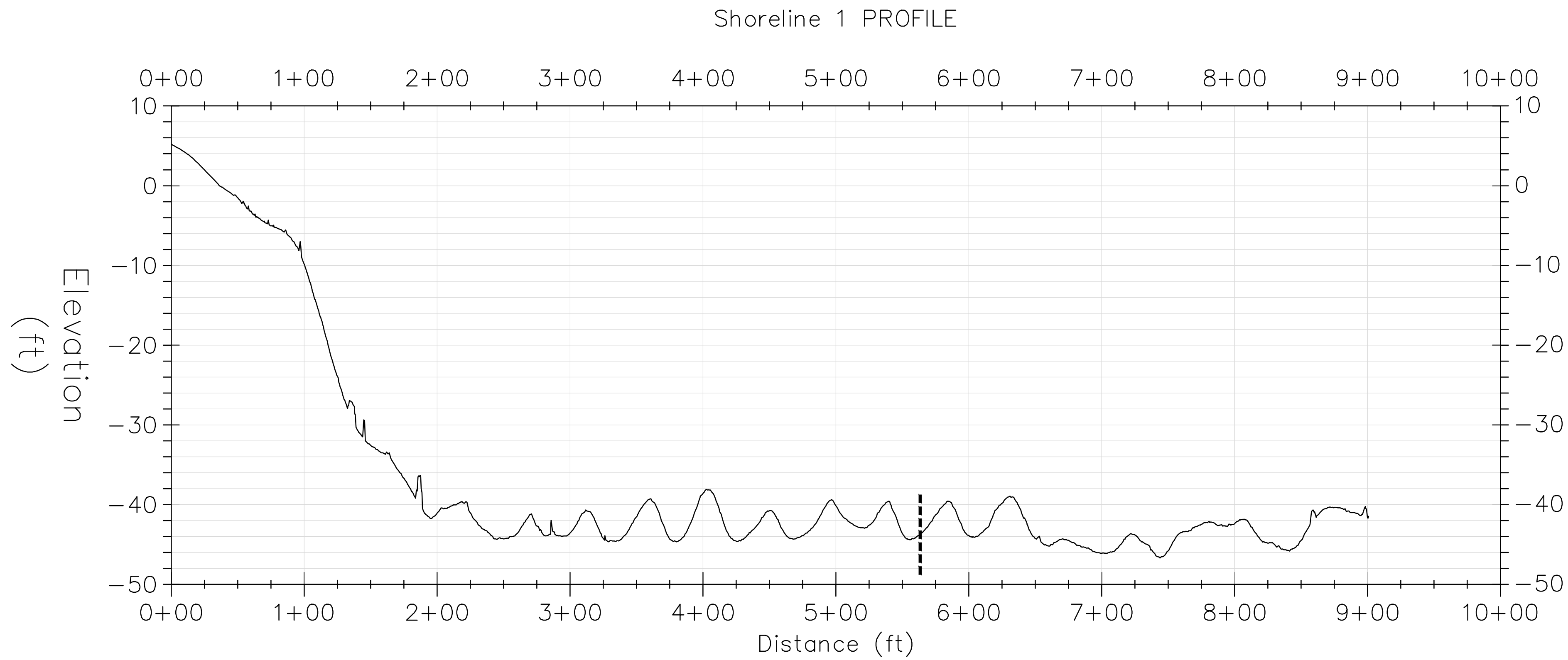
- STUDY AREA BOUNDARY (solid line)
- INNER HARBOR LINE (short-dashed line)
- OUTER HARBOR LINE (long-dashed line)

SCALE:
1"=200' HORIZONTAL
1"=40' VERTICAL
(5X VERTICAL
EXAGGERATION)

C:\USERS\WALTER.BOWLES\DOCUMENTS\PROJECTS\LOCKHEED\SURFACE AND SECTIONS_ALIGNMENT-MOD02.DWG
PLOT/UPDATE: NOV 08 2010 11:28:22

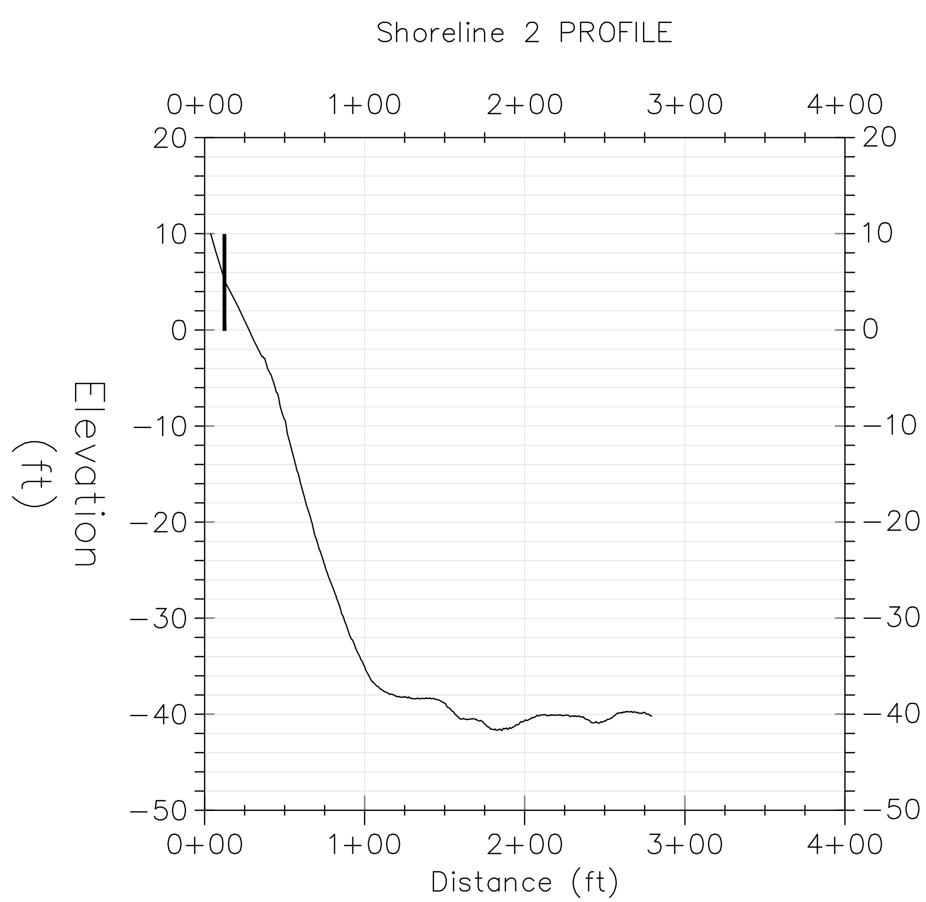
TETRA TECH	Lockheed West Seattle Superfund Site Seattle, WA	FIGURE E4 Existing Site Profiles

PROFILE 7

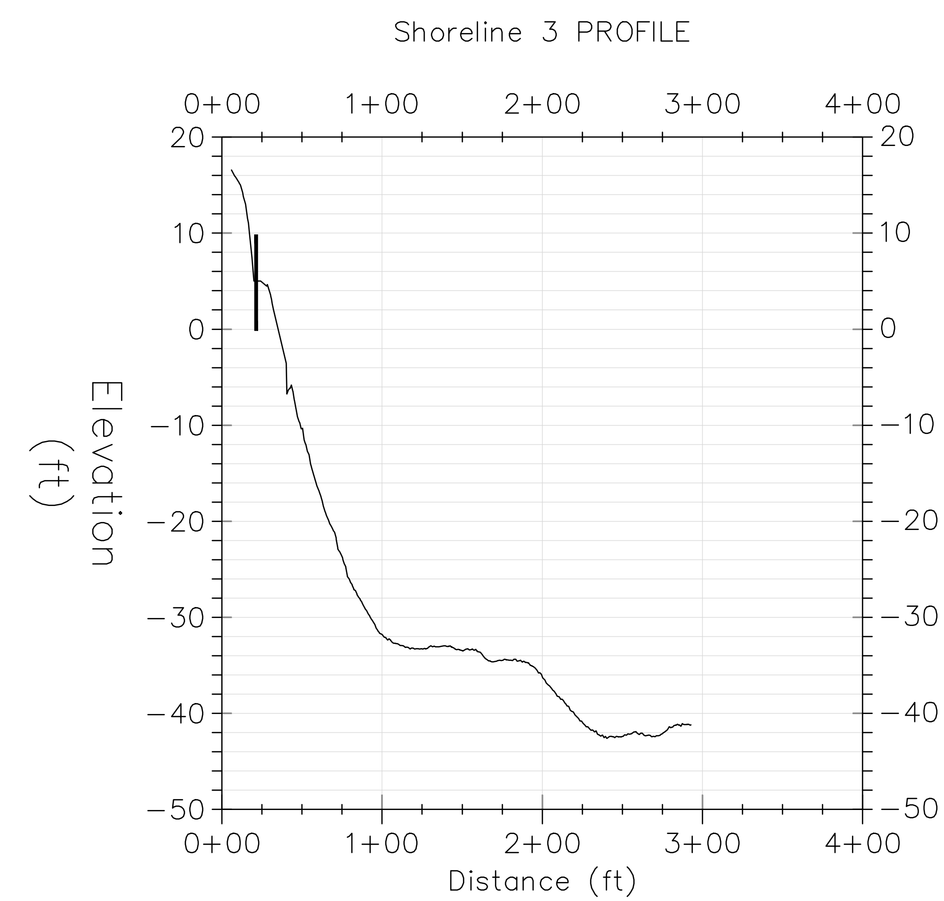


LEGEND

- STUDY AREA BOUNDARY
- INNER HARBOR LINE
- OUTER HARBOR LINE



PROFILE 8



PROFILE 9

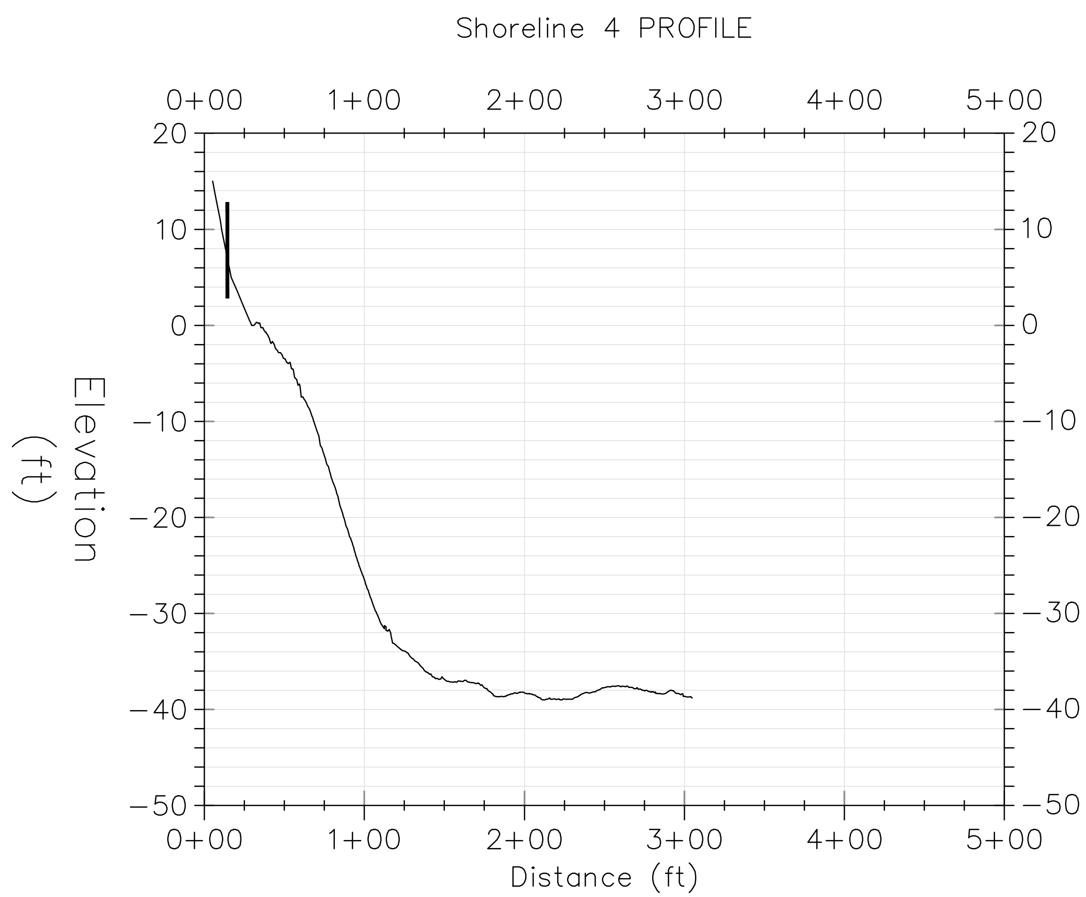
SCALE:
1"=120' HORIZONTAL
1"=20' VERTICAL
(6X VERTICAL EXAGGERATION)

C:\USERS\WALTER.BOWLES\DOCUMENTS\PROJECTS\LOCKHEED\SURFACE AND SECTIONS_ALIGNMENT-MOD02.DWG
PLOT/UPDATE: NOV 08 2010 11:28:22

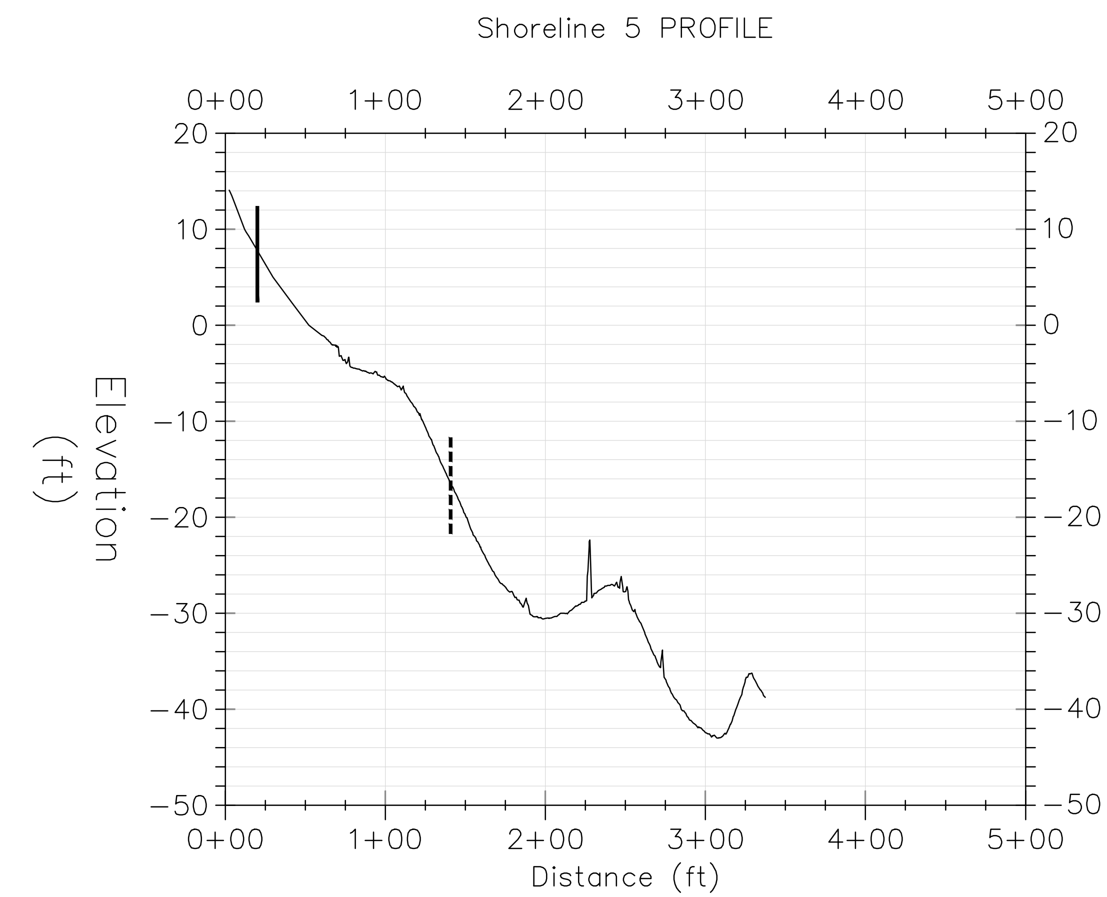
TETRA TECH

Lockheed West Seattle
Superfund Site
Seattle, WA

FIGURE E5
Existing Site Profiles



PROFILE 10



PROFILE 11

LEGEND

STUDY AREA BOUNDARY

INNER HARBOR LINE

OUTER HARBOR LINE

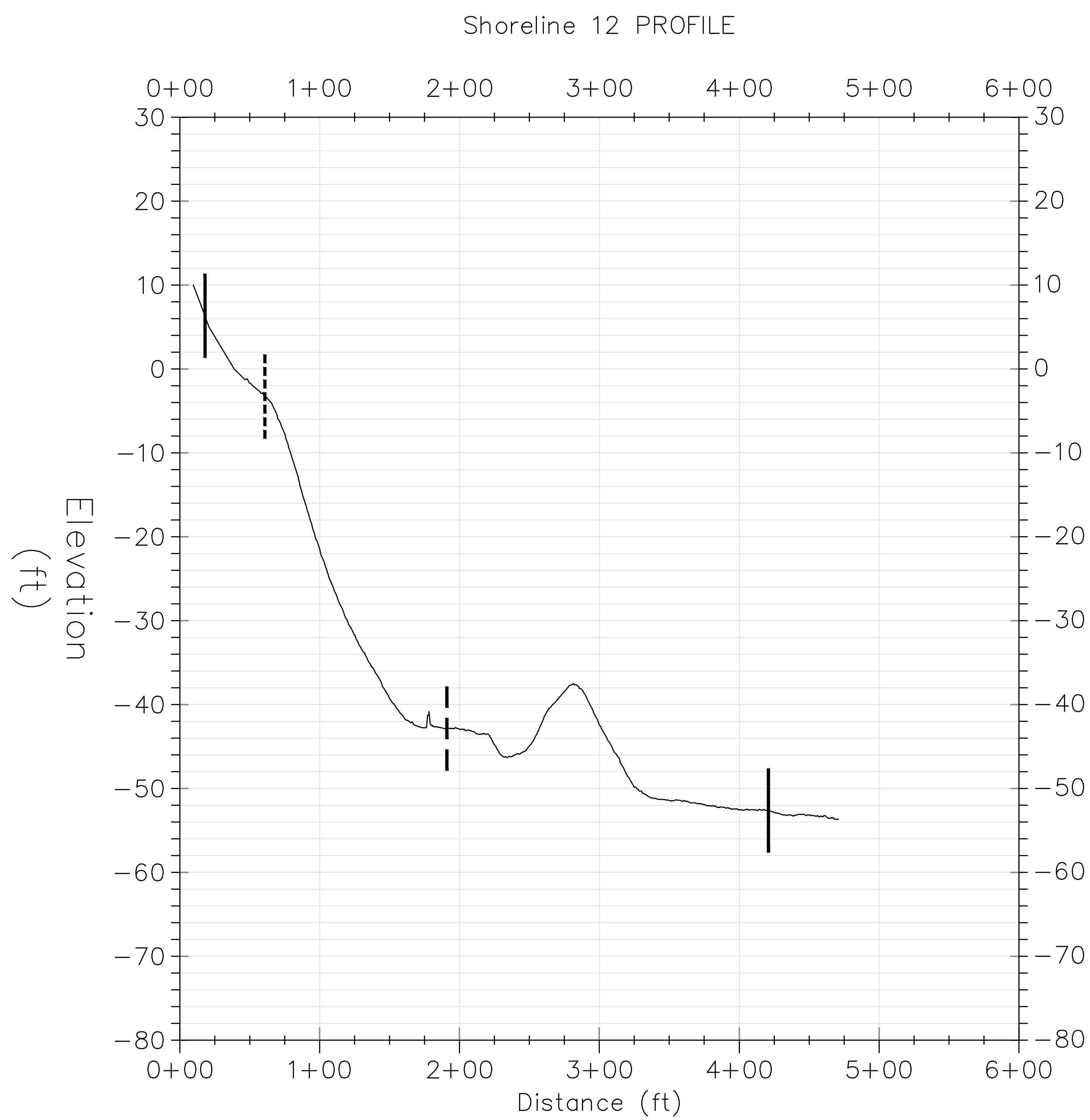
SCALE:
1"=120' HORIZONTAL
1"=20' VERTICAL
(6X VERTICAL
EXAGGERATION)

C:\USERS\WALTER.BOWLES\DOCUMENTS\PROJECTS\LOCKHEED\SURFACE AND SECTIONS_ALIGNMENT-MOD02.DWG
PLOT/UPDATE: NOV 08 2010 11:28:22

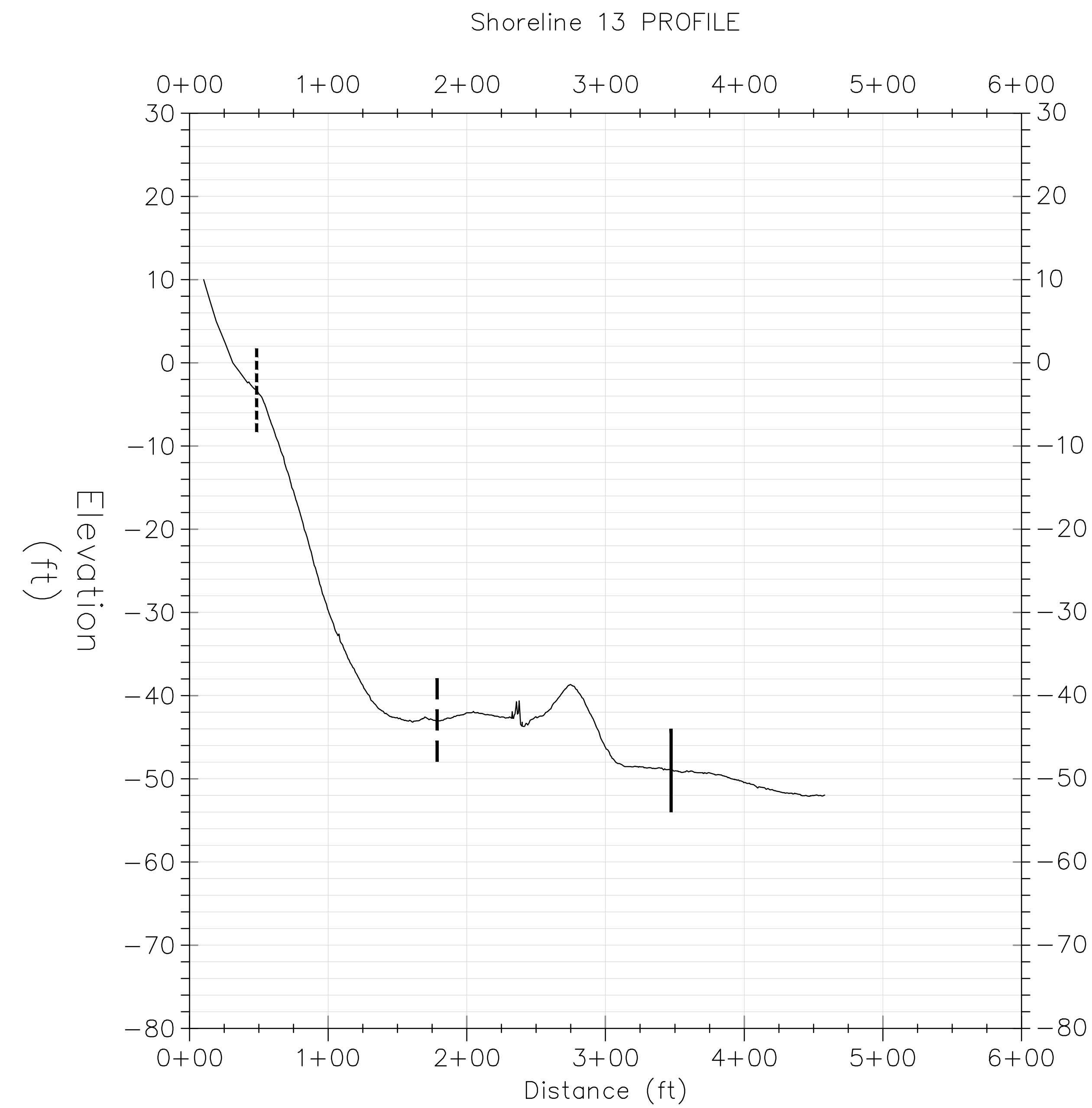
TETRA TECH

Lockheed West Seattle
Superfund Site
Seattle, WA

FIGURE E6
Existing Site Profiles



PROFILE 12



PROFILE 13

LEGEND

- STUDY AREA BOUNDARY
- INNER HARBOR LINE
- OUTER HARBOR LINE

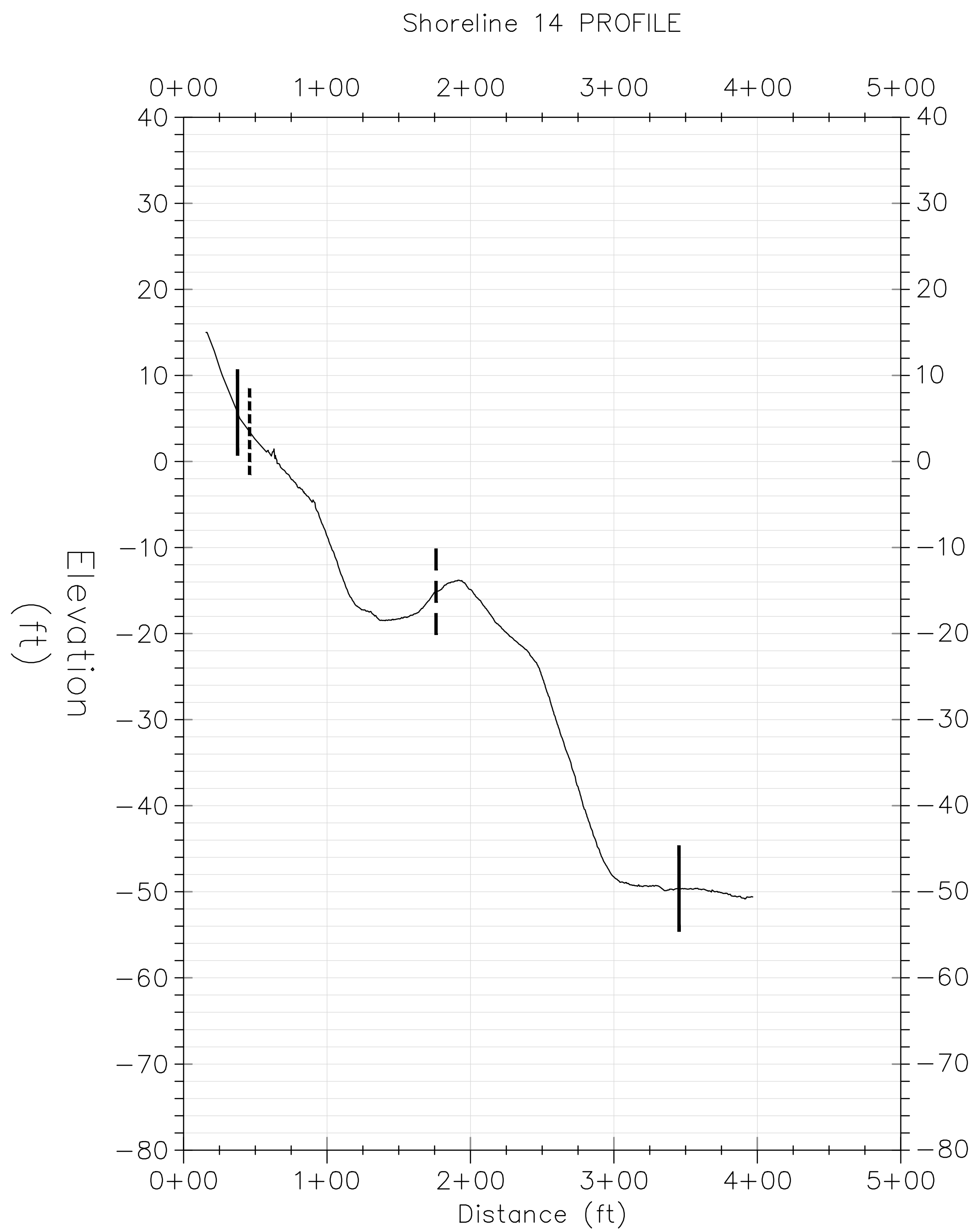
SCALE:
1"=120' HORIZONTAL
1"=20' VERTICAL
(6X VERTICAL
EXAGGERATION)

TETRA TECH

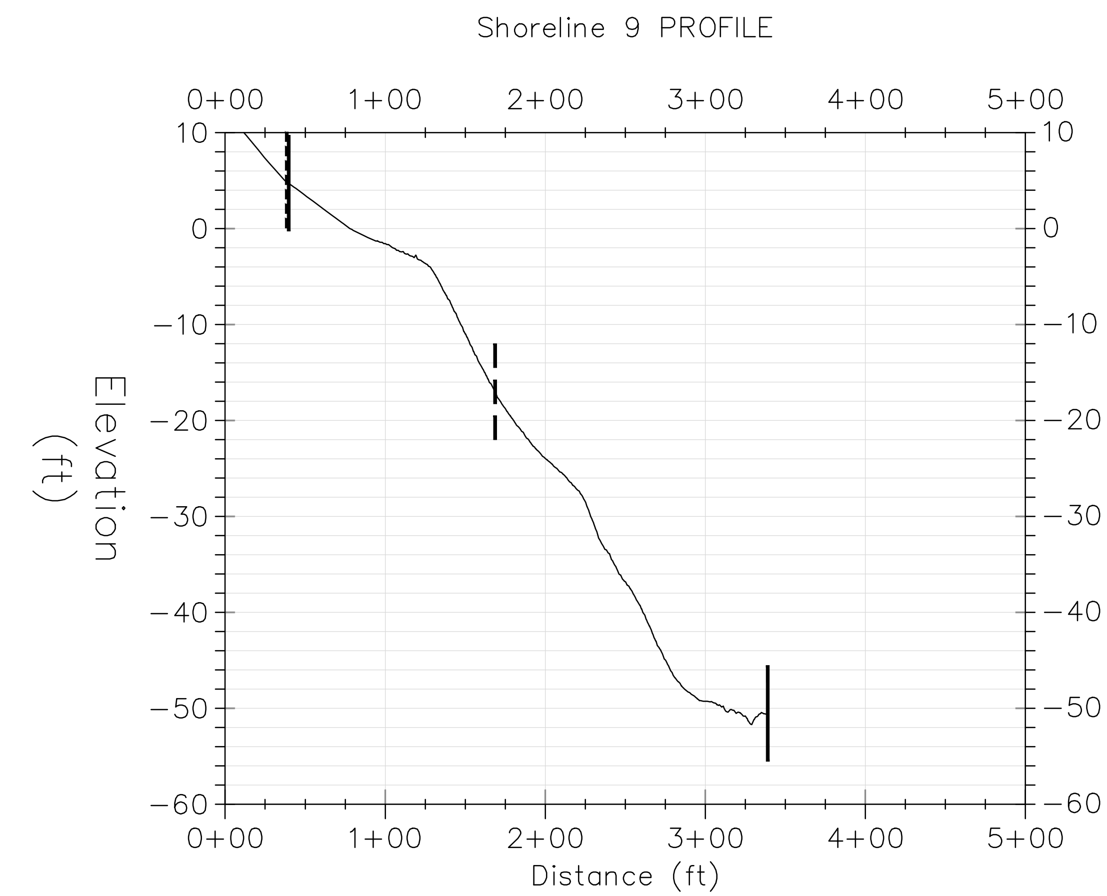
Lockheed West Seattle
Superfund Site
Seattle, WA

FIGURE E7
Existing Site Profiles

C:\USERS\WALTER.BOWLES\DOCUMENTS\PROJECTS\LOCKHEED\SURFACE AND SECTIONS_ALIGNMENT-MOD02.DWG
PLOT/UPDATE: NOV 08 2010 11:28:22



PROFILE 14



PROFILE 15

LEGEND

- STUDY AREA BOUNDARY
- INNER HARBOR LINE
- OUTER HARBOR LINE

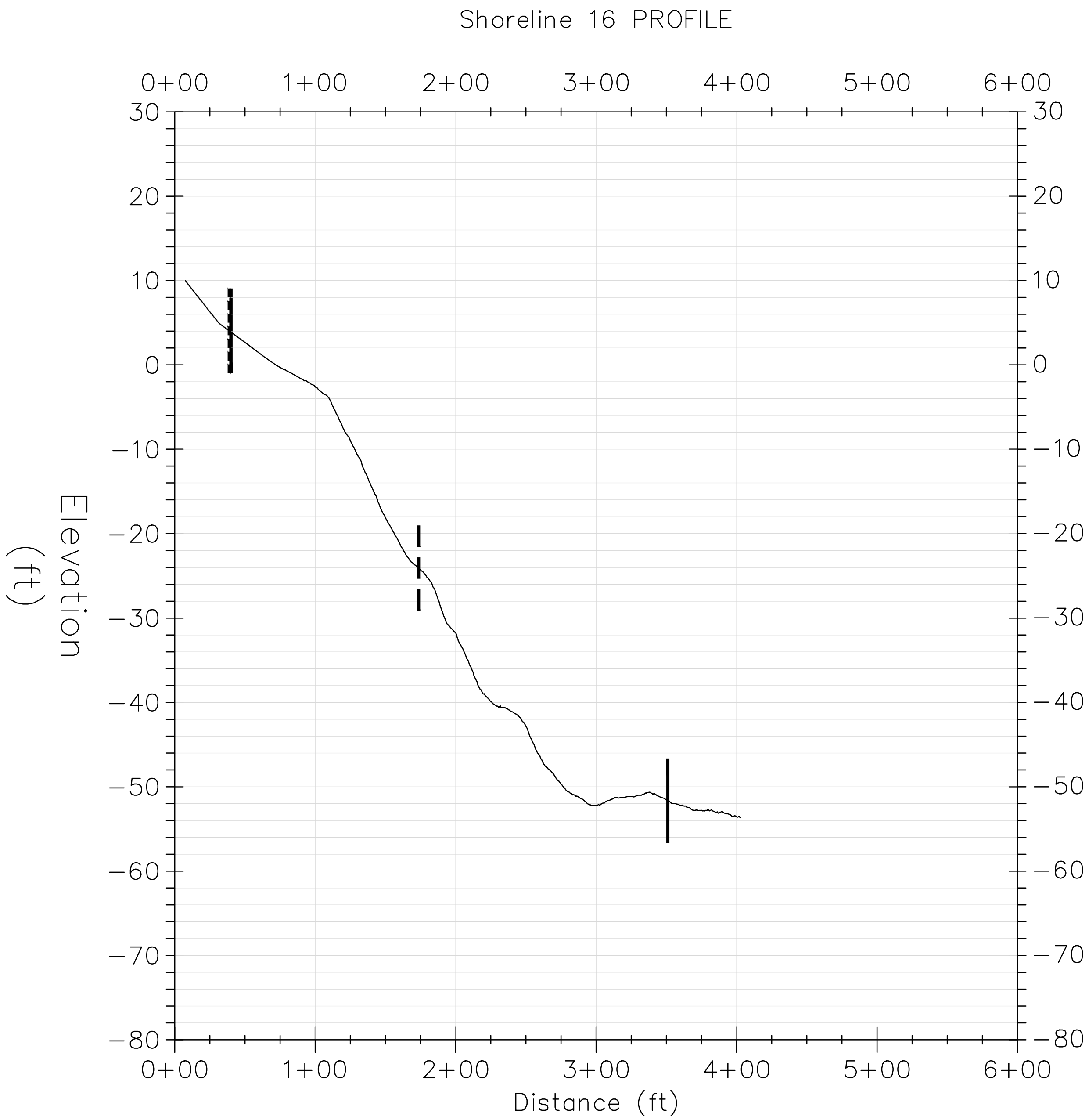
SCALE:
1"=120' HORIZONTAL
1"=20' VERTICAL
(6X VERTICAL
EXAGGERATION)

C:\USERS\WALTER.BOWLES\DOCUMENTS\PROJECTS\LOCKHEED\SURFACE AND SECTIONS_ALIGNMENT-MOD02.DWG
PLOT/UPDATE: NOV 08 2010 11:28:22

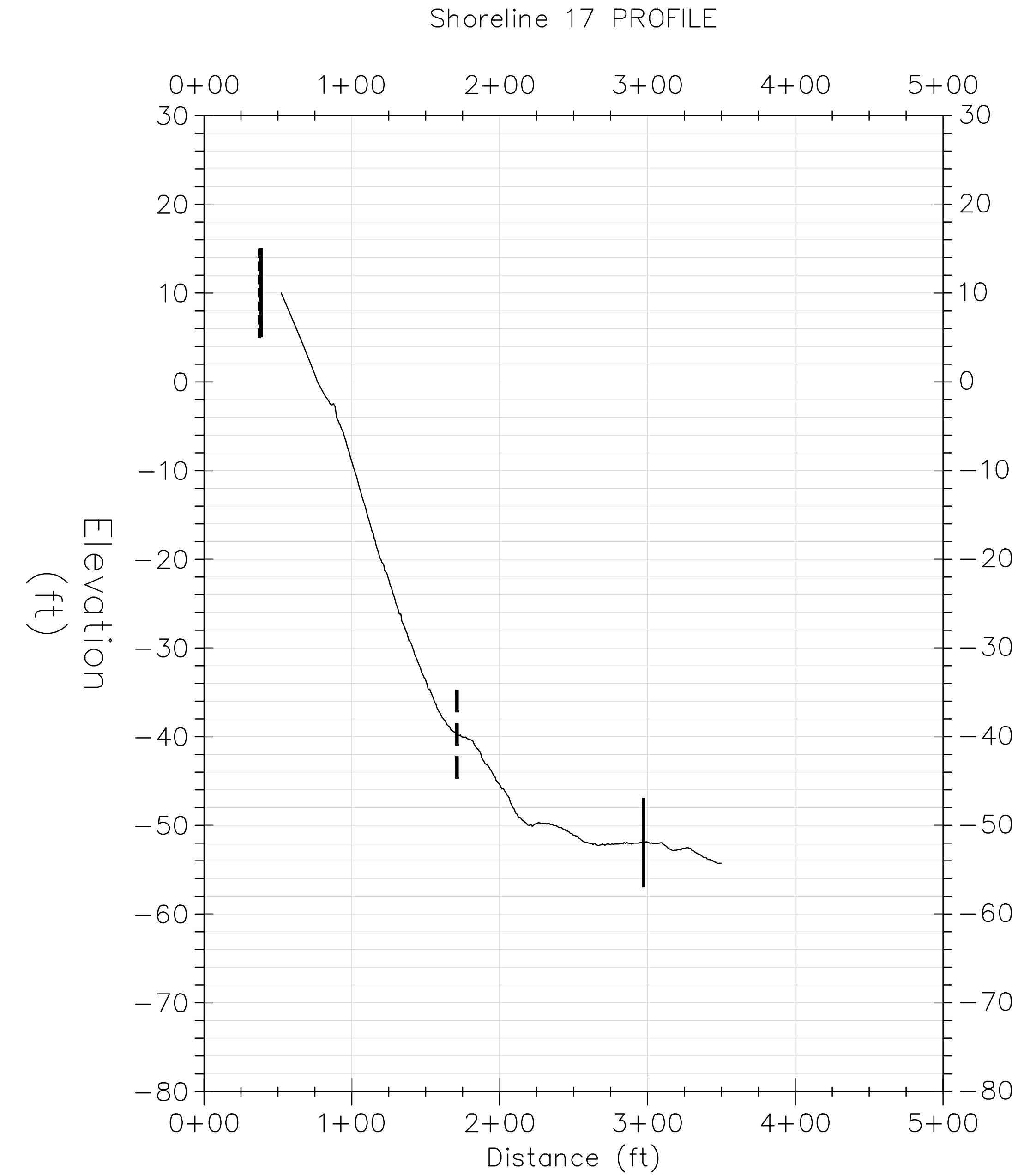
TETRA TECH

Lockheed West Seattle
Superfund Site
Seattle, WA

FIGURE E8
Existing Site Profiles



PROFILE 16



PROFILE 17

LEGEND

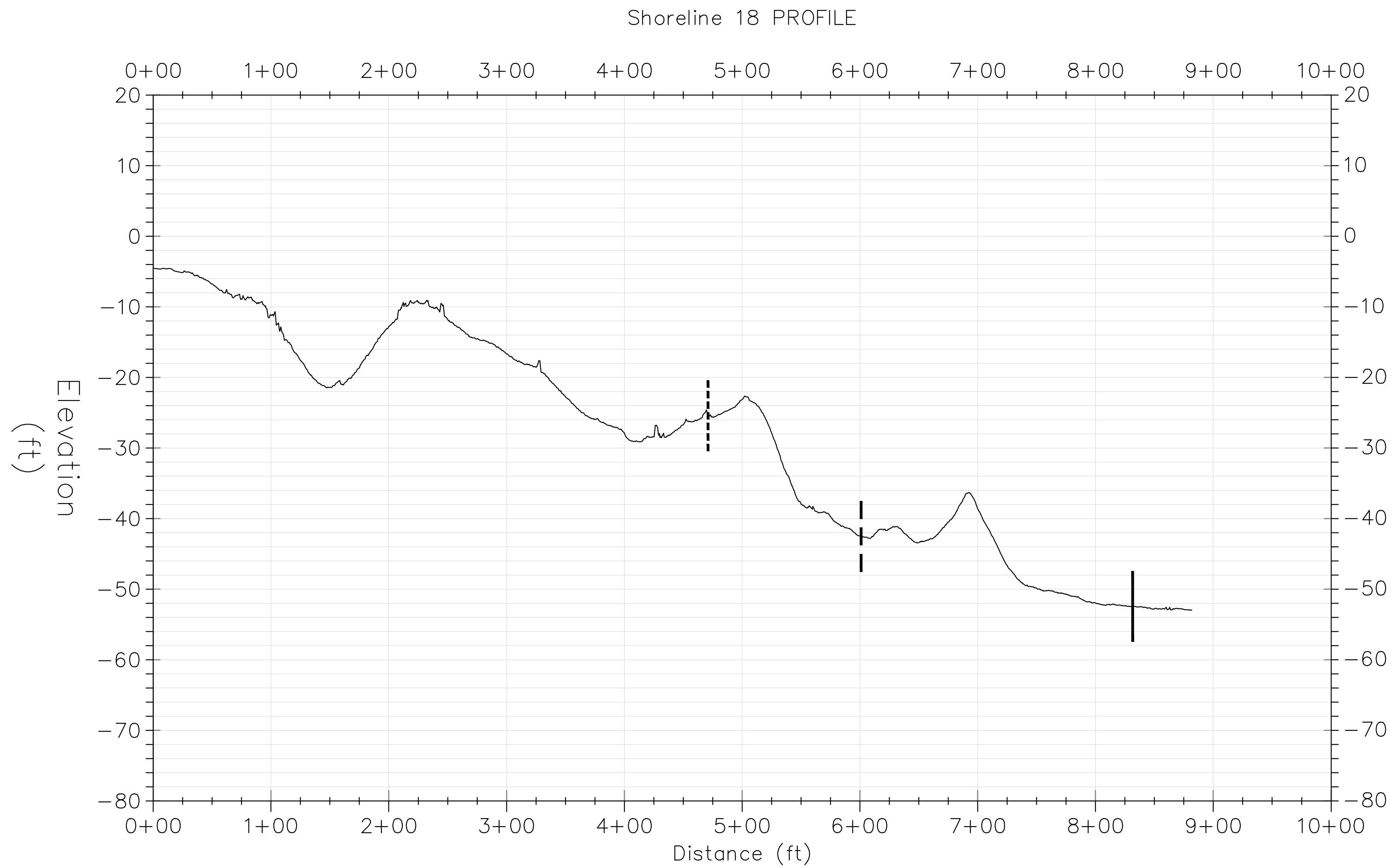
- STUDY AREA BOUNDARY
- INNER HARBOR LINE
- OUTER HARBOR LINE

SCALE:
1"=120' HORIZONTAL
1"=20' VERTICAL
(6X VERTICAL
EXAGGERATION)

TETRA TECH

Lockheed West Seattle
Superfund Site
Seattle, WA

FIGURE E9
Existing Site Profiles



PROFILE 18

LEGEND

STUDY AREA BOUNDARY

INNER HARBOR LINE

OUTER HARBOR LINE

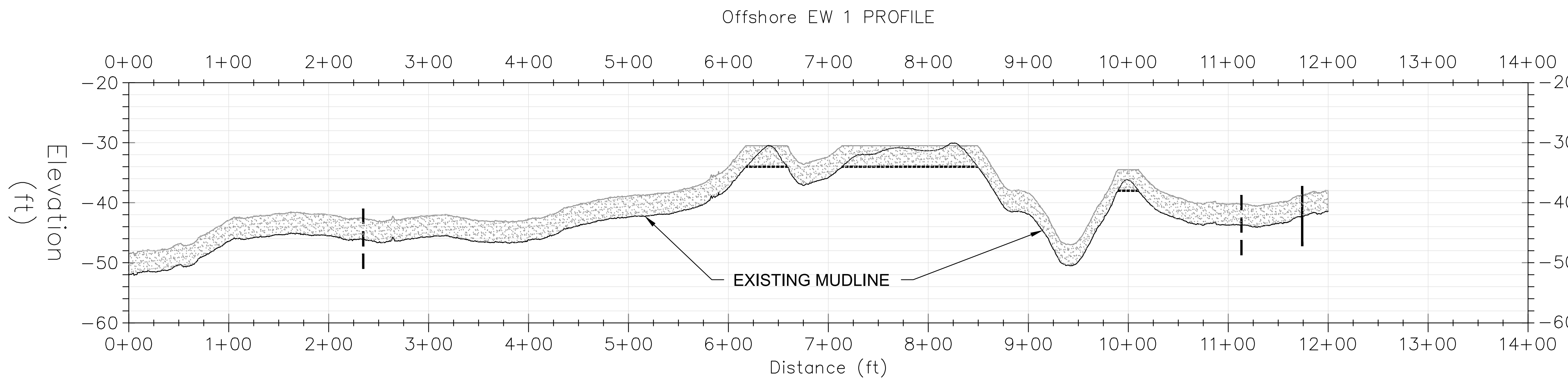
SCALE:
1"=120' HORIZONTAL
1"=20' VERTICAL
(6X VERTICAL EXAGGERATION)

C:\USERS\WALTER.BOWLES\DOCUMENTS\PROJECTS\LOCKHEED\SURFACE AND SECTIONS_ALIGNMENT-MOD02.DWG
PLOT/UPDATE: NOV 08 2010 11:28:22

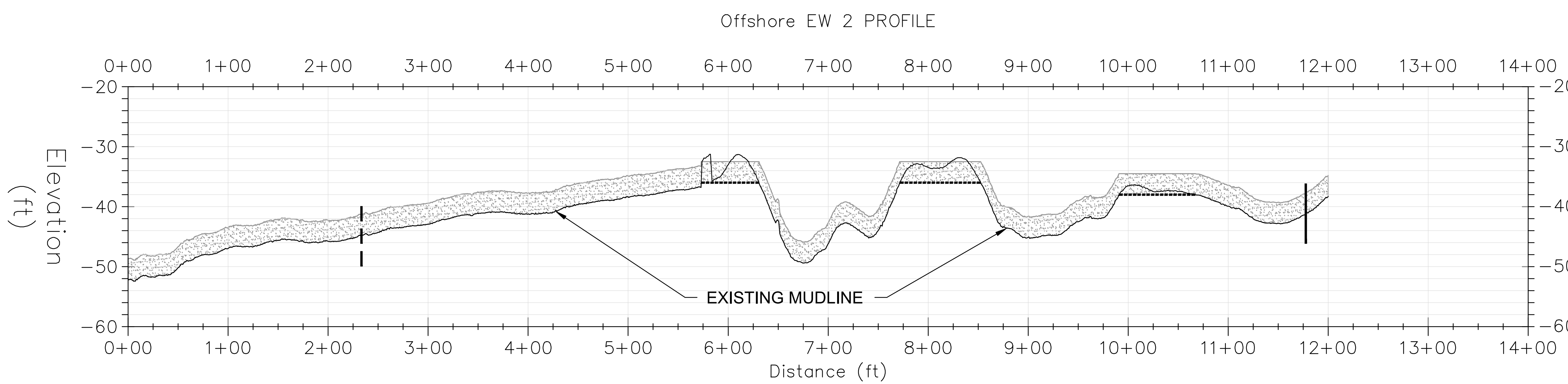
TETRA TECH

Lockheed West Seattle
Superfund Site
Seattle, WA

FIGURE E10
Existing Site Profiles



PROFILE 1



PROFILE 2

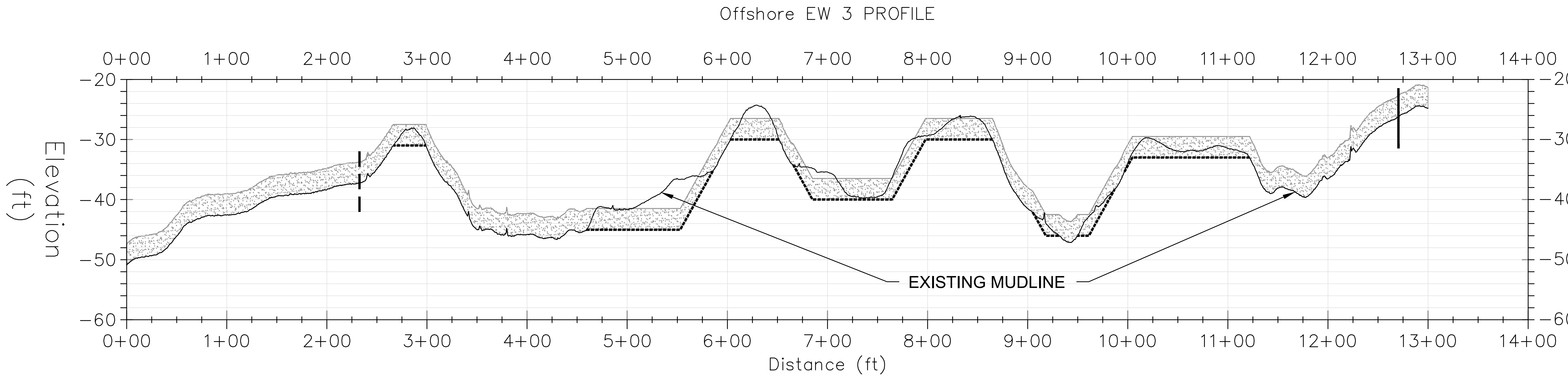
LEGEND

- STUDY AREA BOUNDARY (solid line)
- INNER HARBOR LINE (short dashed line)
- OUTER HARBOR LINE (long dashed line)
- DREDGE LIMIT (dotted line)
- CONVENTIONAL CAP (stippled pattern)

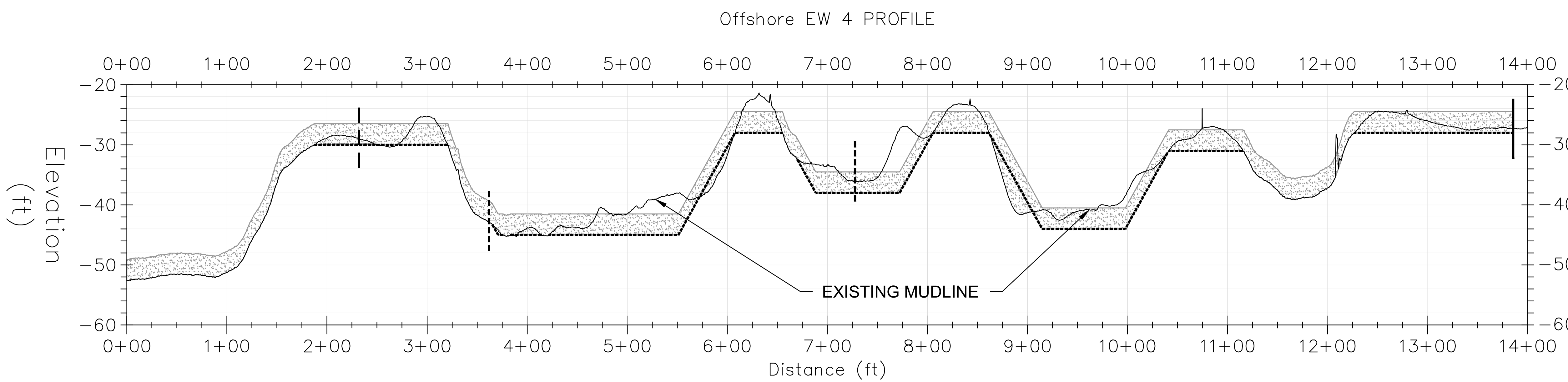
SCALE:
1"=120' HORIZONTAL
1"=20' VERTICAL
(6X VERTICAL
EXAGGERATION)

P:\8945_TTD\V-LOCKHEED\YARD 2\RIFS\CAD\KYLE_DREDGE_CALC-FILES\SURFACE AND SECTIONS_ALIGNMENT-MOD02 PROPOSED XSECTS.DWG
PLOT/UPDATE: NOV 11 2010 14:32:05

TETRA TECH	Lockheed West Seattle Superfund Site Seattle, WA	FIGURE E11 Dredge to Fit Cap Site Profiles



PROFILE 3



PROFILE 4

LEGEND

- STUDY AREA BOUNDARY
- INNER HARBOR LINE
- OUTER HARBOR LINE
- DREDGE LIMIT
- CONVENTIONAL CAP

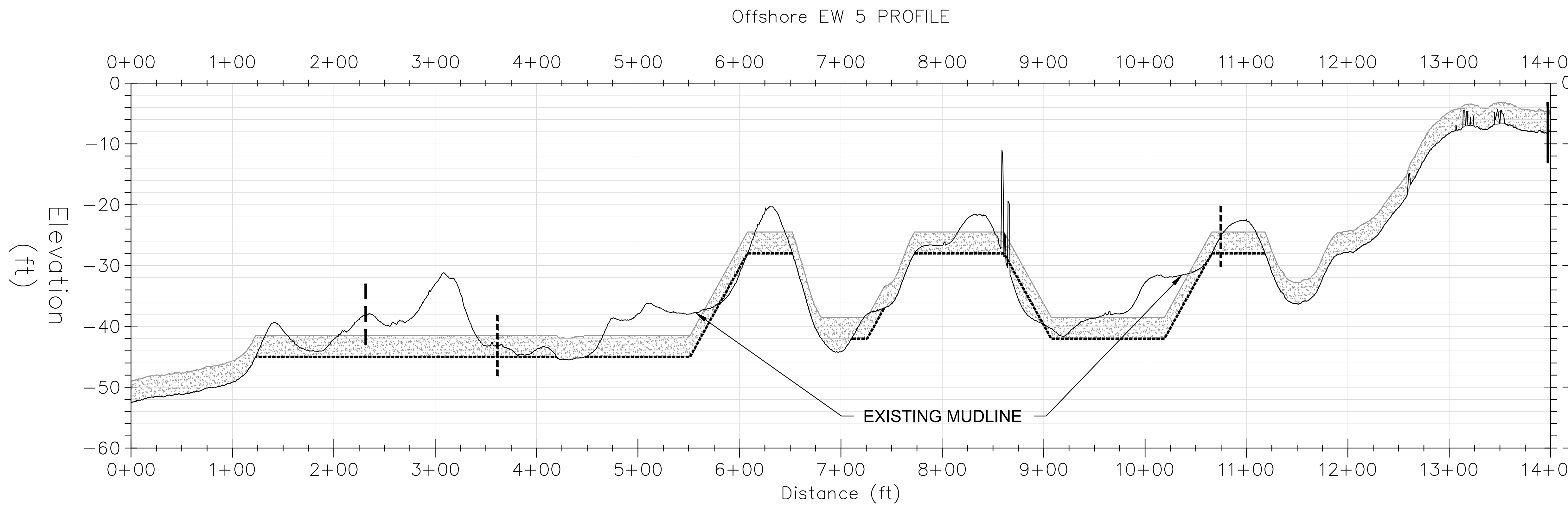
SCALE:
1"=120' HORIZONTAL
1"=20' VERTICAL
(6X VERTICAL
EXAGGERATION)

P:\8945_TTDIV-LOCKHEED\YARD 2\RIFS\CAD\KYLE_DREDGE_CALC-FILES\SURFACE AND SECTIONS_ALIGNMENT-MOD02 PROPOSED XSECTS.DWG
PLOT/UPDATE: NOV 11 2010 14:55:00

TETRA TECH

Lockheed West Seattle
Superfund Site
Seattle, WA

FIGURE E12
Dredge to Fit Cap Site Profiles



PROFILE 5

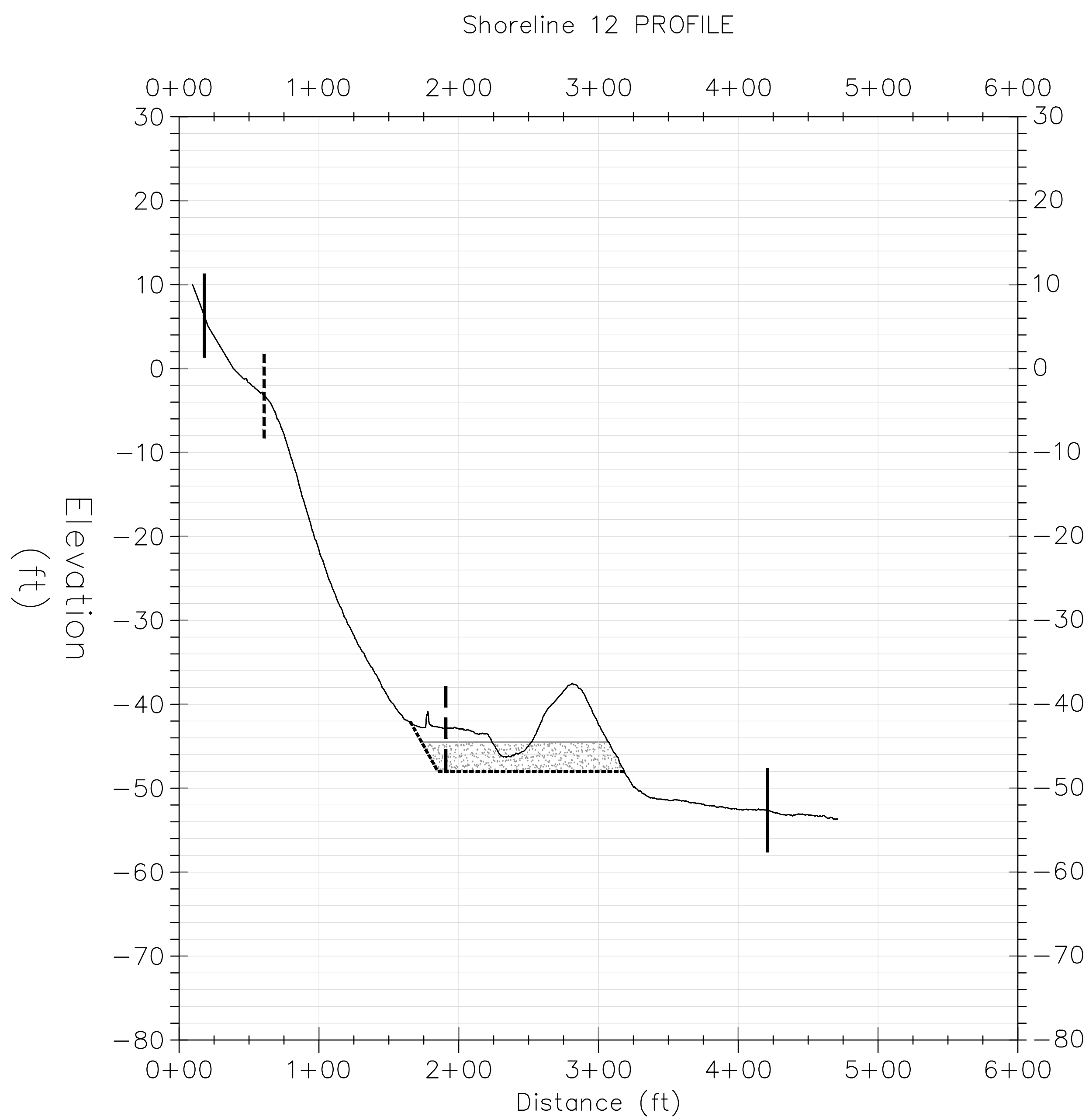
LEGEND

- STUDY AREA BOUNDARY
- INNER HARBOR LINE
- OUTER HARBOR LINE
- DREDGE LIMIT
- CONVENTIONAL CAP

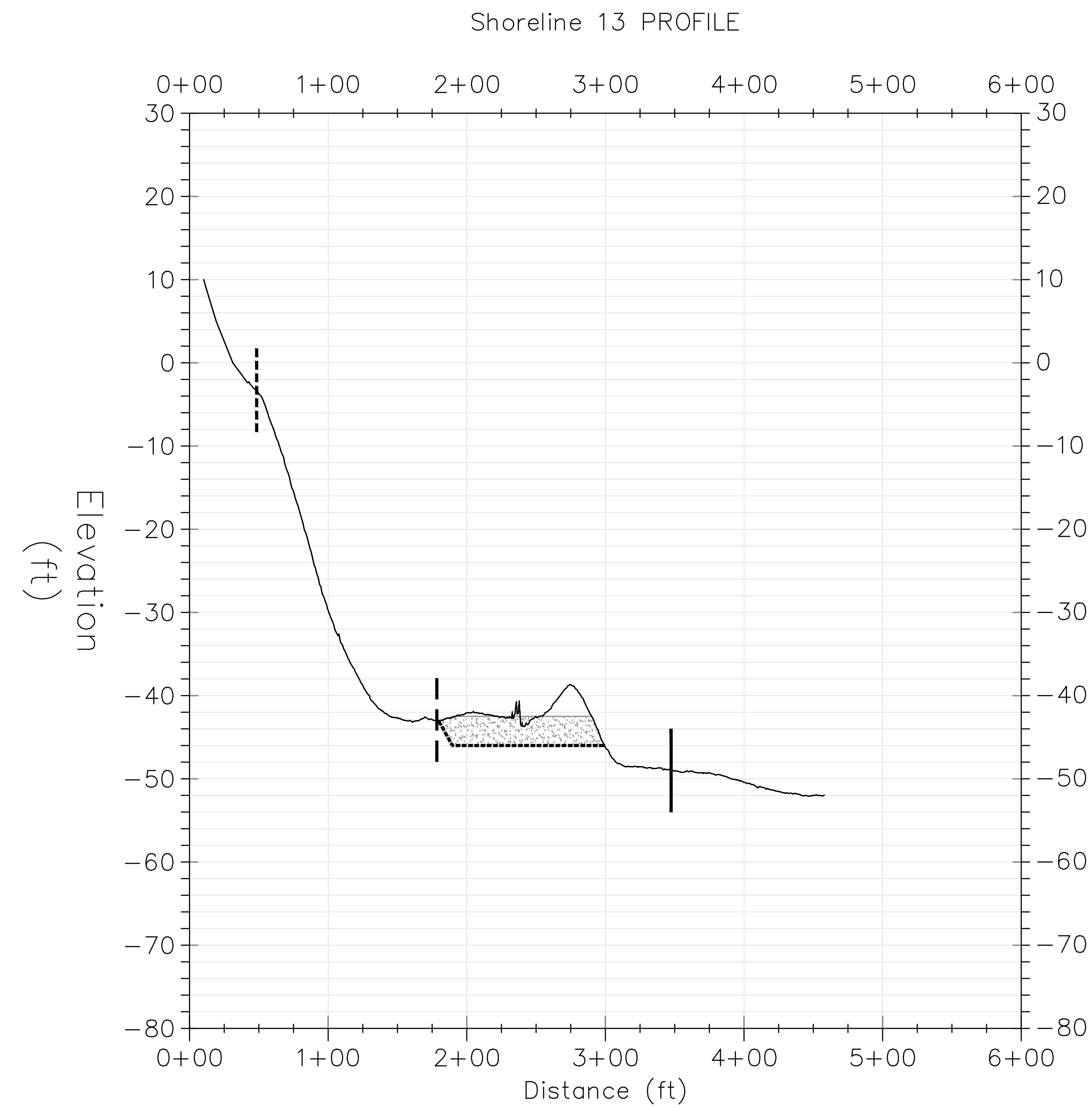
SCALE:
1"=120' HORIZONTAL
1"=20' VERTICAL
(6X VERTICAL
EXAGGERATION)

P:\8945_TTDIV-LOCKHEED\YARD 2\RIFS\CAD\KYLE_DREDGE_CALC-FILES\SURFACE AND SECTIONS_ALIGNMENT-MOD02 PROPOSED XSECTS.DWG
PLOT/UPDATE: NOV 11 2010 14:54:47

TETRA TECH	Lockheed West Seattle Superfund Site Seattle, WA	FIGURE E13 Dredge to Fit Cap Site Profiles



PROFILE 12



PROFILE 13

LEGEND

STUDY AREA BOUNDARY
INNER HARBOR LINE
OUTER HARBOR LINE
DREDGE LIMIT
CONVENTIONAL CAP

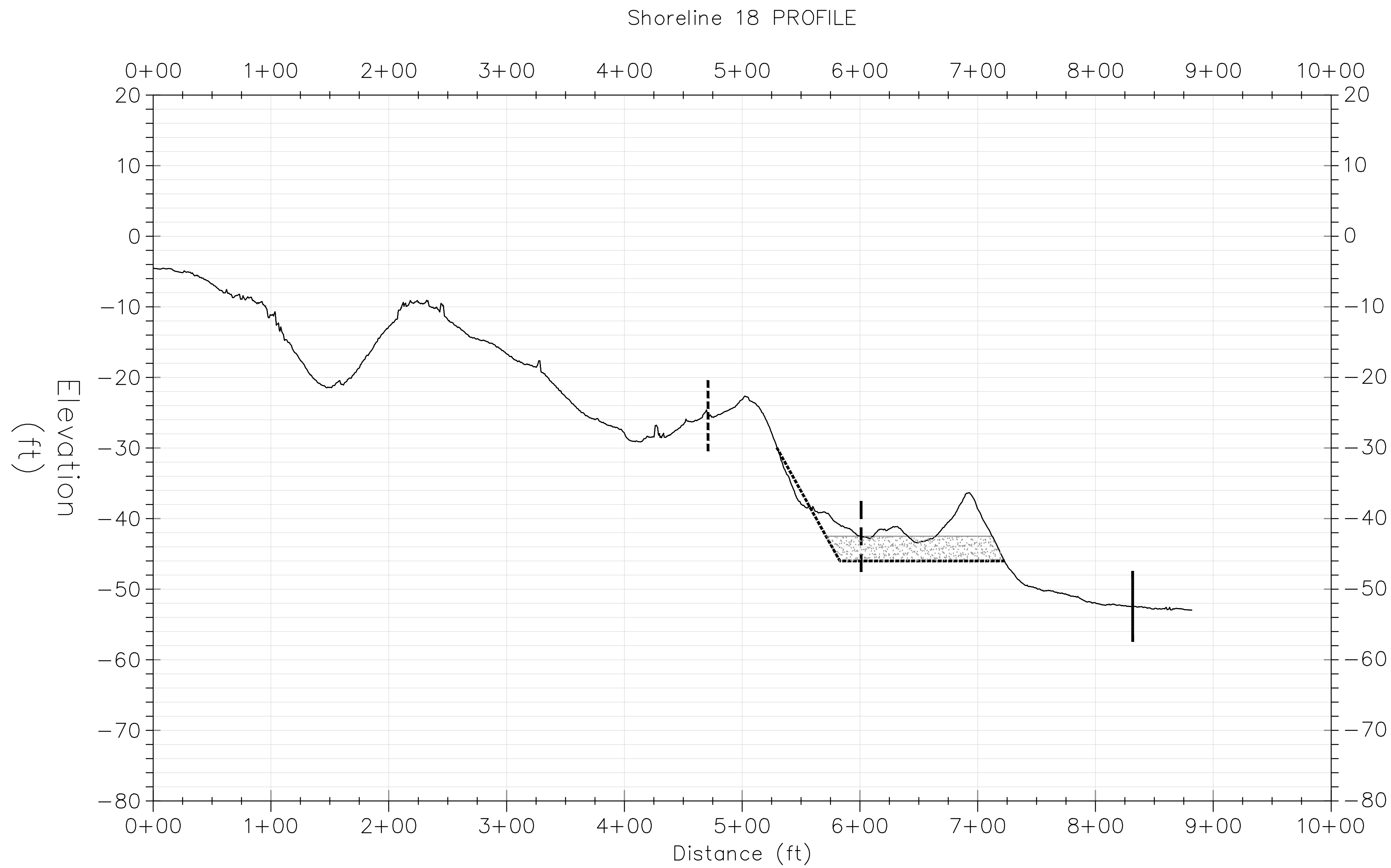
SCALE:
1"=120' HORIZONTAL
1"=20' VERTICAL
(6X VERTICAL
EXAGGERATION)

P:\8945_TTDIV-LOCKHEED\YARD 2\RIFS\CAD\KYLE_DREDGE_CALC-FILES\SURFACE AND SECTIONS_ALIGNMENT-MOD02 PROPOSED XSECTS.DWG
PLOT/UPDATE: NOV 11 2010 15:05:45

TETRA TECH

Lockheed West Seattle
Superfund Site
Seattle, WA

FIGURE E14
Dredge to Fit Cap Site Profiles



PROFILE 18

LEGEND

- STUDY AREA BOUNDARY
- INNER HARBOR LINE
- OUTER HARBOR LINE
- DREDGE LIMIT
- CONVENTIONAL CAP

SCALE:
1"=120' HORIZONTAL
1"=20' VERTICAL
(6X VERTICAL
EXAGGERATION)

TETRA TECH

Lockheed West Seattle
Superfund Site
Seattle, WA

FIGURE E15
Dredge to Fit Cap Site Profiles

C:\USERS\WALTER.BOWLES\DOCUMENTS\PROJECTS\LOCKHEED\SURFACE AND SECTIONS_ALIGNMENT-MOD02.DWG
PLOT/UPDATE: NOV 08 2010 11:28:22

Figure E-16. Alternative 3A1 – Dredge Volume and Contaminant Mass Removal for Arsenic

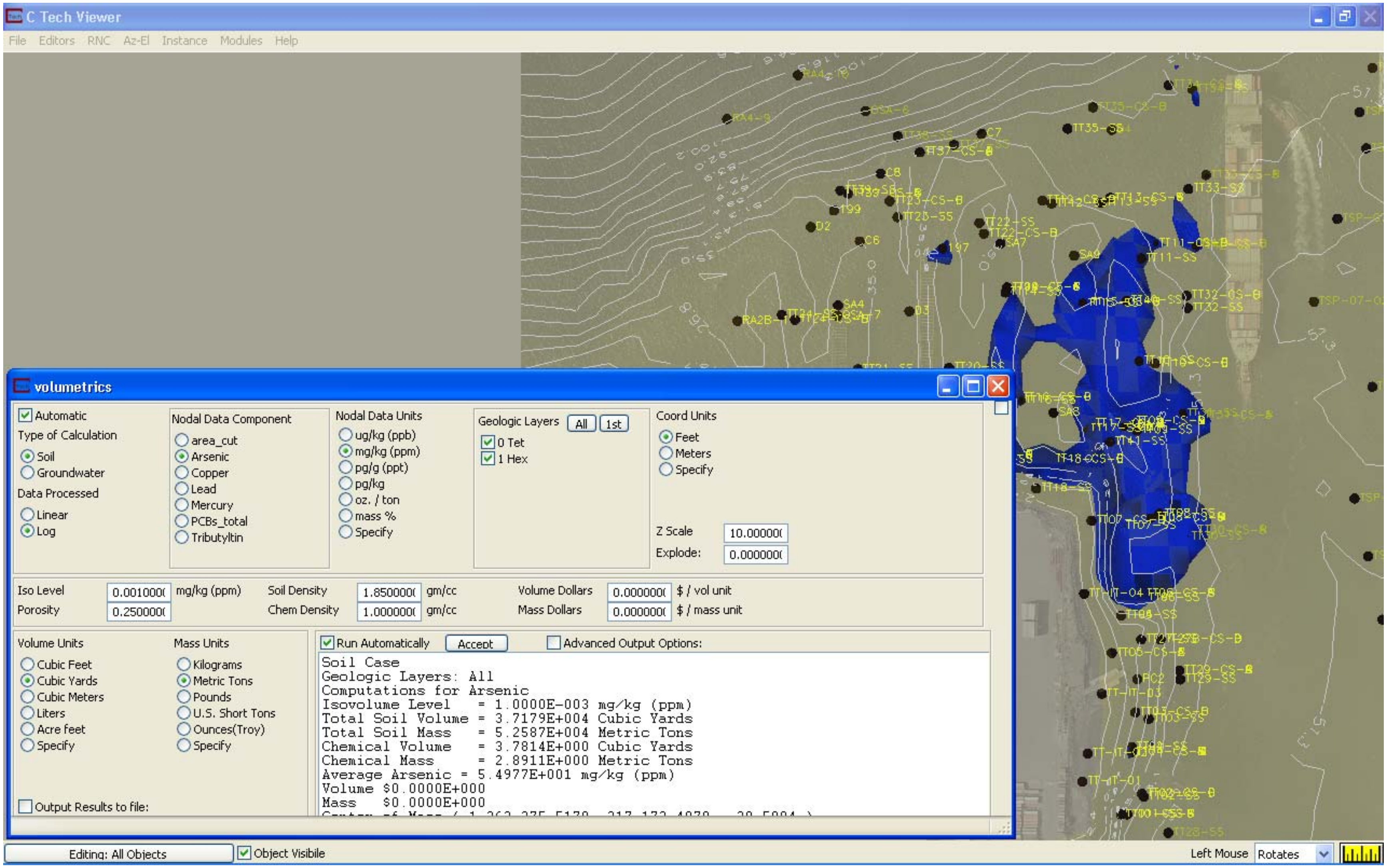


Figure E-17. Alternative 3A2 – Dredge Volume and Contaminant Mass Removal for Arsenic

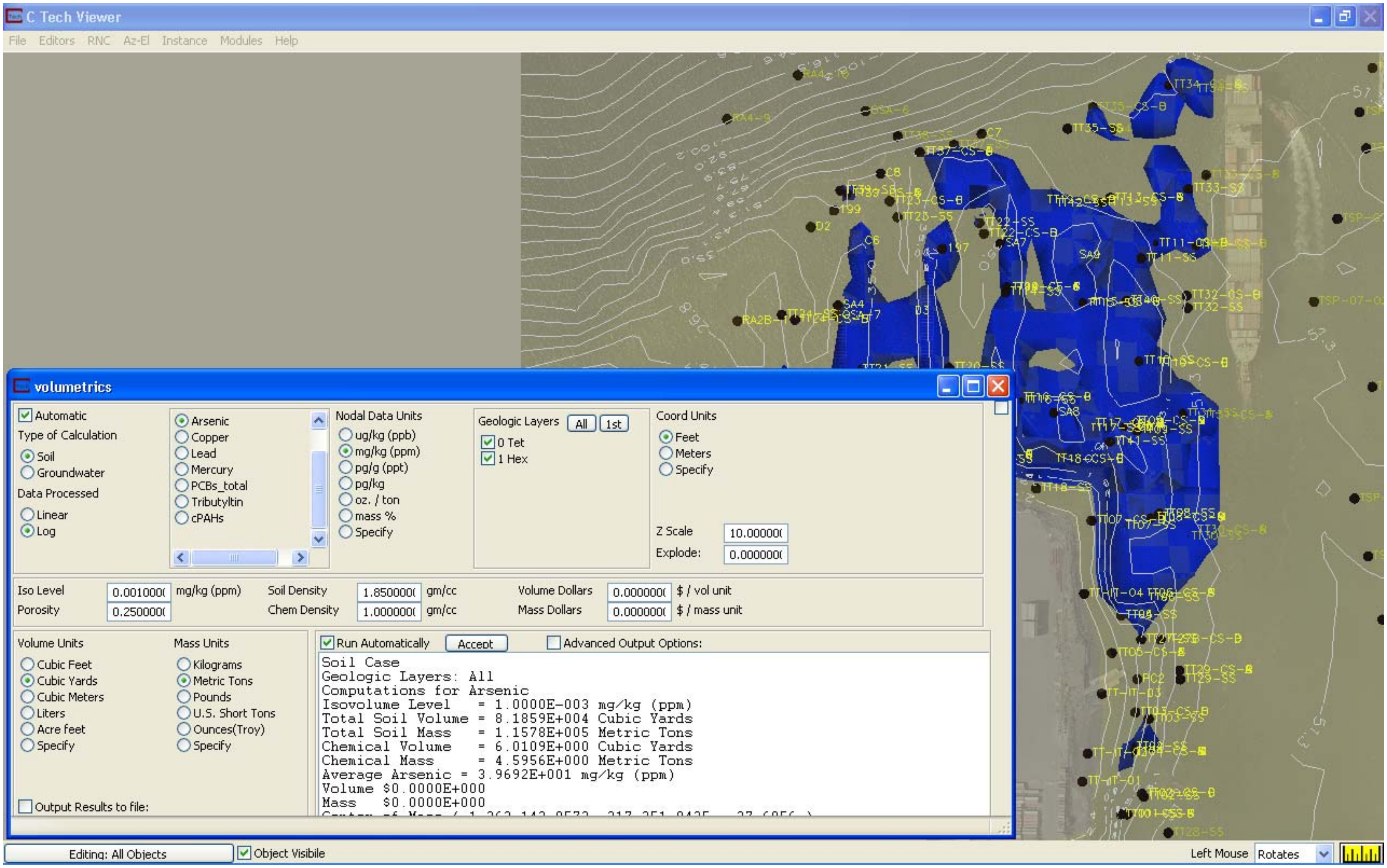


Figure E-18. Alternative 3B – Dredge Volume and Contaminant Mass Removal for Arsenic

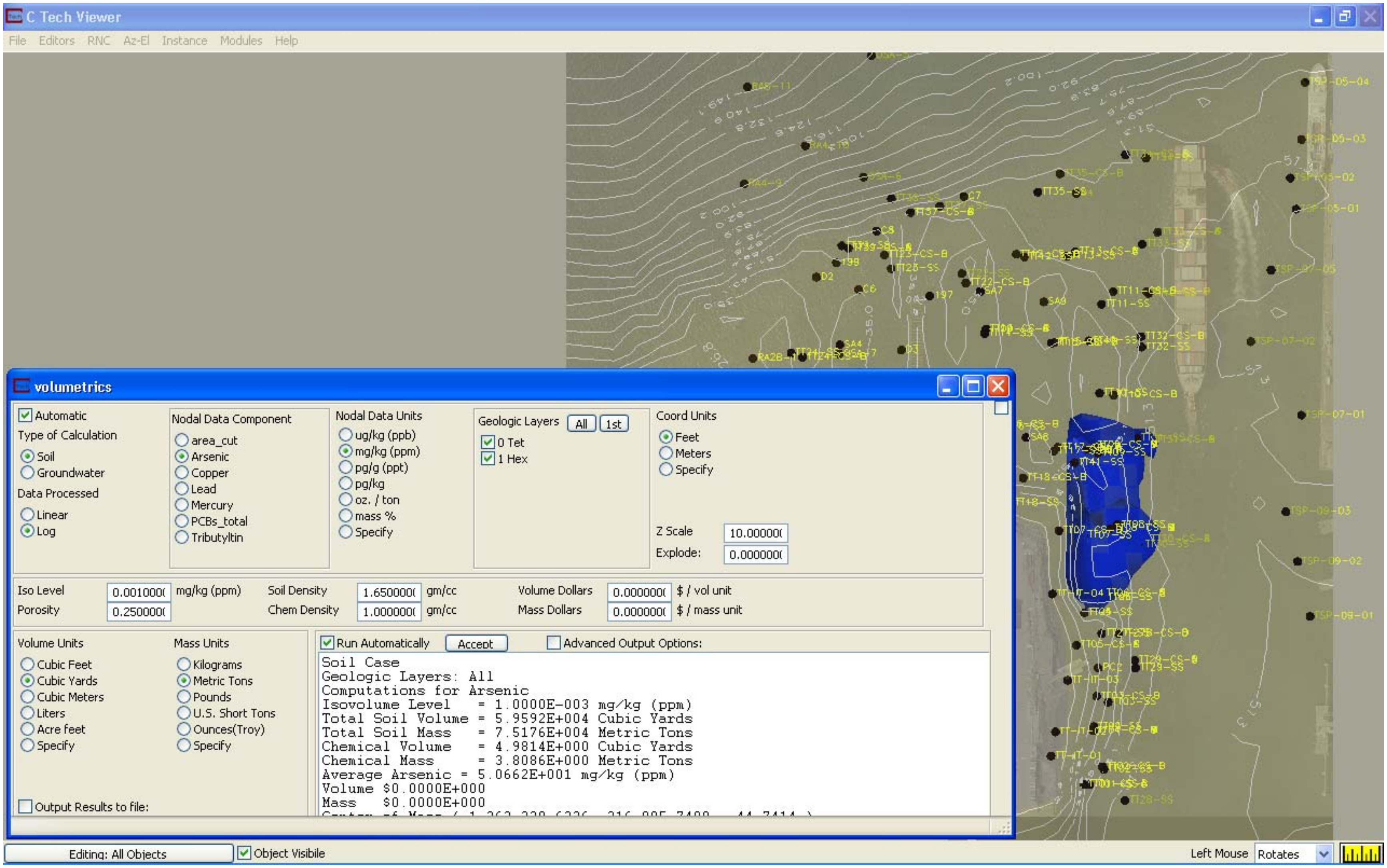
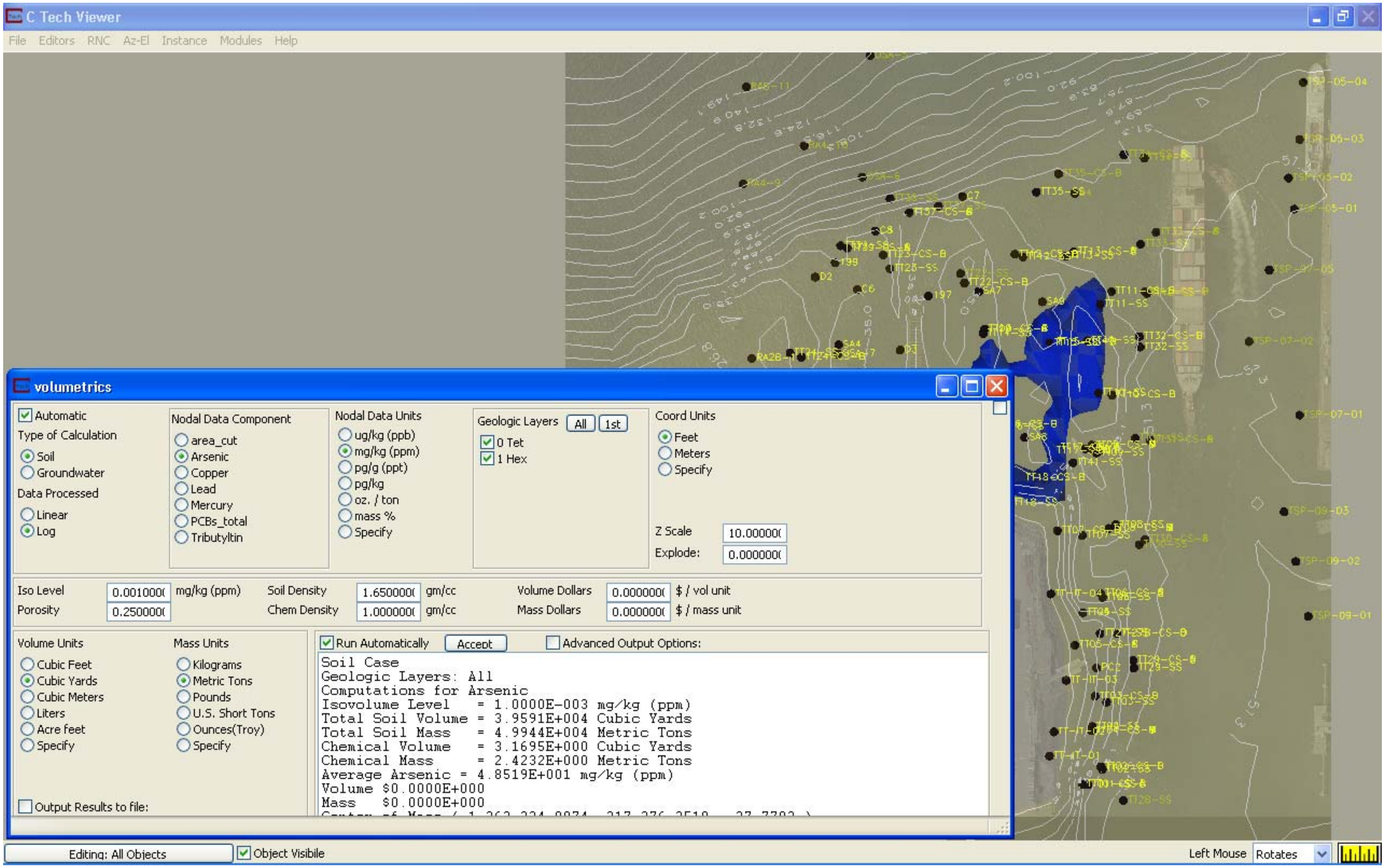


Figure E-19. Alternative 3C – Dredge Volume and Contaminant Mass Removal for Arsenic[1]



[1] The dredge volume and contaminant mass volume for Alternative 3C is combination of the volumetrics shown in this figure in addition to the volumetrics shown in Figure E-18 for Alternative 3B.

Figure E-20. Alternative 4A – Dredge Volume and Contaminant Mass Removal for Arsenic

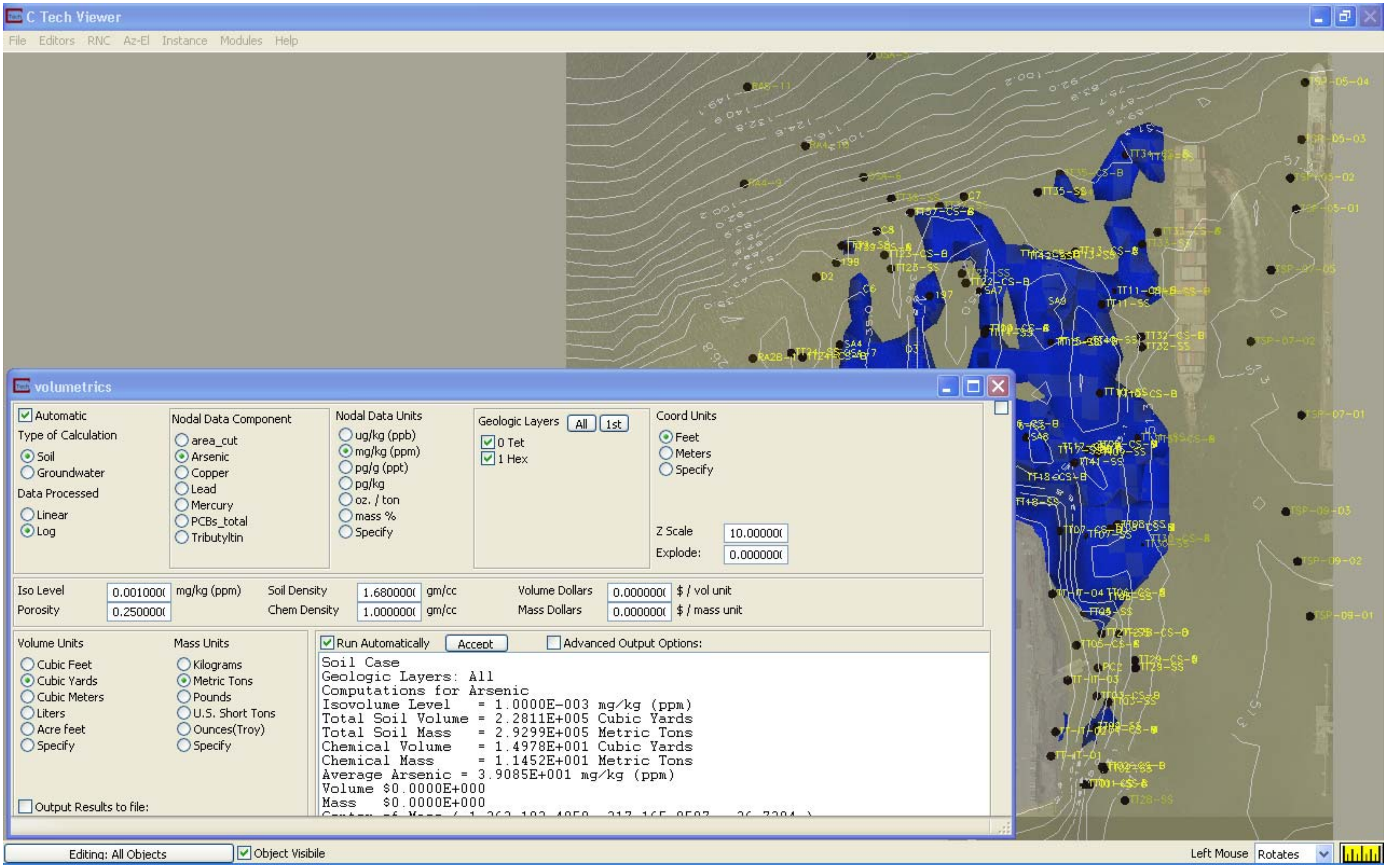


Figure E-21. Alternative 4B – Dredge Volume and Contaminant Mass Removal for Arsenic

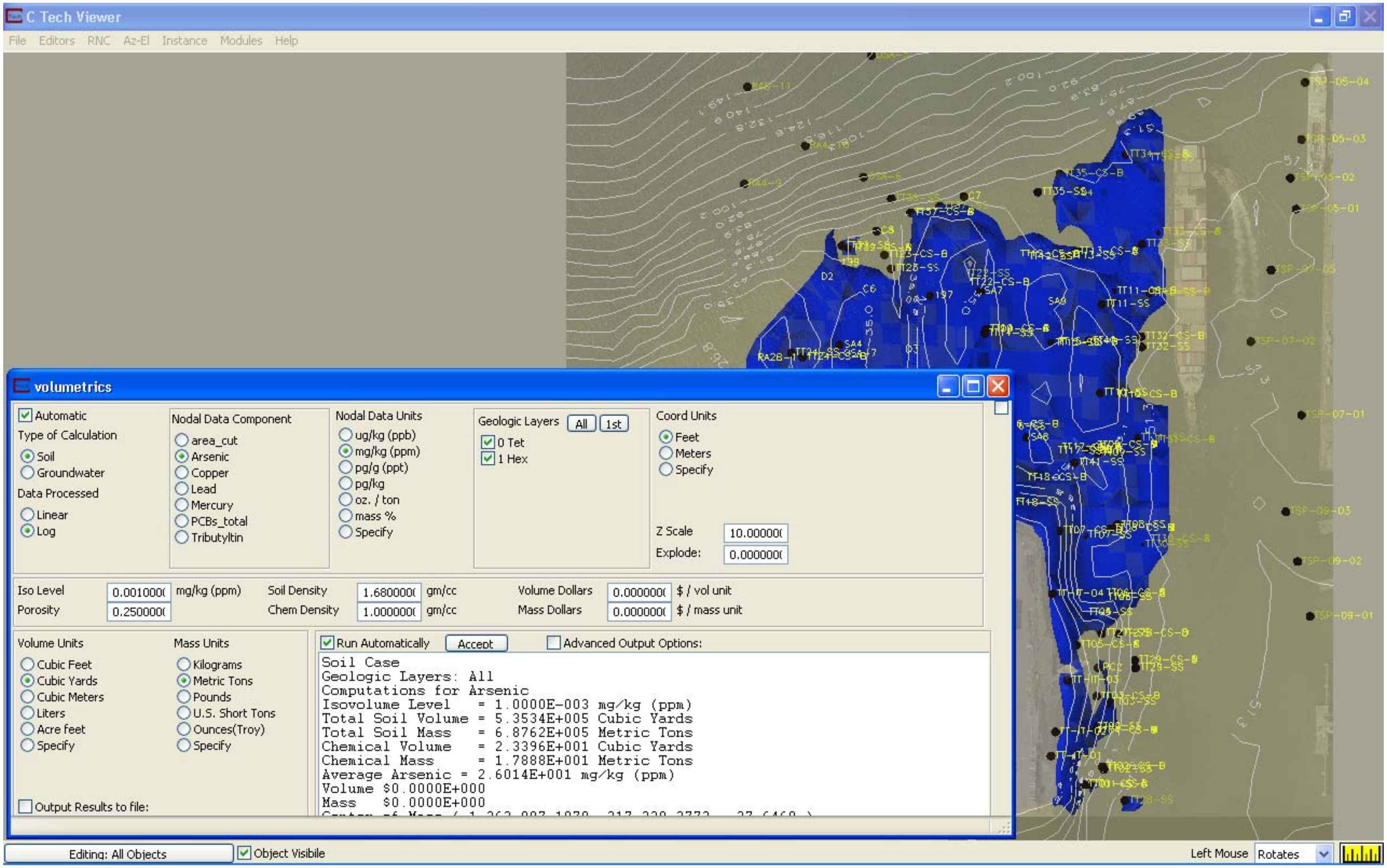
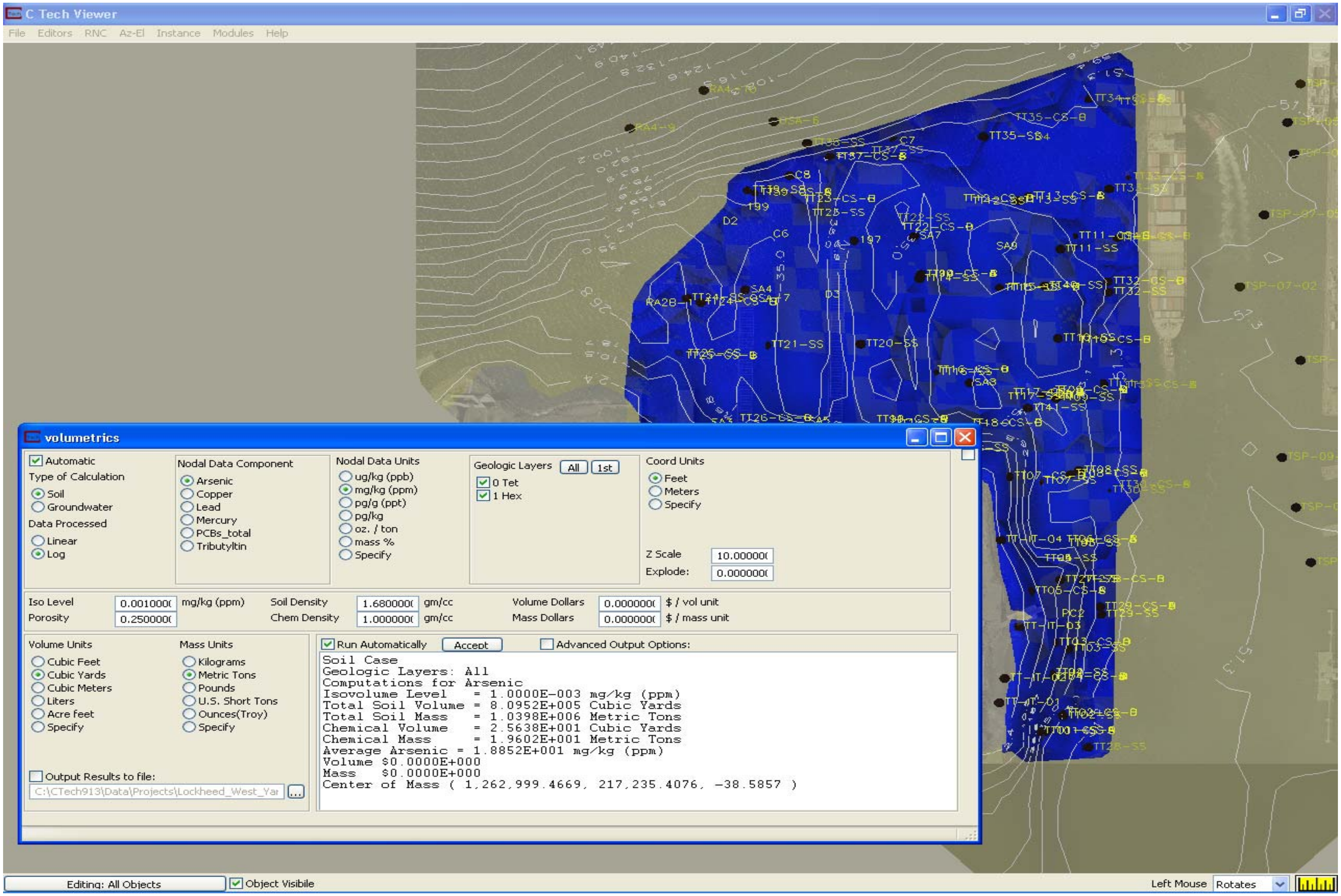


Figure E-22. Alternative 4C – Dredge Volume and Contaminant Mass Removal for Arsenic



APPENDIX F— DETAILED COST ESTIMATES FOR REMEDIAL ALTERNATIVES

TABLE OF CONTENTS

LIST OF TABLES

APPENDIX F
Detailed Cost Estimates for Remedial Alternatives

F.1 INTRODUCTION

This appendix provides detailed cost estimates for the remedial alternatives developed in Section 10 for remediation of contaminated sediment in the Lockheed West site. The cost estimates were developed in accordance with the U.S. Environmental Protection Agency's (EPA) guidance document Guide to Developing and Documenting Cost Estimates during the Feasibility Study (EPA 2000). In this appendix, basis for cost estimates, cost estimating methodology, and the detailed cost estimates for each alternative are provided.

F.2 COST ESTIMATING METHODOLOGY FOR THE FS

The cost of each alternative includes capital costs (i.e., total direct/indirect costs including all labor, equipment, and material costs) and annual or periodic costs (e.g., O&M costs, monitoring, and ongoing administration) incurred over the life of the remedial action. Capital costs are incurred during implementation and startup of the remedy. Annual costs are those costs required to maintain the operation of the remedy over time. According to CERCLA guidance (EPA, 1988), cost estimates for remedial alternatives were developed with an expected accuracy range of –30 to +50 percent.

The costs of remedial alternatives are compared using the estimated present value of the alternative. The net present value allows costs for remedial alternatives to be compared by discounting all costs to the year that the alternative is implemented. In the Guide to Developing and Documenting Cost Estimates During the Feasibility Study (EPA, 2000), EPA suggests that the period of analysis for the present value analysis should be equivalent to the project duration, to provide a complete life cycle cost estimate of the remedial alternative. Most of the remedial alternatives developed for the Lockheed West require long-term activities, institutional controls, and site-wide performance monitoring of the constructed remedy. Present value costs of remedial alternatives were estimated for a 30-year period of analysis as recommended by the CERCLA guidance (EPA, 1988).

F.2.1 Area-Specific Construction Assumptions

For FS cost estimating purpose, general construction assumptions were made for site-wide, MHHW to -10 ft MLLW, below -10 ft MLLW and former shipway area. These assumptions are provided in Table 11-4, compiled in Table F-1, and serve as a basis for the detailed cost estimates.

F.2.2 Volume Estimates

Variation in the scope of each remedial alternative is a significant contributing factor to cost uncertainty. Changes in the volume of sediment dredged and disposed of has a much greater influence on cost than changes of a proportionately similar magnitude in an area remediated using containment technologies (i.e., capping and ENR). Methodology for neat dredge volume estimates used in this FS is provided in Appendix E. Cost estimating volume assumptions for dredge, cap, ENR alternatives are provided in Table F-1. Removal volumes are estimated as the computed neat volume increased by 50% to account for over-dredge, side slopes, box cuts (i.e., design of constructible dredge prisms), and additional characterization, and more removal in intertidal areas for Alternatives 2 through 4. Estimates for cap volumes in shoreline/intertidal area are increased by 20% to account for steep slopes by backfilling the dredged areas to a gentler slope. Cap and ENR volume estimates follow the assumption of 3.5 ft of capping material to achieve a goal of a minimum 3-ft cap, and 12 inches of sand to achieve a 6-in ENR layer.

F.3 APPENDIX ORGANIZATION

Information provided in the remainder of this appendix includes:

- Assumptions common to all remedial alternatives for each task and sub-task (Table F-1);
- Estimates for institutional controls (Table F-2), long-term operations and maintenance monitoring for cap (Table F-3), dredge, ENR, and unremediated areas (Table F-4), and present value analysis of institutional controls and long-term activities (Tables F-5 to F-7);
- Verification sampling cost estimates for Alternatives 2, 3, and 4 (Tables F-8 to F-10); and
- Detailed cost estimates for Alternatives 2, 3, and 4 (Tables F-11 to F-25).

Table F-1.

Basis for Cost Estimates (Page 1 of 3)

Task	Sub-Task		Unit Cost[1/ 2/]		Notes/Assumptions
Pre-Construction	Contractor Submittals, Engineering and Surveying		$150,000 Lump Sum		Estimate for Contractor Work Plan (Quality Control Plan, Waste Management Plan, Environmental Protection Plan, Site Health and Safety Plan), estimate for pre-construction bathymetry and topographic surveying, submittals.
	Mobilization/Demobilization		$500,000 Lump Sum		Estimate to mobilize, demobilize equipment, derrick barge with enclosed bucket or articulated bucket, assist tug.
	Site Preparation, Environmental Controls		$150,000 Lump Sum		Estimate for temporary site facilities, utilities, lease for operations, staging, environmental controls, oil absorbent booms, debris booms.
Pier Demolition	Pile Demolition, Handling, and Delivery to Rail	Creosote Treated Wood	$110 Per Ton	9,900 Ton	Engineer's estimate presented in Tetra Tech 2007 Intermediate Basis of Design for Pier Demolition. Unit cost includes equipment, personnel, fuel; increased 2% per year for 2012 prices. Partial pier demolition cost was calculated for each alternative as applicable.
		Debris and Pilings, Metal Waste		170 Ton	
	Transport and Disposal		$68 Per Ton	10,070 Ton	Engineers estimate presented in Tetra Tech 2007 Intermediate Basis of Design for Pier Demolition. Unit cost increased 2% per year for 2012 prices. Partial pier demolition cost was calculated for each alternative as applicable.
	Demolition QA/QC, Waste Characterization, Monitoring		$456,000		Engineers estimate presented in Tetra Tech 2007 Intermediate Basis of Design for Pier Demolition. Includes construction oversight monitoring, water quality monitoring, labor, equipment for monitoring, waste characterization, post demolition bathy survey, and reporting. Does not include mobilization/demobilization, project submittals, environmental controls, temporary facilities. Partial pier demolition cost was calculated for each alternative as applicable.
Dredging, Residual Management, Disposal	Dredging		$20 Per CY		Estimate based on completed remediation projects in Puget Sound including debris removal. Dredge volumes are estimated by utilizing C-Tech MVS 3-D Model and AuoCAD/Civil3D, then increased by 50% to account for the various causes of volume creep following the guidance by Palermo and Gustavson (2009).
	Material Barge, Assist Tug , Transport Sediments to Transloading Facility		$12 Per Ton		Estimate based on completed remediation projects in Puget Sound.
	Transloading Area Setup		$1,000,000		Estimate for a transloading area setup.
	Water Management		$8,000 Per Day		Estimate for dredged water storage, sampling. Assumed the water would be released back to site. Cost includes contingency for pumping and disposal to sewer or water treatment system. Number of dredge days is calculated assuming daily dredge production of 816 cy/day estimated following ERDC/EL TR-08-29 (2008) guidance document.

Table F-1.
Basis for Cost Estimates (Page 2 of 3)

Task	Sub-Task	Unit Cost[1/ 2/]	Notes/Assumptions
	Handling, Transport and Subtitle D Landfill Disposal	$60 Per Ton	Sediment rehandling costs at the transloading facility including material transfer from barge onto lined bulk material shipping containers, transfer of loaded containers onto trucks, and truck transport of the containers to an intermodal facility for transfer to rail are included in the unit price for material disposal at the Subtitle D landfill ($60/ton). Two Regional Subtitle D facilities that accept wet dredged materials assumed are: Allied Waste Services (Roosevelt Regional Landfill, Roosevelt, WA), and Waste Management Inc. (Columbia Ridge Landfill, Arlington, OR).
	Backfill Material Procurement, Delivery, Placement	$20 Per CY	Estimate based on completed remediation projects in Puget Sound. Backfill material quantities were estimated assuming a 9 inches sand layer placed over the dredge footprint to reach minimum 6 inches of coverage.
Sediment Capping and ENR	Cap Material Procurement, Delivery, Placement	$30 Per CY	Estimate based on completed remediation projects in Puget Sound. Cap material quantities were estimated using 3.5 ft layer of sand over cap footprint to reach minimum 3 ft coverage.
	ENR Material Procurement, Delivery, Placement	$30 Per CY	Estimate based on completed remediation projects in Puget Sound. ENR material quantities were estimated using 1 ft layer of sand over ENR footprint to reach minimum 6 inches of coverage.
	Material Barge, Assist Tug for Capping	$10 Per Ton	Estimate based on completed remediation projects in Puget Sound.
	Material Barge, Assist Tug for ENR	$10 Per Ton	Estimate based on completed remediation projects in Puget Sound.
Shipway Remediation	Removal and Disposal	$100 Per CY	Estimate for removal of approximately 0.5 ft of sediments/blasted sand waste by barge-mounted precision excavator and disposal.
	Cap/Habitat Material Procurement and Placement	$30 Per CY	Estimate based on completed remediation projects in Puget Sound. Assume 3 ft thickness cap/habitat mix will be placed over former shipway area.
Shoreline Remediation	Removal and Disposal	$100 Per CY	Estimate for removal of 3 ft of sediments from -10 ft MLLW and above by barge-mounted precision excavator at low-tide and disposal.
	Backfill Placement	$20 Per CY	Estimate based on completed remediation projects in Puget Sound. Assume 3 ft thickness of backfill/cap placed along the shoreline dredged areas, increased by 20% to account for flattening steep slopes.
	Shoreline Stabilization (Riprap) Procurement and Placement	$50 Per Ton	Estimate based on completed remediation projects in Puget Sound. Assume 2 ft thickness riprap placed along shoreline slopes.
	Habitat Material Procurement and Placement	$30 Per CY	Local contractor quote. Assume 1 ft thickness habitat mix will be placed over existing riprap, newly installed riprap and along shoreline.
	Habitat Enhancement and Riparian Planting	$50,000 Per AC	Estimate for habitat improvements along -10 ft MLLW and above non-riprap areas.
Construction QA&QC, Monitoring	Bathymetric Surveys/ Water Quality Monitoring	$7,000 Per Day	Estimate for multi-beam survey during dredging and water quality sampling analysis including labor, equipment, material costs. Number of dredge/cap/ENR days calculated assuming daily production of 816 cy/day for dredge, 1,071 cy/day for cap/ENR estimated following ERDC/EL TR-08-29 (2008) guidance document. In-water work window is assumed as 180 calendar days.

Table F-1.
Basis for Cost Estimates (Page 3 of 3)

Task	Sub-Task	Unit Cost[1/ 2/]	Notes/Assumptions
	Verification Sediment Sampling (Dredging)	Estimated for each alternative	Assume 4 samples/acre, analytical cost of $2,200/sample, $8,000 labor, equipment, material, reporting/acre sampling
	Verification Sediment Sampling (Capping)	Estimated for each alternative	Assume 2 samples/acre, analytical cost of $2,200/sample, $8,000 labor, equipment, material, reporting /acre sampling
	Verification Sediment Sampling (ENR)	Estimated for each alternative	Assume 2 samples/acre, analytical cost of $2,200/sample, $8,000 labor, equipment, material, reporting /acre sampling
	Remedial Action Completion Reporting	$80,000 Lump Sum	Estimate for project completion reporting including as-built drawings
Engineering, Construction Support, Oversight	Construction Contingency	35%	EPA 540-R-00-002, bid and scope contingency
	Project Management	5%	EPA 540-R-00-002 (2000)
	Remedial Design and Data Collection	8%	EPA 540-R-00-002 (2000)
	Construction Management/QA Support	6%	EPA 540-R-00-002 (2000)
	Agency Oversight	1.5%	Estimate applied at 25% of construction management/quality assurance (QA) support, which is equivalent to 1.5% of base capital cost
	WA State Sales Tax	9.5%	State tax applied to base capital cost minus landfill disposal cost because sales tax is already included in the disposal quote
Institutional Controls, Operations, Maintenance, and Monitoring, Long-term Monitoring	ICs Planning and Implementation	$120,000 Initial Cost + $20,000 Annual Cost	Present Value.[3/] Estimate for initial cost and annual cost for public outreach and education, seafood consumption advisories, deed notice filing, proprietary controls, agency reporting and review for 30 years applied for Alternatives 2 and 3. Public outreach and education, and seafood consumption advisories are applied to Alternative 4 with an initial cost of $80K and an annual cost of $10K. Does not include 3rd party settlement fee for future use restrictions in commerce and navigation due to capping
	Long-Term Monitoring	$2,200 Per Sediment Sample + $8,000 Labor Per Day + $75,000 Lump Sum Bathymetry and SPI camera surveys	Present Value. [3/] Monitoring events at Years 1, 2, 3, 5, 7, 10, 15, 20, 25, and 30. Surface sediment (at all monitoring years), subsurface sediment (at Years 2, 5, 10, 15, 20, 25, and 30), and resident clam tissue analysis (at Years 5, 10, 20, 30). Assume site-wide 40 surface sediment samples at 10-samples/day, 20 subsurface samples at 5-samples/day. For dredge, ENR, and unremediated areas, assume site-wide 40 surface sediment samples at 10-samples/day, and no subsurface samples. Multi-beam bathymetric survey and SPI camera surveys at Years 2, 5, 10, 15, 20, 25, 30. Present value cost was interpolated and adjusted for each alternative based on cap/ENR/unremediated area. For Alternative 4C, site-specific long-term monitoring will not be implemented.
	ENR Repair	$70 Per CY	Assume 5% of ENR area will be repaired as one time contingency.
	Cap Repair	$70 Per CY	Assume 100% cap replacement will be needed through the project life of cap due to mechanical or natural subsurface sediment disturbance activities such as seismic events.

Notes:
1/ Cost in 2012 dollars.
2/ Assume average sediment bulk density is 1.5 tons/cy.
3/ Present value analysis was performed assuming 3% discount for 30 years by following EPA 540-R-00-002 (2000).

F.4 REFERENCES

1. EPA (U.S. Environmental Protection Agency) 2000. A Guide to Developing and Documenting Cost Estimates during the Feasibility Study. EPA 540-R-00-002, OSWER 9355.0-75. July 2000.

2. EPA. 1988. Interim Final Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA. EPA/540/G-89/004. US Environmental Protection Agency, Washington, D.C. October.

3. Palermo, M.R., and K. Gustavson. 2009. "In Situ Volume Creep for Environmental Dredging Remedies," Fifth International Conference on Remediation of Contaminated Sediments, Jacksonville, FL. 2009.

4. Palermo, M.R., P.R. Schroeder, T.J. Estes, and N.R. Francingues. 2008. Technical Guidelines for Environmental Dredging of Contaminated Sediments. ERDC/EL TR-08-29 September.

5. U.S. Army Corps of Engineers. 2008. Technical Guidelines for Environmental Dredging of Contaminated Sediments. Publication ERDC/EL TR-08-29. USACE Environmental Laboratory, Vicksburg, MS. 2008.

TABLE F-2. INSTITUTIONAL CONTROLS

TASK	INITIAL COST	ANNUAL COST
Proprietary Controls		
Restrictive Covenants	$10,000	
Informational Devices		
Education and Public Outreach	$30,000	$5,000
Seafood Consumption Advisories	$50,000	$5,000
Monitoring and Notification of Waterway Users - Reporting to EPA and Ecology	$10,000	$5,000
Site Registry - Deed Notice Filing	$10,000	
Agency Review	$10,000	$5,000
TOTAL COST	$120,000	$20,000

TABLE F-3. LONG-TERM OPERATIONS AND MAINTENANCE MONITORING FOR CAP AREAS

TASK	QUANTITY	UNIT	UNIT COST	TOTAL COST
Sediment Chemistry (Surface)				
Analytical Cost	40	EA	$2,200	$88,000
Daily Labor, Equipment, Materials (10 samples/day)	4	EA	$8,000	$32,000
Subtotal:				**$120,000**
Sediment Chemistry (Subsurface)				
Analytical Cost	20	EA	$2,200	$44,000
Daily Labor, Equipment, Materials (5 samples/day)	4	EA	$8,000	$32,000
Subtotal:				**$76,000**
Tissue				
Subtotal:				**$50,000**
Bathymetry and SPI Camera Surveys	1	LS	$75,000	$75,000
QC, Data management, Reporting	5%			
TOTAL COST (Years 1, 3, 7)				**$126,000**
TOTAL COST (Year 2, 15, 25)				**$284,550**
TOTAL COST (Years 5, 10, 20, 30)				**$337,050**

Notes:
1. Surface sediment monitoring at Years 1, 2, 3, 5, 7,10, 15, 20, 25, and 30
2. Subsurface sediment monitoring, bathymetry, SPI camera surveys at Years 2, 5, 10, 15, 20, 25, and 30
3. Tissue sampling at Years 5, 10, 20, and 30

TABLE F-4. LONG-TERM OPERATIONS AND MAINTENANCE MONITORING FOR DREDGE, ENR, AND UNREMEDIATED AREAS

TASK	QUANTITY	UNIT	UNIT COST	TOTAL COST
Sediment Chemistry (Surface)				
Analytical Cost	40	EA	$2,200	$88,000
Daily Labor, Equipment, Materials (10 samples/day)	4	EA	$8,000	$32,000
Subtotal:				**$120,000**
Tissue				
Subtotal:				**$50,000**
Bathymetry and SPI Camera Surveys	1	LS	$75,000	$75,000
QC, Data management, Reporting	5%			
TOTAL COST (Years 1, 3, 7)				**$126,000**
TOTAL COST (Year 2, 15, 25)				**$204,750**
TOTAL COST (Years 5, 10, 20, 30)				**$257,250**

Notes:
1. Surface sediment monitoring at Years 1, 2, 3, 5, 7,10, 15, 20, 25, and 30
2. Bathymetry, SPI camera surveys at Years 2, 5, 10, 15, 20, 25, and 30
3. Tissue sampling at Years 5, 10, 20, and 30

TABLE F-5. PRESENT VALUE CALCULATION FOR INSTITUTIONAL CONTROLS
(i=3%)

Post Construction Year	IC Cost (Alt. 2 and 3)	Present Value Factor	Present Value	IC Cost (Alt. 4)	Present Value Factor	Present Value	IC Cost (Alt. 3C Plus)	Present Value
0	$120,000	1	$120,000	$80,000	1	$80,000	$10,000	$10,000
1	$20,000	0.9709	$19,417	$10,000	0.9709	$9,709	$5,000	$4,854
2	$20,000	0.9426	$18,852	$10,000	0.9426	$9,426	$5,000	$4,713
3	$20,000	0.9151	$18,303	$10,000	0.9151	$9,151	$5,000	$4,576
4	$20,000	0.8885	$17,770	$10,000	0.8885	$8,885	$5,000	$4,442
5	$20,000	0.8626	$17,252	$10,000	0.8626	$8,626	$5,000	$4,313
6	$20,000	0.8375	$16,750	$10,000	0.8375	$8,375	$5,000	$4,187
7	$20,000	0.8131	$16,262	$10,000	0.8131	$8,131	$5,000	$4,065
8	$20,000	0.7894	$15,788	$10,000	0.7894	$7,894	$5,000	$3,947
9	$20,000	0.7664	$15,328	$10,000	0.7664	$7,664	$5,000	$3,832
10	$20,000	0.7441	$14,882	$10,000	0.7441	$7,441	$5,000	$3,720
11	$20,000	0.7224	$14,448	$10,000	0.7224	$7,224	$5,000	$3,612
12	$20,000	0.7014	$14,028	$10,000	0.7014	$7,014	$5,000	$3,507
13	$20,000	0.6810	$13,619	$10,000	0.6810	$6,810	$5,000	$3,405
14	$20,000	0.6611	$13,222	$10,000	0.6611	$6,611	$5,000	$3,306
15	$20,000	0.6419	$12,837	$10,000	0.6419	$6,419	$5,000	$3,209
16	$20,000	0.6232	$12,463	$10,000	0.6232	$6,232	$5,000	$3,116
17	$20,000	0.6050	$12,100	$10,000	0.6050	$6,050	$5,000	$3,025
18	$20,000	0.5874	$11,748	$10,000	0.5874	$5,874	$5,000	$2,937
19	$20,000	0.5703	$11,406	$10,000	0.5703	$5,703	$5,000	$2,851
20	$20,000	0.5537	$11,074	$10,000	0.5537	$5,537	$5,000	$2,768
21	$20,000	0.5375	$10,751	$10,000	0.5375	$5,375	$5,000	$2,688
22	$20,000	0.5219	$10,438	$10,000	0.5219	$5,219	$5,000	$2,609
23	$20,000	0.5067	$10,134	$10,000	0.5067	$5,067	$5,000	$2,533
24	$20,000	0.4919	$9,839	$10,000	0.4919	$4,919	$5,000	$2,460
25	$20,000	0.4776	$9,552	$10,000	0.4776	$4,776	$5,000	$2,388
26	$20,000	0.4637	$9,274	$10,000	0.4637	$4,637	$5,000	$2,318
27	$20,000	0.4502	$9,004	$10,000	0.4502	$4,502	$5,000	$2,251
28	$20,000	0.4371	$8,742	$10,000	0.4371	$4,371	$5,000	$2,185
29	$20,000	0.4243	$8,487	$10,000	0.4243	$4,243	$5,000	$2,122
30	$20,000	0.4120	$8,240	$10,000	0.4120	$4,120	$5,000	$2,060
TOTAL	$720,000		$512,009	$380,000		$276,004	$5,000	$108,002

TABLE F-6. PRESENT VALUE CALCULATION FOR LONG-TERM MONITORING FOR CAP
(i=3%)

Post Construction Year	LTM Monitoring Cost	Present Value Factor	Present Value
1	$126,000	0.9709	$122,330
2	$284,550	0.9426	$268,216
3	$126,000	0.9151	$115,308
4		0.8885	$0
5	$337,050	0.8626	$290,742
6		0.8375	$0
7	$126,000	0.8131	$102,450
8		0.7894	$0
9		0.7664	$0
10	$337,050	0.7441	$250,797
11		0.7224	$0
12		0.7014	$0
13		0.6810	$0
14		0.6611	$0
15	$284,550	0.6419	$182,642
16		0.6232	$0
17		0.6050	$0
18		0.5874	$0
19		0.5703	$0
20	$337,050	0.5537	$186,616
21		0.5375	$0
22		0.5219	$0
23		0.5067	$0
24		0.4919	$0
25	$284,550	0.4776	$135,903
26		0.4637	$0
27		0.4502	$0
28		0.4371	$0
29		0.4243	$0
30	$337,050	0.4120	$138,860
TOTAL	$2,579,850		$1,793,863

TABLE F-7. PRESENT VALUE CALCULATION FOR LTM OF DREDGE, ENR, UNREMEDIATED AREAS (i=3%)

Post Construction Year	LTM Monitoring Cost	Present Value Factor	Present Value	LTM Monitoring Cost (Alt. 3C Plus)	Present Value
1	$126,000	0.9709	$122,330		$0
2	$204,750	0.9426	$192,997		$0
3	$126,000	0.9151	$115,308		$0
4		0.8885	$0		$0
5	$257,250	0.8626	$221,906	$50,000	$43,130
6		0.8375	$0		$0
7	$126,000	0.8131	$102,450		$0
8		0.7894	$0		$0
9		0.7664	$0		$0
10	$257,250	0.7441	$191,418	$50,000	$37,205
11		0.7224	$0		$0
12		0.7014	$0		$0
13		0.6810	$0		$0
14		0.6611	$0		$0
15	$204,750	0.6419	$131,421	$50,000	$32,093
16		0.6232	$0		$0
17		0.6050	$0		$0
18		0.5874	$0		$0
19		0.5703	$0		$0
20	$257,250	0.5537	$142,433	$50,000	$27,684
21		0.5375	$0		$0
22		0.5219	$0		$0
23		0.5067	$0		$0
24		0.4919	$0		$0
25		0.4776	$0	$50,000	$23,880
26		0.4637	$0		$0
27		0.4502	$0		$0
28		0.4371	$0		$0
29		0.4243	$0		$0
30	$257,250	0.4120	$105,984	$50,000	$20,599
TOTAL	$1,816,500		$1,326,246	$300,000	$184,592

TABLE F-8. VERIFICATION SAMPLING FOR ALTERNATIVE 2

ALT-2A

PARAMETER	DREDGE	CAP-2A1, 2A2, 2A3	CAP-2A4a, 2A2b	CAP-2A4b	CAP-2A4c	ENR-2A1	ENR-2A2	ENR-2A3	ENR-2A2b
Analytical Cost/Sample	$2,200	$2,200	$2,200	$2,200	$2,200	$2,200	$2,200	$2,200	$2,200
Remediation Area	0	10.3	18	30	40	7.7	19.7	29.7	12
Number of Samples per acre	4	2	2	2	2	2	2	2	2
Number of Days (5 samples/day -dredge, 10 samples/day cap-ENR)	0	2.06	3.6	6	8	1.54	3.94	5.94	2.4
Daily Labor, Equipment, Materials	$8,000	$8,000	$8,000	$8,000	$8,000	$8,000	$8,000	$8,000	$8,000
QC, Data management, Reporting	5%								
Subtotal Analytical:	$0	$45,320	$79,200	$132,000	$176,000	$33,880	$86,680	$130,680	$52,800
Subtotal Labor:	$0	$16,480	$28,800	$48,000	$64,000	$12,320	$31,520	$47,520	$19,200
TOTAL COST	$0	$64,890	$113,400	$189,000	$252,000	$48,510	$124,110	$187,110	$75,600

ALT-2B

PARAMETER	DREDGE-2B	CAP-2B	ENR-2B
Analytical Cost/Sample	$2,200	$2,200	$2,200
Remediation Area	10.3	10.3	29.7
Number of Samples per acre	4	2	2
Number of Days (5 samples/day -dredge, 10 samples/day cap-ENR)	8.24	2.06	5.94
Daily Labor, Equipment, Materials	$8,000	$8,000	$8,000
QC, Data management, Reporting	5%		
Subtotal Analytical:	$90,640	$45,320	$130,680
Subtotal Labor:	$65,920	$16,480	$47,520
TOTAL COST	$164,388	$64,890	$187,110

TABLE F-9. VERIFICATION SAMPLING FOR ALTERNATIVE 3

ALT-3A1

PARAMETER	DREDGE	CAP	ENR-3A1
Analytical Cost/Sample	$2,200	$2,200	$2,200
Remediation Area	10.3	5.4	19.7
Number of Samples per acre	4	2	2
Number of Days (5 samples/day -dredge, 10 samples/day cap-ENR)	8.24	1.08	3.94
Daily Labor, Equipment, Materials	$8,000	$8,000	$8,000
QC, Data management, Reporting	5%		
Subtotal Analytical:	$90,640	$23,760	$86,680
Subtotal Labor:	$65,920	$8,640	$31,520
TOTAL COST	$164,388	$34,020	$124,110

ALT-3A2

PARAMETER	DREDGE	CAP	ENR-3A2
Analytical Cost/Sample	$2,200	$2,200	$2,200
Remediation Area	18	5.4	12
Number of Samples per acre	4	2	2
Number of Days (5 samples/day -dredge, 10 samples/day cap-ENR)	14.4	1.08	2.4
Daily Labor, Equipment, Materials	$8,000	$8,000	$8,000
QC, Data management, Reporting	5%		
Subtotal Analytical:	$158,400	$23,760	$52,800
Subtotal Labor:	$115,200	$8,640	$19,200
TOTAL COST	$287,280	$34,020	$75,600

ALT-3B

PARAMETER	DREDGE	CAP	ENR-3B
Analytical Cost/Sample	$2,200	$2,200	$2,200
Remediation Area	4	6.3	19.7
Number of Samples per acre	4	2	2
Number of Days (5 samples/day -dredge, 10 samples/day cap-ENR)	3.2	1.26	3.94
Daily Labor, Equipment, Materials	$8,000	$8,000	$8,000
QC, Data management, Reporting	5%		
Subtotal Analytical:	$35,200	$27,720	$86,680
Subtotal Labor:	$25,600	$10,080	$31,520
TOTAL COST	$63,840	$39,690	$124,110

ALT-3C

PARAMETER	DREDGE	CAP	ENR-3C
Analytical Cost/Sample	$2,200	$2,200	$2,200
Remediation Area	10.3	1.3	18.4
Number of Samples per acre	4	2	2
Number of Days (5 samples/day -dredge, 10 samples/day cap-ENR)	8.24	0.26	3.68
Daily Labor, Equipment, Materials	$8,000	$8,000	$8,000
QC, Data management, Reporting	5%		
Subtotal Analytical:	$90,640	$5,720	$80,960
Subtotal Labor:	$65,920	$2,080	$29,440
TOTAL COST	$164,388	$8,190	$115,920

TABLE F-10. VERIFICATION SAMPLING FOR ALTERNATIVE 4

ALT-4A

PARAMETER	DREDGE	CAP	ENR
Analytical Cost/Sample	$2,200	$2,200	$2,200
Remediation Area	18	0	0
Number of Samples per acre	4	2	2
Number of Days (5 samples/day -dredge, 10 samples/day cap-ENR)	14.4	0	0
Daily Labor, Equipment, Materials	$8,000	$8,000	$8,000
QC, Data management, Reporting	5%		
Subtotal Analytical:	$158,400	$0	$0
Subtotal Labor:	$115,200	$0	$0
TOTAL COST	$287,280	$0	$0

ALT-4B

PARAMETER	DREDGE	CAP	ENR
Analytical Cost/Sample	$2,200	$2,200	$2,200
Remediation Area	30	0	0
Number of Samples per acre	4	2	2
Number of Days (5 samples/day -dredge, 10 samples/day cap-ENR)	24	0	0
Daily Labor, Equipment, Materials	$8,000	$8,000	$8,000
QC, Data management, Reporting	5%		
Subtotal Analytical:	$264,000	$0	$0
Subtotal Labor:	$192,000	$0	$0
TOTAL COST	$478,800	$0	$0

ALT-4C

PARAMETER	DREDGE	CAP	ENR
Analytical Cost/Sample	$2,200	$2,200	$2,200
Remediation Area	40	0	0
Number of Samples per acre	4	2	2
Number of Days (5 samples/day -dredge, 10 samples/day cap-ENR)	32	0	0
Daily Labor, Equipment, Materials	$8,000	$8,000	$8,000
QC, Data management, Reporting	5%		
Subtotal Analytical:	$352,000	$0	$0
Subtotal Labor:	$256,000	$0	$0
TOTAL COST	$638,400	$0	$0

TABLE F-11. ALTERNATIVE 2A1 - CONTAINMENT FOCUS - CAP/ENR TO SQS FOOTPRINT (CAP TO CSL, ENR TO SQS)

DREDGE AREA (AC) =	0	**DREDGE VOLUME (CY) =**	0
CAP AREA (AC) =	10.3	**CAP VOLUME (CY) =**	58,200
ENR AREA (AC) =	7.7	**ENR VOLUME (CY) =**	12,500

TASK	QUANTITY	UNIT	UNIT COST	TOTAL COST
PRE-CONSTRUCTION				
Contractor Submittals, Engineering, Surveying	1	LS	$150,000	$150,000
Mobilization/Demobilization	1	LS	$500,000	$500,000
Site Preparation, Environmental Controls	1	LS	$150,000	$150,000
Subtotal:				**$800,000**
PIER DEMOLITION				
Pier Demolition, Handling and Delivery to Rail				
Creosote Treated Wood	9900	TON	$110	$1,094,000
Debris and Pilings, Metal Waste	170	TON	$110	$19,000
Transport and Disposal	10070	TON	$68	$690,000
Demolition QA/QC, Waste Characterization, Monitoring	1	LS	$456,000	$456,000
Subtotal:				$2,824,000
Subtotal Cost Based on Applicability to Each Alternative:	0%		$2,824,000	**$0**
DREDGING, RESIDUAL MANAGEMENT, DISPOSAL				
Dredging	0	CY	$20	$0
Material Barge, Assist Tug, Transport Sediments to Transloading Facility	0	TON	$12	$0
Transloading Area Setup	0	LS	$1,000,000	$0
Water Management	0	Daily Rate	$8,000	$0
Handling, Transport and Subtitle D Landfill Disposal	0	TON	$60	$0
Backfill Material Procurement, Delivery, Placement	0	CY	$20	$0
Subtotal:				**$0**
SEDIMENT CAPPING & ENR				
Cap Material Procurement, Delivery, Placement	58,200	CY	$30	$1,920,600
ENR Material Procurement, Delivery, Placement	12,500	CY	$30	$412,500
Material Barge and Assist Tug for Capping	87,300	TON	$10	$960,300
Material Barge and Assist Tug for ENR	18,750	TON	$10	$206,250
Subtotal:				**$3,499,650**
SHIPWAY REMEDIATION				
Removal and Disposal	648	CY	$100	$64,815
Cap/Habitat Material Procurement and Placement	7,260	CY	$30	$217,800
Subtotal:				**$282,615**
SHORELINE REMEDIATION				
Removal and Disposal	9,300	CY	$100	$930,000
Backfill Placement	11,160	CY	$20	$223,200
Shoreline Stabilization (Riprap) Procurement and Placement	3,516	TON	$50	$175,817
Habitat Material (Sand & Fish Mix) Procurement and Placement	1,852	CY	$30	$55,556
Habitat Enhancement and Riparian Planting	2.00	AC	$50,000	$100,000
Subtotal:				**$1,484,572**
CONSTRUCTION QA&QC AND MONITORING				
Bathymetric Surveys/ Water Quality Monitoring	54	Daily Rate	$7,000	$380,392
Verification Sediment Sampling (Dredging)	1	LS	$0	$0
Verification Sediment Sampling (Capping)	1	LS	$64,890	$64,890
Verification Sediment Sampling (ENR)	1	LS	$48,510	$48,510
Remedial Action Completion Reporting	1	LS	$80,000	$80,000
Subtotal:				**$573,792**
			BASE CAPITAL COST	**$6,640,629**
ENGINEERING, CONSTRUCTION SUPPORT, OVERSIGHT				
Construction Contingency	35%			$2,324,220
Project Management	5%			$332,031
Remedial Design and Data Collection	8%			$531,250
Construction Management/QA Support	6%			$398,438
Agency Oversight (25% of Construction Management/QA Support)	1.5%			$99,609
WA State Sales Tax	9.5%			$630,860
Subtotal:				**$4,316,409**
			TOTAL CAPITAL COST	**$10,957,038**
ICs, Long-Term OM&M				
ICs Planning and Implementation	1	LS	$512,009	$512,009
Long-Term Operation and Maintenance Monitoring (Cap)	1	LS	$461,920	$461,920
Long-Term OM&M (Dredge, ENR, unremediated area)	1	LS	$918,425	$918,425
ENR Repair	1	LS	$43,750	$43,750
Cap Repair (Full cap repair at $70/CY)	1	LS	$4,074,000	$4,074,000
Subtotal:				**$6,010,104**
			TOTAL COST	**$16,970,000**

TABLE F-12. ALTERNATIVE 2A2a - CONTAINMENT FOCUS - CAP/ENR TO URBAN FOOTPRINT (CAP TO CSL, ENR TO URBAN)

DREDGE AREA (AC) =	0	**DREDGE VOLUME (CY) =**	0
CAP AREA (AC) =	10.3	**CAP VOLUME (CY) =**	58,200
ENR AREA (AC) =	19.7	**ENR VOLUME (CY) =**	31,800

TASK	QUANTITY	UNIT	UNIT COST	TOTAL COST
PRE-CONSTRUCTION				
Contractor Submittals, Engineering, Surveying	1	LS	$150,000	$150,000
Mobilization/Demobilization	1	LS	$500,000	$500,000
Site Preparation, Environmental Controls	1	LS	$150,000	$150,000
Subtotal:				**$800,000**
PIER DEMOLITION				
Pier Demolition, Handling and Delivery to Rail				
Creosote Treated Wood	9900	TON	$110	$1,094,000
Debris and Pilings, Metal Waste	170	TON	$110	$19,000
Transport and Disposal	10070	TON	$68	$690,000
Demolition QA/QC, Waste Characterization, Monitoring	1	LS	$456,000	$456,000
Subtotal:				$2,824,000
Subtotal Cost Based on Applicability to Each Alternative:	0%		$2,824,000	**$0**
DREDGING, RESIDUAL MANAGEMENT, DISPOSAL				
Dredging	0	CY	$20	$0
Material Barge, Assist Tug, Transport Sediments to Transloading Facility	0	TON	$12	$0
Transloading Area Setup	0	LS	$1,000,000	$0
Water Management	0	Daily Rate	$8,000	$0
Handling, Transport and Subtitle D Landfill Disposal	0	TON	$60	$0
Backfill Material Procurement, Delivery, Placement	0	CY	$20	$0
Subtotal:				**$0**
SEDIMENT CAPPING & ENR				
Cap Material Procurement, Delivery, Placement	58,200	CY	$30	$1,920,600
ENR Material Procurement, Delivery, Placement	31,800	CY	$30	$1,049,400
Material Barge and Assist Tug for Capping	87,300	TON	$10	$960,300
Material Barge and Assist Tug for ENR	47,700	TON	$10	$524,700
Subtotal:				**$4,455,000**
SHIPWAY REMEDIATION				
Removal and Disposal	648	CY	$100	$64,815
Cap/Habitat Material Procurement and Placement	7,260	CY	$30	$217,800
Subtotal:				**$282,615**
SHORELINE REMEDIATION				
Removal and Disposal	9,300	CY	$100	$930,000
Backfill Placement	11,160	CY	$20	$223,200
Shoreline Stabilization (Riprap) Procurement and Placement	3,516	TON	$50	$175,817
Habitat Material (Sand & Fish Mix) Procurement and Placement	1,852	CY	$30	$55,556
Habitat Enhancement and Riparian Planting	2.00	AC	$50,000	$100,000
Subtotal:				**$1,484,572**
CONSTRUCTION QA&QC AND MONITORING				
Bathymetric Surveys/ Water Quality Monitoring	54	Daily Rate	$7,000	$380,392
Verification Sediment Sampling (Dredging)	1	LS	$0	$0
Verification Sediment Sampling (Capping)	1	LS	$64,890	$64,890
Verification Sediment Sampling (ENR)	1	LS	$124,110	$124,110
Remedial Action Completion Reporting	1	LS	$80,000	$80,000
Subtotal:				**$649,392**
			BASE CAPITAL COST	**$7,671,579**
ENGINEERING, CONSTRUCTION SUPPORT, OVERSIGHT				
Construction Contingency	35%			$2,685,053
Project Management	5%			$383,579
Remedial Design and Data Collection	8%			$613,726
Construction Management/QA Support	6%			$460,295
Agency Oversight (25% of Construction Management/QA Support)	1.5%			$115,074
WA State Sales Tax	9.5%			$728,800
Subtotal:				**$4,986,526**
			TOTAL CAPITAL COST	**$12,658,106**
ICs, Long-Term OM&M				
ICs Planning and Implementation	1	LS	$512,009	$512,009
Long-Term Operation and Maintenance Monitoring (Cap)	1	LS	$461,920	$461,920
Long-Term OM&M (Dredge, ENR, unremediated area)	1	LS	$918,425	$918,425
ENR Repair	1	LS	$111,300	$111,300
Cap Repair (Full cap repair at $70/CY)	1	LS	$4,074,000	$4,074,000
Subtotal:				**$6,077,654**
			TOTAL COST	**$18,740,000**

TABLE F-13. ALTERNATIVE 2A2b - CONTAINMENT FOCUS - CAP/ENR TO URBAN FOOTPRINT (CAP TO SQS, ENR TO URBAN)

DREDGE AREA (AC) =	0	**DREDGE VOLUME (CY) =**	0
CAP AREA (AC) =	18	**CAP VOLUME (CY) =**	101,700
ENR AREA (AC) =	12	**ENR VOLUME (CY) =**	19,400

TASK	QUANTITY	UNIT	UNIT COST	TOTAL COST
PRE-CONSTRUCTION				
Contractor Submittals, Engineering, Surveying	1	LS	$150,000	$150,000
Mobilization/Demobilization	1	LS	$500,000	$500,000
Site Preparation, Environmental Controls	1	LS	$150,000	$150,000
Subtotal:				**$800,000**
PIER DEMOLITION				
Pier Demolition, Handling and Delivery to Rail				
Creosote Treated Wood	9900	TON	$110	$1,094,000
Debris and Pilings, Metal Waste	170	TON	$110	$19,000
Transport and Disposal	10070	TON	$68	$690,000
Demolition QA/QC, Waste Characterization, Monitoring	1	LS	$456,000	$456,000
Subtotal:				$2,824,000
Subtotal Cost Based on Applicability to Each Alternative:	0%		$2,824,000	**$0**
DREDGING, RESIDUAL MANAGEMENT, DISPOSAL				
Dredging	0	CY	$20	$0
Material Barge, Assist Tug, Transport Sediments to Transloading Facility	0	TON	$12	$0
Transloading Area Setup	0	LS	$1,000,000	$0
Water Management	0	Daily Rate	$8,000	$0
Handling, Transport and Subtitle D Landfill Disposal	0	TON	$60	$0
Backfill Material Procurement, Delivery, Placement	0	CY	$20	$0
Subtotal:				**$0**
SEDIMENT CAPPING & ENR				
Cap Material Procurement, Delivery, Placement	101,700	CY	$30	$3,356,100
ENR Material Procurement, Delivery, Placement	19,400	CY	$30	$640,200
Material Barge and Assist Tug for Capping	152,550	TON	$10	$1,678,050
Material Barge and Assist Tug for ENR	29,100	TON	$10	$320,100
Subtotal:				**$5,994,450**
SHIPWAY REMEDIATION				
Removal and Disposal	648	CY	$100	$64,815
Cap/Habitat Material Procurement and Placement	7,260	CY	$30	$217,800
Subtotal:				**$282,615**
SHORELINE REMEDIATION				
Removal and Disposal	9,300	CY	$100	$930,000
Backfill Placement	11,160	CY	$20	$223,200
Shoreline Stabilization (Riprap) Procurement and Placement	3,516	TON	$50	$175,817
Habitat Material (Sand & Fish Mix) Procurement and Placement	1,852	CY	$30	$55,556
Habitat Enhancement and Riparian Planting	2.00	AC	$50,000	$100,000
Subtotal:				**$1,484,572**
CONSTRUCTION QA&QC AND MONITORING				
Bathymetric Surveys/ Water Quality Monitoring	95	Daily Rate	$7,000	$664,706
Verification Sediment Sampling (Dredging)	1	LS	$0	$0
Verification Sediment Sampling (Capping)	1	LS	$189,000	$189,000
Verification Sediment Sampling (ENR)	1	LS	$75,600	$75,600
Remedial Action Completion Reporting	1	LS	$80,000	$80,000
Subtotal:				**$1,009,306**
			BASE CAPITAL COST	**$9,570,943**
ENGINEERING, CONSTRUCTION SUPPORT, OVERSIGHT				
Construction Contingency	35%			$3,349,830
Project Management	5%			$478,547
Remedial Design and Data Collection	8%			$765,675
Construction Management/QA Support	6%			$574,257
Agency Oversight (25% of Construction Management/QA Support)	1.5%			$143,564
WA State Sales Tax	9.5%			$909,240
Subtotal:				**$6,221,113**
			TOTAL CAPITAL COST	**$15,792,056**
ICs, Long-Term OM&M				
ICs Planning and Implementation	1	LS	$512,009	$512,009
Long-Term Operation and Maintenance Monitoring (Cap)	1	LS	$807,238	$807,238
Long-Term OM&M (Dredge, ENR, unremediated area)	1	LS	$663,123	$663,123
ENR Repair	1	LS	$67,900	$67,900
Cap Repair (Full cap repair at $70/CY)	1	LS	$7,119,000	$7,119,000
Subtotal:				**$9,169,270**
			TOTAL COST	**$24,970,000**

TABLE F-14. ALTERNATIVE 2A3 - CONTAINMENT FOCUS - CAP/ENR TO STUDY AREA BOUNDARY (CAP TO CSL, ENR TO STUDY AREA BOUNDARY)

DREDGE AREA (AC) =	0	**DREDGE VOLUME (CY) =**	0
CAP AREA (AC) =	10.3	**CAP VOLUME (CY) =**	58,200
ENR AREA (AC) =	29.7	**ENR VOLUME (CY) =**	48,000

TASK	QUANTITY	UNIT	UNIT COST	TOTAL COST
PRE-CONSTRUCTION				
Contractor Submittals, Engineering, Surveying	1	LS	$150,000	$150,000
Mobilization/Demobilization	1	LS	$500,000	$500,000
Site Preparation, Environmental Controls	1	LS	$150,000	$150,000
Subtotal:				**$800,000**
PIER DEMOLITION				
Pier Demolition, Handling and Delivery to Rail				
Creosote Treated Wood	9900	TON	$110	$1,094,000
Debris and Pilings, Metal Waste	170	TON	$110	$19,000
Transport and Disposal	10070	TON	$68	$690,000
Demolition QA/QC, Waste Characterization, Monitoring	1	LS	$456,000	$456,000
Subtotal:				$2,824,000
Subtotal Cost Based on Applicability to Each Alternative:	0%		$2,824,000	**$0**
DREDGING, RESIDUAL MANAGEMENT, DISPOSAL				
Dredging	0	CY	$20	$0
Material Barge, Assist Tug, Transport Sediments to Transloading Facility	0	TON	$12	$0
Transloading Area Setup	0	LS	$1,000,000	$0
Water Management	0	Daily Rate	$8,000	$0
Handling, Transport and Subtitle D Landfill Disposal	0	TON	$60	$0
Backfill Material Procurement, Delivery, Placement	0	CY	$20	$0
Subtotal:				**$0**
SEDIMENT CAPPING & ENR				
Cap Material Procurement, Delivery, Placement	58,200	CY	$30	$1,920,600
ENR Material Procurement, Delivery, Placement	48,000	CY	$30	$1,584,000
Material Barge and Assist Tug for Capping	87,300	TON	$10	$960,300
Material Barge and Assist Tug for ENR	72,000	TON	$10	$792,000
Subtotal:				**$5,256,900**
SHIPWAY REMEDIATION				
Removal and Disposal	648	CY	$100	$64,815
Cap/Habitat Material Procurement and Placement	7,260	CY	$30	$217,800
Subtotal:				**$282,615**
SHORELINE REMEDIATION				
Removal and Disposal	9,300	CY	$100	$930,000
Backfill Placement	11,160	CY	$20	$223,200
Shoreline Stabilization (Riprap) Procurement and Placement	3,516	TON	$50	$175,817
Habitat Material (Sand & Fish Mix) Procurement and Placement	1,852	CY	$30	$55,556
Habitat Enhancement and Riparian Planting	2.00	AC	$50,000	$100,000
Subtotal:				**$1,484,572**
CONSTRUCTION QA&QC AND MONITORING				
Bathymetric Surveys/ Water Quality Monitoring	54	Daily Rate	$7,000	$380,392
Verification Sediment Sampling (Dredging)	1	LS	$0	$0
Verification Sediment Sampling (Capping)	1	LS	$64,890	$64,890
Verification Sediment Sampling (ENR)	1	LS	$187,110	$187,110
Remedial Action Completion Reporting	1	LS	$80,000	$80,000
Subtotal:				**$712,392**
			BASE CAPITAL COST	**$8,536,479**
ENGINEERING, CONSTRUCTION SUPPORT, OVERSIGHT				
Construction Contingency	35%			$2,987,768
Project Management	5%			$426,824
Remedial Design and Data Collection	8%			$682,918
Construction Management/QA Support	6%			$512,189
Agency Oversight (25% of Construction Management/QA Support)	1.5%			$128,047
WA State Sales Tax	9.5%			$810,966
Subtotal:				**$5,548,711**
			TOTAL CAPITAL COST	**$14,085,191**
ICs, Long-Term OM&M				
ICs Planning and Implementation	1	LS	$512,009	$512,009
Long-Term Operation and Maintenance Monitoring (Cap)	1	LS	$461,920	$461,920
Long-Term OM&M (Dredge, ENR, unremediated area)	1	LS	$918,425	$918,425
ENR Repair	1	LS	$168,000	$168,000
Cap Repair (Full cap repair at $70/CY)	1	LS	$4,074,000	$4,074,000
Subtotal:				**$6,134,354**
			TOTAL COST	**$20,220,000**

TABLE F-15. ALTERNATIVE 2A4a - CONTAINMENT FOCUS - CAP TO SQS FOOTPRINT (CONVENTIONAL CAP)

DREDGE AREA (AC) =	0	**DREDGE VOLUME (CY) =**	0
CAP AREA (AC) =	18	**CAP VOLUME (CY) =**	101,700
ENR AREA (AC) =	0	**ENR VOLUME (CY) =**	0

TASK	QUANTITY	UNIT	UNIT COST	TOTAL COST
PRE-CONSTRUCTION				
Contractor Submittals, Engineering, Surveying	1	LS	$150,000	$150,000
Mobilization/Demobilization	1	LS	$500,000	$500,000
Site Preparation, Environmental Controls	1	LS	$150,000	$150,000
Subtotal:				**$800,000**
PIER DEMOLITION				
Pier Demolition, Handling and Delivery to Rail				
Creosote Treated Wood	9900	TON	$110	$1,094,000
Debris and Pilings, Metal Waste	170	TON	$110	$19,000
Transport and Disposal	10070	TON	$68	$690,000
Demolition QA/QC, Waste Characterization, Monitoring	1	LS	$456,000	$456,000
Subtotal:				$2,824,000
Subtotal Cost Based on Applicability to Each Alternative:	0%		$2,824,000	**$0**
DREDGING, RESIDUAL MANAGEMENT, DISPOSAL				
Dredging	0	CY	$20	$0
Material Barge, Assist Tug, Transport Sediments to Transloading Facility	0	TON	$12	$0
Transloading Area Setup	0	LS	$1,000,000	$0
Water Management	0	Daily Rate	$8,000	$0
Handling, Transport and Subtitle D Landfill Disposal	0	TON	$60	$0
Backfill Material Procurement, Delivery, Placement	0	CY	$20	$0
Subtotal:				**$0**
SEDIMENT CAPPING & ENR				
Cap Material Procurement, Delivery, Placement	101,700	CY	$30	$3,356,100
ENR Material Procurement, Delivery, Placement	0	CY	$30	$0
Material Barge and Assist Tug for Capping	152,550	TON	$10	$1,678,050
Material Barge and Assist Tug for ENR	0	TON	$10	$0
Subtotal:				**$5,034,150**
SHIPWAY REMEDIATION				
Removal and Disposal	648	CY	$100	$64,815
Cap/Habitat Material Procurement and Placement	7,260	CY	$30	$217,800
Subtotal:				**$282,615**
SHORELINE REMEDIATION				
Removal and Disposal	9,300	CY	$100	$930,000
Backfill Placement	11,160	CY	$20	$223,200
Shoreline Stabilization (Riprap) Procurement and Placement	3,516	TON	$50	$175,817
Habitat Material (Sand & Fish Mix) Procurement and Placement	1,852	CY	$30	$55,556
Habitat Enhancement and Riparian Planting	2.00	AC	$50,000	$100,000
Subtotal:				**$1,484,572**
CONSTRUCTION QA&QC AND MONITORING				
Bathymetric Surveys/ Water Quality Monitoring	95	Daily Rate	$7,000	$664,706
Verification Sediment Sampling (Dredging)	1	LS	$0	$0
Verification Sediment Sampling (Capping)	1	LS	$113,400	$113,400
Verification Sediment Sampling (ENR)	0	LS	$0	$0
Remedial Action Completion Reporting	1	LS	$80,000	$80,000
Subtotal:				**$858,106**
			BASE CAPITAL COST	**$8,459,443**
ENGINEERING, CONSTRUCTION SUPPORT, OVERSIGHT				
Construction Contingency	35%			$2,960,805
Project Management	5%			$422,972
Remedial Design and Data Collection	8%			$676,755
Construction Management/QA Support	6%			$507,567
Agency Oversight (25% of Construction Management/QA Support)	1.5%			$126,892
WA State Sales Tax	9.5%			$803,647
Subtotal:				**$5,498,638**
			TOTAL CAPITAL COST	**$13,958,081**
ICs, Long-Term OM&M				
ICs Planning and Implementation	1	LS	$512,009	$512,009
Long-Term Operation and Maintenance Monitoring (Cap)	1	LS	$807,238	$807,238
Long-Term OM&M (Dredge, ENR, unremediated area)	0	LS	$663,123	$0
ENR Repair	1	LS	$0	$0
Cap Repair (Full cap repair at $70/CY)	1	LS	$7,119,000	$7,119,000
Subtotal:				**$8,438,247**
			TOTAL COST	**$22,400,000**

TABLE F-16. ALTERNATIVE 2A4b - CONTAINMENT FOCUS - CAP TO URBAN FOOTPRINT (CONVENTIONAL CAP)

DREDGE AREA (AC) =	0	**DREDGE VOLUME (CY) =**	0
CAP AREA (AC) =	30	**CAP VOLUME (CY) =**	169,400
ENR AREA (AC) =	0	**ENR VOLUME (CY) =**	0

TASK	QUANTITY	UNIT	UNIT COST	TOTAL COST
PRE-CONSTRUCTION				
Contractor Submittals, Engineering, Surveying	1	LS	$150,000	$150,000
Mobilization/Demobilization	1	LS	$500,000	$500,000
Site Preparation, Environmental Controls	1	LS	$150,000	$150,000
Subtotal:				**$800,000**
PIER DEMOLITION				
Pier Demolition, Handling and Delivery to Rail				
Creosote Treated Wood	9900	TON	$110	$1,094,000
Debris and Pilings, Metal Waste	170	TON	$110	$19,000
Transport and Disposal	10070	TON	$68	$690,000
Demolition QA/QC, Waste Characterization, Monitoring	1	LS	$456,000	$456,000
Subtotal:				$2,824,000
Subtotal Cost Based on Applicability to Each Alternative:	0%		$2,824,000	**$0**
DREDGING, RESIDUAL MANAGEMENT, DISPOSAL				
Dredging	0	CY	$20	$0
Material Barge, Assist Tug, Transport Sediments to Transloading Facility	0	TON	$12	$0
Transloading Area Setup	0	LS	$1,000,000	$0
Water Management	0	Daily Rate	$8,000	$0
Handling, Transport and Subtitle D Landfill Disposal	0	TON	$60	$0
Backfill Material Procurement, Delivery, Placement	0	CY	$20	$0
Subtotal:				**$0**
SEDIMENT CAPPING & ENR				
Cap Material Procurement, Delivery, Placement	169,400	CY	$30	$5,590,200
ENR Material Procurement, Delivery, Placement	0	CY	$30	$0
Material Barge and Assist Tug for Capping	254,100	TON	$10	$2,795,100
Material Barge and Assist Tug for ENR	0	TON	$10	$0
Subtotal:				**$8,385,300**
SHIPWAY REMEDIATION				
Removal and Disposal	648	CY	$100	$64,815
Cap/Habitat Material Procurement and Placement	7,260	CY	$30	$217,800
Subtotal:				**$282,615**
SHORELINE REMEDIATION				
Removal and Disposal	9,300	CY	$100	$930,000
Backfill Placement	11,160	CY	$20	$223,200
Shoreline Stabilization (Riprap) Procurement and Placement	3,516	TON	$50	$175,817
Habitat Material (Sand & Fish Mix) Procurement and Placement	1,852	CY	$30	$55,556
Habitat Enhancement and Riparian Planting	2.00	AC	$50,000	$100,000
Subtotal:				**$1,484,572**
CONSTRUCTION QA&QC AND MONITORING				
Bathymetric Surveys/ Water Quality Monitoring	158	Daily Rate	$7,000	$1,107,190
Verification Sediment Sampling (Dredging)	1	LS	$0	$0
Verification Sediment Sampling (Capping)	1	LS	$189,000	$189,000
Verification Sediment Sampling (ENR)	0	LS	$0	$0
Remedial Action Completion Reporting	1	LS	$80,000	$80,000
Subtotal:				**$1,376,190**
			BASE CAPITAL COST	**$12,328,677**
ENGINEERING, CONSTRUCTION SUPPORT, OVERSIGHT				
Construction Contingency	35%			$4,315,037
Project Management	5%			$616,434
Remedial Design and Data Collection	8%			$986,294
Construction Management/QA Support	6%			$739,721
Agency Oversight (25% of Construction Management/QA Support)	1.5%			$184,930
WA State Sales Tax	9.5%			$1,171,224
Subtotal:				**$8,013,640**
			TOTAL CAPITAL COST	**$20,342,316**
ICs, Long-Term OM&M				
ICs Planning and Implementation	1	LS	$512,009	$512,009
Long-Term Operation and Maintenance Monitoring (Cap)	1	LS	$1,345,397	$1,345,397
Long-Term OM&M (Dredge, ENR, unremediated area)	0	LS	$265,249	$0
ENR Repair	1	LS	$0	$0
Cap Repair (Full cap repair at $70/CY)	1	LS	$11,858,000	$11,858,000
Subtotal:				**$13,715,406**
			TOTAL COST	**$34,060,000**

TABLE F-17. ALTERNATIVE 2A4c - CONTAINMENT FOCUS - CAP TO STUDY AREA BOUNDARY (CONVENTIONAL CAP)

DREDGE AREA (AC) =	0	**DREDGE VOLUME (CY) =**	0
CAP AREA (AC) =	40	**CAP VOLUME (CY) =**	225,900
ENR AREA (AC) =	0	**ENR VOLUME (CY) =**	0

TASK	QUANTITY	UNIT	UNIT COST	TOTAL COST
PRE-CONSTRUCTION				
Contractor Submittals, Engineering, Surveying	1	LS	$150,000	$150,000
Mobilization/Demobilization	1	LS	$500,000	$500,000
Site Preparation, Environmental Controls	1	LS	$150,000	$150,000
Subtotal:				**$800,000**
PIER DEMOLITION				
Pier Demolition, Handling and Delivery to Rail				
Creosote Treated Wood	9900	TON	$110	$1,094,000
Debris and Pilings, Metal Waste	170	TON	$110	$19,000
Transport and Disposal	10070	TON	$68	$690,000
Demolition QA/QC, Waste Characterization, Monitoring	1	LS	$456,000	$456,000
Subtotal:				$2,824,000
Subtotal Cost Based on Applicability to Each Alternative:	0%		$2,824,000	**$0**
DREDGING, RESIDUAL MANAGEMENT, DISPOSAL				
Dredging	0	CY	$20	$0
Material Barge, Assist Tug, Transport Sediments to Transloading Facility	0	TON	$12	$0
Transloading Area Setup	0	LS	$1,000,000	$0
Water Management	0	Daily Rate	$8,000	$0
Handling, Transport and Subtitle D Landfill Disposal	0	TON	$60	$0
Backfill Material Procurement, Delivery, Placement	0	CY	$20	$0
Subtotal:				**$0**
SEDIMENT CAPPING & ENR				
Cap Material Procurement, Delivery, Placement	225,900	CY	$30	$7,454,700
ENR Material Procurement, Delivery, Placement	0	CY	$30	$0
Material Barge and Assist Tug for Capping	338,850	TON	$10	$3,727,350
Material Barge and Assist Tug for ENR	0	TON	$10	$0
Subtotal:				**$11,182,050**
SHIPWAY REMEDIATION				
Removal and Disposal	648	CY	$100	$64,815
Cap/Habitat Material Procurement and Placement	7,260	CY	$30	$217,800
Subtotal:				**$282,615**
SHORELINE REMEDIATION				
Removal and Disposal	9,300	CY	$100	$930,000
Backfill Placement	11,160	CY	$20	$223,200
Shoreline Stabilization (Riprap) Procurement and Placement	3,516	TON	$50	$175,817
Habitat Material (Sand & Fish Mix) Procurement and Placement	1,852	CY	$30	$55,556
Habitat Enhancement and Riparian Planting	2.00	AC	$50,000	$100,000
Subtotal:				**$1,484,572**
CONSTRUCTION QA&QC AND MONITORING				
Bathymetric Surveys/ Water Quality Monitoring	211	Daily Rate	$7,000	$1,476,471
Verification Sediment Sampling (Dredging)	1	LS	$0	$0
Verification Sediment Sampling (Capping)	1	LS	$252,000	$252,000
Verification Sediment Sampling (ENR)	0	LS	$0	$0
Remedial Action Completion Reporting	1	LS	$80,000	$80,000
Subtotal:				**$1,808,471**
			BASE CAPITAL COST	**$15,557,708**
ENGINEERING, CONSTRUCTION SUPPORT, OVERSIGHT				
Construction Contingency	35%			$5,445,198
Project Management	5%			$777,885
Remedial Design and Data Collection	8%			$1,244,617
Construction Management/QA Support	6%			$933,462
Agency Oversight (25% of Construction Management/QA Support)	1.5%			$233,366
WA State Sales Tax	9.5%			$1,477,982
Subtotal:				**$10,112,510**
			TOTAL CAPITAL COST	**$25,670,218**
ICs, Long-Term OM&M				
ICs Planning and Implementation	1	LS	$512,009	$512,009
Long-Term Operation and Maintenance Monitoring (Cap)	1	LS	$1,793,863	$1,793,863
Long-Term OM&M (Dredge, ENR, unremediated area)	0	LS	$0	$0
ENR Repair	1	LS	$0	$0
Cap Repair (Full cap repair at $70/CY)	1	LS	$15,813,000	$15,813,000
Subtotal:				**$18,118,872**
			TOTAL COST	**$43,790,000**

TABLE F-18. ALTERNATIVE 2B - CONTAINMENT FOCUS - CAP/ENR TO STUDY AREA BOUNDARY WITH REMOVAL TO MINIMIZE CHANGES TO WATER DEPTH (DREDGE TO FIT 3 FT CAP TO CSL , ENR TO STUDY AREA BOUNDARY)

DREDGE AREA (AC) =	10.3	**DREDGE VOLUME (CY) =**	51,800
CAP AREA (AC) =	10.3	**CAP VOLUME (CY) =**	58,200
ENR AREA (AC) =	29.7	**ENR VOLUME (CY) =**	48,000

TASK	QUANTITY	UNIT	UNIT COST	TOTAL COST
PRE-CONSTRUCTION				
Contractor Submittals, Engineering, Surveying	1	LS	$150,000	$150,000
Mobilization/Demobilization	1	LS	$500,000	$500,000
Site Preparation, Environmental Controls	1	LS	$150,000	$150,000
Subtotal:				**$800,000**
PIER DEMOLITION				
Pier Demolition, Handling and Delivery to Rail				
Creosote Treated Wood	9900	TON	$110	$1,094,000
Debris and Pilings, Metal Waste	170	TON	$110	$19,000
Transport and Disposal	10070	TON	$68	$690,000
Demolition QA/QC, Waste Characterization, Monitoring	1	LS	$456,000	$456,000
Subtotal:				$2,824,000
Subtotal Cost Based on Applicability to Each Alternative:	0%		$2,824,000	**$0**
DREDGING, RESIDUAL MANAGEMENT, DISPOSAL				
Dredging	51,800	CY	$20	$1,036,000
Material Barge, Assist Tug, Transport Sediments to Transloading Facility	77,700	TON	$12	$932,400
Transloading Area Setup	1	LS	$1,000,000	$1,000,000
Water Management	63	Daily Rate	$8,000	$507,843
Handling, Transport and Subtitle D Landfill Disposal	77,700	TON	$60	$4,662,000
Backfill Material Procurement, Delivery, Placement	0	CY	$20	$0
Subtotal:				**$8,138,243**
SEDIMENT CAPPING & ENR				
Cap Material Procurement, Delivery, Placement	58,200	CY	$30	$1,920,600
ENR Material Procurement, Delivery, Placement	48,000	CY	$30	$1,584,000
Material Barge and Assist Tug for Capping	87,300	TON	$10	$960,300
Material Barge and Assist Tug for ENR	72,000	TON	$10	$792,000
Subtotal:				**$5,256,900**
SHIPWAY REMEDIATION				
Removal and Disposal	648	CY	$100	$64,815
Cap/Habitat Material Procurement and Placement	7,260	CY	$30	$217,800
Subtotal:				**$282,615**
SHORELINE REMEDIATION				
Removal and Disposal	9,300	CY	$100	$930,000
Backfill Placement	11,160	CY	$20	$223,200
Shoreline Stabilization (Riprap) Procurement and Placement	3,516	TON	$50	$175,817
Habitat Material (Sand & Fish Mix) Procurement and Placement	1,852	CY	$30	$55,556
Habitat Enhancement and Riparian Planting	2.00	AC	$50,000	$100,000
Subtotal:				**$1,484,572**
CONSTRUCTION QA&QC AND MONITORING				
Bathymetric Surveys/ Water Quality Monitoring	63	Daily Rate	$7,000	$444,363
Verification Sediment Sampling (Dredging)	1	LS	$164,388	$164,388
Verification Sediment Sampling (Capping)	1	LS	$64,890	$64,890
Verification Sediment Sampling (ENR)	1	LS	$187,110	$187,110
Remedial Action Completion Reporting	1	LS	$80,000	$80,000
Subtotal:				**$940,751**
			BASE CAPITAL COST	**$16,903,081**
ENGINEERING, CONSTRUCTION SUPPORT, OVERSIGHT				
Construction Contingency	35%			$5,916,078
Project Management	5%			$845,154
Remedial Design and Data Collection	8%			$1,352,246
Construction Management/QA Support	6%			$1,014,185
Agency Oversight (25% of Construction Management/QA Support)	1.5%			$253,546
WA State Sales Tax	9.5%			$1,162,903
Subtotal:				**$10,544,113**
			TOTAL CAPITAL COST	**$27,447,194**
ICs, Long-Term OM&M				
ICs Planning and Implementation	1	LS	$512,009	$512,009
Long-Term Operation and Maintenance Monitoring (Cap)	1	LS	$461,920	$461,920
Long-Term OM&M (Dredge, ENR, unremediated area)	1	LS	$576,917	$576,917
ENR Repair	1	LS	$168,000	$168,000
Cap Repair (Full cap repair at $70/CY)	1	LS	$4,074,000	$4,074,000
Subtotal:				**$5,792,846**
			TOTAL COST	**$33,250,000**

TABLE F-19. ALTERNATIVE 3A1 - REMOVAL FOCUS - REMOVE UPTO 3 FEET OVER CSL FOOTPRINT, CAP/ENR TO URBAN FOOTPRINT

(REMOVE UPTO 3FT TO CSL, CAP TO > 2xSQS, ENR TO URBAN)

DREDGE AREA (AC) =	10.3	DREDGE VOLUME (CY) =	55,500
CAP AREA (AC) =	5.4	CAP VOLUME (CY) =	30,500
ENR AREA (AC) =	19.7	ENR VOLUME (CY) =	31,800

TASK	QUANTITY	UNIT	UNIT COST	TOTAL COST
PRE-CONSTRUCTION				
Contractor Submittals, Engineering, Surveying	1	LS	$150,000	$150,000
Mobilization/Demobilization	1	LS	$500,000	$500,000
Site Preparation, Environmental Controls	1	LS	$150,000	$150,000
Subtotal:				**$800,000**
PIER DEMOLITION				
Pier Demolition, Handling and Delivery to Rail				
Creosote Treated Wood	9900	TON	$110	$1,094,000
Debris and Pilings, Metal Waste	170	TON	$110	$19,000
Transport and Disposal	10070	TON	$68	$690,000
Demolition QA/QC, Waste Characterization, Monitoring	1	LS	$456,000	$456,000
Subtotal:				$2,824,000
Subtotal Cost Based on Applicability to Each Alternative:	0%		$2,824,000	**$0**
DREDGING, RESIDUAL MANAGEMENT, DISPOSAL				
Dredging	55,500	CY	$20	$1,110,000
Material Barge, Assist Tug, Transport Sediments to Transloading Facility	83,250	TON	$12	$999,000
Transloading Area Setup	1	LS	$1,000,000	$1,000,000
Water Management	68	Daily Rate	$8,000	$544,118
Handling, Transport and Subtitle D Landfill Disposal	83,250	TON	$60	$4,995,000
Backfill Material Procurement, Delivery, Placement	5,929	CY	$20	$118,580
Subtotal:				**$8,766,698**
SEDIMENT CAPPING & ENR				
Cap Material Procurement, Delivery, Placement	30,500	CY	$30	$1,006,500
ENR Material Procurement, Delivery, Placement	31,800	CY	$30	$1,049,400
Material Barge and Assist Tug for Capping	45,750	TON	$10	$503,250
Material Barge and Assist Tug for ENR	47,700	TON	$10	$524,700
Subtotal:				**$3,083,850**
SHIPWAY REMEDIATION				
Removal and Disposal	648	CY	$100	$64,815
Cap/Habitat Material Procurement and Placement	7,260	CY	$30	$217,800
Subtotal:				**$282,615**
SHORELINE REMEDIATION				
Removal and Disposal	9,300	CY	$100	$930,000
Backfill Placement	11,160	CY	$20	$223,200
Shoreline Stabilization (Riprap) Procurement and Placement	3,516	TON	$50	$175,817
Habitat Material (Sand & Fish Mix) Procurement and Placement	1,852	CY	$30	$55,556
Habitat Enhancement and Riparian Planting	2.00	AC	$50,000	$100,000
Subtotal:				**$1,484,572**
CONSTRUCTION QA&QC AND MONITORING				
Bathymetric Surveys/ Water Quality Monitoring	68	Daily Rate	$7,000	$476,103
Verification Sediment Sampling (Dredging)	1	LS	$164,388	$164,388
Verification Sediment Sampling (Capping)	1	LS	$34,020	$34,020
Verification Sediment Sampling (ENR)	1	LS	$124,110	$124,110
Remedial Action Completion Reporting	1	LS	$80,000	$80,000
Subtotal:				**$878,621**
			BASE CAPITAL COST	**$15,296,356**
ENGINEERING, CONSTRUCTION SUPPORT, OVERSIGHT				
Construction Contingency	35%			$5,353,724
Project Management	5%			$764,818
Remedial Design and Data Collection	8%			$1,223,708
Construction Management/QA Support	6%			$917,781
Agency Oversight (25% of Construction Management/QA Support)	1.5%			$229,445
WA State Sales Tax	9.5%			$978,629
Subtotal:				**$9,468,106**
			TOTAL CAPITAL COST	**$24,764,462**
ICs, Long-Term OM&M				
ICs Planning and Implementation	1	LS	$512,009	$512,009
Long-Term Operation and Maintenance Monitoring (Cap)	1	LS	$242,172	$242,172
Long-Term OM&M (Dredge, ENR, unremediated area)	1	LS	$1,080,891	$1,080,891
ENR Repair	1	LS	$111,300	$111,300
Cap Repair (Full cap repair at $70/CY)	1	LS	$2,135,000	$2,135,000
Subtotal:				**$4,081,371**
			TOTAL COST	**$28,850,000**

TABLE F-20. ALTERNATIVE 3A2 - REMOVAL FOCUS - REMOVE UPTO 3 FEET OVER SQS FOOTPRINT, CAP/ENR TO URBAN FOOTPRINT

(REMOVE UP TO 3FT TO SQS, CAP TO >2xSQS, ENR TO URBAN)

DREDGE AREA (AC) =	18	**DREDGE VOLUME (CY) =**	123,000
CAP AREA (AC) =	5.4	**CAP VOLUME (CY) =**	30,500
ENR AREA (AC) =	12	**ENR VOLUME (CY) =**	19,400

TASK	QUANTITY	UNIT	UNIT COST	TOTAL COST
PRE-CONSTRUCTION				
Contractor Submittals, Engineering, Surveying	1	LS	$150,000	$150,000
Mobilization/Demobilization	1	LS	$500,000	$500,000
Site Preparation, Environmental Controls	1	LS	$150,000	$150,000
Subtotal:				**$800,000**
PIER DEMOLITION				
Pier Demolition, Handling and Delivery to Rail				
Creosote Treated Wood	9900	TON	$110	$1,094,000
Debris and Pilings, Metal Waste	170	TON	$110	$19,000
Transport and Disposal	10070	TON	$68	$690,000
Demolition QA/QC, Waste Characterization, Monitoring	1	LS	$456,000	$456,000
Subtotal:				$2,824,000
Subtotal Cost Based on Applicability to Each Alternative:	75%		$2,824,000	**$2,118,000**
DREDGING, RESIDUAL MANAGEMENT, DISPOSAL				
Dredging	123,000	CY	$20	$2,460,000
Material Barge, Assist Tug, Transport Sediments to Transloading Facility	184,500	TON	$12	$2,214,000
Transloading Area Setup	1	LS	$1,000,000	$1,000,000
Water Management	151	Daily Rate	$8,000	$1,205,882
Handling, Transport and Subtitle D Landfill Disposal	184,500	TON	$60	$11,070,000
Backfill Material Procurement, Delivery, Placement	15,246	CY	$20	$304,920
Subtotal:				**$18,254,802**
SEDIMENT CAPPING & ENR				
Cap Material Procurement, Delivery, Placement	30,500	CY	$30	$1,006,500
ENR Material Procurement, Delivery, Placement	19,400	CY	$30	$640,200
Material Barge and Assist Tug for Capping	45,750	TON	$10	$503,250
Material Barge and Assist Tug for ENR	29,100	TON	$10	$320,100
Subtotal:				**$2,470,050**
SHIPWAY REMEDIATION				
Removal and Disposal	648	CY	$100	$64,815
Cap/Habitat Material Procurement and Placement	7,260	CY	$30	$217,800
Subtotal:				**$282,615**
SHORELINE REMEDIATION				
Removal and Disposal	9,300	CY	$100	$930,000
Backfill Placement	11,160	CY	$20	$223,200
Shoreline Stabilization (Riprap) Procurement and Placement	3,516	TON	$50	$175,817
Habitat Material (Sand & Fish Mix) Procurement and Placement	1,852	CY	$30	$55,556
Habitat Enhancement and Riparian Planting	2.00	AC	$50,000	$100,000
Subtotal:				**$1,484,572**
CONSTRUCTION QA&QC AND MONITORING				
Bathymetric Surveys/ Water Quality Monitoring	151	Daily Rate	$7,000	$1,055,147
Verification Sediment Sampling (Dredging)	1	LS	$287,280	$287,280
Verification Sediment Sampling (Capping)	1	LS	$34,020	$34,020
Verification Sediment Sampling (ENR)	1	LS	$75,600	$75,600
Remedial Action Completion Reporting	1	LS	$80,000	$80,000
Subtotal:				**$1,532,047**
			BASE CAPITAL COST	**$26,942,086**
ENGINEERING, CONSTRUCTION SUPPORT, OVERSIGHT				
Construction Contingency	35%			$9,429,730
Project Management	5%			$1,347,104
Remedial Design and Data Collection	8%			$2,155,367
Construction Management/QA Support	6%			$1,616,525
Agency Oversight (25% of Construction Management/QA Support)	1.5%			$404,131
WA State Sales Tax	9.5%			$1,507,848
Subtotal:				**$16,460,706**
			TOTAL CAPITAL COST	**$43,402,793**
ICs, Long-Term OM&M				
ICs Planning and Implementation	1	LS	$512,009	$512,009
Long-Term Operation and Maintenance Monitoring (Cap)	1	LS	$242,172	$242,172
Long-Term OM&M (Dredge, ENR, unremediated area)	1	LS	$1,080,891	$1,080,891
ENR Repair	1	LS	$67,900	$67,900
Cap Repair (Full cap repair at $70/CY)	1	LS	$2,135,000	$2,135,000
Subtotal:				**$4,037,971**
			TOTAL COST	**$47,450,000**

TABLE F-21. ALTERNATIVE 3B - REMOVAL FOCUS - REMOVE TO CSL IN DRY DOCK 1, CAP/ENR TO URBAN FOOTPRINT

(REMOVE TO CSL IN DRY DOCK 1, CAP TO CSL, ENR TO URBAN)

DREDGE AREA (AC) =	4.0	**DREDGE VOLUME (CY) =**	90,000
CAP AREA (AC) =	6.3	**CAP VOLUME (CY) =**	35,600
ENR AREA (AC) =	19.7	**ENR VOLUME (CY) =**	31,800

TASK	QUANTITY	UNIT	UNIT COST	TOTAL COST
PRE-CONSTRUCTION				
Contractor Submittals, Engineering, Surveying	1	LS	$150,000	$150,000
Mobilization/Demobilization	1	LS	$500,000	$500,000
Site Preparation, Environmental Controls	1	LS	$150,000	$150,000
Subtotal:				**$800,000**
PIER DEMOLITION				
Pier Demolition, Handling and Delivery to Rail				
Creosote Treated Wood	9900	TON	$110	$1,094,000
Debris and Pilings, Metal Waste	170	TON	$110	$19,000
Transport and Disposal	10070	TON	$68	$690,000
Demolition QA/QC, Waste Characterization, Monitoring	1	LS	$456,000	$456,000
Subtotal:				$2,824,000
Subtotal Cost Based on Applicability to Each Alternative:	0%		$2,824,000	**$0**
DREDGING, RESIDUAL MANAGEMENT, DISPOSAL				
Dredging	90,000	CY	$20	$1,800,000
Material Barge, Assist Tug, Transport Sediments to Transloading Facility	135,000	TON	$12	$1,620,000
Transloading Area Setup	1	LS	$1,000,000	$1,000,000
Water Management	110	Daily Rate	$8,000	$882,353
Handling, Transport and Subtitle D Landfill Disposal	135,000	TON	$60	$8,100,000
Backfill Material Procurement, Delivery, Placement	4,840	CY	$20	$96,800
Subtotal:				**$13,499,153**
SEDIMENT CAPPING & ENR				
Cap Material Procurement, Delivery, Placement	35,600	CY	$30	$1,174,800
ENR Material Procurement, Delivery, Placement	31,800	CY	$30	$1,049,400
Material Barge and Assist Tug for Capping	53,400	TON	$10	$587,400
Material Barge and Assist Tug for ENR	47,700	TON	$10	$524,700
Subtotal:				**$3,336,300**
SHIPWAY REMEDIATION				
Removal and Disposal	648	CY	$100	$64,815
Cap/Habitat Material Procurement and Placement	7,260	CY	$30	$217,800
Subtotal:				**$282,615**
SHORELINE REMEDIATION				
Removal and Disposal	9,300	CY	$100	$930,000
Backfill Placement	11,160	CY	$20	$223,200
Shoreline Stabilization (Riprap) Procurement and Placement	3,516	TON	$50	$175,817
Habitat Material (Sand & Fish Mix) Procurement and Placement	1,852	CY	$30	$55,556
Habitat Enhancement and Riparian Planting	2.00	AC	$50,000	$100,000
Subtotal:				**$1,484,572**
CONSTRUCTION QA&QC AND MONITORING				
Bathymetric Surveys/ Water Quality Monitoring	110	Daily Rate	$7,000	$772,059
Verification Sediment Sampling (Dredging)	1	LS	$63,840	$63,840
Verification Sediment Sampling (Capping)	1	LS	$39,690	$39,690
Verification Sediment Sampling (ENR)	1	LS	$124,110	$124,110
Remedial Action Completion Reporting	1	LS	$80,000	$80,000
Subtotal:				**$1,079,699**
			BASE CAPITAL COST	**$20,482,339**
ENGINEERING, CONSTRUCTION SUPPORT, OVERSIGHT				
Construction Contingency	35%			$7,168,819
Project Management	5%			$1,024,117
Remedial Design and Data Collection	8%			$1,638,587
Construction Management/QA Support	6%			$1,228,940
Agency Oversight (25% of Construction Management/QA Support)	1.5%			$307,235
WA State Sales Tax	9.5%			$1,176,322
Subtotal:				**$12,544,020**
			TOTAL CAPITAL COST	**$33,026,359**
ICs, Long-Term OM&M				
ICs Planning and Implementation	1	LS	$512,009	$512,009
Long-Term Operation and Maintenance Monitoring (Cap)	1	LS	$282,533	$282,533
Long-Term OM&M (Dredge, ENR, unremediated area)	1	LS	$1,051,050	$1,051,050
ENR Repair	1	LS	$111,300	$111,300
Cap Repair (Full cap repair at $70/CY)	1	LS	$2,492,000	$2,492,000
Subtotal:				**$4,448,892**
			TOTAL COST	**$37,480,000**

TABLE F-22. ALTERNATIVE 3C - REMOVAL FOCUS - REMOVE TO CSL IN DRY DOCK AREAS, CAP/ENR TO URBAN FOOTPRINT

(REMOVE TO CSL IN DRY DOCK AREAS, ENR TO URBAN)

DREDGE AREA (AC) =	10.3	**DREDGE VOLUME (CY) =**	148,500
CAP AREA (AC) =	1.3	**CAP VOLUME (CY) =**	7,400
ENR AREA (AC) =	18.4	**ENR VOLUME (CY) =**	29,700

TASK	QUANTITY	UNIT	UNIT COST	TOTAL COST
PRE-CONSTRUCTION				
Contractor Submittals, Engineering, Surveying	1	LS	$150,000	$150,000
Mobilization/Demobilization	1	LS	$500,000	$500,000
Site Preparation, Environmental Controls	1	LS	$150,000	$150,000
Subtotal:				**$800,000**
PIER DEMOLITION				
Pier Demolition, Handling and Delivery to Rail				
Creosote Treated Wood	9900	TON	$110	$1,094,000
Debris and Pilings, Metal Waste	170	TON	$110	$19,000
Transport and Disposal	10070	TON	$68	$690,000
Demolition QA/QC, Waste Characterization, Monitoring	1	LS	$456,000	$456,000
Subtotal:				$2,824,000
Subtotal Cost Based on Applicability to Each Alternative:	0%		$2,824,000	**$0**
DREDGING, RESIDUAL MANAGEMENT, DISPOSAL				
Dredging	148,500	CY	$20	$2,970,000
Material Barge, Assist Tug, Transport Sediments to Transloading Facility	222,750	TON	$12	$2,673,000
Transloading Area Setup	1	LS	$1,000,000	$1,000,000
Water Management	182	Daily Rate	$8,000	$1,455,882
Handling, Transport and Subtitle D Landfill Disposal	222,750	TON	$60	$13,365,000
Backfill Material Procurement, Delivery, Placement	12,463	CY	$20	$249,260
Subtotal:				**$21,713,142**
SEDIMENT CAPPING & ENR				
Cap Material Procurement, Delivery, Placement	7,400	CY	$30	$244,200
ENR Material Procurement, Delivery, Placement	29,700	CY	$30	$980,100
Material Barge and Assist Tug for Capping	11,100	TON	$10	$122,100
Material Barge and Assist Tug for ENR	44,550	TON	$10	$490,050
Subtotal:				**$1,836,450**
SHIPWAY REMEDIATION				
Removal and Disposal	648	CY	$100	$64,815
Cap/Habitat Material Procurement and Placement	7,260	CY	$30	$217,800
Subtotal:				**$282,615**
SHORELINE REMEDIATION				
Removal and Disposal	9,300	CY	$100	$930,000
Backfill Placement	11,160	CY	$20	$223,200
Shoreline Stabilization (Riprap) Procurement and Placement	3,516	TON	$50	$175,817
Habitat Material (Sand & Fish Mix) Procurement and Placement	1,852	CY	$30	$55,556
Habitat Enhancement and Riparian Planting	2.00	AC	$50,000	$100,000
Subtotal:				**$1,484,572**
CONSTRUCTION QA&QC AND MONITORING				
Bathymetric Surveys/ Water Quality Monitoring	182	Daily Rate	$7,000	$1,273,897
Verification Sediment Sampling (Dredging)	1	LS	$164,388	$164,388
Verification Sediment Sampling (Capping)	1	LS	$8,190	$8,190
Verification Sediment Sampling (ENR)	1	LS	$115,920	$115,920
Remedial Action Completion Reporting	1	LS	$80,000	$80,000
Subtotal:				**$1,642,395**
			BASE CAPITAL COST	**$27,759,174**
ENGINEERING, CONSTRUCTION SUPPORT, OVERSIGHT				
Construction Contingency	35%			$9,715,711
Project Management	5%			$1,387,959
Remedial Design and Data Collection	8%			$2,220,734
Construction Management/QA Support	6%			$1,665,550
Agency Oversight (25% of Construction Management/QA Support)	1.5%			$416,388
WA State Sales Tax	9.5%			$1,367,447
Subtotal:				**$16,773,788**
			TOTAL CAPITAL COST	**$44,532,963**
ICs, Long-Term OM&M				
ICs Planning and Implementation	1	LS	$512,009	$512,009
Long-Term Operation and Maintenance Monitoring (Cap)	1	LS	$58,301	$58,301
Long-Term OM&M (Dredge, ENR, unremediated area)	1	LS	$1,216,831	$1,216,831
ENR Repair	1	LS	$103,950	$103,950
Cap Repair (Full cap repair at $70/CY)	1	LS	$518,000	$518,000
Subtotal:				**$2,409,090**
			TOTAL COST	**$46,950,000**

TABLE F-23. ALTERNATIVE 4A - REMOVAL TO SQS BOUNDARY

DREDGE AREA (AC) =	18	**DREDGE VOLUME (CY) =**	342,000
CAP AREA (AC) =	0	**CAP VOLUME (CY) =**	0
ENR AREA (AC) =	0	**ENR VOLUME (CY) =**	0

TASK	QUANTITY	UNIT	UNIT COST	TOTAL COST
PRE-CONSTRUCTION				
Contractor Submittals, Engineering, Surveying	1	LS	$150,000	$150,000
Mobilization/Demobilization	3	LS	$500,000	$1,500,000
Site Preparation, Environmental Controls	1	LS	$150,000	$150,000
Subtotal:				**$1,800,000**
PIER DEMOLITION				
Pier Demolition, Handling and Delivery to Rail				
Creosote Treated Wood	9900	TON	$110	$1,094,000
Debris and Pilings, Metal Waste	170	TON	$110	$19,000
Transport and Disposal	10070	TON	$68	$690,000
Demolition QA/QC, Waste Characterization, Monitoring	1	LS	$456,000	$456,000
Subtotal:				$2,824,000
Subtotal Cost Based on Applicability to Each Alternative:	75%		$2,824,000	**$2,118,000**
DREDGING, RESIDUAL MANAGEMENT, DISPOSAL				
Dredging	342,000	CY	$20	$6,840,000
Material Barge, Assist Tug, Transport Sediments to Transloading Facility	513,000	TON	$12	$6,156,000
Transloading Area Setup	1	LS	$1,000,000	$1,000,000
Water Management	419	Daily Rate	$8,000	$3,352,941
Handling, Transport and Subtitle D Landfill Disposal	513,000	TON	$60	$30,780,000
Backfill Material Procurement, Delivery, Placement	21,780	CY	$20	$435,600
Subtotal:				**$48,564,541**
SEDIMENT CAPPING & ENR				
Cap Material Procurement, Delivery, Placement	0	CY	$30	$0
ENR Material Procurement, Delivery, Placement	0	CY	$30	$0
Material Barge and Assist Tug for Capping	0	TON	$10	$0
Material Barge and Assist Tug for ENR	0	TON	$10	$0
Subtotal:				**$0**
SHIPWAY REMEDIATION				
Removal and Disposal	648	CY	$100	$64,815
Cap/Habitat Material Procurement and Placement	7,260	CY	$30	$217,800
Subtotal:				**$282,615**
SHORELINE REMEDIATION				
Removal and Disposal	9,300	CY	$100	$930,000
Backfill Placement	11,160	CY	$20	$223,200
Shoreline Stabilization (Riprap) Procurement and Placement	3,516	TON	$50	$175,817
Habitat Material (Sand & Fish Mix) Procurement and Placement	1,852	CY	$30	$55,556
Habitat Enhancement and Riparian Planting	2.00	AC	$50,000	$100,000
Subtotal:				**$1,484,572**
CONSTRUCTION QA&QC AND MONITORING				
Bathymetric Surveys/ Water Quality Monitoring	419	Daily Rate	$7,000	$2,933,824
Verification Sediment Sampling (Dredging)	1	LS	$287,280	$287,280
Verification Sediment Sampling (Capping)	1	LS	$0	$0
Verification Sediment Sampling (ENR)	1	LS	$0	$0
Remedial Action Completion Reporting	1	LS	$80,000	$80,000
Subtotal:				**$3,301,104**
			BASE CAPITAL COST	**$57,550,832**
ENGINEERING, CONSTRUCTION SUPPORT, OVERSIGHT				
Construction Contingency	35%			$20,142,791
Project Management	5%			$2,877,542
Remedial Design and Data Collection	8%			$4,604,067
Construction Management/QA Support	6%			$3,453,050
Agency Oversight (25% of Construction Management/QA Support)	1.5%			$863,262
WA State Sales Tax	9.5%			$2,543,229
Subtotal:				**$34,483,941**
			TOTAL CAPITAL COST	**$92,034,772**
ICs, Long-Term OM&M				
ICs Planning and Implementation	1	LS	$80,000	$80,000
Long-Term Operation and Maintenance Monitoring (Cap)	0	LS	$0	$0
Long-Term OM&M (Dredge, ENR, unremediated area)	0.15	LS	$1,259,934	$188,990
Cap/ENR Repair	1	LS	$0	$0
Subtotal:				**$268,990**
			TOTAL COST	**$92,310,000**

TABLE F-24. ALTERNATIVE 4B - REMOVAL TO URBAN FOOTPRINT

DREDGE AREA (AC) =	30	**DREDGE VOLUME (CY) =**	802,500
CAP AREA (AC) =	0	**CAP VOLUME (CY) =**	0
ENR AREA (AC) =	0	**ENR VOLUME (CY) =**	0

TASK	QUANTITY	UNIT	UNIT COST	TOTAL COST
PRE-CONSTRUCTION				
Contractor Submittals, Engineering, Surveying	1	LS	$150,000	$150,000
Mobilization/Demobilization	6	LS	$500,000	$3,000,000
Site Preparation, Environmental Controls	1	LS	$150,000	$150,000
Subtotal:				**$3,300,000**
PIER DEMOLITION				
Pier Demolition, Handling and Delivery to Rail				
Creosote Treated Wood	9900	TON	$110	$1,094,000
Debris and Pilings, Metal Waste	170	TON	$110	$19,000
Transport and Disposal	10070	TON	$68	$690,000
Demolition QA/QC, Waste Characterization, Monitoring	1	LS	$456,000	$456,000
Subtotal:				$2,824,000
Subtotal Cost Based on Applicability to Each Alternative:	100%		$2,824,000	**$2,824,000**
DREDGING, RESIDUAL MANAGEMENT, DISPOSAL				
Dredging	802,500	CY	$20	$16,050,000
Material Barge, Assist Tug, Transport Sediments to Transloading Facility	1,203,750	TON	$12	$14,445,000
Transloading Area Setup	1	LS	$1,000,000	$1,000,000
Water Management	983	Daily Rate	$8,000	$7,867,647
Handling, Transport and Subtitle D Landfill Disposal	1,203,750	TON	$60	$72,225,000
Backfill Material Procurement, Delivery, Placement	36,300	CY	$20	$726,000
Subtotal:				**$112,313,647**
SEDIMENT CAPPING & ENR				
Cap Material Procurement, Delivery, Placement	0	CY	$30	$0
ENR Material Procurement, Delivery, Placement	0	CY	$30	$0
Material Barge and Assist Tug for Capping	0	TON	$10	$0
Material Barge and Assist Tug for ENR	0	TON	$10	$0
Subtotal:				**$0**
SHIPWAY REMEDIATION				
Removal and Disposal	648	CY	$100	$64,815
Cap/Habitat Material Procurement and Placement	7,260	CY	$30	$217,800
Subtotal:				**$282,615**
SHORELINE REMEDIATION				
Removal and Disposal	9,300	CY	$100	$930,000
Backfill Placement	11,160	CY	$20	$223,200
Shoreline Stabilization (Riprap) Procurement and Placement	3,516	TON	$50	$175,817
Habitat Material (Sand & Fish Mix) Procurement and Placement	1,852	CY	$30	$55,556
Habitat Enhancement and Riparian Planting	2.00	AC	$50,000	$100,000
Subtotal:				**$1,484,572**
CONSTRUCTION QA&QC AND MONITORING				
Bathymetric Surveys/ Water Quality Monitoring	983	Daily Rate	$7,000	$6,884,191
Verification Sediment Sampling (Dredging)	1	LS	$478,800	$478,800
Verification Sediment Sampling (Capping)	1	LS	$0	$0
Verification Sediment Sampling (ENR)	1	LS	$0	$0
Remedial Action Completion Reporting	1	LS	$80,000	$80,000
Subtotal:				**$7,442,991**
			BASE CAPITAL COST	**$127,647,825**
ENGINEERING, CONSTRUCTION SUPPORT, OVERSIGHT				
Construction Contingency	35%			$44,676,739
Project Management	5%			$6,382,391
Remedial Design and Data Collection	8%			$10,211,826
Construction Management/QA Support	6%			$7,658,870
Agency Oversight (25% of Construction Management/QA Support)	1.5%			$1,914,717
WA State Sales Tax	9.5%			$5,265,168
Subtotal:				**$76,109,711**
			TOTAL CAPITAL COST	**$203,757,537**
ICs, Long-Term OM&M				
ICs Planning and Implementation	1	LS	$80,000	$80,000
Long-Term Operation and Maintenance Monitoring (Cap)	0	LS	$0	$0
Long-Term OM&M (Dredge, ENR, unremediated area)	0.15	LS	$1,259,934	$188,990
Cap/ENR Repair	1	LS	$0	$0
Subtotal:				**$268,990**
			TOTAL COST	**$204,030,000**

TABLE F-25. ALTERNATIVE 4C - REMOVAL TO STUDY AREA BOUNDARY

DREDGE AREA (AC) =	40	**DREDGE VOLUME (CY) =**	1,214,300
CAP AREA (AC) =	0	**CAP VOLUME (CY) =**	0
ENR AREA (AC) =	0	**ENR VOLUME (CY) =**	0

TASK	QUANTITY	UNIT	UNIT COST	TOTAL COST
PRE-CONSTRUCTION				
Contractor Submittals, Engineering, Surveying	1	LS	$150,000	$150,000
Mobilization/Demobilization	9	LS	$500,000	$4,500,000
Site Preparation, Environmental Controls	1	LS	$150,000	$150,000
Subtotal:				**$4,800,000**
PIER DEMOLITION				
Pier Demolition, Handling and Delivery to Rail				
Creosote Treated Wood	9900	TON	$110	$1,094,000
Debris and Pilings, Metal Waste	170	TON	$110	$19,000
Transport and Disposal	10070	TON	$68	$690,000
Demolition QA/QC, Waste Characterization, Monitoring	1	LS	$456,000	$456,000
Subtotal:				$2,824,000
Subtotal Cost Based on Applicability to Each Alternative:	100%		$2,824,000	**$2,824,000**
DREDGING, RESIDUAL MANAGEMENT, DISPOSAL				
Dredging	1,214,300	CY	$20	$24,286,000
Material Barge, Assist Tug, Transport Sediments to Transloading Facility	1,821,450	TON	$12	$21,857,400
Transloading Area Setup	1	LS	$1,000,000	$1,000,000
Water Management	1,488	Daily Rate	$8,000	$11,904,902
Handling, Transport and Subtitle D Landfill Disposal	1,821,450	TON	$60	$109,287,000
Backfill Material Procurement, Delivery, Placement	48,400	CY	$20	$968,000
Subtotal:				**$169,303,302**
SEDIMENT CAPPING & ENR				
Cap Material Procurement, Delivery, Placement	0	CY	$30	$0
ENR Material Procurement, Delivery, Placement	0	CY	$30	$0
Material Barge and Assist Tug for Capping	0	TON	$10	$0
Material Barge and Assist Tug for ENR	0	TON	$10	$0
Subtotal:				**$0**
SHIPWAY REMEDIATION				
Removal and Disposal	648	CY	$100	$64,815
Cap/Habitat Material Procurement and Placement	7,260	CY	$30	$217,800
Subtotal:				**$282,615**
SHORELINE REMEDIATION				
Removal and Disposal	9,300	CY	$100	$930,000
Backfill Placement	11,160	CY	$20	$223,200
Shoreline Stabilization (Riprap) Procurement and Placement	3,516	TON	$50	$175,817
Habitat Material (Sand & Fish Mix) Procurement and Placement	1,852	CY	$30	$55,556
Habitat Enhancement and Riparian Planting	2.00	AC	$50,000	$100,000
Subtotal:				**$1,484,572**
CONSTRUCTION QA&QC AND MONITORING				
Bathymetric Surveys/ Water Quality Monitoring	1,488	Daily Rate	$7,000	$10,416,789
Verification Sediment Sampling (Dredging)	1	LS	$638,400	$638,400
Verification Sediment Sampling (Capping)	1	LS	$0	$0
Verification Sediment Sampling (ENR)	1	LS	$0	$0
Remedial Action Completion Reporting	1	LS	$80,000	$80,000
Subtotal:				**$11,135,189**
			BASE CAPITAL COST	**$189,829,678**
ENGINEERING, CONSTRUCTION SUPPORT, OVERSIGHT				
Construction Contingency	35%			$66,440,387
Project Management	5%			$9,491,484
Remedial Design and Data Collection	8%			$15,186,374
Construction Management/QA Support	6%			$11,389,781
Agency Oversight (25% of Construction Management/QA Support)	1.5%			$2,847,445
WA State Sales Tax	9.5%			$7,651,554
Subtotal:				**$113,007,026**
			TOTAL CAPITAL COST	**$302,836,704**
ICs, Long-Term OM&M				
ICs Planning and Implementation	0	LS	$276,004	$0
Long-Term Operation and Maintenance Monitoring (Cap)	0	LS	$0	$0
Long-Term OM&M (Dredge, ENR, unremediated area)	0	LS	$1,259,934	$0
Cap/ENR Repair	1	LS	$0	$0
Subtotal:				**$0**
			TOTAL COST	**$302,840,000**

APPENDIX G— ESTIMATION OF SHORT-TERM EFFECTIVENESS METRICS AND SUSTAINABILITY MEASURES

TABLE OF CONTENTS

LIST OF TABLES

APPENDIX G

Estimation of Short-term Effectiveness Metrics and Sustainability Measures

G.1 INTRODUCTION

This appendix presents the methods used for estimating short-term effectiveness metrics for the remedial alternatives developed in Section 11 and evaluated in Sections 12 and 13 of this Lockheed West FS. Short-term environmental impacts of the active remedial actions were evaluated consistent with EPA's Green Remediation policy to enhance the environmental benefits of federal cleanup programs by promoting technologies and practices that are sustainable (EPA 2008, EPA 2010a, EPA 2010b). EPA's Green Remediation strategy outlines the principles of green remediation and describes opportunities to reduce the footprint of cleanup activities throughout the life of a project. Sustainability measures to reduce the environmental footprint of cleanup activities to the maximum extent possible are also briefly discussed in this Appendix.

G.2 METHODOLOGY FOR SHORT-TERM EFFECTIVENESS METRICS

The potential environmental footprint of a cleanup action is associated with the emission of carbon dioxide (CO_2) and other greenhouse gases (GHG) contributing to climate change. The net carbon emission associated with a defined activity is often referred as the activity's carbon footprint (EPA 2010a). Recently, short-term environmental impacts and cleanup action environmental footprints have been evaluated for Lower Duwamish Waterway (LDW) remedial alternatives (AECOM 2010). Similar methodology and assumptions used in LDW FS were followed here to estimate short-term effectiveness metrics for the Lockheed West FS. The analysis was limited to the estimates of carbon dioxide (CO_2) emissions, particulate matter with a diameter of 10 µm or less (PM_{10}) emissions, and energy consumption.

G.2.1 Remediation Activities Evaluated

Total fuel consumption, gas emissions, and energy consumption were estimated based on the construction activities scheduled for each alternative:

- Dredging of sediments using a barge-mounted derrick crane for removals below -10 ft MLLW, and by a barge-mounted precision excavator for removals above -10 ft MLLW (i.e., former shipway remediation, shoreline/intertidal habitat remediation);
- Transloading of sediments to the off-loading facility by barge and tugboat. Off-loading of dredged material by derrick crane at the transloading facility;
- Transportation of dredged material by truck from the transloading facility to the train transfer station in Seattle, WA, and from train transfer station to the offloading facility in Roosevelt, WA by train, and truck transfer from the landfill offloading site to the landfill cell; and
- Capping using barge mounted derrick crane for placements below -10 ft MLLW and barge mounted backhoe for placements above -10 ft MLLW.

Other than these main construction activities, emissions from survey boat operations during construction QA/QC monitoring and other miscellaneous activities from small scale construction equipment (e.g. front end loaders) that could be used during transloading/transporting of dredged material were accounted by increasing emissions during dredging by 25%. There are tertiary activities such as mining of aggregate for capping, ENR, and residuals management; manufacturing of construction equipment; construction materials, fuels, lubricants, staging equipment and support facilities; transport workers to/from site; electricity generation for consumption at the site; and landfill management that are not included in the metrics.

G.2.2 Inventory of Metrics

Gas emissions include estimates of CO_2 emissions and PM_{10} emissions using an emission factor approach, where the emission factors represent the mass of gas emitted per unit of activity data. Collection of activity data (e.g., throughput, operating hours, etc.) requires knowledge of the equipment and facilities involved. Usually, emission factors estimate CO_2 emissions more accurately than the other GHG (e.g., CO, NOx, SOx, and PM_{10}) emissions, whose estimates are affected by specific characteristics of the fuel, equipment, and the operating conditions. Energy consumption refers to thermal and electrical energy consumption. Thermal energy consumption arises from fuel combustion, based on the average heating value for diesel fuel (158 megajoules per gallon [MJ/gal]), and it is directly related to the amount of diesel fuel consumed during the project. Background data (i.e. air pollutant emission factors) used for the calculations were obtained mostly from EPA (1995a, 1995b) and the LDW FS (AECOM 2010).

G.2.3 Results

Table G-1 presents the calculation results of estimates for total fuel consumption, CO_2 emissions, PM_{10} emissions, energy consumption and required landfill volume for remedial alternatives. In general, dredging and transportation activities would require the most fuel consumption and associated CO_2 and PM_{10} emissions. Alternative 4C would produce the highest CO_2 and PM_{10} emissions, consume the most fuel and energy, and require the highest landfill volume. As the dredge volume and cap volume of the alternatives decrease, GHG emissions decrease. Alternative 2A1 would have the smallest environmental footprint after no action alternative.

Table G-2 summarizes the CO_2 emissions and the percentages of emissions for each activity category for each alternative. For containment focus alternatives (Alternatives 2A1, 2A2a, 2A2b, 2A3, 2A4a, 2A4b, and 2A4c), most of the CO_2 emissions (about 66 percent of total emissions) are due to transportation of cap material delivery to the site and dredged material transport to the landfill (from the common remedy element of shipway and shoreline/intertidal remediation work). For removal focus alternatives (Alternative 3A1, 3A2, 3B and 3C) including Alternative 2B which has a removal component, 26 percent to 46 percent and 26 percent to 44 percent of the CO_2 emissions are due to dredging and transportation activity, respectively and the rest is due mostly from transloading of dredged material (19 percent to 23 percent) and capping activities (5 percent to 16 percent). For complete removal alternatives (Alternative 4A, 4B, and 4C), an average 55 percent of CO_2 emissions are due to dredging followed by an average 26 percent from transloading, and an average 17 percent from transportation of dredged material. Alternative 4C would produce the most CO_2 emissions totaling 26,700 long tons in six years, followed by Alternative 4A and 4B producing 7,800 long tons and 17,800 long tons in three and six years, respectively. Other alternatives would produce 1,075 long tons to 4,000 long tons based on the equipment operations required to complete the capping and removal activities within specified AOPAs.

G.3 SUSTAINABILITY MEASURES

EPA's Green Remediation strategy outlines the goal of comprehensively evaluating cleanup actions to ensure protection of human health and the environment and to reduce the environmental footprint of cleanup activities to the maximum extent possible (EPA 2010). Green remediation comprises a range of best practices that may be applied throughout the Superfund cleanup process. The best management practices of green remediation provide potential means to improve waste management; conserve or preserve energy, fuel, water, and other natural resources; reduce green house gas (GHG) emissions; promote sustainable long-term stewardship; and reduce adverse impacts on local communities during and after remediation activities.

In general, CO_2 production is driven largely by fuel consumption during on-site and off-site activities. Similar to discussion provided in LDW FS, reducing CO_2 emissions on a large scale is difficult for the Lockheed West remedial alternatives because of the type of activities required for sediment remediation and the limitations of available technologies to reduce CO_2 emissions associated with heavy construction equipment. It may be possible to reduce CO_2 emissions by using alternative fuels and adopting sustainable BMPs during the project. A reduction in CO_2 emissions can be achieved by using biodiesel in the smaller construction equipment (e.g., front-end loaders). Some electric dredges are currently in use that would reduce emissions associated with dredging activities; however, this technology is new and not widely used (AECOM 2010). Emissions of PM_{10} are primarily generated through the operation of construction (i.e., internal combustion in construction equipment) and dust generated by transportation equipment. The best way to reduce GHG emission is through the use of BMPs. Some BMPs considered in the LDW FS could also be applicable to Lockheed West site (ILEPA 2008, AECOM 2010):

- Collect site-specific data and create sediment management zones,
- Perform construction sequentially to reduce unnecessary movement of construction equipment,
- Analyze various alternative technologies that could reduce energy consumption, waste, and emissions,
- Recycle uncontaminated materials removed (i.e. metals, construction debris, tires, etc.),
- Limit on-site vehicle speed to reduce particle suspension and increase fuel efficiency (EPA 2008),

- Select properly sized and powered equipment,
- Based on availability, consider Tier 2 engines for equipment (likely to have a cost premium associated with this option),
- Select fuel efficient equipment,
- Select lower GHG emitting fuel sources (e.g., biodiesel) for small equipment and trucks,
- Provide alternatives to diesel-powered generators for use during construction, and
- Use low sulphur fuels when possible.

G.4 REFERENCES

1. AECOM. 2010. Draft Final Feasibility Study. Lower Duwamish Waterway, Seattle, Washington. October 2010.

2. Illinois Environmental Protection Agency (ILEPA) 2008. Greener Cleanups: How to Maximize the Environmental Benefits of Site Remediation. February 2008.

3. EPA (U.S. Environmental Protection Agency). 2010a. Region 10 Superfund, RCRA, LUST, and Brownfields Clean and Green Policy. July 2010.

4. EPA. 2010b. Superfund Green Remediation Strategy. EPA Office of Superfund Remediation and Technology Innovation. September 2010.

5. EPA. 2008. Green Remediation: Incorporating Sustainable Environmental Practices into Remediation of Contaminated Sites. April 2008.

6. EPA 1995a. Compilation of Air Pollutant Emission Factors, Volume I, Stationary Point and Area Sources, AP 42, Fifth Edition. January 1995.

7. EPA 1995b. Compilation of Air Pollutant Emission Factors, Volume II, Appendix H: Highway Mobile Source Emission Factor Tables, AP 42, Fifth Edition.

Table G-1. Estimation of Short-term Effectiveness Metrics

		Alternative 1	Alternative 2								Alternative 3				Alternative 4		
		1	2A1	2A2a	2A2b	2A3	2A4a	2A4b	2A4c	2B	3A1	3A2	3B	3C	4A	4B	4C
Gas Emission																	
Input Data	Dredge Volume (<-10 ft MLLW in cy)	0	0	0	0	0	0	0	0	51,800	55,500	123,000	90,000	148,500	342,000	802,500	1,214,300
	Dredge Volume (>-10 ft MLLW in cy) [a]	0	9,950	9,950	9,950	9,950	9,950	9,950	9,950	9,950	9,950	9,950	9,950	9,950	9,950	9,950	9,950
	Cap, ENR, Backfill Volume (<-10 ft MLLW in cy) [b]	0	70,700	90,000	121,100	106,200	101,700	169,400	225,900	106,200	68,229	65,146	72,240	51,663	21,780	36,300	48,400
	Backfill, Habitat Mix Volume (>-10 ft MLLW in cy) [c]	0	20,280	20,280	20,280	20,280	20,280	20,280	20,280	20,280	20,280	20,280	20,280	20,280	20,280	20,280	20,280
Gas Emission due to Dredging [d]																	
Dredging [e]	Fuel Consumption (gal)	0	2,700	2,700	2,700	2,700	2,700	2,700	2,700	51,700	55,200	119,200	87,900	143,300	326,600	762,600	1,152,600
	Carbon Dioxide (CO_2 in long ton) [f]	0	34.3	34.3	34.3	34.3	34.3	34.3	34.3	673.1	718.7	1,551.0	1,144.1	1,865.5	4,251.5	9,929.9	15,007.7
	Particulate Matter (PM_{10} in long ton)	0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	10.4	11.1	23.9	17.7	28.8	65.6	153.2	231.5
Gas Emission due to Transloading [g]																	
Transloading	Fuel Consumption (gal)	0	5,300	5,300	5,300	5,300	5,300	5,300	5,300	32,900	34,900	70,800	53,200	84,400	187,300	432,400	651,500
	Carbon Dioxide (CO_2 in long ton)	0	57.7	57.7	57.7	57.7	57.7	57.7	57.7	357.9	379.4	770.7	579.4	918.5	2,040.1	4,709.5	7,096.6
	Particulate Matter (PM_{10} in long ton)	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.2	0.3	0.6	1.5	2.2
Gas Emission due to Transportation [h]																	
Transportation	Fuel Consumption (gal)	0	66,000	79,400	100,900	90,600	87,500	134,400	173,500	105,700	80,500	98,100	93,400	96,300	132,200	277,100	406,000
	Carbon Dioxide (CO_2 in long ton)	0	718.9	864.9	1,099.1	986.9	953.1	1,464.0	1,889.9	1,151.4	876.9	1,068.6	1,017.4	1,049.0	1,440.0	3,018.4	4,422.5
	Particulate Matter (PM_{10} in long ton)	0	0.5	0.6	0.7	0.6	0.6	1.0	1.2	0.8	0.6	0.7	0.7	0.7	0.9	2.0	2.9
	Total Truck Miles	0	6,000	6,000	6,000	6,000	6,000	6,000	6,000	38,000	40,000	80,000	60,000	96,000	212,000	488,000	735,000
	Total Train Miles	0	2,000	2,000	2,000	2,000	2,000	2,000	2,000	11,000	12,000	23,000	18,000	28,000	61,000	141,000	212,000
Gas Emission due to Capping [i]																	
Capping, ENR, Backfill, Habitat Mix	Fuel Consumption (gal)	0	21,600	26,800	35,300	31,200	30,000	48,400	63,800	31,200	20,900	20,100	22,000	16,400	8,300	12,300	15,500
	Carbon Dioxide (CO_2 in long ton)	0	281.3	349.0	459.7	406.3	390.7	630.3	830.8	406.3	272.2	261.7	286.5	213.6	108.1	160.2	201.8
	Particulate Matter (PM_{10} in long ton)	0	0.5	0.6	0.8	0.7	0.7	1.1	1.4	0.7	0.5	0.4	0.5	0.4	0.2	0.3	0.3
Total Gas Emission due to Remedial Activities																	
	Fuel Consumption (1,000 gal)	0	96	114	144	130	126	191	245	222	192	308	257	340	654	1,484	2,226
	Carbon Dioxide (CO_2 in long ton)	0	1,092	1,306	1,651	1,485	1,436	2,186	2,813	2,589	2,247	3,652	3,027	4,047	7,840	17,818	26,729
	Particulate Matter (PM_{10} in long ton)	0	1.5	1.7	2.0	1.9	1.8	2.6	3.2	11.9	12.2	25.3	19.0	30.1	67.4	156.9	237.0
Energy Consumption (MJ) [j]		0	15,200	18,100	22,800	20,600	19,900	30,200	38,800	35,100	30,300	48,800	40,600	53,800	103,500	234,600	351,800
Depleted Natural Resources (cy) [k]		0	91,000	110,300	141,400	126,500	122,000	189,700	246,200	126,500	88,600	85,500	92,600	72,000	42,100	56,600	68,700
Landfill Volume (cy) [l]		0	11,940	11,940	11,940	11,940	11,940	11,940	11,940	74,100	78,540	159,540	119,940	190,140	422,340	974,940	1,469,100

Notes:

a/ Former shipway remediation and shoreline remediation dredge volume

b/ Cap + ENR + Backfill (i.e. residual management) volume

c/ Former shipway remediation and shoreline remediation backfill, habitat mix volume

d/ Assumptions: 1) barge mounted derrick crane will be used for removal below -10 ft MLLW (33 cy/hr, 25 gal/hr); 2) barge mounted backhoe will be used for removal above -10 ft MLLW (50 cy/hr, 10.6 gal/hr); 3) emission factor for CO2 is 26.635 lb/gal; 4) emission factor for PM10 is 0.45 lb/gal (Source : AECOM, 2010).

e/ Calculated gas emission was increased by 25% to account for emissions from survey boat and other miscellaneous activities from small scale construction equipment (e.g. front end loaders) that could be used during transloading/transporting of dredged material.

f/ 1 long ton = 2,204 lb

g/ Assumptions: 1) dredged material will be barged from the dredging site to the transloading facility (1,600 cy/barge, 10 miles, 4.6 miles/hr, 85 gal/hr); 2) dredged material will be off-loaded from barge by derrick crane at the transloading facility (60 cy/hr, 25 gal/hr); 3) emission factor for CO2 is 24.4 lb/gal; 4) emission factor for PM10 is 0.00771 lb/gal (Source: AECOM, 2010).

h/ Assumptions: 1) dredged material will be transported by truck from the transloading facility to train transfer station in Seattle, WA, and from landfilll offloading site to the landfill cell (20 cy/truck, 12 miles/round trip, 0.2 gal/miles) in Roosevelt, WA 2) dredged material will be carried by rail from train transfer station in Seattle, WA to the offloading facility in Roosevelt, WA (150 cy/car; 22 car/trip; 570 mile/round trip, 0.22 gal/miles); 3) cap, ENR, backfill, habitat mix will be delivered by barge (122.7 cy/hr; 85 gal/hr). 4) emission factor for CO2 is 24.4 lb/gal; 5) emission factor for PM10 is 0.0282 lb/gal (Source: AECOM, 2010).

i/ Assumptions: 1) barge mounted derrick crane will be used for material placement below -10 ft MLLW (92 cy/hr, 25 gal/hr); 2) barge mounted backhoe will be used for material placement above -10 ft MLLW (92 cy/hr, 10.6 gal/hr); 3) emission factor for CO2 is 29.17 lb/gal; 4) emission factor for PM10 is 0.0489 lb/gal (Source : AECOM, 2010).

j/ Energy content of diesel fuel = 158.041 MJ/gal (Source: EPA; AECOM 2010).

k/ Cap, ENR, backfill, habitat mix volume.

l/ Assume 20% bulking factor.

CO_2 = carbon dioxide; cy = cubic yard; ENR = Enhanced Natural Recovery; gal = gallon; MLLW = mean lower low water; PM_{10} = particulated matter with diameter 10 µm or less; MJ = megajoules.

Table G-2. Summary of Carbon Dioxide Emissions by Alternative

Remedial Alternative		Carbon Dioxide Emissions								
		Dredging		Transloading		Transportation		Capping		Total (long tons)
		(long tons)	(% of total)	(long tons)	(% of total)	(long tons)	(% of total)	(long tons)	(% of total)	
Alternative 2	2A1	34	3%	58	5%	719	66%	281	26%	1,092
	2A2a	34	3%	58	4%	865	66%	349	27%	1,306
	2A2b	34	2%	58	3%	1,099	67%	460	28%	1,651
	2A3	34	2%	58	4%	987	66%	406	27%	1,485
	2A4a	34	2%	58	4%	953	66%	391	27%	1,436
	2A4b	34	2%	58	3%	1,464	67%	630	29%	2,186
	2A4c	34	1%	58	2%	1,890	67%	831	30%	2,813
	2B	673	26%	358	14%	1,151	44%	406	16%	2,589
Alternative 3	3A1	719	32%	379	17%	877	39%	272	12%	2,247
	3A2	1,551	42%	771	21%	1,069	29%	262	7%	3,652
	3B	1,144	38%	579	19%	1,017	34%	286	9%	3,027
	3C	1,865	46%	918	23%	1,049	26%	214	5%	4,047
Alternative 4	4A	4,252	54%	2,040	26%	1,440	18%	108	1%	7,840
	4B	9,930	56%	4,710	26%	3,018	17%	160	1%	17,818
	4C	15,008	56%	7,097	27%	4,423	17%	202	1%	26,729

APPENDIX H— LIQUEFACTION POTENTIAL AND SEISMIC STABILITY EVALUATION OF REMEDIAL ALTERNATIVES

TABLE OF CONTENTS

ATTACHMENTS

LIST OF TABLES

LIST OF FIGURES

APPENDIX H
Liquefaction Potential and Seismic Stability Evaluation of Remedial Alternatives

SUMMARY

An evaluation was conducted of the seismic stability and liquefaction potential of three remediation alternatives at the Lockheed West Site (Site)—Alternatives 2A2a, 3A1, and 3C—which would serve as representative feasibility study (FS) alternatives for cap-only, dredge and cap, and dredge-only scenarios, respectively. The evaluation methodology and criteria were established with EPA's concurrence based on the meeting with the U.S. Environmental Protection Agency (EPA) on August 18, 2011, and the comments transmitted to Tetra Tech on August 25, 2011, on the July 21 Seismic Evaluation Approach Memo. The memo was then revised by Tetra Tech and resubmitted to EPA on September 1, 2011. Events and outcomes assessed included liquefaction susceptibility and initiation; liquefaction-induced deformation; slope stability for static conditions, 100-, 500-, and 2,500-year events; and earthquake-induced displacement. Prior studies of the area were evaluated, and more conservative values for peak ground acceleration (PGA) were used in this evaluation compared to the prior studies. A range of standard penetration test values were used for liquefaction analysis. With the conservatism built into the evaluation, the findings indicate the following:

- At 100-year event, ground movement and deformation intersecting contaminated sediments is unlikely and no contamination release is predicted.
- At 500-year event, ground movement and deformation intersecting contaminated sediments is likely, however no contamination release is predicted.
- At 2,500-year event, ground movement and deformation intersecting contaminated sediments is likely and contamination release is predicted.

- When ground movement intersecting contaminated sediments is predicted, the liquefaction-induced hazards and slope displacements are such that corrective measures, such as cap repair and/or replacement, are feasible;

The findings of this seismic evaluation were incorporated into the detailed evaluation and comparative analysis of the remedial alternatives in this FS. The findings suggest that there exists a risk of earthquake-induced ground movements affecting the stability of contaminated sediments, which may require sediment cap repair. Therefore, the FS cost estimates where capping is part of the remedy were revised by incorporating full cap replacement/repair cost and associated contingencies.

H.1 INTRODUCTION

This appendix presents the results of the liquefaction potential and seismic stability evaluation of representative FS alternatives at the Site. The main objective of this study is to assess and differentiate long-term effectiveness of the proposed representative alternatives (i.e., 2A2a, 3A1, and 3C) by evaluating the stability of the sediments within the remedial action areas during seismic event with nominal 100-yearr, 500-year, and 2,500-year recurrence intervals. The representative alternatives and seismic events were established with EPA concurrence. Alternatives 2A2a, 3A1, and 3C represent cap-only, dredge and cap, and dredge-only scenarios. Alternative 2A2a involves conventional capping over the areas defined by the risk drivers to the cleanup screening level (CSL) footprint, and enhanced natural recovery (ENR) over the remaining area to the Urban area of potential action (AOPA) footprint. Alternative 3A1 involves removal of up to 3 feet of sediment over the area defined by the risk-drivers to the CSL footprint, placing a conventional cap over residual contamination greater than two times the Sediment Quality Standard (SQS), and performing ENR over the remaining area to the Urban AOPA footprint. Alternative 3C includes removal of sediments over the area associated with former dry docks 1, 2, and 3, and ENR over the remaining area to the Urban AOPA footprint. Refer to Section 11 of this FS for additional details of each alternative. While these three alternatives were selected as the representative alternatives for the analyses, the findings of the study are applicable to other FS alternatives and conclusions were presented accordingly.

This seismic evaluation includes:

- Summary of Site background and subsurface conditions available for use in the evaluation (Section H.2);
- Review and summaries of relevant reports and studies conducted at this site, the adjacent Pacific Sound Resources (PSR) site, and other sites in the general vicinity (Section H.3);
- General overview of earthquake hazards and risks in Pacific Northwest and the methodology used to define seismic inputs for the nominal 100-year, 500-year, and 2,500-year recurrence intervals (Section H.4);
- Evaluation of liquefaction susceptibility and liquefaction initiation analysis of site sediments (Sections H.5.1 and H.5.2);
- Liquefaction induced deformation analysis (Section H.5.3);
- Static and seismic slope stability analysis of site profiles including the delta shelf slope (Section H.6);
- Earthquake induced displacement and slope deformation analysis (Section H.6.4);
- Conclusions based on the analyses conducted (Section H.7); and
- Representative boring logs are included in Attachment 1, and results of the analyses are included in Attachments 2 and 3.

H.2 SITE BACKGROUND

The analysis was performed using the existing geotechnical data presented in previous geotechnical investigations conducted at the Lockheed West Site, the nearby PSR Marine Sediment Unit, and the Lockheed Shipyard #1 Sediment Operable Unit (Enviros, 1990; Hart Crowser, 1995; URS, 2003; Hart Crowser, 2003; Tetra Tech, 2008). The boring log and subsurface core sampling locations are shown in Figure H-1 (Figures H-1 through H-9 are located at the end of this appendix). The locations of the site profiles are also shown in Figure H-1. The site profiles are included in Figures H-2 and H-3. The seismic evaluation is focused on the stability of sediments within the remedial action limits of three representative FS alternatives (i.e., Alternatives 2A2a, 3A1, and 3C) for cap only, dredge and cap, and dredge-focus alternatives, respectively (Figures H-4 to H-6). The site profiles representing the alternatives are included in Figures H-7 to H-9.

H.2.1 Subsurface Conditions

Existing geotechnical data presented in previous geotechnical investigations conducted at or near the Lockheed West Site were reviewed to construct a general subsurface cross-section for the site. Representative boring logs (i.e., HC-8, HC-9, HC-10, and HC-15) located within the dry dock hot spot area in Figure H-1 were used to define the general stratigraphy of the remedial action area for representative Alternatives 2A2a, 3A1, and 3C. Representative boring logs were extracted from the Hart Crowser (1995) report and included in Attachment 1. General subsurface conditions indicate that the simplified site profile is composed of an upper layer of 3 feet of very loose sandy silt, followed by a 10- to 20-foot layer of interbedded soft sandy silt and loose silty sand, underlain by medium dense to dense silty sand to a depth of 75 to 100 feet, below which the material become very dense. This pattern is consistent with deltaic deposits. These delta deposits transition to glacial till at about 150-foot depth; below 300 feet the glacial till behaves as bedrock. The bedrock at the site is at a range of 650 to 1,000 feet (Hart Crowser, 2003).

H.2.2 Site Bathymetry

The most recent high-resolution bathymetric survey for the Site was conducted by Tetra Tech in 2006 (Tetra Tech, 2006). The site profiles are included in Figures H-2 and H-3 with no vertical exaggeration. These cross-sections show that existing bottom profile is generally flat to 2 percent slope where there are no bottom undulations. These profiles represent the actual bathymetric conditions of the site. In contrast, the site profiles included in the main body of the FS show vertical exaggeration. In the absence of vertical exaggeration, these profiles show that the slopes are relatively shallow, even considering the shelf break outside the study area. Figures H-7 to H-9 show the same profiles with 2-times vertical exaggeration to illustrate the extent of cap and removal areas under Alternatives 2A2a and 3A1. Profile 5 in Figure H-9 extends parallel to the shoreline and shows the berms under former piers with 2H:1V (25 degree) or flatter side slopes. The delta shelf has an approximately 7H:1V (8 degree) to 4.5H:1V (13 degree) slope (Figures H-7 and H-8). The shoreline slopes are, on average, 2H:1V (30 degree) or flatter (Figures H-7 to H-9).

H.3 REVIEW OF RELEVANT SELECTED REPORTS AND STUDIES

Available geotechnical investigations, studies, and design reports were reviewed to gather the background information on previous stability analyses conducted at and nearby the Site. The findings of the reviewed reports are summarized below:

- **Lockheed Shipyard #2 Sediment Characterization and Geotechnical Study (Enviros, 1990)**

A geotechnical investigation in combination with deep boreholes (up to 150 feet) and shallow borings (4 feet to 26 feet) was conducted to determine the subsurface conditions in the vicinity of the Lockheed West site to evaluate the feasibility of constructing a confined disposal facility on the site. The soil units delineated include wood debris, saw dust along the shoreline; mixed dredge material, alluvium and debris in 6 feet to 17 feet; loose silt and sand deltaic deposits in 20 feet to 30 feet; and medium dense to dense alluvial deltaic deposits 30 feet below mudline.

Seismic evaluation and liquefaction potential analysis included a magnitude 7.5 seismic event with a PGA of 0.32g (where g is the acceleration due to gravity). A simplified liquefaction approach developed by Seed and Idriss (1977) was conducted. It was determined that the design event would initiate liquefaction at the site. Stabilization techniques were recommended to minimize the risk of failure of the proposed confined disposal facility berm due to liquefaction. The techniques included removal of a minimum of 10 feet of soft loose silty sand materials, vibrofloatation, and vibro-replacement. Out of the applicable stabilization alternatives, vibro-emplaced rock columns were recommended to stabilize the proposed berm foundation as part of the Port of Seattle Terminal 5 development.

- **Geotechnical Engineering Design Study Southwest Harbor Project Terminal 5 Expansion, Port of Seattle, WA (Hart Crowser, 1995)**

A design study was conducted in 1995 for Southwest Harbor Project to evaluate earthquake hazards for the site and to provide design recommendations for the proposed dredge spoil containment berm (nearshore contained aquatic disposal berm) and concrete apron along West Waterway for Port of Seattle Terminal 5 development. This study expanded the sediment characterization and geotechnical study conducted by Enviros in 1990 by additional geotechnical investigation and provided geotechnical design recommendations. The geotechnical investigation included 25 borings at depths of 40 feet to 170 feet. Liquefaction potential, static and seismic slope stability, deformation, and settlement analyses were conducted.

Simplified liquefaction analyses developed by Seed and Idriss (1977), Seed at al. (1984), and Seed and Harder (1990) were conducted. Two seismic scenarios were evaluated for liquefaction analysis: a magnitude 6.5 with PGA of 0.15g and a magnitude 7.5 with PGA of 0.27g. The liquefaction zone was determined to be 10 to 40 feet for a magnitude 6.5 earthquake, and exceeding 50 feet for a magnitude 7.5 earthquake. The analyses indicated that after a containment berm was placed, the liquefaction zone was reduced to 20 feet and 40 feet during magnitude 6.5 and 7.5 earthquakes, respectively.

Static and seismic slope stability of the proposed berms with 2H:1V side slopes was analyzed. Seismic slope stability was performed by a pseudo-static slope stability method by applying 0.1g and 0.12g earthquake loads for 6.5 and 7.5 magnitude earthquakes. The subsurface soil was assumed to liquefy to depths of 20 to 30 feet, an undrained residual shear strength was assigned to the liquefied zone, and the soil strength of the non-liquefied soil was reduced by 20 percent to account for cyclic pore pressure generation. Static slope stability and pseudo-static slope stability results were acceptable (i.e., a factor of safety $\geq$ 1) while the reduced strength analysis produced an unsafe factor of safety for a magnitude 7.5 earthquake. Deformation analysis was conducted using Newmark-type analysis by comparing yield acceleration that produces a factor of safety of 1 to a scaled ground motion recorded for the 1949 Olympia earthquake. The results showed about 1-foot displacement, which would require repair of the berm.

Mitigation approaches were recommended to reduce the potential liquefaction hazard. The mitigation alternatives included removal and replacement of 15 to 20 feet loose alluvium, installation of a deep rigid bulkhead, and installation of stone columns and timber pinch piles along the slopes.

- **Geotechnical Considerations for the Proposed Southwest Harbor CAD Facility (Palmer 1999)**

This report reviews and comments on the Hart Crowser (1995) report. Stability issues related to submarine seismic and non-seismic landslides and case histories were presented. Per the initial comments and concerns of Washington Department of Natural Resources (WDNR), the nearshore confined aquatic disposal (CAD) footprint was revised to be smaller and set back to 300 feet from the delta shelf slope break. The report summarizes case histories of submarine landslides in fjord-delta environments of the Pacific Northwest and points out the critical delta slope stability conditions even under existing static forces. Recommendations include establishment of criteria that defined acceptable risk of containment failure between the parties, evaluation of global stability of the delta slope under design earthquake ground motions, and evaluation of worst-case scenario.

- **Final 100% Remedial Design Submittal Sediment Remediation Lockheed Shipyard #1 Sediment Operable Unit, Seattle, WA, Attachment B-1 (Hart Crowser, 2003)**

Slope stability analysis of the waterfront containment area shoreline slopes at the Lockheed Shipyard #1 Sediment Operable Unit was performed for 475-year and 2,475-year seismic events. The analyzed seismic events are a 475-year event with a magnitude of 6.8 and a PGA of 0.32g, and a 2,475-year event with a magnitude of 7.5 and a PGA of 0.5g. Lateral spreading was estimated as 1 to 5 feet and at least 15 feet for 475-year and 2,475-year events, respectively. It was anticipated that the sediments would still be contained during a 475-year event but would not be contained due to complete collapse of the slopes during 2,475-year event. The analysis based on the 475-year event resulted in marginally stable slopes for the existing and post-remediation slopes. The report noted that strong shaking would cause parts of the cap to slough and slide in isolated areas which could be repaired following the earthquake.

- **Final Design PSR Superfund Site Marine Sediment Unit (URS, 2003)**

The PSR Superfund site is located to the immediate west of the project site where sediment area remedial actions were implemented at the PSR Marine Sediment Unit in

2002. The isolation cap was designed to extend beyond the edge of delta shelf to address the contamination where the shelf slopes are 12 degrees (4.5H:1V) to 27 degrees (2H:1V). Liquefaction analysis indicated liquefiable deposits to the depth of 30 to 50 feet. The design seismic event for slope stability analysis was selected as a return period of 100 years, a magnitude of 6.8, and a PGA of 0.13g (associated with the ground PGA of 0.22g measured at Harbor Island). The analysis resulted in predicted slope failure which would cause short-term disruption to the benthic community in the affected slide zone. A contingency cost was added to operation and maintenance costs to repair cap damage associated with future seismic damage. The design study noted that no liquefaction was observed during the Nisqually earthquake, while the seismic event should have triggered liquefaction based on the liquefaction analysis and predictions. The report also noted that based on the previous case histories in Puget Sound, a large submarine landslide (with dimensions of 10 to 20 feet deep, 100 feet wide, and several hundred feet in the direction of the delta slope) may occur on the delta slope during a large earthquake with a magnitude of 7 or larger.

- **Seismic Stability of a Sloping Cap (McCabe, 2004)**

A follow-up publication on re-assessment of PSR cap slopes after the Nisqually earthquake concluded that even though a PGA of 0.22g was measured in adjacent onshore areas, a post-earthquake bathymetric study did not show any detectable change at the site. One likely reason for the high liquefaction resistance was reported as likely damping and reduction of ground motion at submarine slopes and the presence of higher percentage of low plasticity fine contents of sediments than was reflected in the original design report.

- **Liquefaction Susceptibility and Site Class Maps of Washington State By County (Palmer et al. 2004)**

The liquefaction susceptibility and National Earthquake Hazard Reduction Program site class maps were presented for 39 counties in Washington State. The report is a general guide to delineate areas based on their potential for liquefaction or ground shaking enhanced by near-surface soil conditions. A site-specific investigation to assess the actual geologic conditions and the potential for liquefaction or amplified ground shaking is recommended. Liquefaction susceptibility maps were generated using large geotechnical boring datasets to calculate liquefaction factors of safety for two magnitude 7.3 earthquake scenarios, one having a 0.15 g PGA and the other a 0.30 g PGA. This study categorizes the soils in the vicinity of Harbor Island, Lockheed West, and PSR as Class E, which amplifies the ground motions the most and is the most prone to liquefaction (Figure H-10).

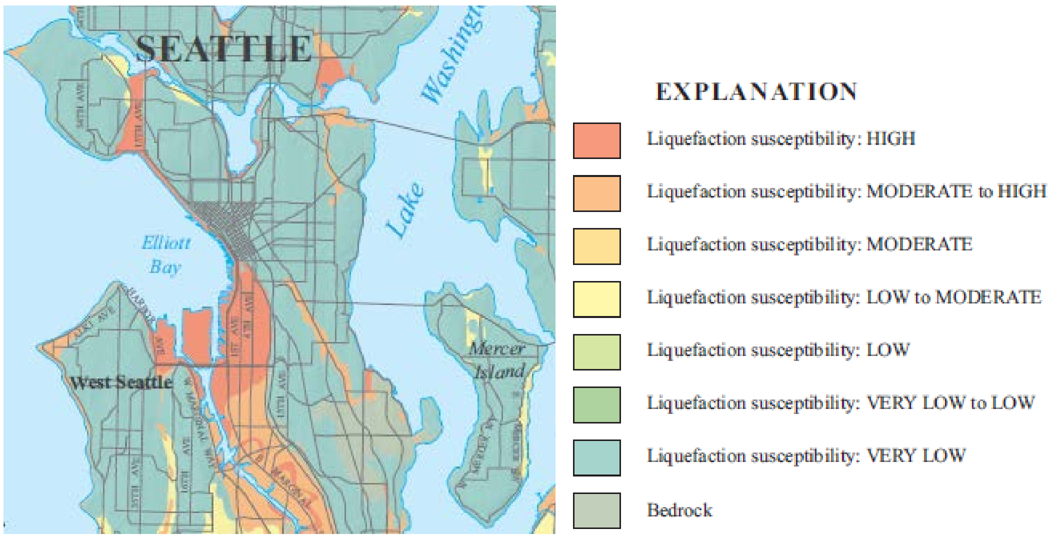


Figure H-10. A snapshot from Liquefaction Susceptibility Map of King County Washington (Palmer et al. 2004)

- **Liquefaction Potential Evaluation Duwamish Sediment Other Area and Southwest Bank Corrective Measure Alternatives Study, Boeing Plant 2 (Amec, 2010)**

The most recent liquefaction potential evaluation report representative of nearby sites was prepared for Boeing Plant 2 Corrective Measure Alternatives Summary. A peak ground acceleration of 0.3g for a magnitude 6.5 earthquake was selected as the seismic design event. It was determined that the proposed cap alternative will be subject to liquefaction with a factor safety value 0.95, a 5-foot backfill scenario would be stable with a factor of safety of 1.0, while the existing sediments would also liquefy under a factor of safety value of 0.96.

H.3.1 Summary of Seismic Analysis and Design Parameters Used in Previous Studies

The seismic analysis and design parameters used for the proposed projects at this site (Lockheed Shipyard No. 2), at nearby Lockheed Shipyard No. 1, for the cap design at PSR site, and for Boeing Plant 2 remedial actions are summarized in Table H-1.

Table H-1.
Summary of Seismic Analysis and Design Parameters Used in Previous Studies

Study/Site	Analysis	Analysis Parameters	Result
Enviros 1990/Lockheed Shipyard No. 2	Liquefaction potential	M7.5, PGA 0.32g	Liquefaction expected
Hart Crowser 1995/ Lockheed Shipyard No. 2	Liquefaction potential	M6.5, PGA 0.15 M7.5, PGA 0.27	Liquefaction expected
	Seismic slope stability	M6.5, PGA 0.1 M7.5, PGA 0.12	FOS>1 – 1 ft displacement FOS<1 – flow slide
Hart Crowser 2003/ Lockheed Shipyard No. 1	Liquefaction potential	475-year, PGA of 0.32g 2,475-year, PGA of 0.5g	Lateral spreading of 1 to 5 ft Lateral spreading of ≥15 ft
	Seismic slope stability	475-year, PGA of 0.16g	FOS: 0.89-1.49
URS 2003/PSR	Liquefaction potential	100-year, M6.8, PGA of 0.13g	Liquefaction expected
	Seismic slope stability	100-year, M6.8, PGA of 0.065	FOS: 0.78-1.30
McCabe 2004/PSR	Liquefaction potential	Nisqually event: M6.8, PGA of 0.22g	Liquefaction expected but not observed
Palmer et al., 2004	Liquefaction susceptibility	M7.3, PGA of 0.15g and 0.3g	Liquefaction expected
Amec 2010/Boeing Plant 2 – Duwamish River	Liquefaction potential	PGA of 0.3g	Liquefaction expected
Notes: M = magnitude; FOS = factor of safety; PGA = peak ground acceleration			

H.3.2 Applicability of the Reviewed Studies for the Lockheed West Site

The following notes summarize the applicability of relevant selected reports and studies to the liquefaction potential and seismic stability evaluation to the Lockheed West Site:

- The upper 50 to 70 feet of site sediments are expected to be susceptible to liquefaction and the liquefaction is expected to be initiated in the upper 10 to 20 feet of sediments at any seismic event analyzed. The analysis presented in this appendix reanalyzes the liquefaction susceptibility and initiation potential of Site sediments by incorporating the latest scientific and engineering developments in this geographic area.

- The reviewed studies provide limited information on liquefaction induced hazards, which are lateral spreading, post-liquefaction settlement, and flow slides. The current analysis will evaluate these hazards to assess the scale of damage expected due to liquefaction and interpretation of such damage in terms of the expected risk and the repair requirements of the proposed remedy.
- The Palmer (1999) study expresses concerns for proposed construction of a confined disposal facility at this site due to proximity to the delta shelf slope (approximately 15 degree) and the potential submarine seismic and non-seismic landslides. Current remedial alternatives do not include a confined disposal facility. Alternative 2A2a includes a cap layer over a 10-acre area where the outer edge is 400 feet from the delta shelf slope and the slope is approximately 8 degrees (Figure H-7), well below the 15 degree delta shelf slope assumed by Palmer (1999). Slope stability evaluations are presented in Section H.6.
- The PSR cap design was designed for a 100-year event with a PGA of 0.13g, and the cap was constructed over the delta shelf slope break where the slope is at 12 to 27 degrees. The seismic evaluation of the Lockheed West Site uses more conservative seismic design parameters, the delta shelf slope is 8 to 13 degrees, and the edge of the proposed cap is 400 feet from the delta shelf.
- A variety of seismic design parameters were used in the previous studies. The current analysis of the Lockheed West Site uses the most recent and accepted methodology to determine the seismic design parameters. The seismic design parameters are presented in Sections H.4.2 and H.5.2.

H.4 EARTHQUAKE HAZARD AND RISK

H.4.1 Background

The seismicity of Washington State is dominated by two main tectonic processes. The state lies on the North American plate, which is composed of a series of blocks that experience north-south modes of movement. To the west, the Juan de Fuca plate is moving eastward and subducting beneath the North American plate. These movements produce a complex set of stress conditions such as north-south compression in the upper crust transitioning to east-west compression at depth and a correspondingly complex pattern of seismicity (Kramer, 2008).

Because of the subduction process, the Puget Lowland basin is vulnerable to earthquakes from three sources: 1) in the subducting Juan de Fuca plate (benioff zone or intraplate quake); 2) between the colliding Juan de Fuca and North American plates (subduction zone or interplate quake); 3) in the overriding North America plate (shallow crustal quake) (EERI, 2005).

The 1949 Olympia (M6.8), 1965 Seattle-Tacoma (M6.5), and 2001 Nisqually (M6.8) earthquakes are examples of intraplate earthquakes (magnitudes of 6.5 to 7.1 at about 40 to 60 km deep). The Cascadia Subduction Zone is the 1,100-kilometer (km)-long boundary between the subducting Juan de Fuca plate and the overlying North American plate (Figure H-11a).

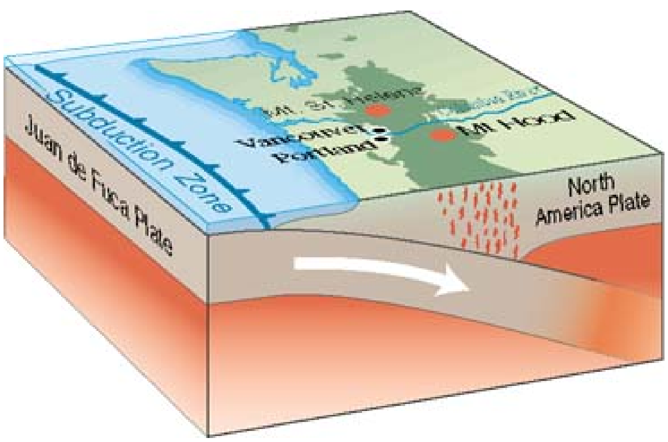


Figure H-11a. Illustration of Cascadia Subduction Zone
Source: http://earthquake.usgs.gov/learn/glossary/?term=subduction%20zone

Subduction zones are known to produce the largest earthquakes, known as interplate earthquakes. The Cascadia Subduction Zone is known to have produced at least six great interplate earthquakes (i.e., magnitudes likely greater than 9) in the past 3,500 years. The most recent subduction zone interplate earthquakes in the world include the January 2011 Chile (M7.1) and March 2011 Japan (M9.0) earthquakes. The January 2011 Chile earthquake occurred as a result of shallow thrust faulting on or near the subduction interface between the Nazca and South America tectonic plates. The magnitude 9.0 Tohoku earthquake in Japan on March 11, 2011, resulted from thrust faulting on or near the subduction zone plate boundary between the

Pacific and North America plates. The Japan Trench subduction zone has hosted nine events of magnitude 7 or 8 since 1973; however, a predecessor M9.0 earthquake may have occurred approximately 1,100 years ago (USGS, 2011).

The Puget Lowland is also known to be traversed by a number of shallow crustal faults. The best-known of these is the Seattle Fault, known to have produced several large, shallow earthquakes, most recently about 1,100 years ago (Kramer, 2008). U.S. Geological Survey (USGS) estimates the probability of occurrence of a Seattle Fault earthquake (M6.5 or greater) as 5 percent in 50 years and the approximate recurrence interval is 1,000 years (EERI, 2005). The Site is located about one mile to the edge of the modeled Seattle Fault. A PGA of 0.5g to 0.75g is expected at the Site for the Seattle Fault scenario earthquake (Figure H-11b). A M6.7 Seattle Fault earthquake scenario is expected to cause three types of ground failures: surface fault rupture and associated flooding from tsunamis and seiches; liquefaction-induced ground failure and associated lateral spreading, loss of bearing capacity and ground settlement, and local flooding; and seismically induced landslides (EERI, 2005).

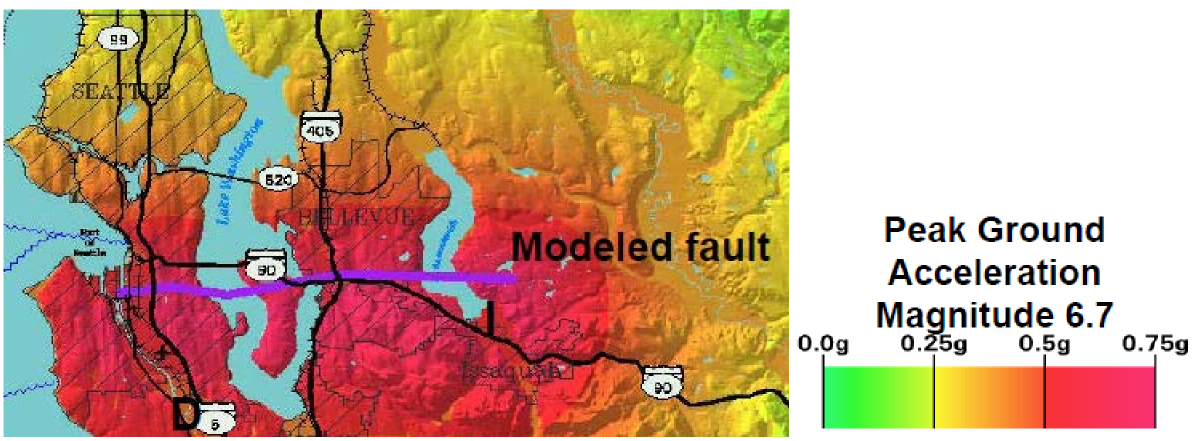


Figure H-11b. Peak Ground Accelerations for Seattle Fault Scenario Earthquake Using Soil Map (EERI, 2005)

Source: http://www.eeri.org/wp-content/uploads/2011/05/seattscen_ch1.pdf

Seismic stability analysis of the Duwamish River delta near Elliott Bay and Harbor Island indicates that soil liquefaction and ground failure of native deltaic deposits are likely during moderate to large earthquake events. An investigation of the state properties of native soil using field data indicates that large-strain flow failure may occur at the delta front along the northern end of Harbor Island under an earthquake scenario for the City of Seattle (Kayen and Barnhardt, 2007). This is a scenario of a magnitude 6.5 or greater earthquake on the Seattle Fault with approximate recurrence interval of 1,000 years (5 percent probability of occurrence in 50 years). There is evidence that the last Seattle Fault earthquake with a magnitude of 7.0 or greater occurred about 1,100 years ago (EERI, 2005). Another USGS study mapped southern Puget Sound delta fronts after the 2001 Nisqually earthquake (Gardner et al., 2001). This study mapped a series of large historic landslides as shown in Figure H-12. The closest historic landslides observed are within 1 km of the Site, about 1,500 feet from the delta shelf. This mapping demonstrates that large-scale flow slides typically occur on the steeper forefront of deltaic deposits with head scarps above, but relatively close to the slope break. The Lockheed West Site setting with flat to 2 percent slope bottom profiles is different than the areas where landslides have occurred; therefore, the historical experience did not indicate any large-scale flow slides extending into the Site.

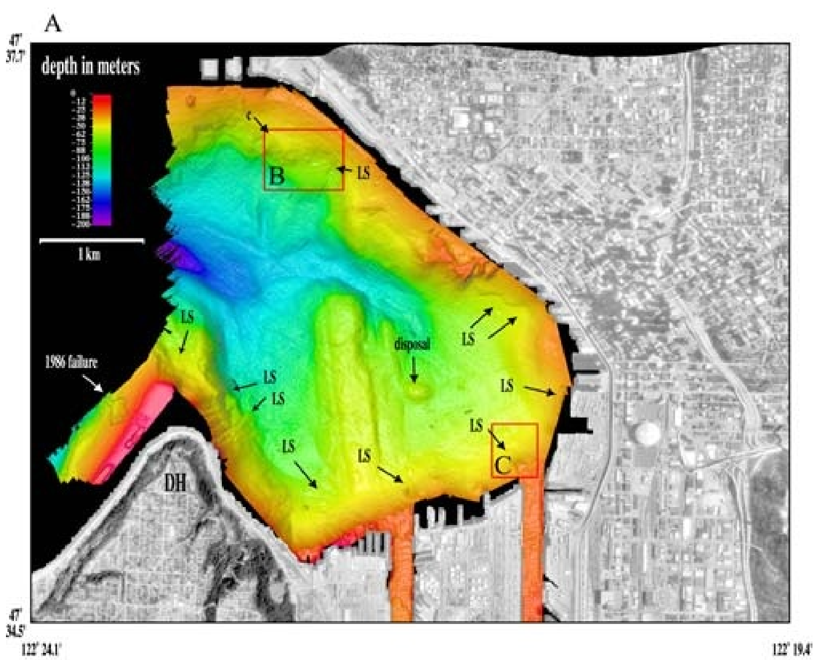


Figure H-12. Historic Landslides in Duwamish River Delta (Gardner et al., 2001)

H.4.2 Probabilistic Seismic Hazard Analyses for Lockheed West

The earthquake hazard at a site can be modeled probabilistically by considering all seismic source zones around a site, and the probability that these source zones will produce earthquakes of various sizes. The USGS performed probabilistic seismic hazard analyses (PSHA) throughout the United States and prepared national seismic hazard maps. The USGS PSHA utilizes knowledge of fault locations and historical seismicity with probabilistic analyses and predicts expected levels of shaking for future earthquakes. In this analysis, 2002 USGS National Seismic Hazard Mapping Program (NSHMP) Hazard Maps were used to estimate site-specific PGAs for the slope stability analysis consistent with the database built into the liquefaction evaluation tool, WSliq, utilized in Section H.5.

In probabilistic seismic hazard analyses, the sum of the hazard calculation is broken into its components (referred to as deaggregation), which is often used to determine what earthquake scenario input (magnitude-distance pair) contributes the most to the overall earthquake hazard at a site. PSHA combines the probabilities of all earthquake scenarios with different magnitudes and distances with predictions of resulting ground motion intensity in order to compute seismic hazard at a site (McGuire, 2004). PSHA also incorporates uncertainties in ground motion predictions, by considering multiple ground motion prediction models (GMPMs), formerly known as attenuation equations (Lin and Baker, 2011). USGS deaggregation plots for peak acceleration with a mean return period of 108 years (50 percent probability of exceedance in 75 years; nominal 100-year event), 475 years (10 percent probability of exceedance in a 50-year period; nominal 500-year event), and 2,475 years (2 percent probability of exceedance in 50 years; nominal 2,500-year event) were generated using the 2002 USGS National Seismic Hazard Mapping tool and presented below (Figures H-13a, b, and c). The heights of the columns in the figures illustrate the relative contributions of each magnitude-distance pair to the return-year peak acceleration of corresponding PGA. For example, Figure H-13b shows a USGS deaggregation plot for PGA at the Site for a mean return period of 475 years; the heights of the columns in the figure illustrate the relative contributions of each magnitude-distance combination to the 475-year peak acceleration of 0.34 g. At the Site, the 475-year mean and modal magnitudes are 6.59 and 6.63, respectively. The distribution of magnitude values contributing to peak acceleration is important for liquefaction hazard evaluations because magnitude is taken as a proxy for duration for evaluation of liquefaction potential. These PSHA deaggregation plots define the PGAs (i.e., 0.16g, 0.34g, 0.7g) for the corresponding seismic events (Figures H-13a, b, and c). Recently, the USGS has updated its hazard maps based on updated source and attenuation models (Peterson et al., 2008). For comparison purpose, the deaggregation plots were also generated using 2008 USGS NSHMP maps. These plots are shown in Figures H-13d, e, and f.

These probabilistic PGAs are for soil profiles classified in building codes as Site Class B (rock profile). Consideration was given to modifying them to account for soils in the upper 300 feet above the glacial till that behaves as bedrock. While soft soil profiles can significantly increase the ground surface response for smaller ground motions, their low strength limits the peak acceleration they are capable of transmitting when subject to larger ground motions.

The International Building Code (IBC) design process is one guidance that accounts for this effect by applying a Site Coefficient (F_a) for a "soft soil profile," which varies from F_a=2.5 for a 0.2 second mapped spectral acceleration (S_S) of 0.25g to F_a=0.9 for S_S > 1.0g. For evaluation of liquefaction consequences for buildings, the design PGA determined using the default IBC equation for this Site is 0.36g [Design PGA = (S_s*F_a*2/3)/2.5; IBC 2003, Equation 16-38, 16-40]. A site-specific analysis would be performed for building design to refine the PGA value; however, this is not warranted for this evaluation. The IBC design earthquake motions are two-thirds those for a 2,475-year event and can be considered to approximate a 475-year event. The probabilistic PGA for a 475-year event is 0.34g, essentially the same as the IBC liquefaction analysis value of 0.36g. If one assumes the design earthquake is equal to the full 2,475-year event (leaving out the two-thirds factor), the PGA for liquefaction analysis determined in accordance with the IBC procedure would be 0.55g. The fact that this is significantly less than the 2,475-year event probabilistic PGA of 0.7g (Figure H-13c) reflects the typical reduction in PGA that can be expected for soft ground subject to large ground motions. Our conservative approach in PGAs is also supported if we compare the deaggregation plots generated by the 2002 and 2008 USGS NSHMP maps. The 2008 USGS PSHA deaggregation plots result in PGAs of 0.14g, 0.31g, and 0.61g for 108-, 475-, and 2,475-year seismic events, respectively, compared to 0.16g, 0.34g, and 0.7g generated by the 2002 NSHMP. Therefore, we believe the range of probabilistic PGAs determined in this section are suitable for use as the design seismic events for the seismic slope stability analyses in this appendix and represent a conservative range of values for the soil profile at the Lockheed West Site.

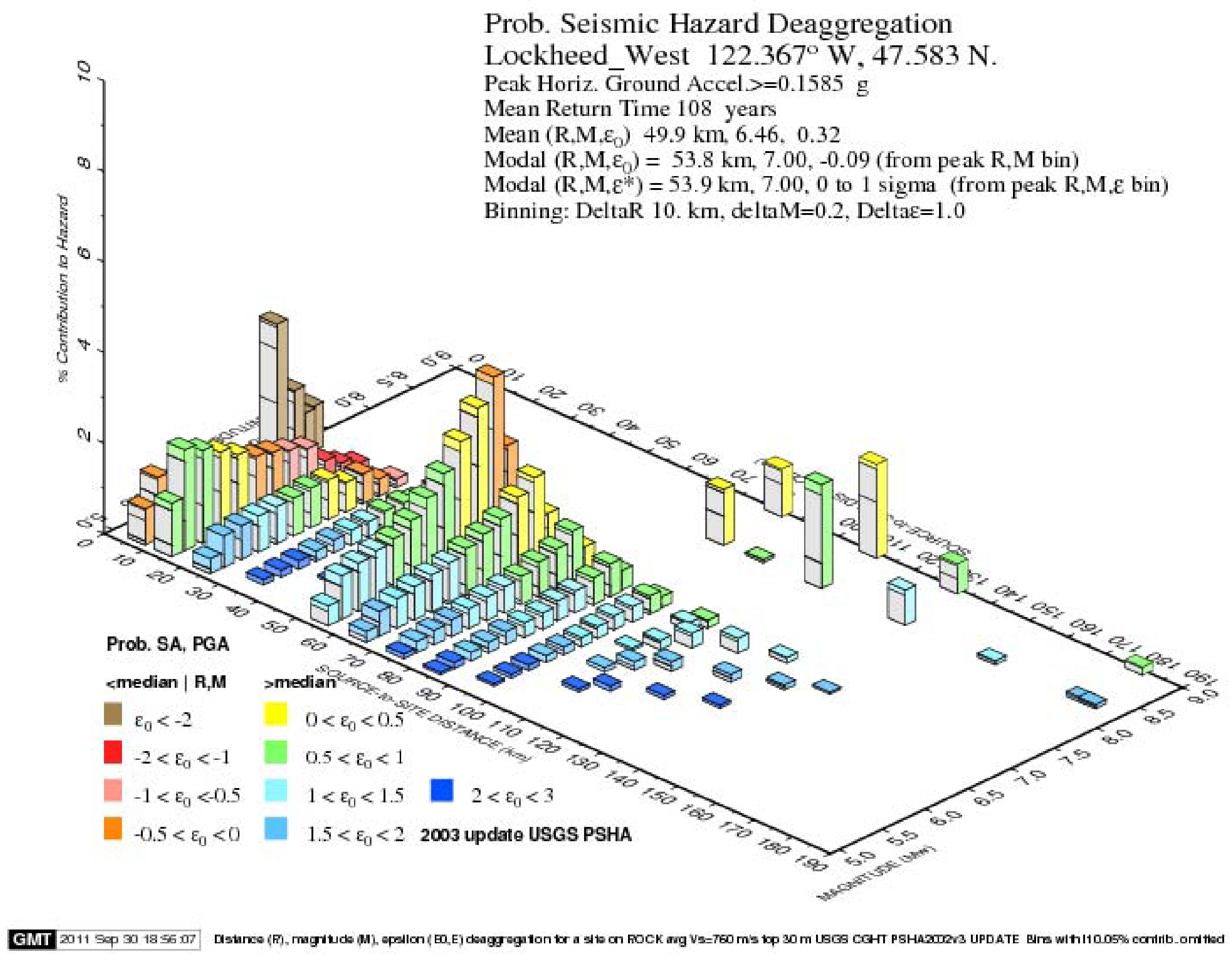


Figure H-13a. Magnitude and Distance Deaggregation Plot of 108-Year Peak Acceleration Hazard for the Lockheed West Site

Source: https://geohazards.usgs.gov/deaggint/2002/

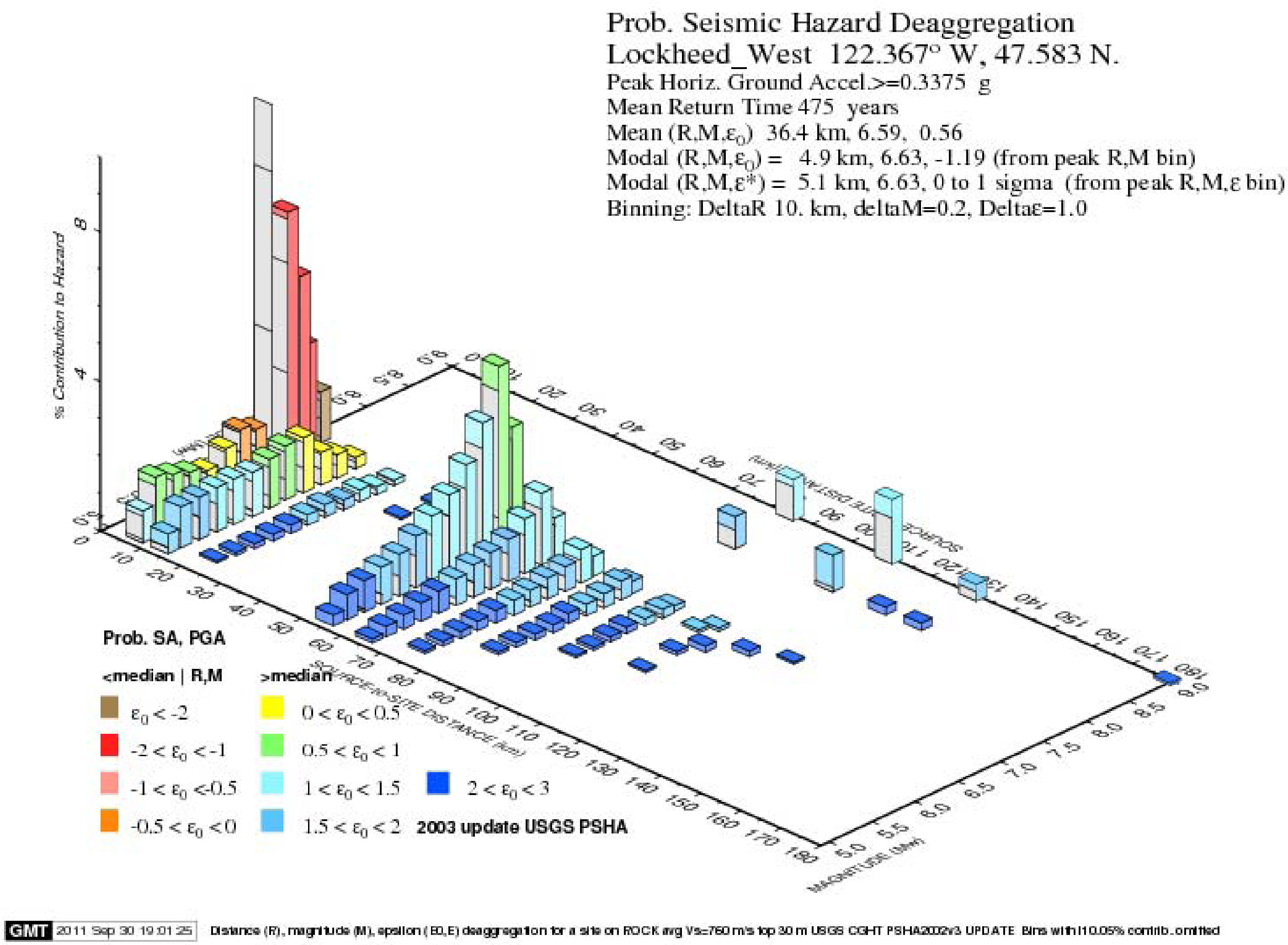


Figure H-13b. Magnitude and Distance Deaggregation Plot of 475-year Peak Acceleration Hazard for the Lockheed West Site

Source: https://geohazards.usgs.gov/deaggint/2002/

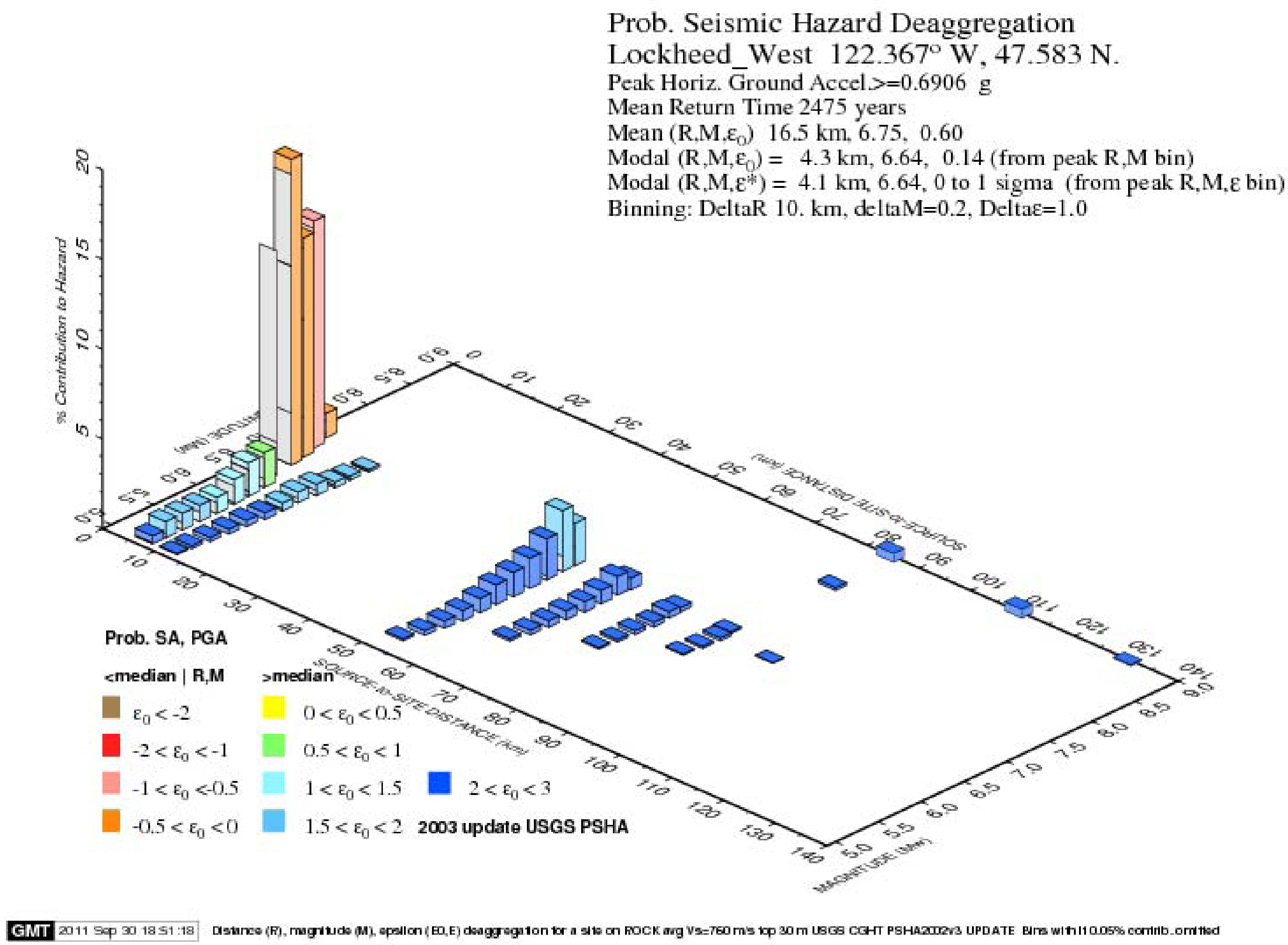


Figure H-13c. Magnitude and Distance Deaggregation Plot of 2,475-Year Peak Acceleration Hazard for the Lockheed West Site

Source: https://geohazards.usgs.gov/deaggint/2002/

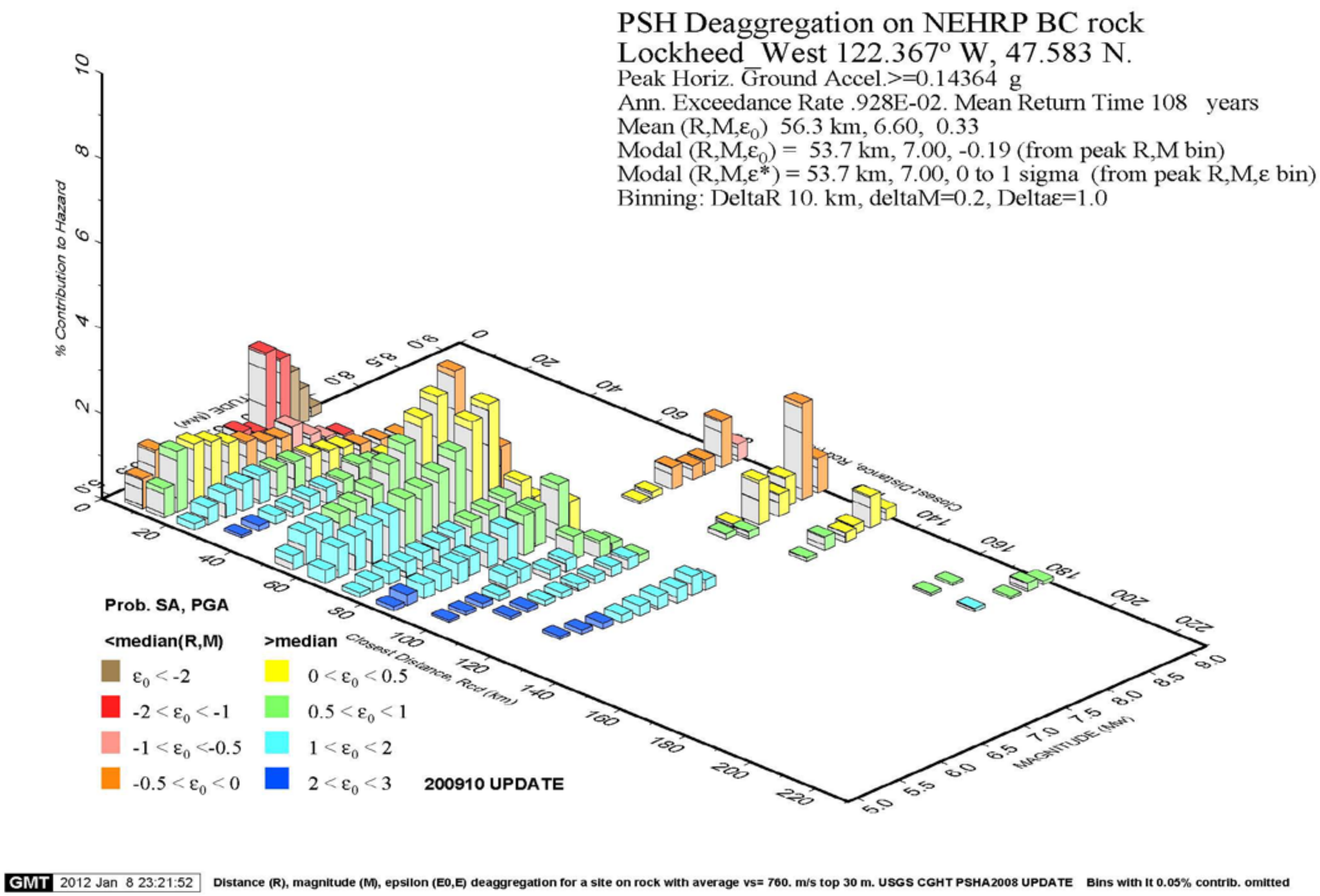


Figure H-13d. Magnitude and Distance Deaggregation Plot of 108-Year Peak Acceleration Hazard for the Lockheed West Site

Source: https://geohazards.usgs.gov/deaggint/2008/

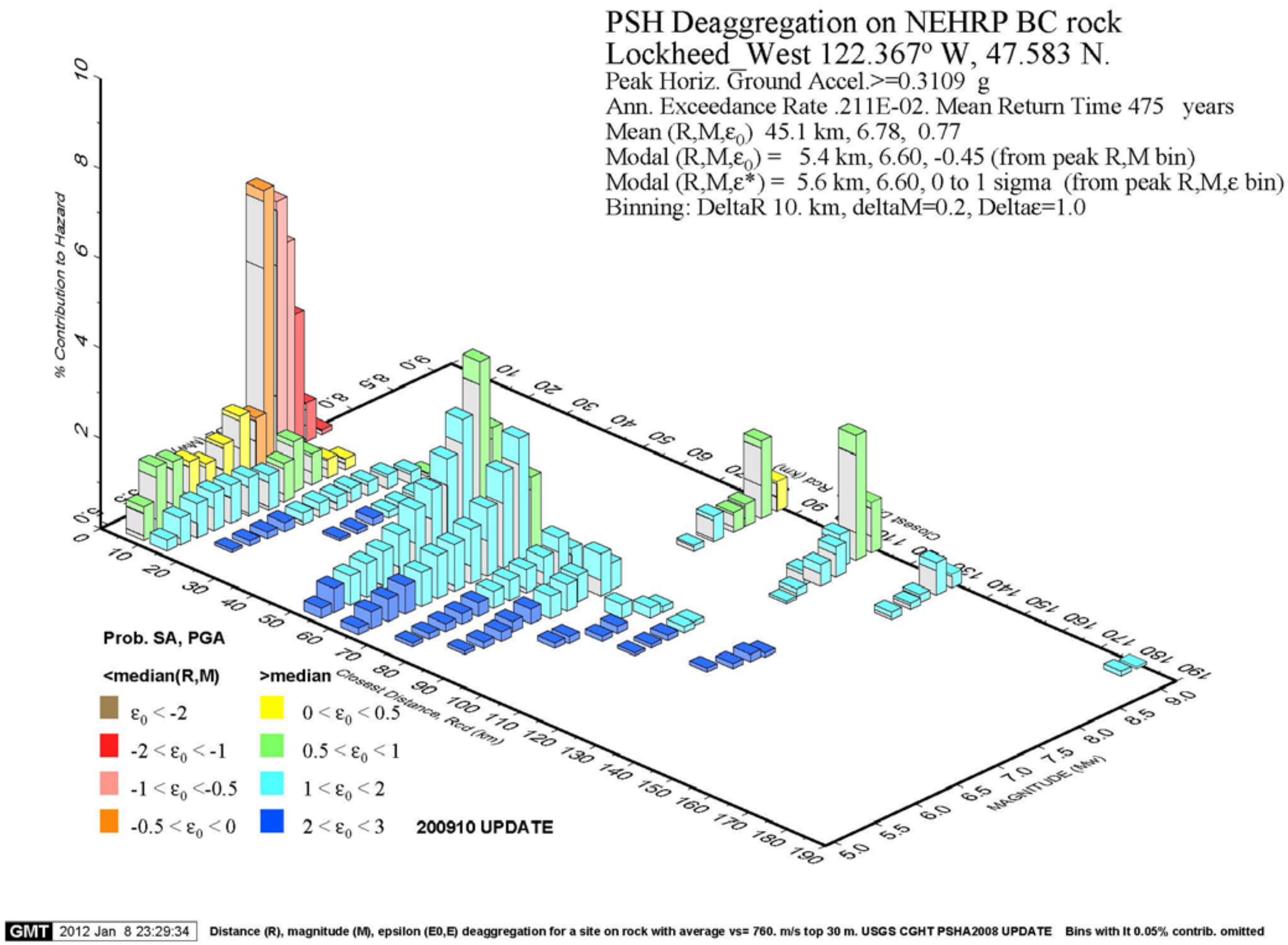


Figure H-13e. Magnitude and Distance Deaggregation Plot of 475-year Peak Acceleration Hazard for the Lockheed West Site

Source: https://geohazards.usgs.gov/deaggint/2008/

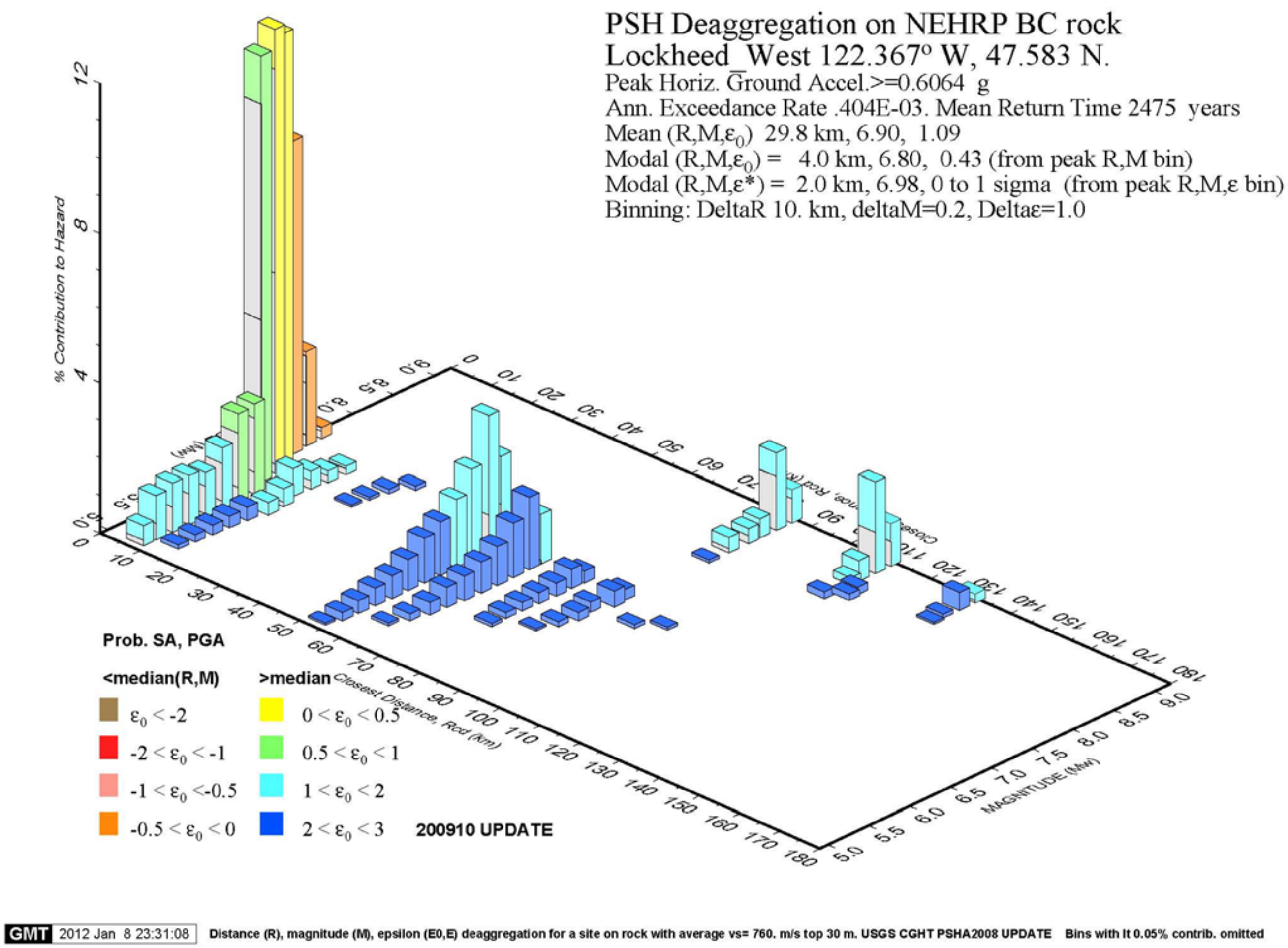


Figure H-13f. Magnitude and Distance Deaggregation Plot of 2,475-Year Peak Acceleration Hazard for the Lockheed West Site

Source: https://geohazards.usgs.gov/deaggint/2008/

H.5 LIQUEFACTION POTENTIAL EVALUATION

Soil liquefaction is an earthquake-related phenomenon in which strong shaking causes a soil deposit to lose its strength and stiffness as a result of the generation of pore water pressure. Liquefaction occurs most commonly in loose, saturated, clean silty sands and non-plastic silts. Accurate and consistent evaluation of liquefaction hazards requires consideration of ground motions at all hazard levels and of the underlying distributions of earthquake magnitudes that contribute to those motions.

H.5.1 Liquefaction Potential Evaluation Procedure

Liquefaction potential was evaluated using a program, WSliq, developed by the University of Washington (Kramer, 2008). USGS probabilistic seismic hazard analysis database for Washington State is built into the WSliq package. The program computes PGAs for each return period using the 2002 USGS database by interpolating the seismic hazard data for the site by using an inverse distance weighting procedure for the selected single, multiple, or performance-based liquefaction analyses. Evaluation of liquefaction potential depends on the anticipated level of loading imposed on a soil profile—the cyclic stress ratio (CSR)—and the inherent resistance of the soil profile to liquefaction—the cyclic resistance ratio (CRR) for resistance. The WSliq program incorporates the most commonly used form of the cyclic stress approach recommended at the 1996 National Earthquake Hazards Reductions Program (NEHRP) workshop (Youd et al., 2001), a deterministic procedure by Idriss and Boulanger (2004), and a probabilistic procedure using SPT data (Cetin et al., 2004) and/or CPT data (Moss et al., 2006).

The WSliq program gives the option of single, multiple and performance-based liquefaction analyses. A single scenario analysis is performed for ground motions with a certain return period and a peak ground acceleration (i.e., a selected seismic event). Multiple-scenario analysis results are computed for all magnitude values with weighting factors proportional to the relative contribution of each magnitude to the ground motion parameter used to compute the expected value of the result. The multiple scenario analyses eliminate the controversial issue of using certain magnitudes in liquefaction hazard evaluations. Performance-based analyses consider ground motions with all return periods and the contributions of magnitude to all of those return periods. Performance-based analysis is in developing stage in current beta version of WSliq program (personal communication with Dr. Kramer, October 2011). Multiple-scenario analysis was used for 108, 475, and 2,475 years of return periods in liquefaction susceptibility, initiation, and deformation analysis.

H.5.2 Liquefaction Susceptibility and Initiation Analysis Results

Liquefaction analysis is highly dependent on the geotechnical properties of soil, particularly standard penetration test (SPT) results, initial water content, plasticity index, and liquid limit. Due to limited geotechnical information and highly variable SPT measurements observed at the Site, two sets of liquefaction analyses were conducted; one with lower-bound and one with upper-bound SPT results measured at the same depth of subsurface but approximately 250 feet apart (Hart Crowser, 1995). Boring locations (i.e., HC-8, HC-9, HC-10, and HC-15) are shown in Figure H-1 and the boring logs are included in Attachment 1. The SPT results at each boring log were tabulated by depth, then minimum and maximum measurements at each 10-foot interval were identified and two sets of SPT results were compiled for the analysis. This approach intends to provide a lower bound and higher bound risk to the liquefaction initiation and deformation mechanisms by incorporating variations and uncertainties in the subsurface conditions within approximately 10 acres of the area of concern. Liquefaction susceptibility and initiation analysis was performed for existing conditions and Alternatives 2A2a, 3A1, and, 3C. Computed factors of safety equal or greater than 1.0 indicate liquefaction is unlikely given the design-basis earthquake, whereas values below 1.0 indicate that liquefaction is likely.

The analysis results show that the upper 50 feet of site sediments are susceptible to liquefaction (See Attachment 2, WSliq results). Liquefaction is likely initiated with all three return periods evaluated. Table H-2 summarizes the calculated factor of safety for liquefaction initiation for the upper 50 feet of sediments where below 50 feet the sediments are classified as medium dense sand and not considered susceptible to liquefaction. Note that the seismic parameters computed by WSliq are not identical with the 2002 USGS deaggregation plots because the program computes PGAs using the methodologies built into it; the parameters are more conservative than both the 2002 and 2008 USGS deaggregation plots presented in Figures H-13a through H-13f.

Table H-2.
Liquefaction Initiation Analysis Results

Return Period/ PGA	Depth (ft)	Factor of Safety for Liquefaction Initiation (Lower bound SPT-Higher bound SPT)			
		Existing Conditions	Alternative 2A2a	Alternative 3A1	Alternative 3C
108-years/ M6.46, 0.176g	0-10	0.4-0.8	0.4-0.9	0.4-1.0	-
	10-20	0.5-7.9	0.5-7.8	0.5-8.4	0.5-8.7
	20-30	0.7-12.4	0.7-13.1	0.7-13.0	0.7-12.4
	30-40	1.2-13.6	1.2-14.0	1.213.9	1.4-13.1
	40-50	0.7-15.4	0.7-16.2	0.7-15.8	0.6-14.0
475-years/ M6.58, 0.378g	0-10	0.2-0.4	0.2-0.4	0.2-0.4	-
	10-20	0.2-3.6	0.2-3.5	0.2-3.8	0.2-3.9
	20-30	0.3-5.6	0.3-6.0	0.3-5.9	0.3-5.6
	30-40	0.5-6.2	0.5-6.4	0.5-6.3	0.6-6.0
	40-50	0.3-7.0	0.3-7.4	0.3-7.2	0.3-6.3
2,475-years/ M6.71, 0.754g	0-10	0.1-0.2	0.1-0.2	0.1-0.2	-
	10-20	0.1-1.7	0.1-1.7	0.1-1.8	0.1-1.9
	20-30	0.2-2.8	0.2-2.9	0.2-2.9	0.2-2.8
	30-40	0.3-3.1	0.3-3.1	0.3-3.1	0.3-2.9
	40-50	0.2-3.5	0.2-3.7	0.2-3.6	0.1-3.1

Notes:
1/ The boring logs are at about 250 feet spaced to a depth 75 feet to 125 feet.
2/ Lower bound standard penetration test (SPT) results are in the range of 1 to 45, higher bound SPT results are in the range of 8 to 100 assigned to 12 layers of subsurface soil.
3/ The results are reported at mid-point of layers. No factor of safety value was reported for the top 10-feet depth interval for Alternative 3C because the layer is to be dredged.
4/ Factor of safety for liquefaction initiation varies at each layer. Washington State Department of Transportation recommended factor of safety (weighted average of NCEER, Idriss and Boulanger [2004], and Cetin et al. [2004] liquefaction models) is reported.

The results of the existing conditions presented in Table H-2 suggest that the top 10 feet of loose silty sediments within the dry dock hot spot area form a homogenous liquefiable layer and the liquefaction will likely be initiated during the analyzed seismic events. Below 10 feet, the zones of liquefaction are sporadic rather than a homogeneous liquefiable layer because the liquefied sediments are interbedded within denser, less liquefiable materials within the dry dock hot spot area. Liquefiable layers where the liquefaction is likely be initiated with all three return period seismic activities take up approximately 13 to 36 percent of subsurface characterized by the representative boring logs where the logs extend to a depth of 75 to 125 feet. Based on the available core data, the overall dry dock hot spot area is likely to stay intact during a seismic event while experiencing liquefied zones within the liquefiable layers.

Liquefaction susceptibility and initiation analysis was performed for Alternative 2A2a, where a 3-foot sand cap was placed over the existing soil profile within the dry dock hot spot area. Similar to the existing conditions summarized above, the top 10-foot layer of loose silty sand is predicted to liquefy under the seismic events evaluated. Below 10 feet, sporadic liquefaction is expected (Table H-2).

Alternative 3A1 involves removal of the top 3 feet of sediments and replacement with 3 feet of cap material over the same dry dock hot spot area as evaluated for Alternative 2A2a. The analysis results indicated that the potential stability benefits of removing the top 3 feet of soft liquefiable layer and replacing it with the cap material in the overall 125-foot defined subsurface are negligible. The liquefaction initiation analysis results are consistent with the predicted results for the existing conditions and Alternative 2A2a, with the prediction that the top 10 feet may form a homogenous liquefiable layer and below 10 feet a layer with sporadic liquefaction spots (Table H-2).

Alternative 3C involves removal of approximately the top 15 feet of sediment within the dry dock hot spot area. Therefore, the top 15 feet of the liquefiable layer was eliminated from the soil profile for the liquefaction initiation analysis. The results show that the profile with 15 feet of sediment removed within the dry dock hot spot area will likely experience sporadic liquefaction with a predicted depth of liquefaction of approximately 40 feet rather than a homogeneous liquefiable layer as in Alternatives 2A2a and 3A1 because the liquefied sediments are interbedded within denser, less liquefiable materials (Table H-2 and Attachment 2).

In summary, the liquefaction initiation analyses show that the site sediments are susceptible to liquefaction, and the liquefaction is potentially initiated under the three evaluated seismic events. Overall, the existing conditions show the worst-case liquefaction initiation. There is very slight improvement with the Alternatives 2A2a and 3A1 due to application of a 3-foot non-liquefiable sand cap layer compared to the existing conditions. During design, the sand cap layer will be engineered such that the cap layer will be considered non-liquefiable. The design measures include adjustment of the plasticity index, water content to liquid limit ratio, and application of a quarry spall layer over the sand cap layer. Alternative 3C also shows improvement in liquefaction initiation potential compared to existing conditions due to elimination of the top

15 feet of the liquefiable layer. In the next section, the possible consequences of liquefaction are evaluated.

H.5.3 Liquefaction-Induced Deformation Analysis

Deformation analysis (i.e., amount of sediment movement) due to liquefaction provides a better understanding of the potential hazards associated with various remedial construction alternatives if the liquefaction is initiated. Liquefaction-induced deformation analysis includes lateral spreading, post-liquefaction settlement, and flow slides due to residual strength of liquefied soil.

Lateral spreading occurs in mildly-sloping ground when the combined downslope static and earthquake-induced inertial forces exceed the undrained resistance of the soil. Because the inertial forces are required to exceed the resistance of the soil, lateral movement ceases when shaking ends. Modeling of lateral spreading is complicated by the complex non-linear behavior of soils (particularly moderately dense soils) under seismic loading. As a result, the state-of-the-practice for lateral spreading analysis is based on a level ground liquefaction analysis and empirical relationships to predict lateral displacement that account for various soil properties, seismic parameters, and geometric conditions.

In areas that experience liquefaction, post-earthquake settlements will occur as shaking-induced excess porewater pressure dissipates and the liquefied soil consolidates. Once liquefaction starts, flow slides may occur due to the potential for gross instability. Evaluation of the potential for flow slide development requires evaluation of the residual strength of a liquefied soil and associated slope stability analysis. Slope stability is evaluated in Section H.6.

Deformation analysis of liquefied soil was analyzed using WSliq with the option of weighting individual layer contributions to deformation analysis according to the probability of liquefaction. WSliq utilizes four empirical liquefaction models (i.e., Youd et al., 2002 [most commonly used]; Kramer and Baska, 2007 [an improved approach to Youd et al. 2002], Zhang et al., 2004 [cumulative strain-type model]; and Idriss and Boulanger, 2008 [upper bound estimate]) and also reports Washington State Department of Transportation (WSDOT) recommended (weighted average) using models of Kramer and Baska (2007) and Youd et al. (2002). The lateral spreading and post-liquefaction estimates for all analyses are summarized in Table H-3. WSliq analyses results for all the analyses are included in Attachment 2.

Table H-3.
Liquefaction-Induced Deformation Analysis Results

Return Period/PGA	Scenario	Liquefaction Analysis with Lower Bound SPT results		Liquefaction Analysis with Higher Bound SPT results	
		Lateral Spreading Estimate (ft)[1/]	Post-Liquefaction Settlement (ft)[2/]	Lateral Spreading Estimate (ft)	Post-Liquefaction Settlement (ft)
108-years/0.176g	Existing Conditions	0.7-5.3	2.9	0	0.2
	Alternative 2A2a	0.6-5.1	2.9	0	0.2
	Alternative 3A1	0.5-4.3	2.6	0	0.1
	Alternative 3C	0.2-1.5	1.3	0	0
475-years/0.378g	Existing Conditions	1.7-8.3	3.5	0.2-0.6	0.3
	Alternative 2A2a	1.8-8.4	3.6	0.2-0.6	0.3
	Alternative 3A1	1.6-7.4	3.3	0.2-0.4	0.2
	Alternative 3C	0.7-3.9	1.7	0.1	0
2,475-years/0.754g	Existing Conditions	4.3-9.0	3.7	0.6-0.8	0.4
	Alternative 2A2a	4.2-9.2	3.7	0.6-0.8	0.4
	Alternative 3A1	3.7-8.1	3.4	0.5	0.3
	Alternative 3C	2.1-4.3	1.8	0.2-0.3	0

Notes:
1/ Lateral spreading is estimated using Washington State Department of Transportation (WSDOT) recommended weighted average of Youd et al. (2002) and Baska and Kramer (2007) models (lower bound estimate) and Idriss and Boulanger (2008) model (higher bound estimate). The range of lateral spreading is reported.
2/ Post-liquefaction settlement was predicted using the WSDOT recommended method, weighted average of four deterministic models.
SPT = standard penetration test

Lateral spreading estimates presented in Table H-3 suggest that the liquefaction-induced lateral spreading could be up to 9 feet for the 2,475-year event assuming the lower bound estimates of soil strength. Due to variability in the site soil stratigraphy, lateral displacement is expected to be sporadic in the range of 0 to 9 feet and to be confined within non-liquefiable layers in the dry dock hot spot area due to existence of layers with higher shear strength. Predicted post-liquefaction settlements could be up to 4 feet for the 2,475-year event for the low-bound SPT case where the soil stratigraphy was assumed as homogenous soft layers of up to 50 feet. In reality, some differential settlement will be expected but probably not to the extent of 4 feet due to the presence of interbedded layers with different shear strength. For 108- and 475-year events, the predicted post-liquefaction settlement is in the range of 0 to 3 feet and again probably not to the extent of 3 feet due to the presence of interbedded layers with different shear strength.

Predicted liquefaction induced hazard potential is similar for existing conditions, Alternative 2A2a, and Alternative 3A1, whereas there is some improvement in the predicted hazard potential for Alternative 3C. These results indicate that liquefaction induced lateral spreading and post liquefaction settlements are predicted to be tolerable and the contaminated sediments subject to various remedial actions will remain within the dry dock hot spot area. Areas adjacent to the dry dock area are expected to be affected in the same way with limited movement of the sediment.

The deformation/lateral spreading analysis was also conducted as part of the slope stability evaluation discussed in Section H.6.4 where simplified displacement charts and equations based on Newmark-type analyses were utilized as recommended by the WSDOT (2010) Geotechnical Design Manual (GDM).

H.6 SLOPE STABILITY EVALUATION

Gravitational and seepage forces cause instability in natural slopes. The most common modes of slope failures include rotational slips and translational and compound slips where the failure surface is influenced by the presence of stratum with high strength (Figure H-14).

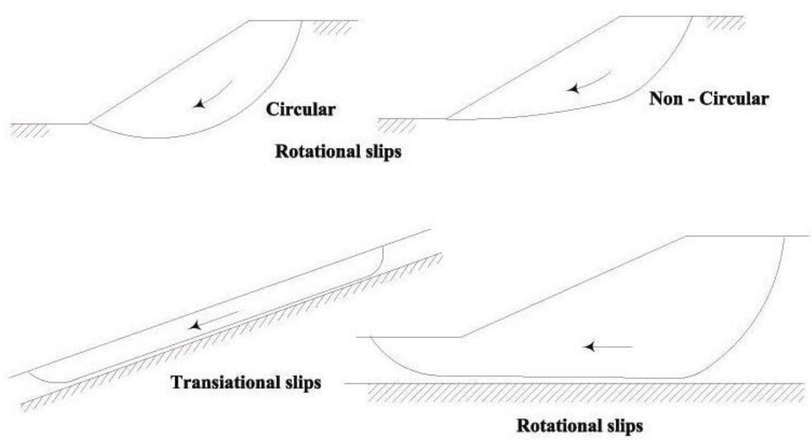


Figure H-14. Types of Slope Failure (Craig, 1989)

In stability analyses, a factor of safety is calculated. This factor is defined as the ratio of resisting (stabilizing) forces to the driving forces trying to displace the slope. A factor of safety equal or greater than 1 implies that the slope is stable. A factor of safety less than 1 implies that the slope is not stable and slope movement is possible. A failed slope with rotational slip may resemble the illustration below (Figure H-15).

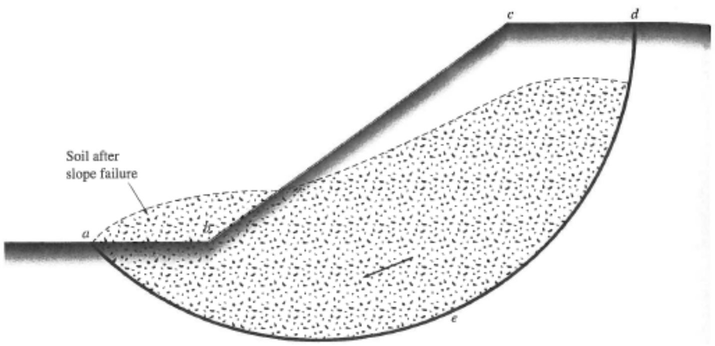


Figure H-15. Illustration of a Failed Slope with Rotational Slip (Das, 1994)

To evaluate the stability of Lockheed West Site submerged slopes, a conventional two-dimensional limit-equilibrium analysis was performed to investigate the stability of the slopes. The computer program, SLOPE/W (GeoStudio, 2004), was used to calculate the factors of safety compared to potential failure. The slope stability analysis methods within SLOPE/W include Ordinary, Bishop, Janbu, Spencer, and Morgenstern-Price.

H.6.1 Static Slope Stability Analysis Procedure

Profile 1, the transect crossing the largest dimension of the potential remedial action area (i.e., the dry dock 1 hot spot area), shown in Figure H-7 (see Figures section of the report) was selected as the representative transect for slope stability analyses of Alternatives 2A2a, 3A1, and 3C. The slope stability profiles generated from the SLOPE/W analyses are slightly different than the full profile shown in Figure H-1 and this is indicated on Figure H-7. A potential concern is the stability of the sediments under the former dry dock where the depth of contamination is estimated at 10- to 15-foot depth. Global slope stability analysis including the delta shelf was performed to assess the large-scale slope stability issues and associated stability of residual contamination under the former dry dock area. The stability of local steeper slopes such as the berms under piers with a side slope of 2H:1V and flatter is not considered critical because during design a stable capping slope will be determined; if a slope stability failure occurs, the failure of those berms would be localized, easily repairable by placing additional cap material if the monitoring activity indicates a repair action is needed. Therefore, the focus of the slope stability analysis is the large-scale stability of the proposed alternatives.

The analyses of Alternatives 2A2a and 3A1 were combined because the slope stability analyses do not differ between these two alternatives (cap only versus 3 feet dredge and cap). Alternative

3C involves dredging 10 to 15 feet under the former dry dock area. Other than Profile 1, Profile 4 (Figure H-8) was also analyzed to assess the stability of the sediments under the ENR area; ENR is common to all three alternatives (Figures H-2 to H-4). Simplified stratigraphy and the strength parameters used in the analyses are summarized in Table H-4. Spencer's method was chosen for the analysis, which satisfies both the equilibrium of forces and moments. Static slope stability was evaluated using the geotechnical parameters listed in Table H-4, and the results are summarized in Section H.6.3.

Table H-4.
Geotechnical Parameters Used for Slope Stability Analyses[1/]

Soil Layer Description	Total Unit Weight (pcf)	Friction Angle (degrees)	Undrained Shear Strength (psf)[2/]
Cap (3-4 ft)	110	32	0
Loose silty/sand (40 ft - 50 ft)	95	0	500
Medium dense sand (60 ft -70 ft)	100	28	0
Denser sand/glacial till (300 ft)	105	32	0

Notes:
1/ The parameters were selected using Hart Crowser (1995) and URS (2003) reports.
2/ Undrained shear strength of loose silty layer was reported as 35 psf for top 2.5 ft upper silt, 35 psf to 1,000 psf (linearly increasing) for 10 ft intermediate silt in PSR cap stability evaluations (URS 2003). Hart Crowser (1995) indicated undrained strength in the range of 670 psf (at former Pier 24 area) to 1,600 psf (at a location along outer harbor line) for the top 5 to 33 ft of soft silty sediments.

H.6.2 Seismic Slope Stability Analysis Procedure

The seismic slope stability was evaluated using the pseudo-static stability analyses method. A horizontal pseudo-static coefficient equal to 0.5 of the design PGA was applied as recommended by the WSDOT (2010) GDM and consistent with the PSR cap seismic slope stability analysis (URS, 2003).

The WSDOT GDM states that a horizontal pseudo-static coefficient of 0.5 of the design PGA and a vertical pseudo-static coefficient equal to zero should be used when seismic stability of slopes is evaluated, not considering liquefaction. The manual also that notes that for soils that exhibit a significant drop in strength to a residual value due to liquefaction, the soil strength loss caused by the deformation should be considered in the slope design. In such cases, the slope stability is evaluated using residual shear strengths but without seismic inertial forces because the drop in shear strength will not be complete until after seismic shaking is complete (WSDOT, 2010). A range of shear strength reduction was estimated at this site based on the WSliq analysis (resulting in a conservative strength reduction of 87 to 95 percent) if the liquefaction was initiated. Note that the cap design at the adjacent PSR site only assumed a 20 to 30 percent reduction in strength parameters after liquefaction (URS, 2003). Following the WSDOT GDM recommendations, pseudo-static slope stability was evaluated with the reduced shear strength values (Table H-5, column 3).

H.6.3 Slope Stability Analyses Results

Static and seismic slope stability analyses results modeled for Profile 1 and Profile 4 are summarized in Table H-5.

Table H-5.
Slope Stability Analysis Results

Model	Minimum Factor of Safety				
	Static (w/measured strength)	Pseudo-static (w/reduced strength – after liquefaction)	108-years	475-years	2,475-years
Alt. 2A2a and 3A1_Profile 1	5.35	1.17 - 0.31	1.60	0.87	0.46
Alt. 3C_Profile 1	4.57	1.31 - 0.60	1.57	0.89	0.46
ENR_Profile 4	4.00	1.42 - 0.92	1.53	0.88	0.47

Notes:
1/ Static slope stability analysis with reduced strength case represent after liquefaction conditions.
2/ Seismic coefficient for 108-, 475-, and 2,475-year events are 0.08g, 0.17g, and 0.345g –all 0.5 of max PGAs determined by USGS PSHA.
3/ The range of reduced shear strength values are 25 to 65 psf for the top 40 to 50 ft loose silty sand layer; and a friction angle of 20 to 24 degree for the underlying 60 to 70 ft medium dense sand. Reduced shear strength values were used for the pseudo-static analysis only.

Slope stability analysis results indicate that the analyzed slopes are stable under existing conditions and in a 108-year seismic event. Slope stability failure is predicted during 475- and 2,475-year seismic events. Slope stability failure after the liquefaction is initiated may or may not occur depending on the estimated reduced shear strength values (the factor of safety [FOS] is in the range of 0.31 to 1.42 in Table H-5, column 3). A displacement analysis for the slopes after the liquefaction is initiated was performed and discussed in the following section.

The plots illustrating the model of the slope cross sections and the most critical potential failure surfaces searched by the computer program (SLOPE/W) for each of the analysis are included in Attachment 2. For those cases where slope stability failure is predicted, the most critical slip surface from any event does not cross through the former dry dock 1 area where contamination may be left in place. Representative SLOPE/W figures presented below show the most critical slip surface (minimum FOS) not affecting the stability of contaminated sediments under dry dock area and the one that potentially would affect the sediments under the dry dock 1 area for Profile 1, Alternatives 2A2a and 3A1, 475-year event analysis (Figure H-16). The area shaded with dark green represents the slide mass corresponding to the slip surface that may potentially fail.

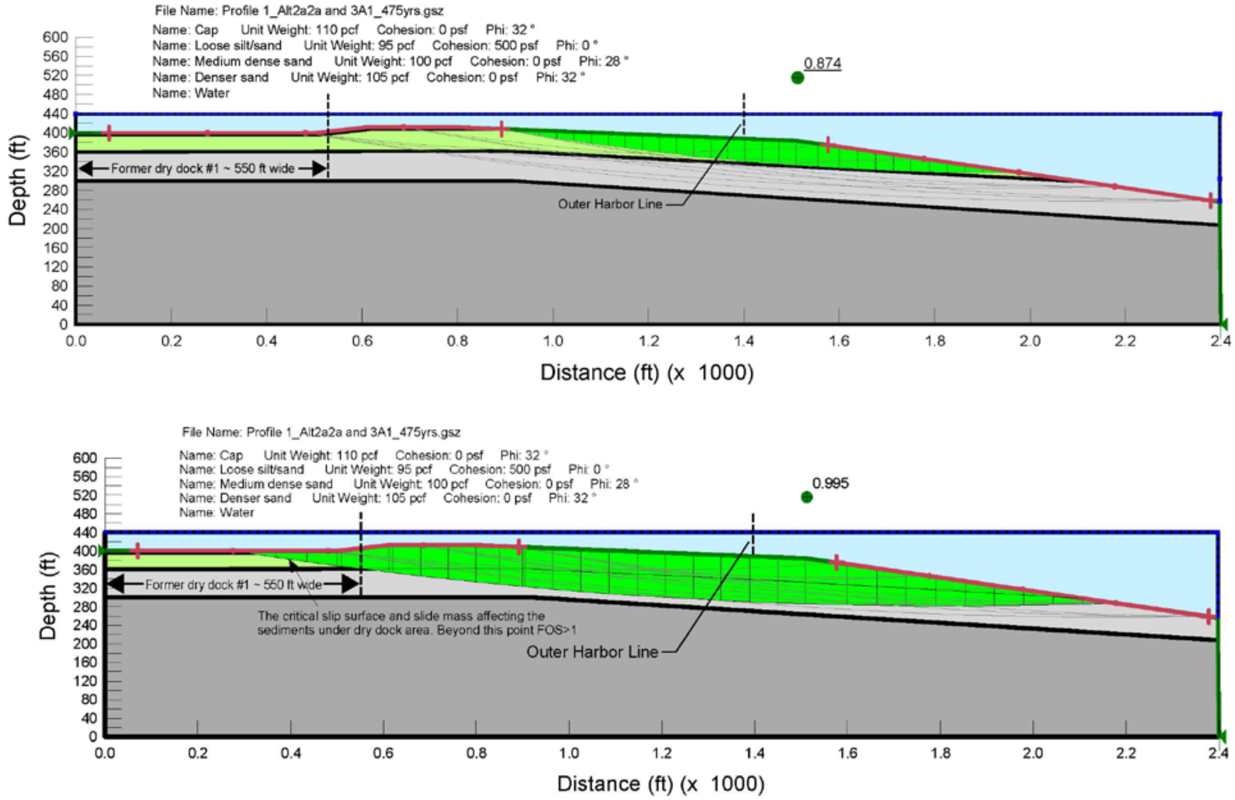


Figure H-16. SLOPE/W Plots of Profile 1, Alternatives 2A2a and 3A1, 475-year Event: the most critical slip surface and slide mass (above); the critical slip surface and slide mass affecting the stability of sediments under dry dock 1 area (below)

Similarly for Profile 1, Alternative 3C, the most critical slip surface and the one that potentially may affect the stability of sediments under the former dry dock 1 area are shown below (Figure H-17).

For Profile 1, 2,475-year analysis, and Profile 4, 475-year and 2,475-year analyses, there exist potential slip surfaces that may affect the stability of contaminated sediments that may remain under the former dry dock 1 area for Profile 1 and under the ENR area for Profile 4 (Attachment 3).

Slope stability analyses results suggest that there is a slight difference between the alternatives from a slope stability standpoint.

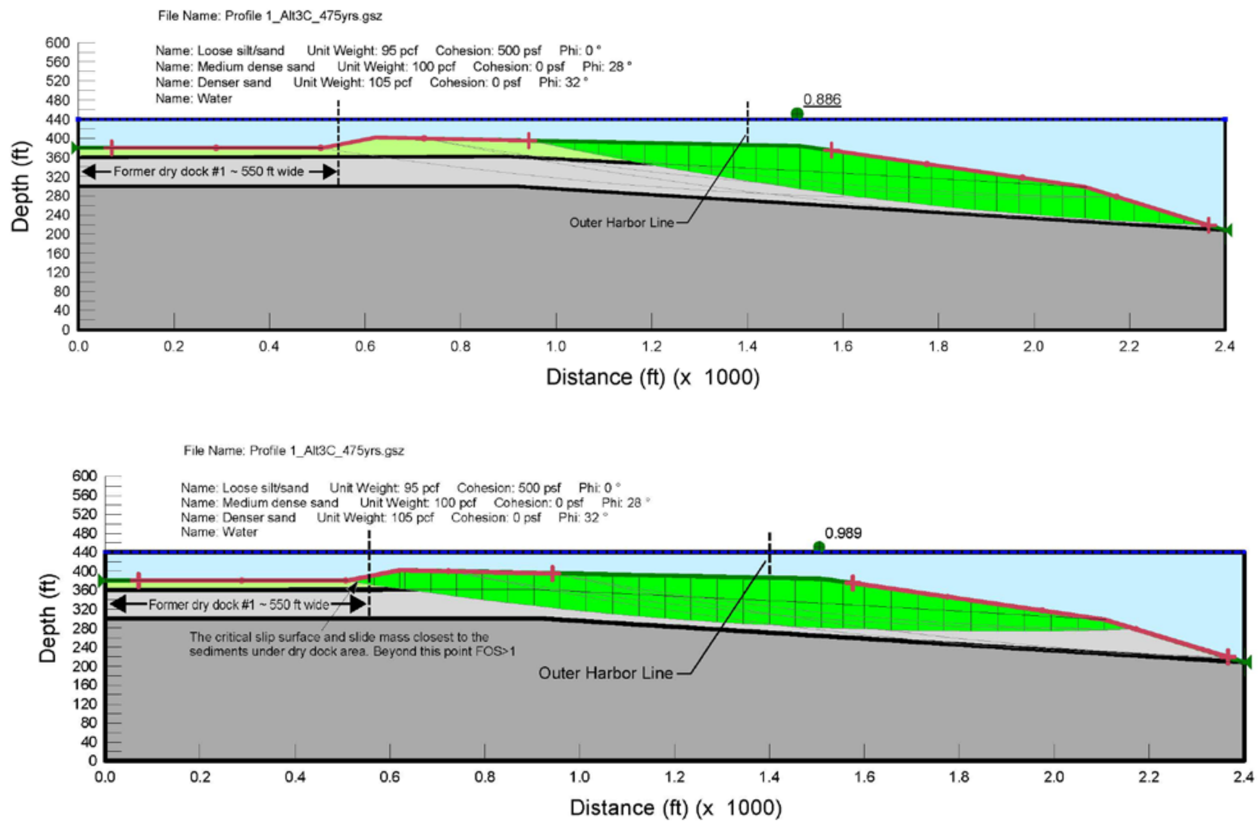


Figure H-17. SLOPE/W Plots of Profile 1, Alternative 3C, 475-year Event: the most critical slip surface and slide mass (above); the critical slip surface and slide mass affecting the stability of sediments under dry dock 1 area (below)

H.6.4 Earthquake Induced Displacement Analysis

The magnitude of seismically induced slope deformation/lateral spreading can be estimated using the methods recommended by the WSDOT (2010) GDM. Acceptable methods include Newmark sliding block (time history) analysis, simplified displacement charts and equations based on Newmark-type analyses, or dynamic stress-deformation models.

Displacement analysis was performed using Newmark-based displacement charts (Makdisi and Seed, 1978; Seed et al., 1984; Bray and Travasarou, 2007) as referenced in WSDOT (2010) and

NCHRP (2008). The methodology involves the following steps: 1) Identify the yield acceleration of the slope by completing limit equilibrium stability analyses. The yield acceleration is the horizontal pseudo-static coefficient required to bring the factor of safety to unity; 2) Identify the design earthquake maximum PGAs; and 3) Estimate the displacement by utilizing the Newmark-based displacement charts (Attachment 3). The WSDOT GDM notes that the Newmark-type analyses may not be directly applicable to deformation/lateral spreading analysis because the Newmark-based displacement charts were not developed for soil that weakens during earthquake shaking, as is the case for soil liquefaction. The liquefaction mechanisms were better captured in the empirical liquefaction models based on case histories of lateral spreading utilized by WSliq (Section H.5.3). These simplified Newmark-based charts should be used cautiously, especially with regard to the selection of a yield acceleration to be used to enter these design charts (WSDOT, 2010). Therefore, both the deformation analysis conducted here and in Section H.5.3 should be considered in assessment of the stability of site sediments while keeping in mind the limitations behind the methodologies.

Following the Newmark-type analysis methodology, seismically induced slope deformation was estimated to be in the range of 1 to 20 feet for the analyzed seismic events. The same deformation was estimated in Section H.5.3 to be in the range of 1 to 9 feet in liquefaction-induced lateral spreading analysis. These estimates indicate that a seismically induced displacement is likely to remain within or in the near vicinity of the dry dock 1 area such that potential movement of remaining contaminants is limited to within the site. Displacement analysis methodology is applicable for the cases where the FOS is greater than 1 after liquefaction, as in Table H-5, which shows slope stability analysis after liquefaction where FOS values are 1.17, 1.31, and 1.47. Such analysis is not applicable if the post-earthquake shaking (static-residual strength case after liquefaction) slope stability FOS is less than 1.0, as in Table H-5, which shows slope stability analysis after liquefaction during 108-, 475- and 2,475-year events where FOS values are 0.31, 0.60, 0.92; the slope will be unstable during gravity (static) loading and therefore a flow slide is likely (WSDOT, 2010). Based on the slope stability analyses, the critical slip surface of such flow slides after liquefaction will not substantially affect the stability of sediments under former dry dock area, as shown below for Profile 1 (Figure H-18). Similarly for Profile 4, the critical slip surface for the potential flow slide that may occur after liquefaction will not affect the stability of sediments under most of the ENR area (Figure H-19; Attachment 3).

The flow slide analysis presented above is based on static residual strength after liquefaction for the profile of interest within the Outer Harbor Line. Seismically induced flow slides typically originate on the steeper portion of deltaic deposits (seaward-sloping delta fronts) where similar strength reductions occur but higher driving forces are present. These failure surfaces regress upslope to a head scarp with limited extent into the relatively level upper portion of these deposits. This is the much more probable seismic or post-seismic flow slide scenario for the site.

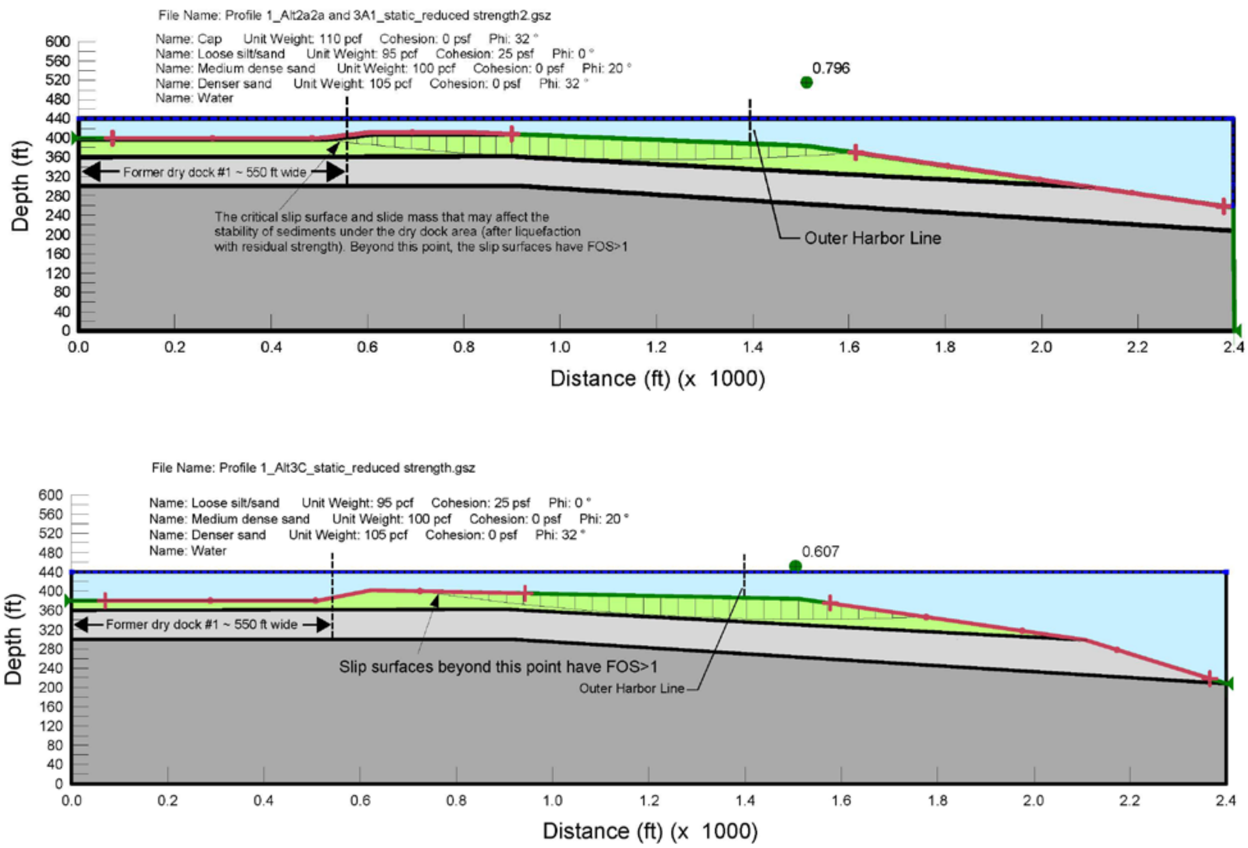


Figure H-18. SLOPE/W Plots of Profile 1, Alternatives 2A2A, 3A1, 3C, after Liquefaction Scenario: the critical slip surface and slide mass closest to the sediments under dry dock 1 area

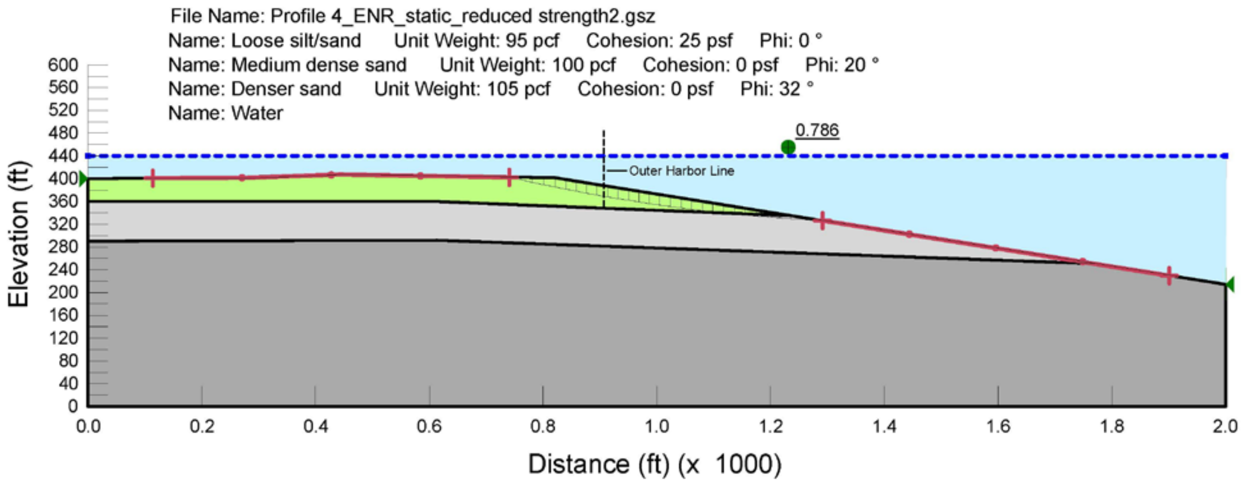


Figure H-19. SLOPE/W Plots of Profile 4 after Liquefaction Scenario: the critical slip surface and slide mass

H.7 CONCLUSIONS

The conclusions of the liquefaction potential and seismic stability evaluation of the remedial alternatives are summarized as follows:

- The upper 50 feet of site sediments are considered susceptible to liquefaction. The liquefaction is potentially initiated by 108 (100)-, 475 (500)-, and 2,475 (2,500)-year seismic events. These findings are consistent with previous analyses in the area.
- Lateral spreading and post-liquefaction settlement due to liquefaction is predicted to be up to 9 feet and up to 4 feet, respectively, for the 2,475-year event using the most conservative strength estimates. These hazards were predicted by WSliq and summarized in Table H-3. Contaminated sediments are expected to remain within the dry dock hot spot area for all the alternatives. A similar hazard potential is expected for the existing conditions, Alternatives 2A2a and 3A1. Similar hazard potential is also expected for the rest of the containment-focus alternatives (Alternative 2) and Alternatives 3A1, 3A2, and 3B. The liquefaction-induced hazard potential is estimated to be less for Alternative 3C due to removal of the top 15 feet of liquefiable layer within the remedial action area. The same conclusion is also applicable to complete removal alternatives (Alternative 4) where the uppermost prone-to-liquefaction layer is removed from the subsurface profile.

- Based on the liquefaction-induced deformation analysis, there exists a risk of potential upwelling, exposure, and spreading of contaminated sediments beneath the capped or ENR areas due to liquefaction; however, the hazard is expected to be localized and remain within the dry dock hot spot area. Such an event may cause short-term disruption to the benthic community in the affected zone but could be repaired by placement of additional cap or ENR material.

- Slope stability analysis for the analyzed post remediation profiles shows stable slopes for static conditions and for a 108-year event, and potential failure for 475-year and 2,475-year events (Table H-5). However, current analyses indicate that potential slope failure during the 475-year event will not likely affect the stability of contaminated sediment under the dry dock 1 hot spot area but failure during the 2,475-year event is likely. The proposed alternatives have a minor effect on the existing topography and stratigraphy; therefore, slope stability conditions do not differ significantly among the alternatives. This conclusion is applicable to all FS alternatives.

- Stability of locally steeper slopes such as the berms under piers, former dredge cuts with a typical side slope 2H:1V or flatter are not considered critical. A stable capping slope will be determined during design. If local slope stability failure of those capped berms or former dredge cuts occur, such failure would be localized and easily repairable by placing additional cap material.

- Earthquake-induced displacements/lateral spreading was predicted to be in the range of 1 to 20 feet by Newmark-type analysis and in the range of 1 to 9 feet by WSliq for the analyzed seismic events. These estimates indicate that sediments associated with a seismically induced displacement are likely to remain within or in the near vicinity of the dry dock 1 area. The magnitude of such displacement is similar for all alternatives and applicable to small scale slopes such as berms under piers, former dredge cuts with a typical side slope 2H:1V or flatter.

A potential for a flow slide may exist due to very low residual strength conditions after liquefaction. Although under the conservative assumptions, the analysis suggests that a large-scale flow slide could occur on the relatively flat upper portion of the deltaic sediments (e.g., in the vicinity of the former dry dock areas), these types of flow slides tend to occur on the steeper forefront of the deltaic deposits and relatively close to the slope break. Remedial alternatives evaluated as part of this analysis include Alternatives 2A2a and 3A1, which include a cap layer over a 6- to 10-acre area and where the outer edge of the cap is 400 feet from the delta shelf slope and the slope is 8 degrees, well below the 15 degree delta shelf slope assumed by Palmer (1999). Thus, the current analysis does not suggest occurrence of a large-scale flow slide that may affect the stability of contaminated sediments; however, a potential risk for a flow slide has been noted to exist for the region (Kayen and Barnhardt, 2007). If such a landslide occurred, the extent of the damage, if any, could be determined and repaired. This possibility was considered in the FS. The implication of a flow slide that may require a subsequent cap repair is applicable to the FS alternatives that include capping as part of the remedy.

- During the 2001 Nisqually earthquake, a PGA of 0.22 was measured at Harbor Island. Such magnitude of PGA is expected to affect this site similar to the 108- and 475-year events analyzed. During the Nisqually earthquake, liquefaction initiation was predicted, and liquefaction-induced hazards including a potential flow slide could have occurred. However, post-earthquake bathymetry surveys in the vicinity of the Lockheed West Site do not indicate any recognizable effect of liquefaction, slope failures, or flow slides.
- The findings of these analyses for nominal 100-year and 500-year events do not suggest a large-scale failure (i.e., excessive deformation and ground movement intersecting contaminated soils and contaminant release). The impact of a nominal 100-year event is expected to be less than a nominal 500-year event. Any earthquake-induced damage on the sediment cap will require repair or full replacement of the cap as part of the long-term operation and maintenance plan of the remedy. The need for localized repair of ENR areas will be evaluated as appropriate.

H.8 LIMITATIONS

This study was conducted in accordance with the current state-of-the-practice to evaluate seismic hazards at the Site for purposes of the FS. The geotechnical information available for the Site provides limited data to complete the analysis scoped for this study. The geotechnical parameters necessary for analyses were estimated based on the geotechnical data presented in Enviros (1990), Hart Crowser (1995), URS (2003), Hart Crowser (2003), and Tetra Tech (2008) reports for this Site, the nearby PSR Marine Sediment Unit, and the Lockheed Shipyard #1 Sediment Operable Unit. We believe the analyses presented in this appendix are comprehensive for the purpose of this FS.

H.9 REFERENCES

1. Amec. 2010. Liquefaction Potential Evaluation Duwamish Sediment Other Area and Southwest Bank Corrective Measure Alternatives Study, Boeing Plant 2.

2. Bray, J. D., and T. Travasarou. 2007. Simplified Procedure for Estimating Earthquake-Induced Deviatoric Slope Displacements. Journal of Geotechnical and Geoenvironmental Engineering 133(4): 381-392.

3. Cetin, K.O., R.B. Seed, A. Der Kiureghian, K. Tokimatsu, L.F. Harder, R.E. Kayen, and R.E.S. Moss. 2004. Standard Penetration Test-based Probabilistic and Deterministic Assessment of Seismic Soil Liquefaction Potential. Journal of Geotechnical and Geoenvironmental Engineering 130(12): 1314-1340.

4. Craig, R.F. 1989. Soil Mechanics. Fourth Edition. ELBS Edition. London.

5. Das, B.M. 1994. Principles of Geotechnical Engineering. PWS Publishing. Boston.

6. EERI (Earthquake Engineering Research Institute). 2005. Scenario for a Magnitude 6.7 Earthquake on the Seattle Fault. Oakland, CA. June.

7. Enviros. 1990. Lockheed Shipyard #2 Sediment Characterization and Geotechnical Study.

8. Gardner, J.V. E.J. van den Ameele, G. Gelfenbaum, W. Barnhardt, H. Lee, and S. Palmer. 2001. Mapping Southern Puget Sound Delta Fronts After the 2001 Nisqually Earthquake. Available at: http://geopubs.wr.usgs.gov/open-file/of01-266/html/article.htm#duwamish

9. GeoStudio. 2004. SLOPE/W 2004. GEO-SLOPE International Ltd. Calgary, Canada.

10. Hart Crowser. 1995. Geotechnical Engineering Design Study Southwest Harbor Project Terminal 5 Expansion, Port of Seattle, WA.

11. Hart Crowser. 2003. Final 100% Remedial Design Submittal Sediment Remediation Lockheed Shipyard #1 Sediment Operable Unit, Seattle WA, Attachment B-1.

12. Idriss, I.M., and R.W. Boulanger. 2008. Soil Liquefaction during Earthquakes, EERI Monograph 12, Earthquake Engineering Research Institute, Oakland, California. 262 pp.

13. IBC (International Building Code). 2003. Section 1615. Earthquake Loads-Site ground Motion. International Code Council. Falls Church, Virginia.

14. Kayen, R.E., and W.A. Barnhardt. 2007. Seismic Stability of the Duwamish River Delta, Seattle, Washington. USGS Professional Paper 1661-E. May.

15. Kramer, S. 2008. Evaluation of Liquefaction Hazards in Washington State. WSDOT. December.

16. Kramer, S.L., and D.A. Baska. 2007. Estimation of Permanent Displacements due to Lateral Spreading. *Journal of Geotechnical and Geoenvironmental Engineering*.

17. Lin, T., and J. Baker. 2011. Probabilistic Seismic Hazard Deaggregation of Ground Motion Prediction Models. 5th International Conference on Earthquake Engineering. Santiago, Chile. January.

18. McGuire, R.K. 2004. Seismic hazard and risk analysis, Earthquake Engineering Research Institute, Oakland, CA.

19. Makdisi, F.I., and B.H. Seed. 1977. A Simplified Procedure for Estimating Earthquake-Induced Deformations in Dams and Embankments. Earthquake Engineering Research Center Report No. UCB/EERC-77/19, University of California, Berkeley, CA. August

20. McCabe, W.M. 2004. Seismic Stability of a Sloping Sediment Cap. Ports 2004: Port Development in the Changing World Proceedings of Ports Conference 2004. ASCE Conf. Proc. doi:10.1061/40727(2004)104.

21. McGuire, R.K. 2004. Seismic Hazard and Risk Analysis. Earthquake Engineering Research Institute, Oakland, CA.

22. Moss, R.E.S., R.B. Seed, R.E. Kayen, J.P. Stewart, A. der Kiureghian, and K.O. Cetin, K.O. 2006. CPT-Based Probabilistic and Deterministic Assessment of in Situ Seismic Soil Liquefaction Potential. Journal of Geotechnical and Geoenvironmental Engineering 132 (8): 1032-1051.

23. National Cooperative Highway Research Program (NCHRP) Report 611. 2008. Bridges, Other Structures, and Hydraulics and Hydrology Seismic Analysis and Design of Retaining Walls, Buried Structures, Slopes, and Embankments. Transportation Research Board. Washington, DC.

24. Petersen, M., et al. 2008. Documentation for the 2008 Update of the National Seismic Hazard Maps, USGS OFR 08–1128. Available online at http://pubs.usgs.gov/of/2008/1128/

25. URS. 2003. Final Design PSR Superfund Site Marine Sediment Unit. Prepared for USEPA, Region 10. February.

26. Palmer, S.P. 1999. Geotechnical Considerations for the Proposed Southwest Harbor CAD Facility. Washington Division of Geology and Earth Resources. Washington State Department of Natural Resources. Olympia, WA. June.

27. Palmer S.P., S.L. Magniso, E.L. Bilderback, J.L. Poelstra, D.S. Folger, and R.A. Niggeman. 2004. Liquefaction Susceptibility and Site Class Maps of Washington State, By County. Washington Division of Geology and Earth Resources. Washington State Department of Natural Resources. Open File Report 20004-20. Olympia, WA. September 2004.

28. Seed, H.B., R.T. Wong, I.M. Idriss, and K. Tokimatsu. 1984. Moduli and Damping Factors for Dynamic Analyses of Cohesionless Soils. Report Number EERC 84-14, Earthquake Engineering Research Center, University of California, Berkley, CA, September.

29. Tetra Tech. 2006. High-Resolution Multibeam Sonar Bathymetric Survey conducted for Lockheed Martin Corporation. Prepared by Tetra Tech, Inc., Bothell, WA.

30. Tetra Tech. 2008. Remedial Investigation Data Report. Prepared for Lockheed Martin Corporation. Revision 1. January.

31. USGS (United States Geological Service). 2011. Magnitude 9.0 - Near the East Coast of Honshu, Japan. March 11.

32. WSDOT (Washington State Department of Transportation). 2010. Washington State Department of Transportation Geotechnical Design Manual. M 46-03.01. Olympia, Washington. January.

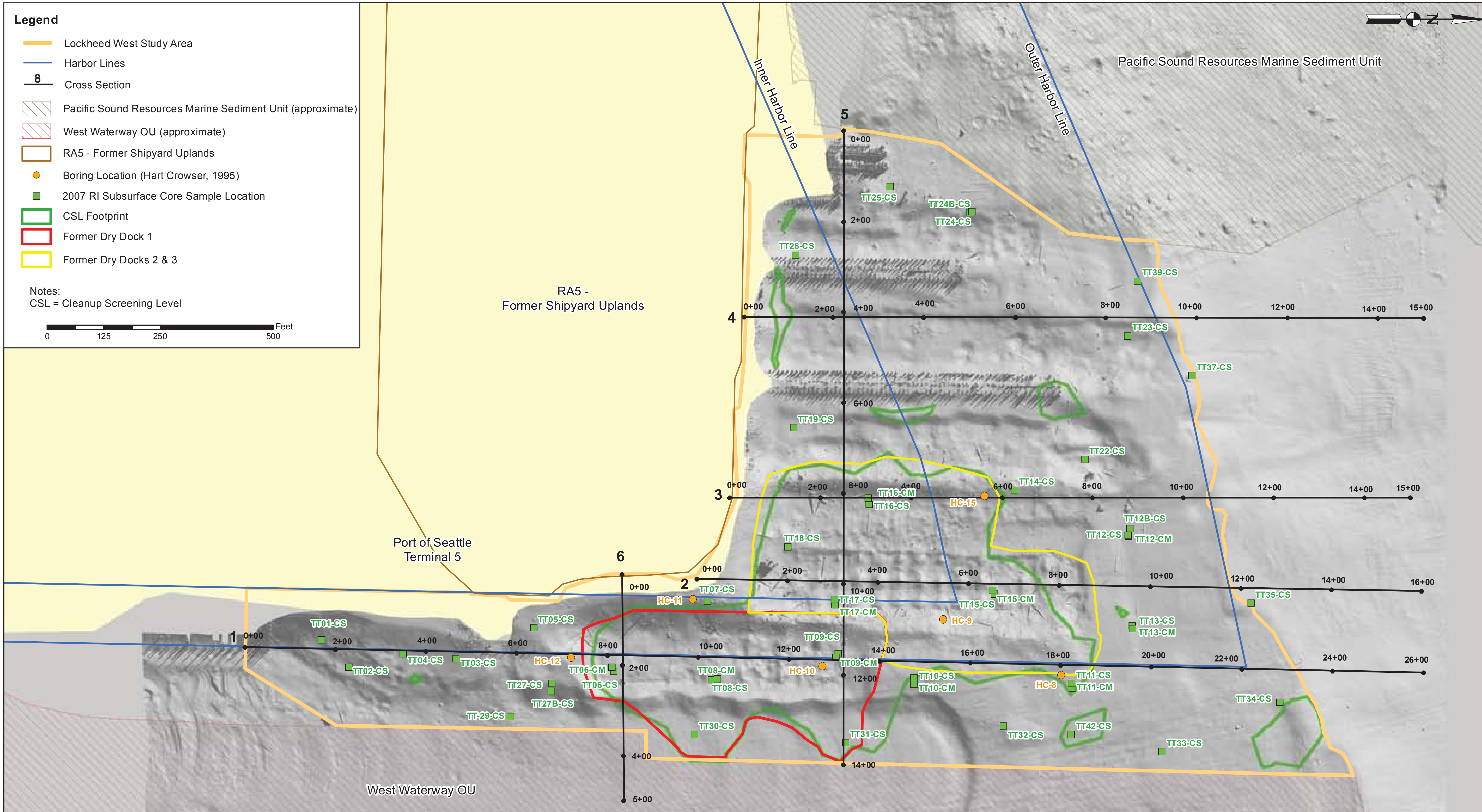
33. Youd, T.L., et al. 2001. Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Workshops on Evaluation of Liquefaction Resistance of Soils. *Journal of Geotechnical and Geoenvironmental Engineering* 127(10): 817-833.

34. Youd, T.L., Hansen, C.M., and Bartlett, S.F. 2002. Revised Multilinear Regression Equations for Prediction of Lateral Spread Displacement. *Journal of Geotechnical and Geoenvironmental Engineering* 128(12): 1007-1017.

35. Zhang, G., P.K .Robertson, and R.W.I. Brachman. 2004. Estimating Liquefaction Induced Lateral Displacements using the Standard Penetration Test or Cone Penetration Test. *Journal of Geotechnical and Geoenvironmental Engineering* 130(8): 861-871.

FIGURES

(H-1 through H-9)

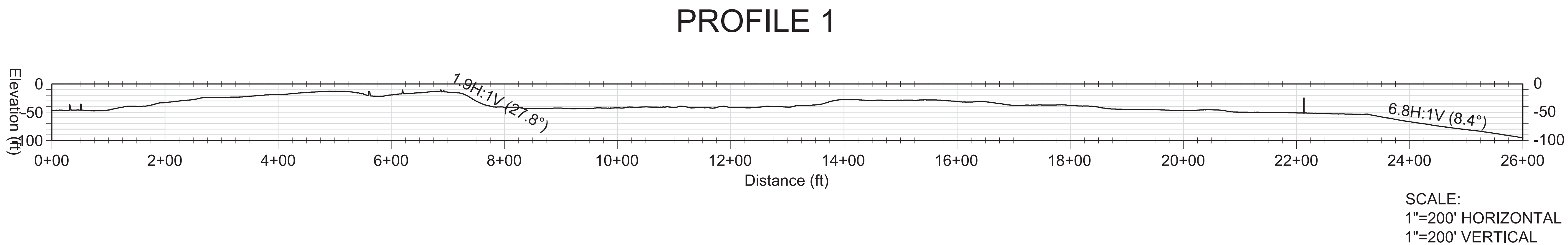


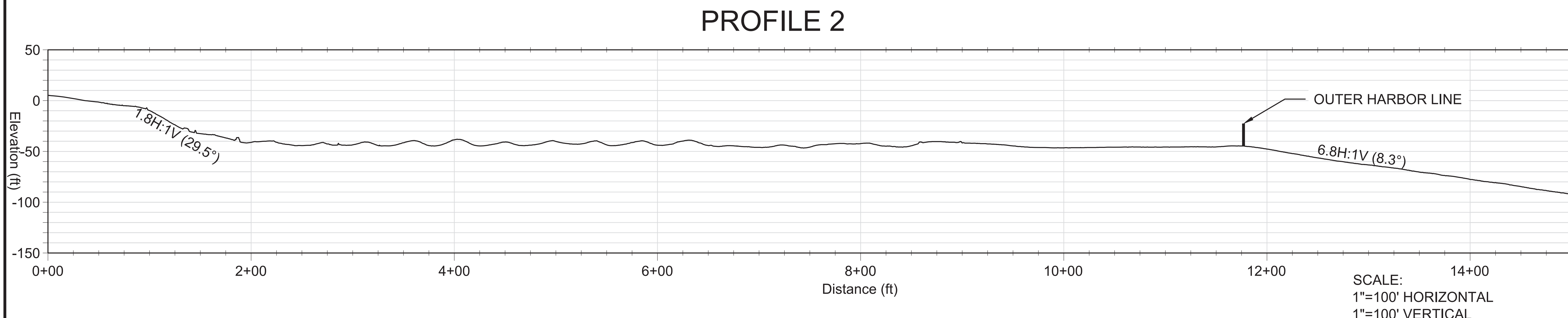
TETRA TECH

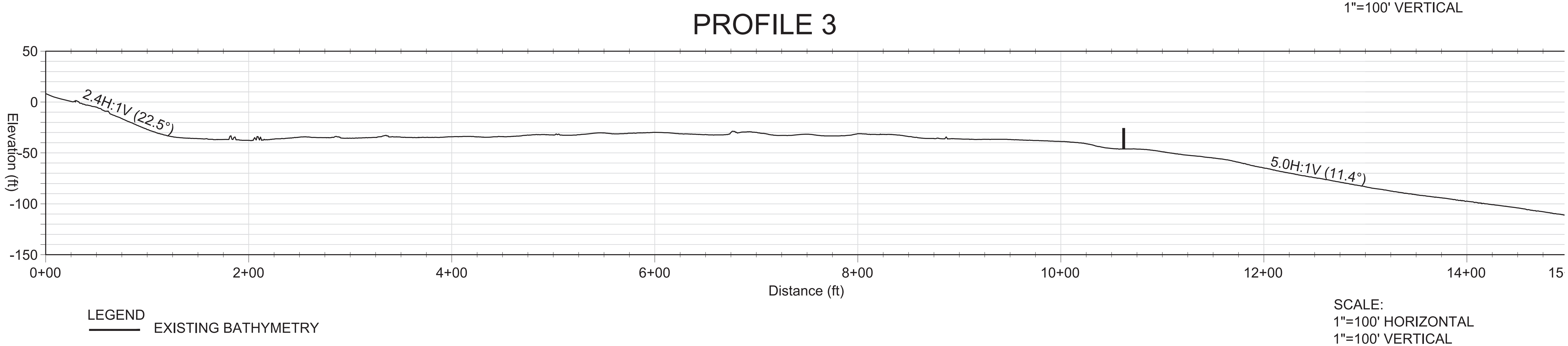
Lockheed West Seattle Superfund Site, Seattle, WA

Figure H-1
Former Dry Dock Hot Spot Area, Boring Locations and Profiles

Z:\Pdrive\Projects_2006\Lockheed\maps\RIFS_Report\Fig_H-1.mxd







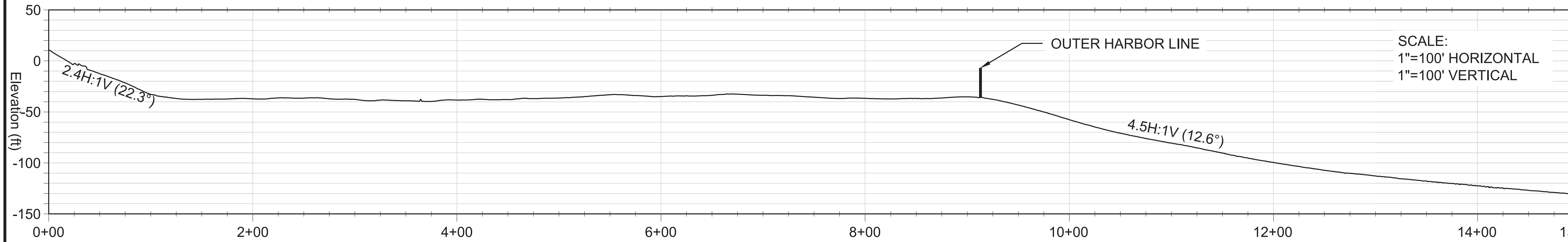
P:\8945_TTDIV-Lockheed\Yard 2\RIFS\CAD\Seismic Analysis\Surface and Sections_Alignment-delta_shelf.dwg
PLOT/UPDATE October 17, 2011 09:50:26

TETRA TECH

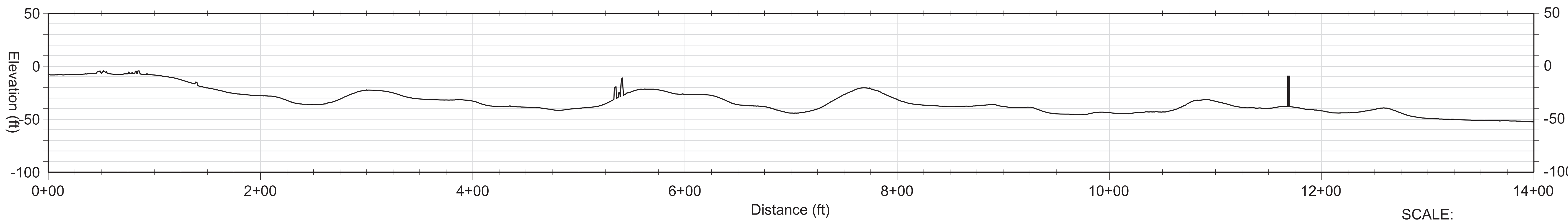
Lockheed West Seattle
Superfund Site
Seattle, WA

FIGURE H-2
Existing Site Profiles

PROFILE 4

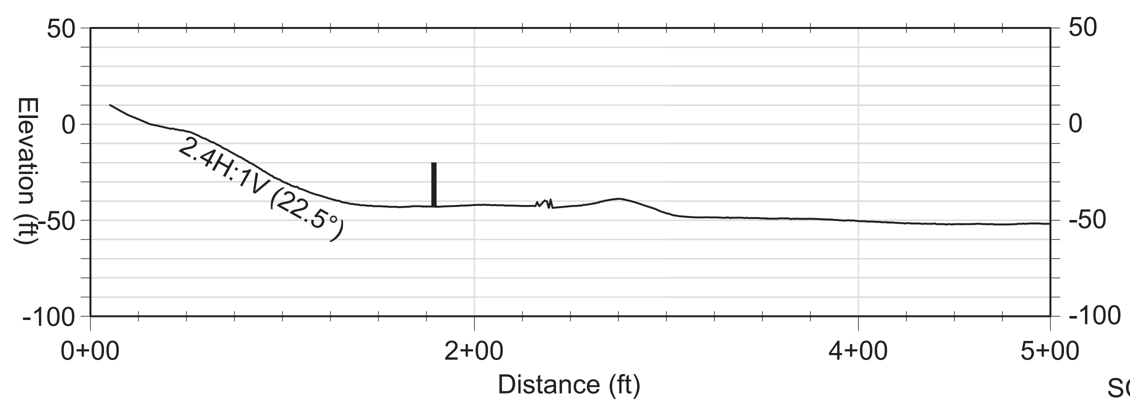


PROFILE 5



SCALE:
1"=100' HORIZONTAL
1"=100' VERTICAL

PROFILE 6



SCALE:
1"=100' HORIZONTAL
1"=100' VERTICAL

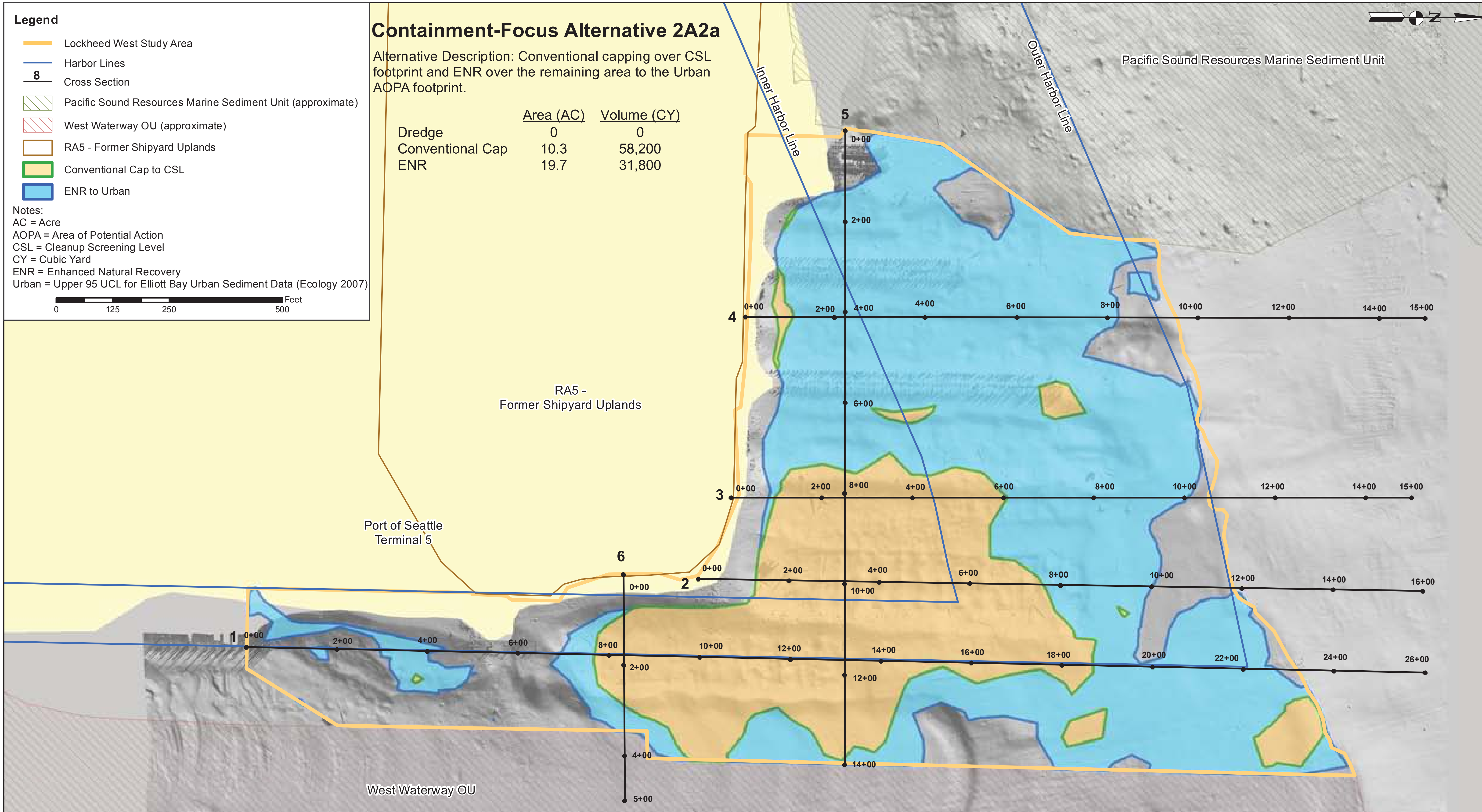
LEGEND
EXISTING BATHYMETRY

P:\8945_TTDIV-Lockheed\Yard 2\RIFS\CAD\Seismic Analysis\Surface and Sections_Alignment-delta_shelf.dwg
PLOT/UPDATE October 17, 2011 10:11:34

TETRA TECH

Lockheed West Seattle
Superfund Site
Seattle, WA

FIGURE H-3
Existing Site Profiles

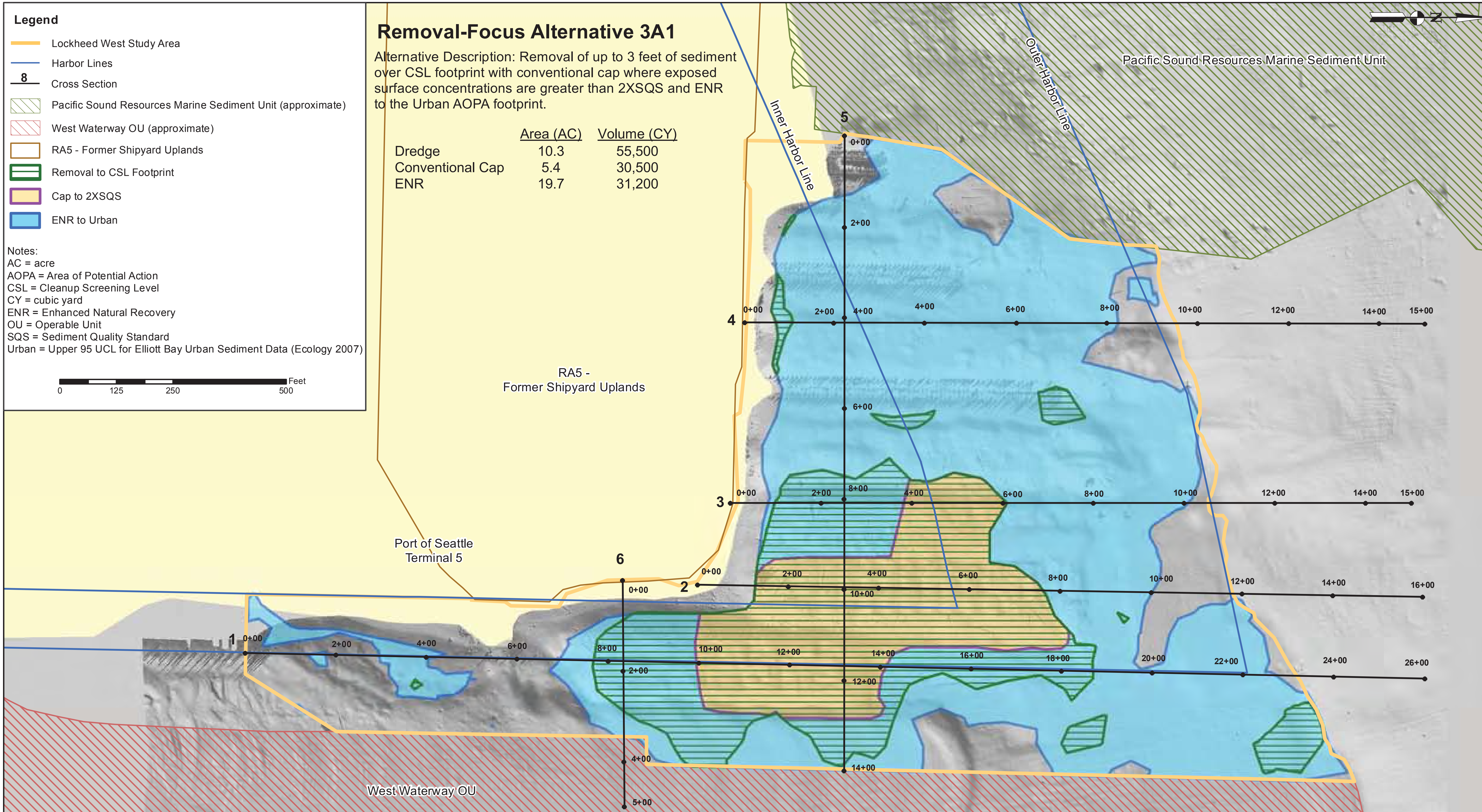


Lockheed West Seattle Superfund Site, Seattle, WA

Figure H-4
Containment-Focus Alternative 2A2a Profiles

TETRA TECH

P:\Pdrive\Projects_2006\Lockheed\maps\RIFS_Report\Fig_H-4.mxd

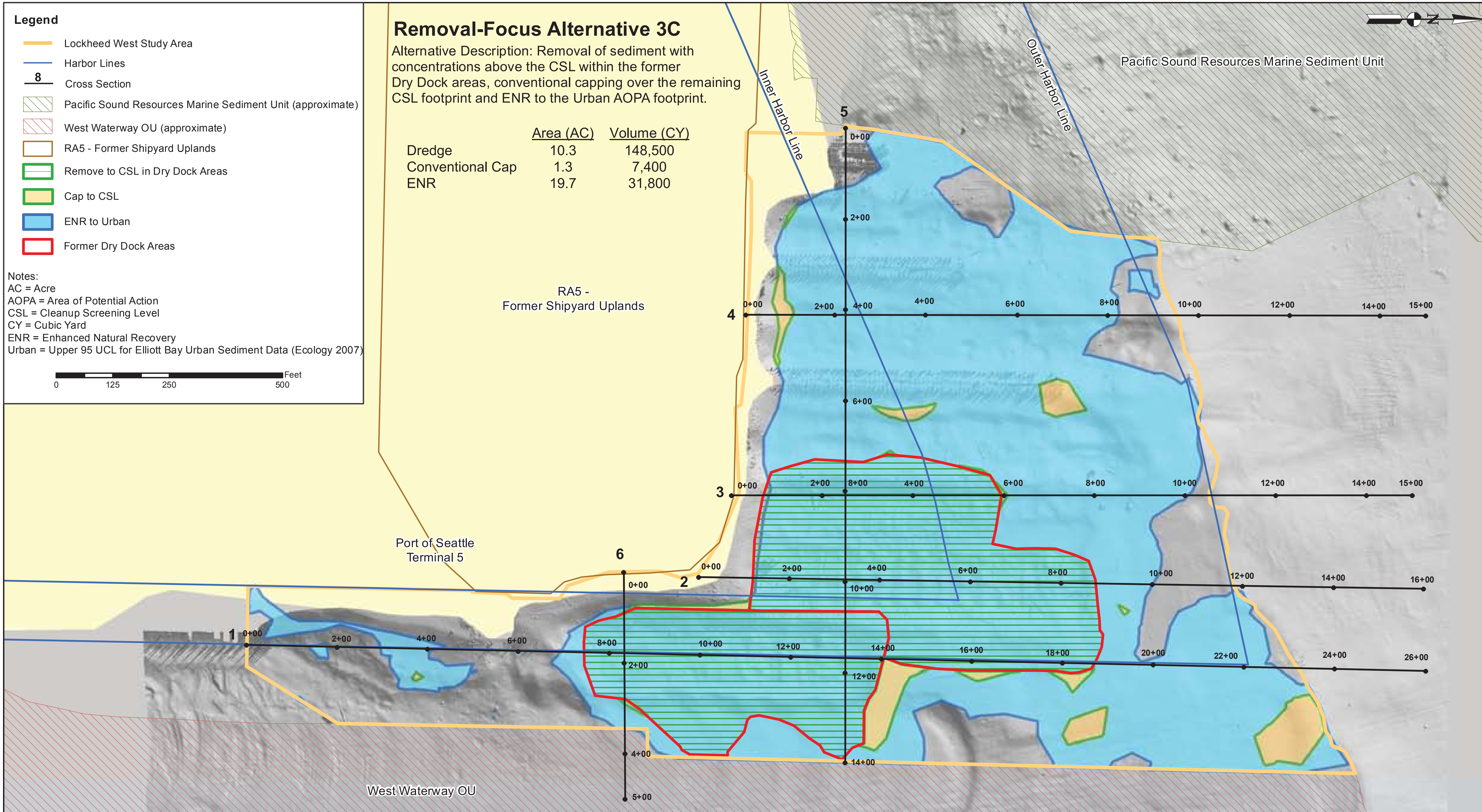


Lockheed West Seattle Superfund Site, Seattle, WA

Figure H-5
Removal-Focus Alternative 3A1 Profiles

TETRA TECH

Z:\Pdrive\Projects_2006\Lockheed\maps\RIFS_Report\Fig_H-5.mxd

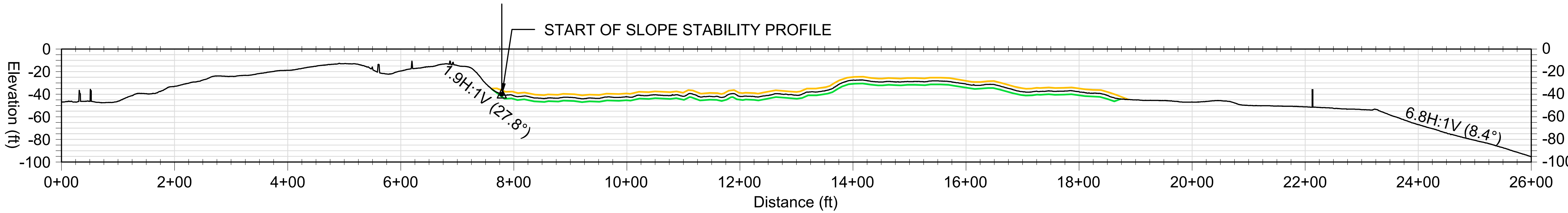


TETRA TECH

Lockheed West Seattle Superfund Site, Seattle, WA

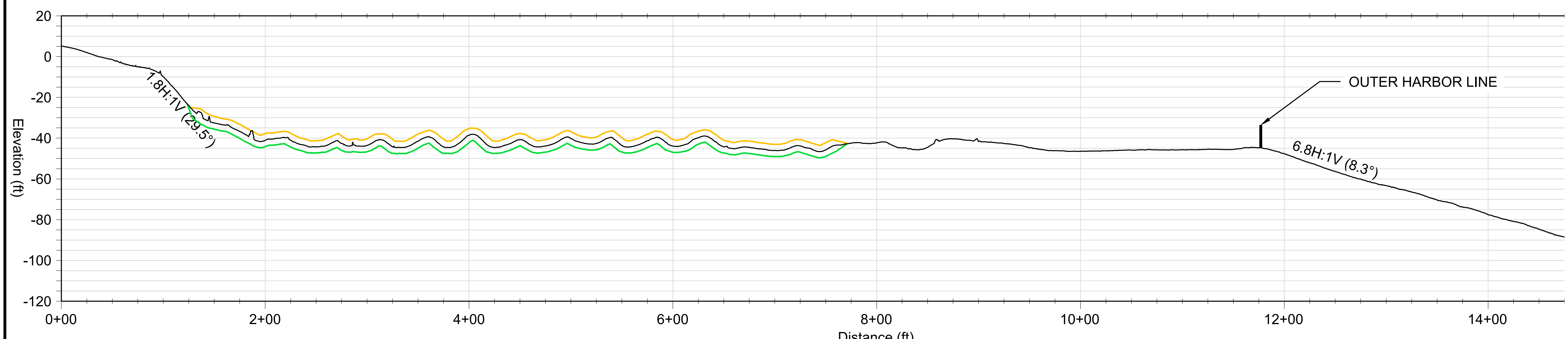
Figure H-6
Removal-Focus Alternative 3C Profiles

PROFILE 1



SCALE:
1"=200' HORIZONTAL
1"=100' VERTICAL
(2X VERTICAL
EXAGGERATION)

PROFILE 2



SCALE:
1"=100' HORIZONTAL
1"=50' VERTICAL
(2X VERTICAL
EXAGGERATION)

LEGEND

- EXISTING BATHYMETRY
- 3 FT CAP OVER CSL
- 3 FT REMOVAL TO CSL

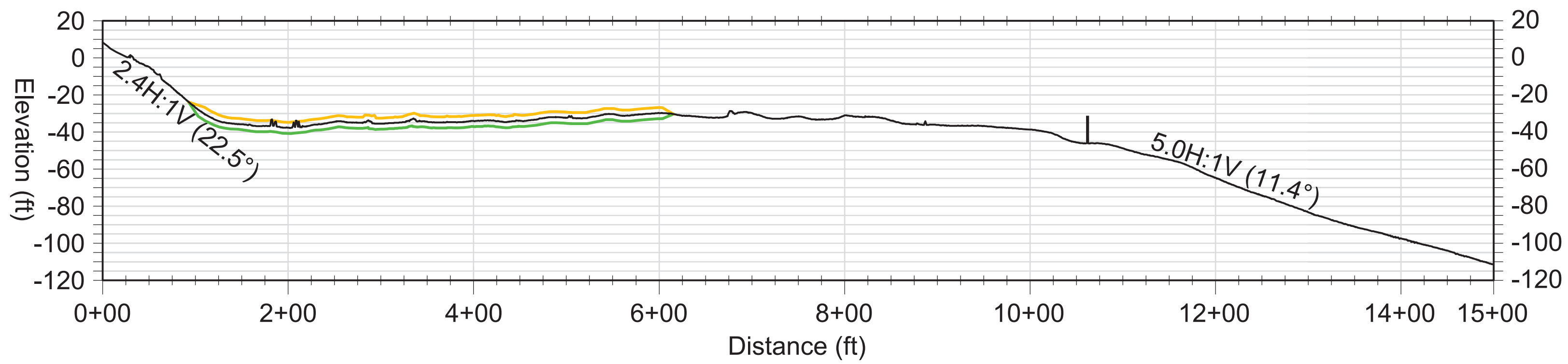
P:\8945_TTDIV-Lockheed\Yard 2\RIFS\CAD\Seismic Analysis\Surface and Sections_Alignment-delta_shelf.dwg
PLOT/UPDATE November 14, 2011 12:26:49

TETRA TECH

Lockheed West Seattle
Superfund Site
Seattle, WA

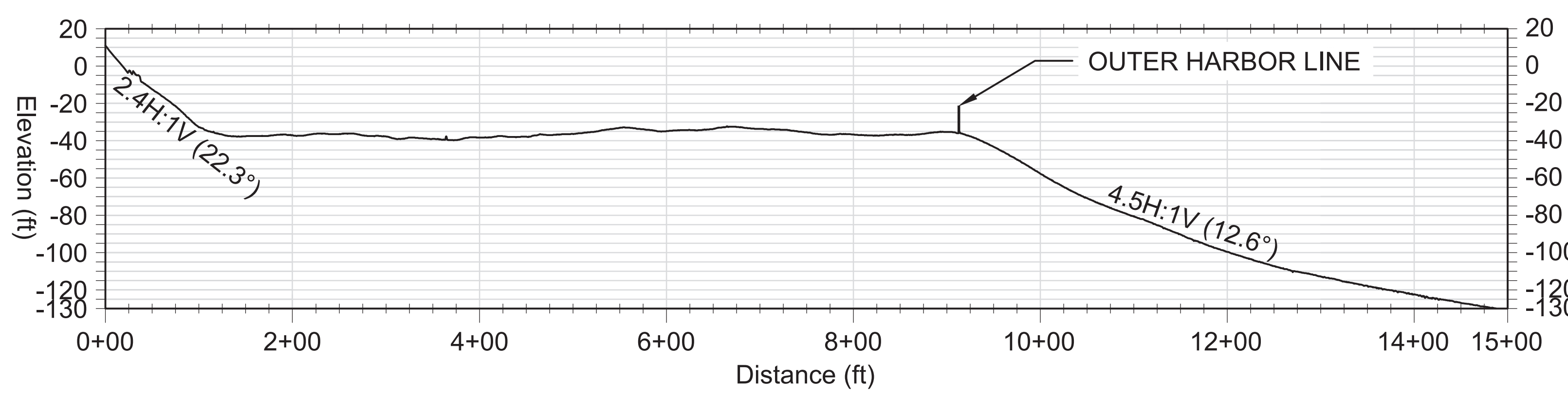
FIGURE H-7
Existing Site Profiles

PROFILE 3



SCALE:
1"=200' HORIZONTAL
1"=100' VERTICAL
(2X VERTICAL
EXAGGERATION)

PROFILE 4



SCALE:
1"=200' HORIZONTAL
1"=100' VERTICAL
(2X VERTICAL
EXAGGERATION)

LEGEND

EXISTING BATHYMETRY
3 FT CAP OVER CSL
3 FT REMOVAL TO CSL

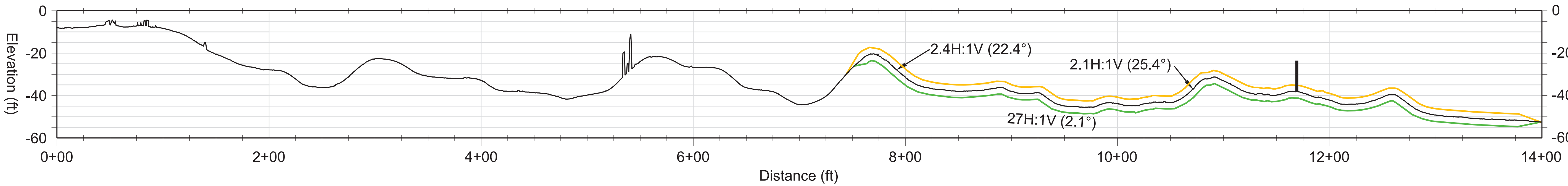
P:\8945_TTDIV-Lockheed\Yard 2\RIFS\CAD\Seismic Analysis\Surface and Sections_Alignment-delta_shelf.dwg
PLOT/UPDATE October 17, 2011 09:48:54

TETRA TECH

Lockheed West Seattle
Superfund Site
Seattle, WA

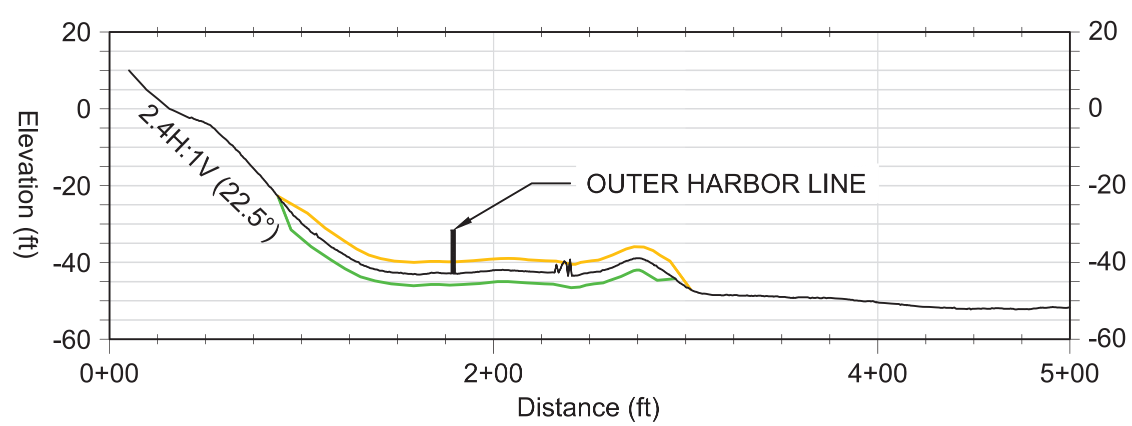
FIGURE H-8
Existing Site Profiles

PROFILE 5



SCALE:
1"=100' HORIZONTAL
1"=50' VERTICAL
(2X VERTICAL
EXAGGERATION)

PROFILE 6



SCALE:
1"=100' HORIZONTAL
1"=50' VERTICAL
(2X VERTICAL
EXAGGERATION)

LEGEND

- EXISTING BATHYMETRY
- 3 FT CAP OVER CSL
- 3 FT REMOVAL TO CSL

P:\8945_TTDIV-Lockheed\Yard 2\RIFS\CAD\Seismic Analysis\Surface and Sections_Alignment-delta_shelf.dwg
PLOT/UPDATE September 23, 2011 12:42:33

TETRA TECH

Lockheed West Seattle
Superfund Site
Seattle, WA

FIGURE H-9
Existing Site Profiles

ATTACHMENT 1

BORING LOGS (HART CROWSER, 1995)

Exploration Plan

HC-1 Boring Location and Numb (Hart Crowser, Current St

D1 Boring Location and Numb (Hong West Consulting Eng 1989)

A A' Cross Section Location and Designation

Outer Harbor Line

Note: Base map prepared from drawing provided by Port of Seattle entitle "Terminal 5 and Seattle Steel", dat August 17, 1986.

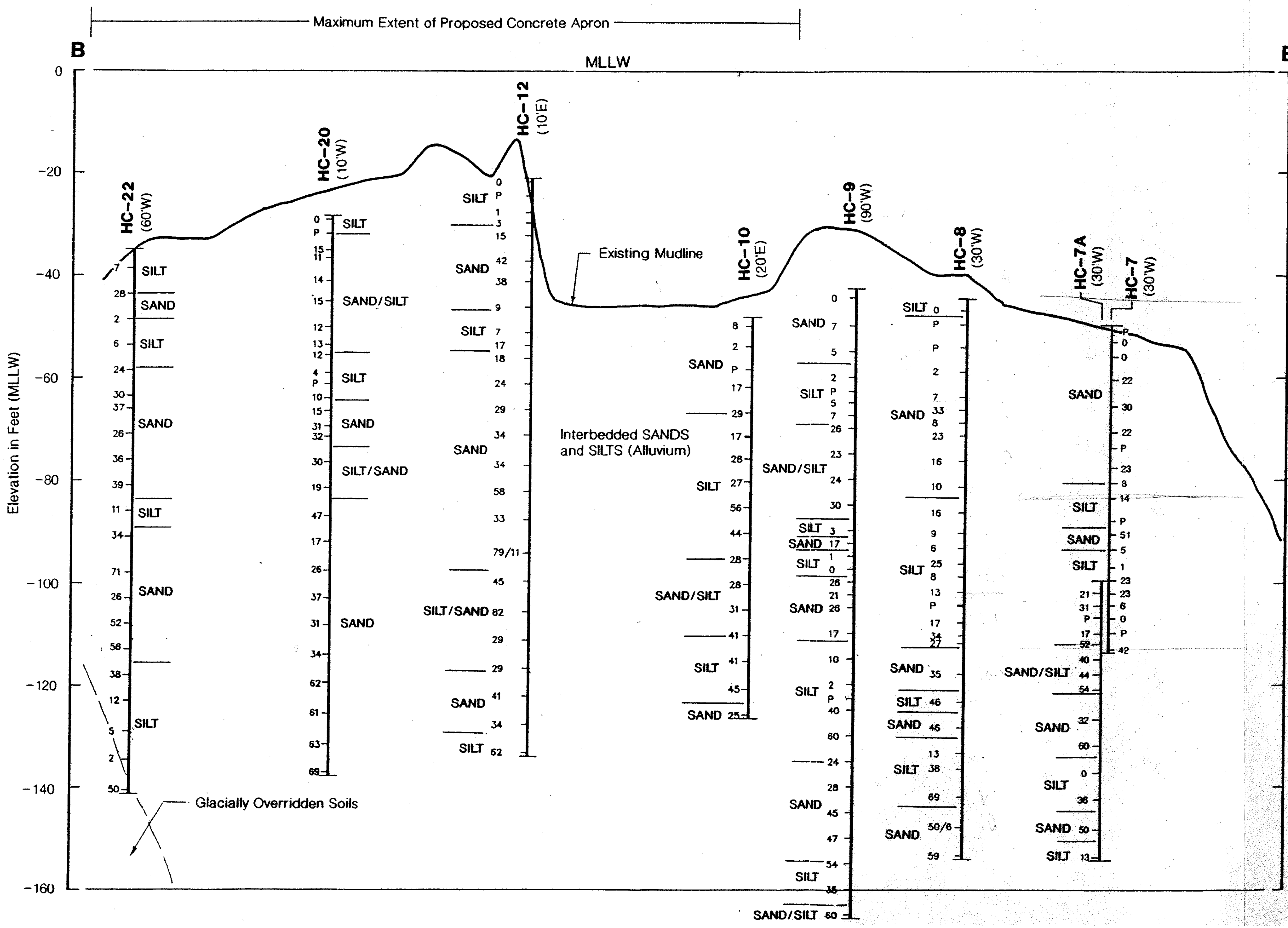
0 300
Scale in Feet

HARTCROWS

J-3528 4/

Figure 2

Generalized Subsurface Cross Section B–B'



HC-22 Boring Number
(60'W) Offset Distance and Direction
Boring Location
22 SPT Blow Count Value
P Undisturbed Shelby Sample

SILT/SAND Soil units based on visual observation and laboratory analysis of selected samples

Horizontal Scale in Feet: 0, 250, 500

Vertical Scale in Feet: 0, 20, 40

Vertical Exaggeration x 12.5

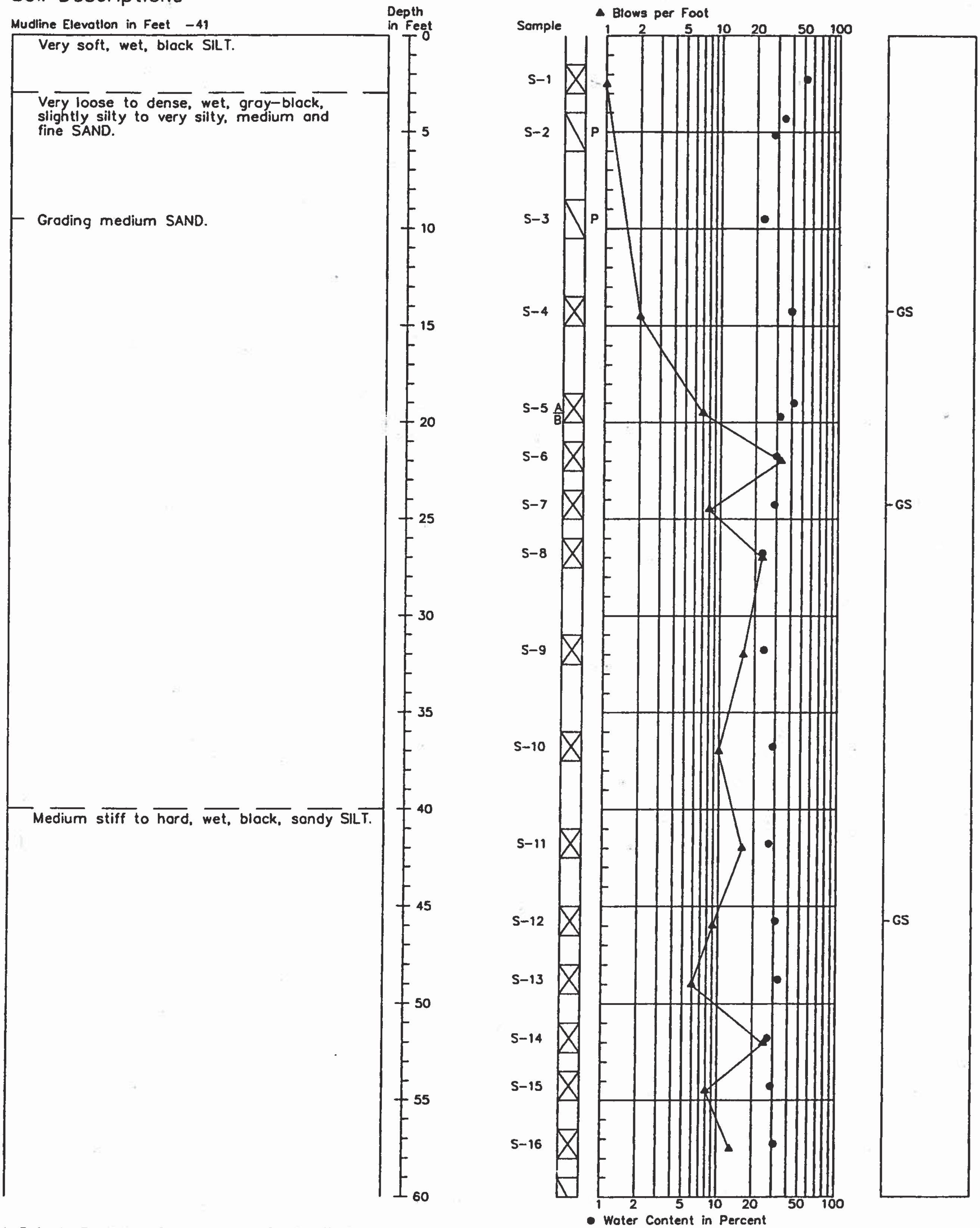
HARTCROWSER

J-3528 4/95

Figure 5

Boring Log HC-8

Soil Descriptions



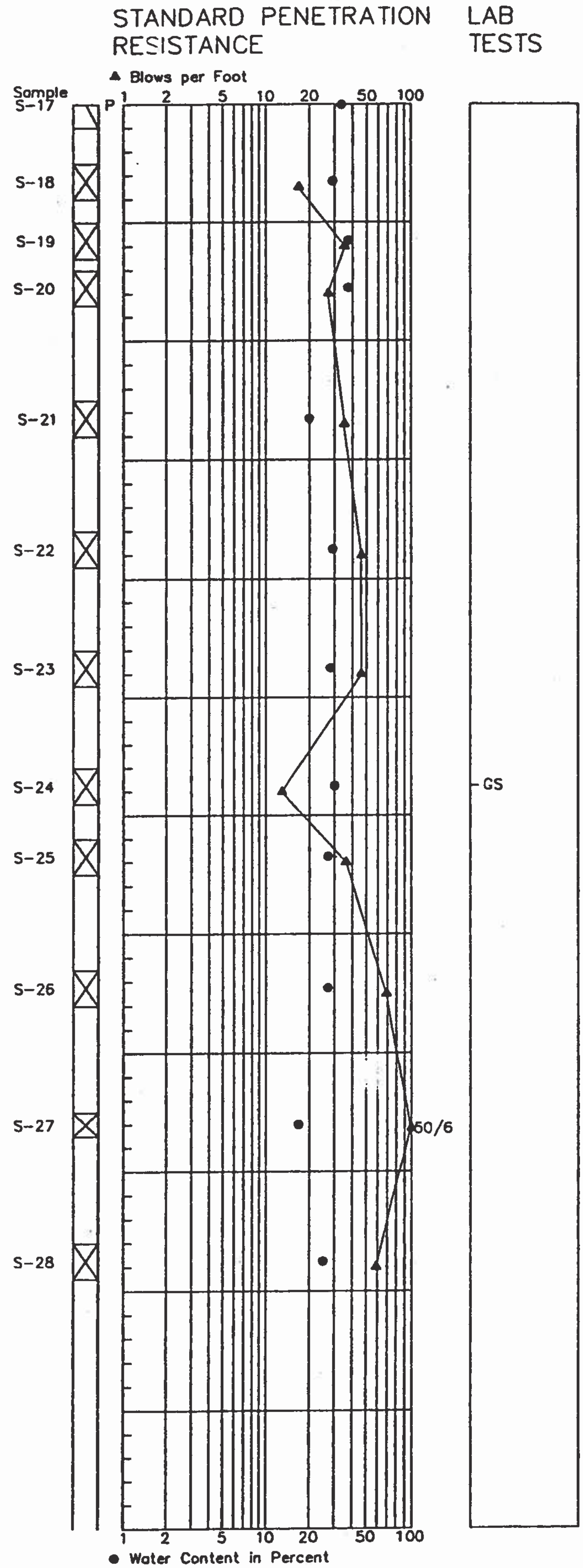
1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER
J-3528 3/92
Figure A-10 1/2

Boring Log HC-8

Soil Descriptions

Depth in Feet	Soil Descriptions
60–70	Medium stiff to stiff, wet, black, sandy SILT
70–76	Dense, wet, dark gray, medium SAND with shell fragments.
76–81	Hard, wet, dark gray, sandy SILT.
81–86.5	Dense, wet, dark gray, slightly silty, fine SAND.
86.5–100	Stiff to hard, wet, dark gray, sandy SILT.
100–110	Very dense, wet, dark gray, fine to medium SAND.
110	Bottom of Boring at 110.0 Feet. Completed 3/30/92.



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

J-3528 3/92

Figure A-10 2/2

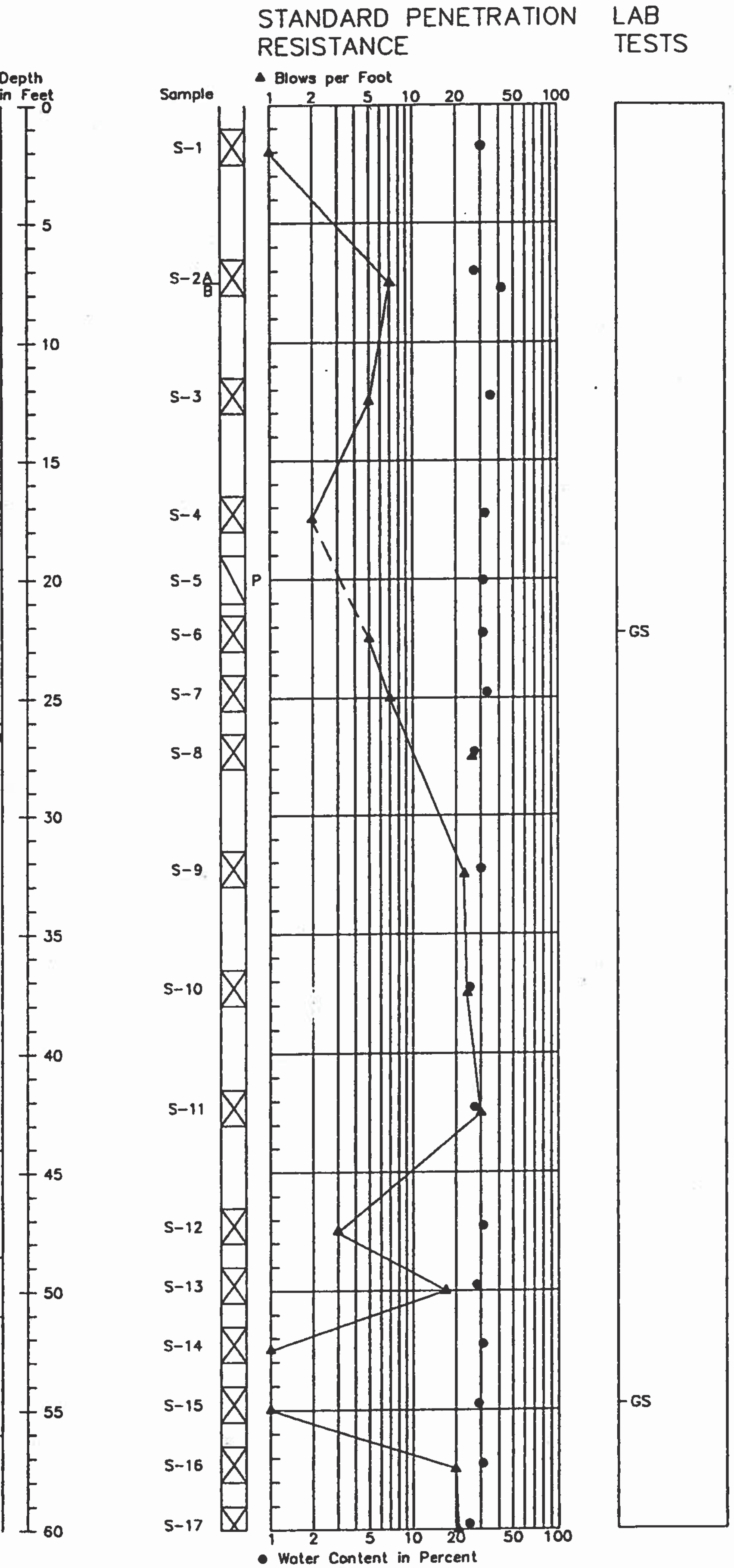
Boring Log HC-9

Soil Descriptions

Mudline Elevation in Feet -40

Depth in Feet

Depth (ft)	Description
0	Very loose to loose, wet, black SAND to silty SAND. Shell fragments to a depth of 10 feet.
	- Sulfur-like odor.
~14	Very soft to medium stiff, wet, gray-brown to black, sandy to very sandy SILT.
	- Grading slightly silty, fine SAND.
~26	Medium dense, wet, gray-brown, silty, medium to fine SAND interbedded with sand and silt.
~44	Soft, wet, gray-brown, sandy SILT.
~48.5	Medium dense, wet, gray-brown silty, fine to medium SAND.
~51	Very soft, wet, gray-brown to black, very sandy SILT.
~56	Medium dense, wet, gray-brown, very silty to slightly silty, fine to medium SAND with shell fragments.



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

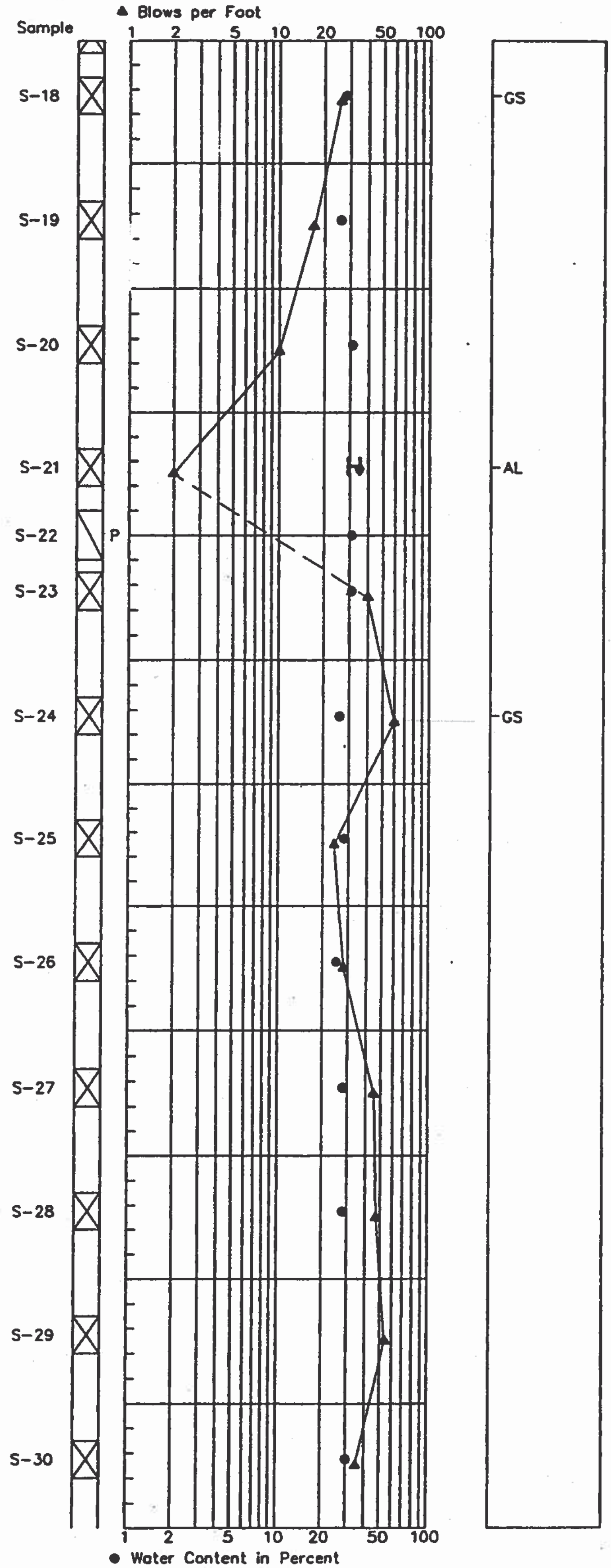
J-3528 3/92

Figure A-11 1/3

Boring Log HC-9

Soil Descriptions

Soil Descriptions	Depth in Feet
Medium dense, wet, gray-brown very silty to slightly silty, fine to medium SAND with shell fragments.	60
Stiff to very soft, wet, gray-brown, sandy SILT to SILT. — Shell fragments.	68
Dense to very dense, wet, dark gray-brown, very silty, fine SAND.	78
Very stiff, wet, gray-brown, very sandy SILT.	89
Medium dense to very dense, wet, dark gray-brown, silty to slightly silty, fine SAND with some interbedded sandy SILT.	94
Hard, wet, gray-brown, sandy SILT.	114



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

J-3528 3/92

Figure A-11 2/3

Boring Log HC-9

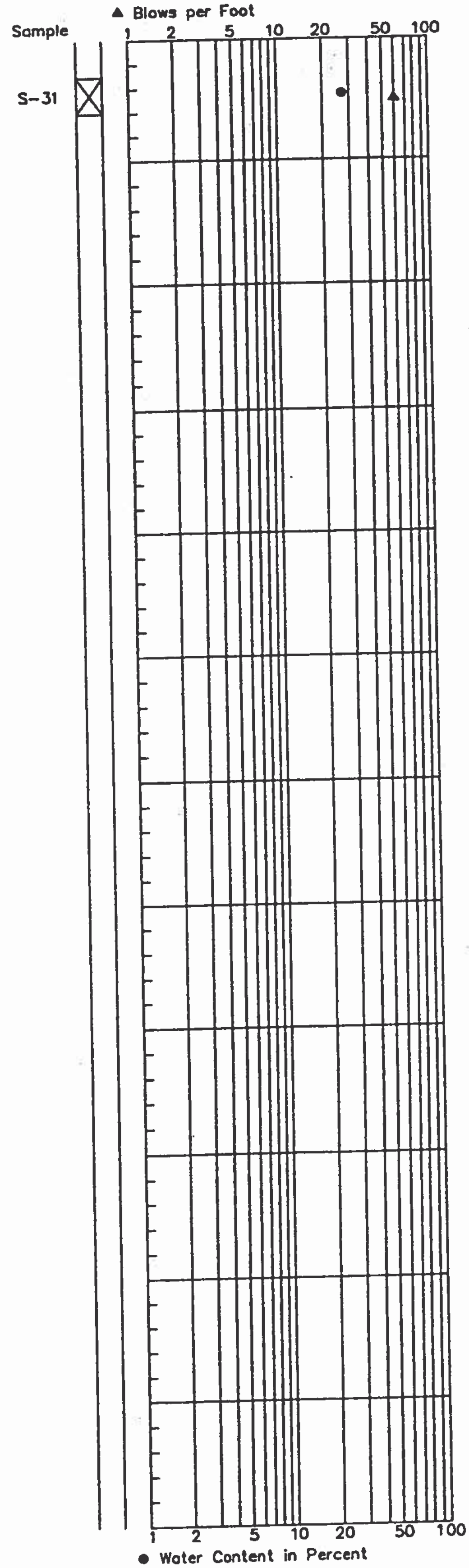
Soil Descriptions

Depth in Feet

Soil Descriptions	Depth in Feet
Very dense, wet, gray-brown, silty, fine SAND and sandy SILT.	120
Bottom of Boring at 123 Feet. Completed 4/10/92.	125
	130
	135
	140
	145
	150
	155
	160
	165
	170
	175
	180

STANDARD PENETRATION RESISTANCE

LAB TESTS



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

J-3528 3/92

Figure A-11 3/3

Boring Log HC-10

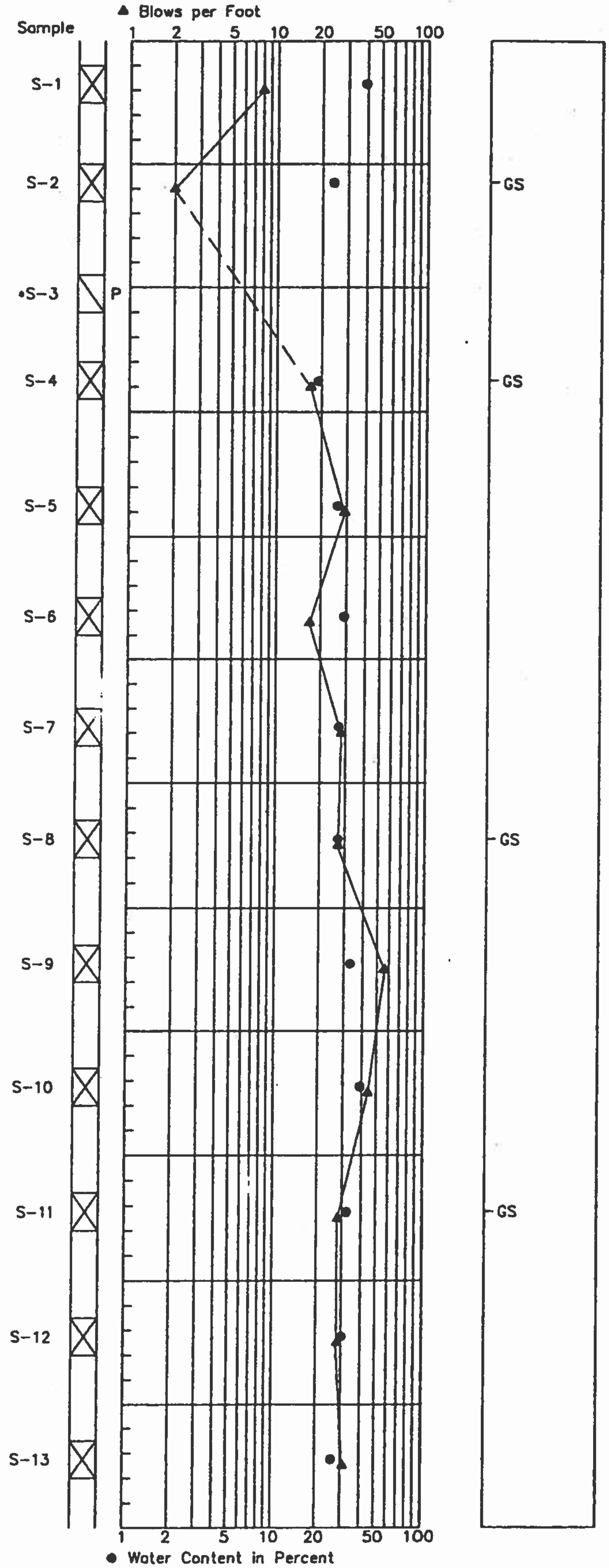
Soil Descriptions

Mudline Elevation in Feet -43

Depth in Feet	Soil Description
0	Very loose to medium dense, wet, black to gray-brown, slightly silty to silty, medium and fine SAND with petroleum-like odor to a depth of 6.5 feet.
~14	Grading very sandy SILT.
~21	Very stiff to hard, wet, gray-brown, sandy to very sandy SILT.
~27.5	Grading very silty, fine SAND.
~41.5	Grading very silty, fine SAND.
~54.5	Dense, wet, gray-brown, very silty to silty, fine SAND with sandy SILT.

STANDARD PENETRATION RESISTANCE

LAB TESTS



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

J-3528 4/92

Figure A-12 1/2

Boring Log HC-10

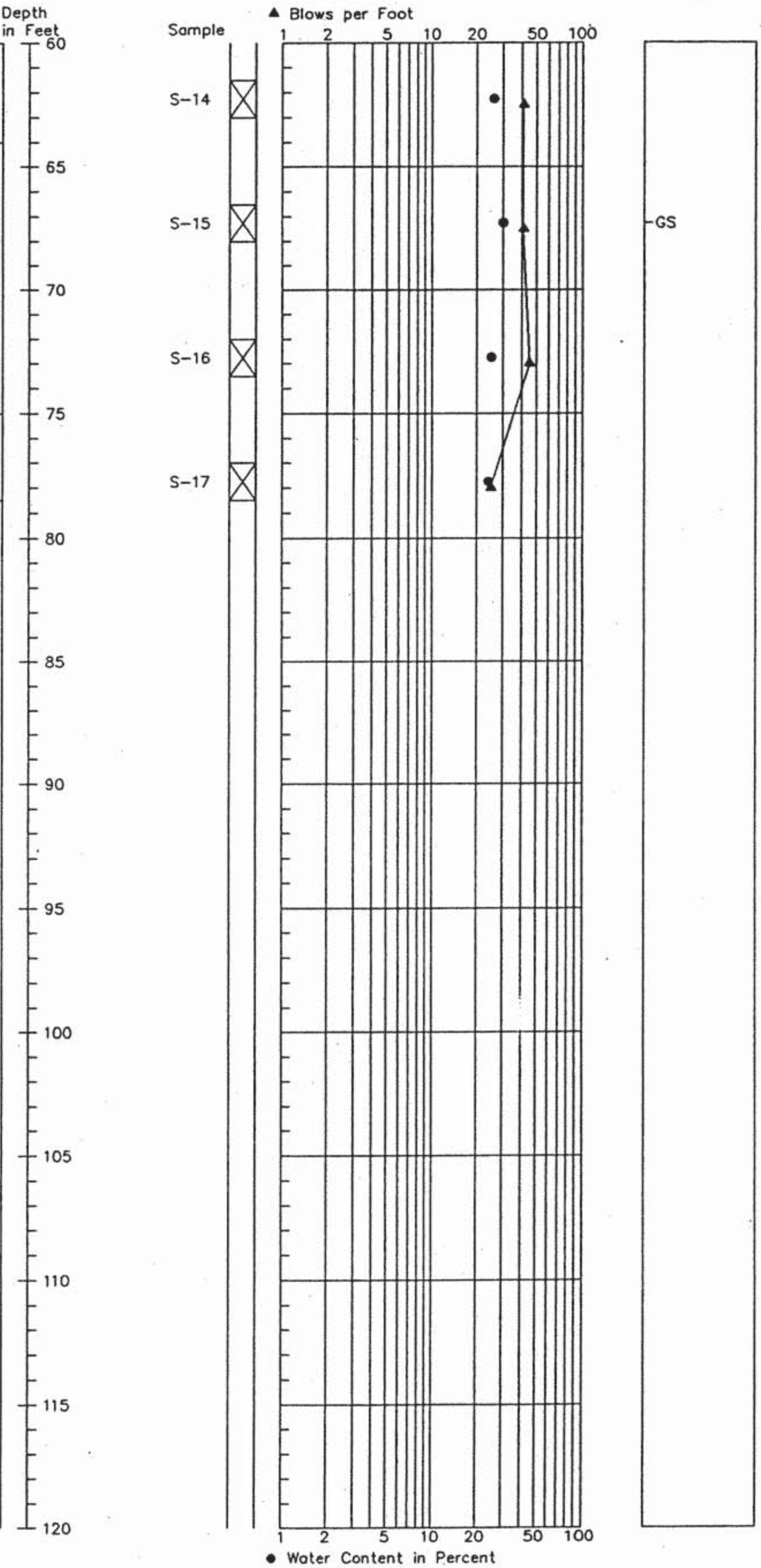
Soil Descriptions

Depth in Feet

Depth (ft)	Soil Description
60	Dense, wet, gray–brown, very silty to silty, fine SAND with sandy SILT.
	Hard, wet, gray–brown, sandy SILT.
75	Medium dense, wet, gray–brown, silty, fine SAND.
	Bottom of Boring at 78.5 Feet. Completed 4/3/92.

STANDARD PENETRATION RESISTANCE

LAB TESTS



1. Refer to Figure A–1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

J-3528 4/92

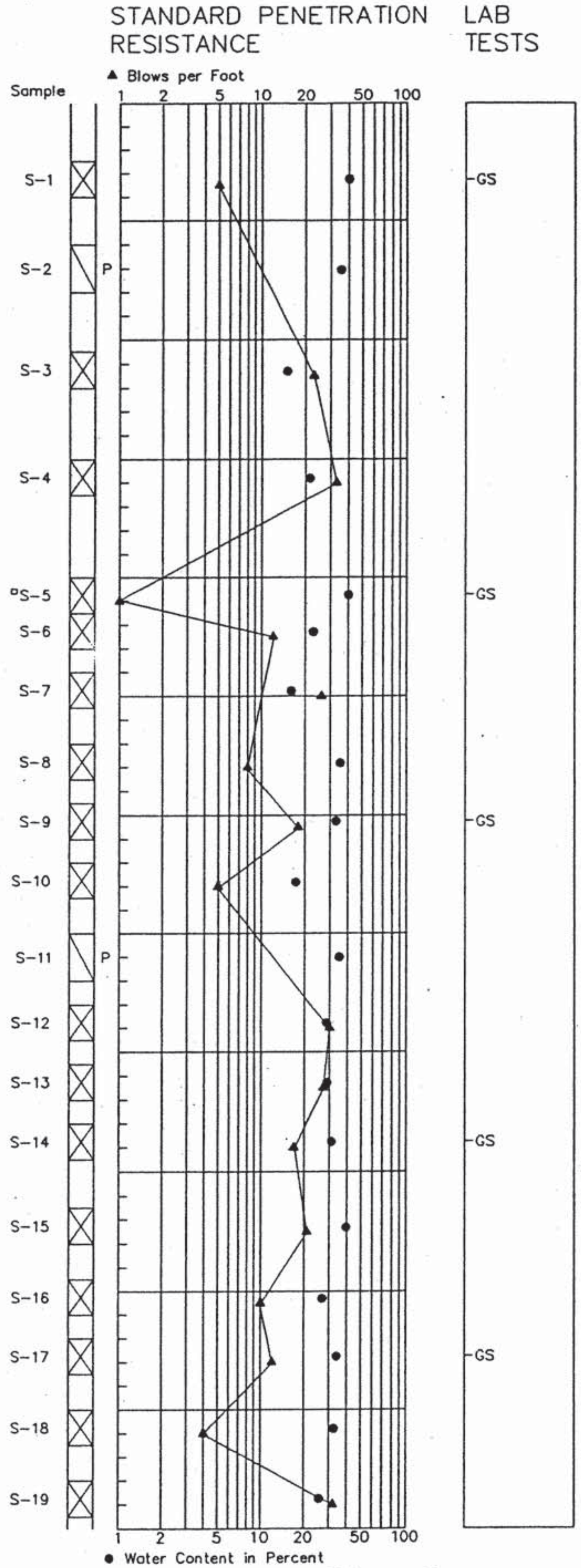
Figure A-12 2/2

Boring Log HC-15

Soil Descriptions

Mudline Elevation in Feet −28

Depth in Feet	Soil Description
0	Loose to dense, wet, black, silty to very silty, fine and medium SAND.
~3	Grading slightly gravelly.
~7	Petroleum−like odor.
~23.5	Medium stiff to very stiff, wet, black, slightly sandy SILT.
~28	Grading very silty SAND.
~43	Medium dense, wet, black, very silty to slightly silty, fine SAND.
~56	Interbedded layer of SILT.
60	



1. Refer to Figure A−1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

▫ Low blow count may be due to drilling disturbance, not considered to reflect actual density conditions.

HARTCROWSER

J-3528 4/92

Figure A-17 1/2

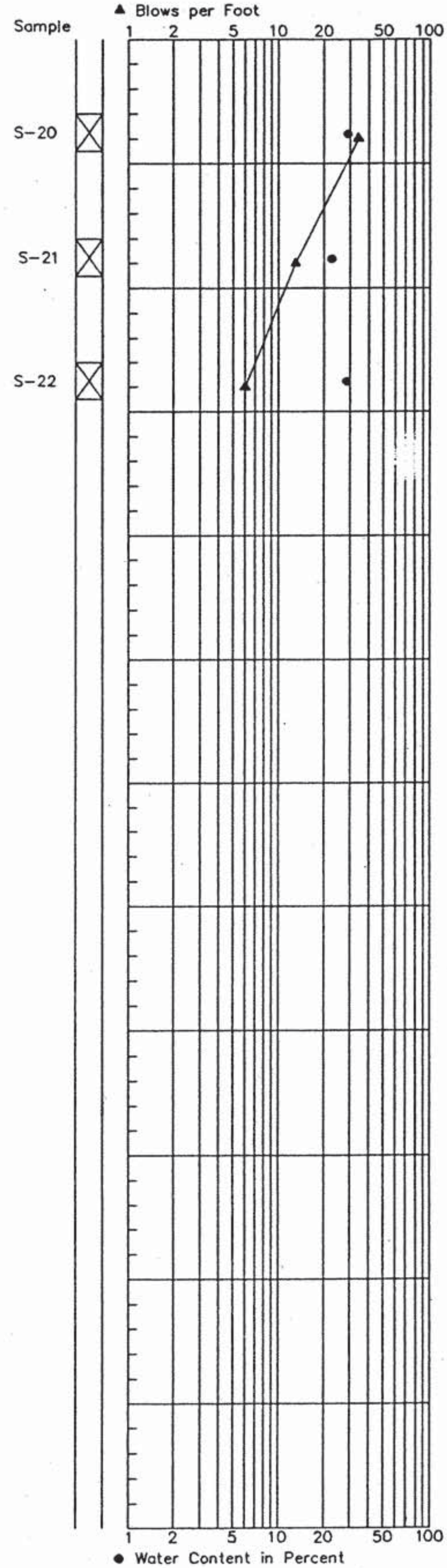
Boring Log HC-15

Soil Descriptions

Depth in Feet	Soil Descriptions
60	Hard to stiff, wet, black, sandy to very sandy SILT.
~71	Loose, wet, black, medium SAND.
74.5	Bottom of Boring at 74.5 Feet. Completed 4/1/92.

STANDARD PENETRATION RESISTANCE

LAB TESTS



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

J-3528 4/92

Figure A-17 2/2

ATTACHMENT 2

LIQUEFACTION POTENTIAL EVALUATION BY WSLIQ

EXISTING CONDITIONS

108 YEARS, 475 YEARS, 2,475 YEARS – LOWER-BOUND SPT

108 YEARS, 475 YEARS, 2,475 YEARS – UPPER-BOUND SPT

Liquefaction Hazard Evaluation Report
by WSLiq Program beta (May, 2009)

Site Name: Lockheed West Seattle
Site Location (N,W) = 47.583 , 122.367
Job No: 106-8945
Analyst: TetraTech
Date: 10/13/2011 4:21:29 PM

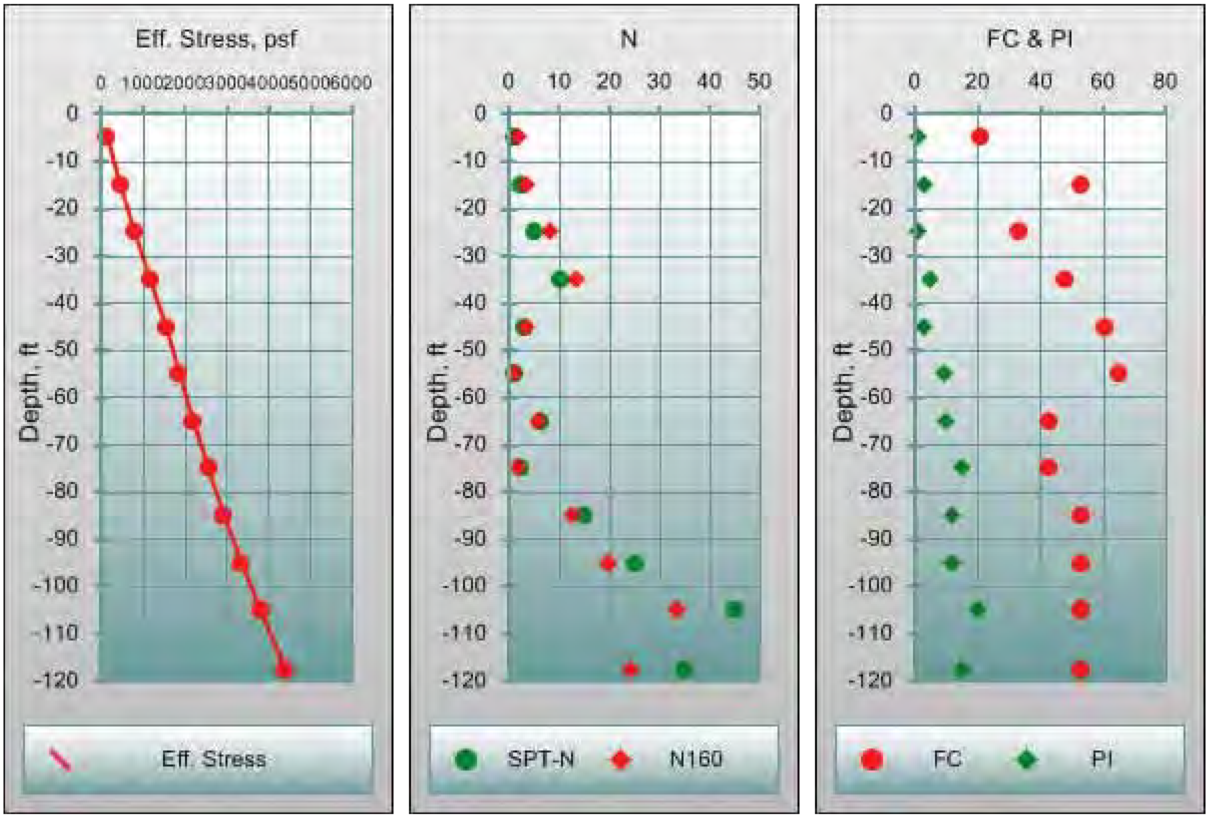
=== Soil Profile ===
Unit: ft
The number of soil layers: 12
GWT at top of layer: 1
GWT depth: 0.00
SPT Energy Ratio (%): 60.00
Amplification Factors: a= 0.1400 b= 0.0200
Elevation: 0.00
Ground Surface: Infinite Slope (%)= 0.2

Layer	Descpt.	Thickness (ft)	Unit Weight (lb/ft3)	Nm	N160	Vs ft/sec
1	Loose_silty_sand	10	90.00	1	1.7	330.0
2	Soft_sandy_silt	10	95.00	2	3.4	403.5
3	Soft_silt	10	100.00	5	8.2	526.3
4	Medium_dense_silty_sand	10	100.00	10	13.5	643.4
5	Soft_silty_sand	10	100.00	3	3.5	453.8
6	Loose_silty_sand	10	90.00	1	1.1	330.0
7	Soft_silty_sand	10	100.00	6	5.9	554.9
8	Loose_silty_sand	10	95.00	2	1.8	403.5
9	Medium_dense_sand	10	105.00	15	12.8	723.7
10	Medium_dense_silty_sand	10	105.00	25	19.9	839.3
11	Dense_sand	10	110.00	45	33.6	995.3
12	Dense_sand	15	110.00	35	24.3	925.3

Layer	FC (%)	PI	wc/LL	D50 (mm)	Ini. Eff. Stress (psf)	Ini. Total Stress (psf)
1	21	1	1	1128.0	138.0	450.00
2	53	3	0.9	1128.0	439.0	1375.00
3	33	1	1	1598.0	790.0	2350.00
4	47.5	5	0.9	1786.0	1166.0	3350.00

5	60.5	3	1	2068.0	1542.0	4350.00
6	65	9	0.9	2350.0	1868.0	5300.00
7	42.5	10	0.8	2726.0	2194.0	6250.00
8	42.5	15	1	3572.0	2545.0	7225.00
9	53	12	0.9	4700.0	2921.0	8225.00
10	53	12	0.9	3347.0	3347.0	9275.00
11	53	20	1	3773.0	3798.0	10350.00
12	53	15	0.9	4305.5	4393.0	11725.00

Soil Profile Plots



=== Susceptibility Evaluation ===

Threshold: 0.5

Weighting factors: B-I= 0.50   B-S= 0.50

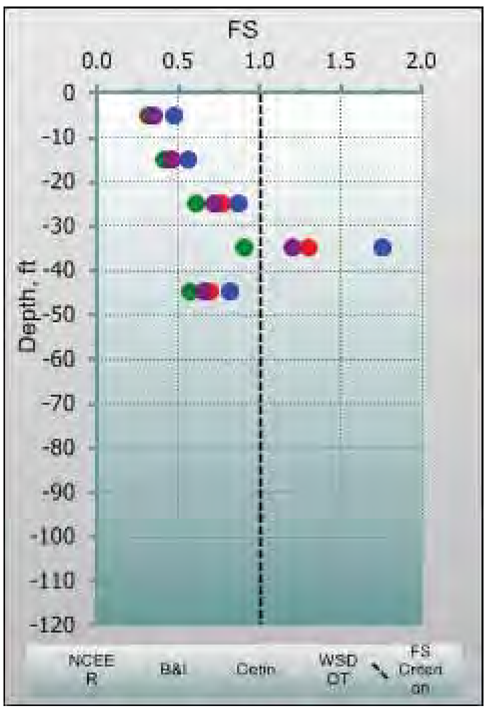
Layer	PI	wc/LL	B-I	B-S	Suscep. Index	Potential
1	1.00	1.00	1.00	0.76	0.88	YES
2	3.00	0.90	0.96	0.63	0.80	YES
3	1.00	1.00	1.00	0.76	0.88	YES
4	5.00	0.90	0.62	0.63	0.62	YES
5	3.00	1.00	0.96	0.76	0.86	YES
6	9.00	0.90	0.09	0.59	0.34	NO
7	10.00	0.80	0.05	0.41	0.23	NO
8	15.00	1.00	0.01	0.37	0.19	NO
9	12.00	0.90	0.02	0.48	0.25	NO
10	12.00	0.90	0.02	0.48	0.25	NO
11	20.00	1.00	0.00	0.13	0.06	NO
12	15.00	0.90	0.01	0.31	0.16	NO

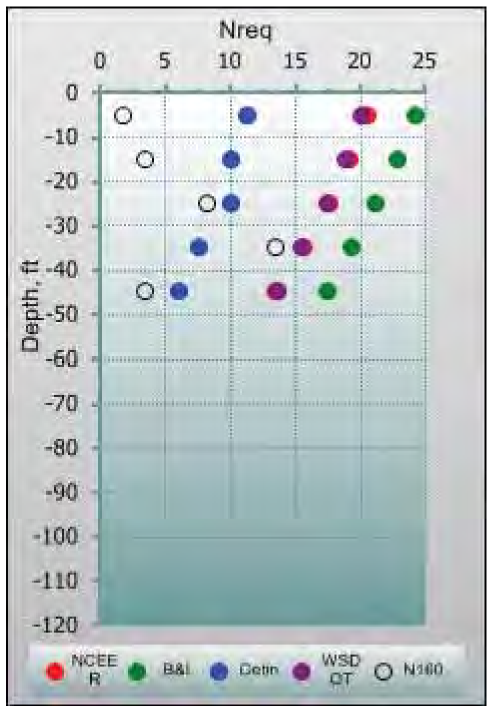
```
=== Initiation ===
---------------------------------------------------

Initiation - Multiple Scenario
-----------------------------------------
Retrun Period (yrs) = 108
Models Selected :
Use All Deterministic Models.
--WSDOT Recommended--
   Use NCEER, Boulanger & Idriss, and
   Cetin's model with weighting factors
   of 0.4, 0.4, and 0.2 respectively.
-----------------------------------------


===== Mean Mw and FS ==============
---NCEER Model------------
--- PGA = 0.176  Mw = 6.46---------

Layer  (N1)60    CSR     CRR     FS     Nreq
-----  ------  ------  ------  ------  ------
    1    1.70   0.247   0.077    0.31    20.6
    2    3.40   0.226   0.105    0.47    19.3
    3    8.18   0.202   0.155    0.77    17.6
    4   13.47   0.177   0.230    1.30    15.7
    5    3.51   0.153   0.106    0.70    13.5


===== Mean Mw and FS ==============
---Boulanger and Idriss Model------------
--- PGA = 0.176  Mw = 6.46---------

Layer  (N1)60    CSR     CRR     FS     Nreq
-----  ------  ------  ------  ------  ------
    1    1.70   0.291   0.094    0.32    24.3
    2    3.40   0.267   0.111    0.42    23.0
    3    8.50   0.239   0.148    0.62    21.2
    4   13.49   0.216   0.195    0.91    19.3
    5    3.67   0.197   0.113    0.57    17.6


===== Mean Mw and FS ==============
---Cetin et al. Model------------
--- PGA = 0.176  Mw = 6.46---------

Layer  (N1)60    CSR     CRR     FS     Nreq
-----  ------  ------  ------  ------  ------
    1    1.60   0.354   0.167    0.47    11.4
    2    3.20   0.287   0.161    0.56    10.1
    3    8.00   0.215   0.187    0.87    10.2
    4   13.47   0.170   0.299    1.76     7.6
    5    3.51   0.148   0.121    0.82     6.1

---WSDOT Recommended------------
--- PGA = 0.176  Mw = 6.46---------
```

Layer	(N1)60	CSR	CRR	FS	Nreq
1	1.70	0.286	0.102	0.36	20.2
2	3.40	0.255	0.119	0.47	18.9
3	8.18	0.219	0.159	0.72	17.5
4	13.47	0.191	0.230	1.20	15.5
5	3.51	0.170	0.112	0.66	13.7

Table of FS

#	Depth ft	NCEER	B&I	Cetin PL=0.60	WSDOT PL=0.60
1	-5.00	0.31	0.32	0.47	0.36
2	-15.00	0.47	0.42	0.56	0.47
3	-25.00	0.77	0.62	0.87	0.72
4	-35.00	1.30	0.91	1.76	1.20
5	-45.00	0.70	0.57	0.82	0.66



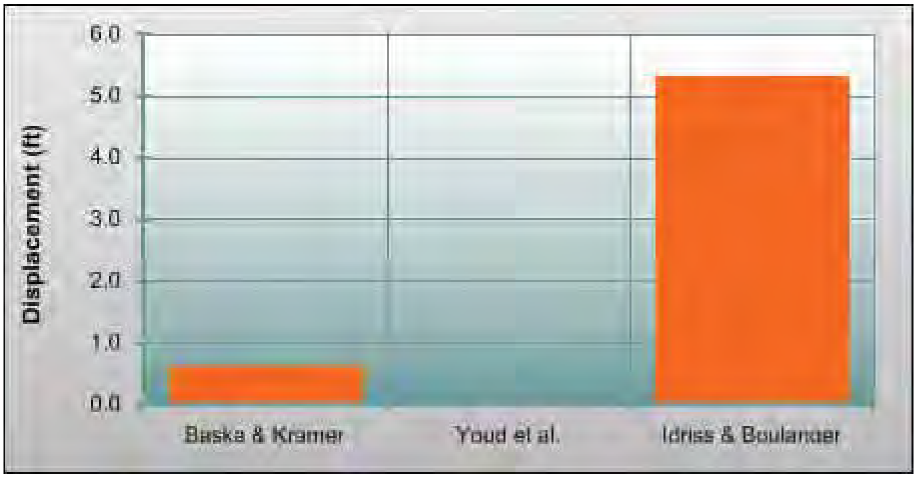


=== Effects ===

** Lateral Spreading **

>>>Multiple Scenario Results
Model Selected :
WSDOT Recommended (weighted average)
using models of Baska & Kramer and Youd et al.

```
Baska & Kramer: 0.65 ft
Youd et al.: 0.00 ft
Idriss & Boulanger: 5.34 ft

----------------------------------------
Weighting factors: Baska and Kramer = 0.65
                   Youd et al.      = 0.35

 WSDOT Recommended: 0.42 ft
```

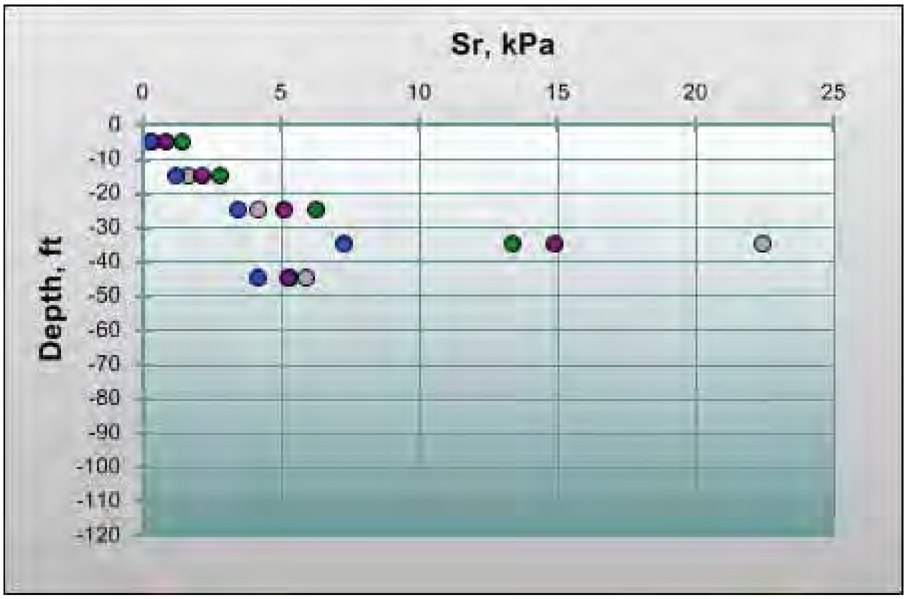



```
=== Effects ===
---------------------------------------------------


** Settlement **
----------------
>>>Multiple Scenario Results
Groud Surface Settlement MULTIPLE Scenario
Return Period (yrs) = 108
Model Selected :
   WSDOT Recommended (weighted average)
   using all deterministic models.
   -----------------------------------------
   Weighting factors = 0.25 for each model
-----------------------------------------


WSDOT Recommended:
=================
Total ground surface settlement = 2.85 ft
----------------------------------------------
  #    Depth thickness    ev    Weight    dh
          ft        ft     %              ft
----------------------------------------------
  1     5.00      10.0  9.870    1.00    0.99
  2    15.00      10.0  8.526    1.00    0.85
  3    25.00      10.0  3.202    1.00    0.32
  4    35.00      10.0  0.997    0.99    0.10
```

5	45.00	10.0	5.941	1.00	0.59
6	55.00	10.0	0.001	0.00	0.00
7	65.00	10.0	0.001	0.00	0.00
8	75.00	10.0	0.001	0.00	0.00
9	85.00	10.0	0.001	0.00	0.00
10	95.00	10.0	0.001	0.00	0.00
11	105.00	10.0	0.001	0.00	0.00
12	117.50	15.0	0.001	0.00	0.00


```
=== Effects ===
---------------------------------------------------


** Residual Strength **
-----------------------
====== Soil Layers Selected ==================
Layer 1
Layer 2

====== Models Selected =======================
Use recommended models:
  Kramer & Wang, Deterministic (KWD), w/ weighting factor = 0.5
  Idriss & Boulanger           (IDB), w/ weighting factor = 0.3
  Olson & Stark                (OLS), w/ weighting factor = 0.2
The residual strength is estimated as:
  Residual Strength =
    0.5*(Kramer & Wang) + 0.3*(Idriss & Boulanger) + 0.2*(Olson & Stark)

--------------------------------------------------------

###### Unweighted Residual Strength ####################

Kramer & Wang Deterministic Model:
   Layer 1:  Sr =    29 psf =   1.4 kPa = 0.014 atm
   Layer 2:  Sr =    59 psf =   2.8 kPa = 0.028 atm
------------------------------------------------------
```

```
Idriss & Boulanger Model:
   Layer 1:  Sr =     7 psf =   0.3 kPa = 0.003 atm
   Layer 2:  Sr =    34 psf =   1.6 kPa = 0.016 atm
------------------------------------------------------
Olson & Stark Model:
   Layer 1:  Sr =     6 psf =   0.3 kPa = 0.003 atm
   Layer 2:  Sr =    24 psf =   1.2 kPa = 0.012 atm
------------------------------------------------------
WSDOT Recommended Model:
   Layer 1:  Sr =    18 psf =   0.9 kPa = 0.008 atm
   Layer 2:  Sr =    44 psf =   2.1 kPa = 0.021 atm
------------------------------------------------------
```



Liquefaction Hazard Evaluation Report
by WSLiq Program beta (May, 2009)

Site Name: Lockheed West Seattle
Site Location (N,W) = 47.583 , 122.367
Job No: 106-8945
Analyst: TetraTech
Date: 10/9/2011 3:55:15 PM

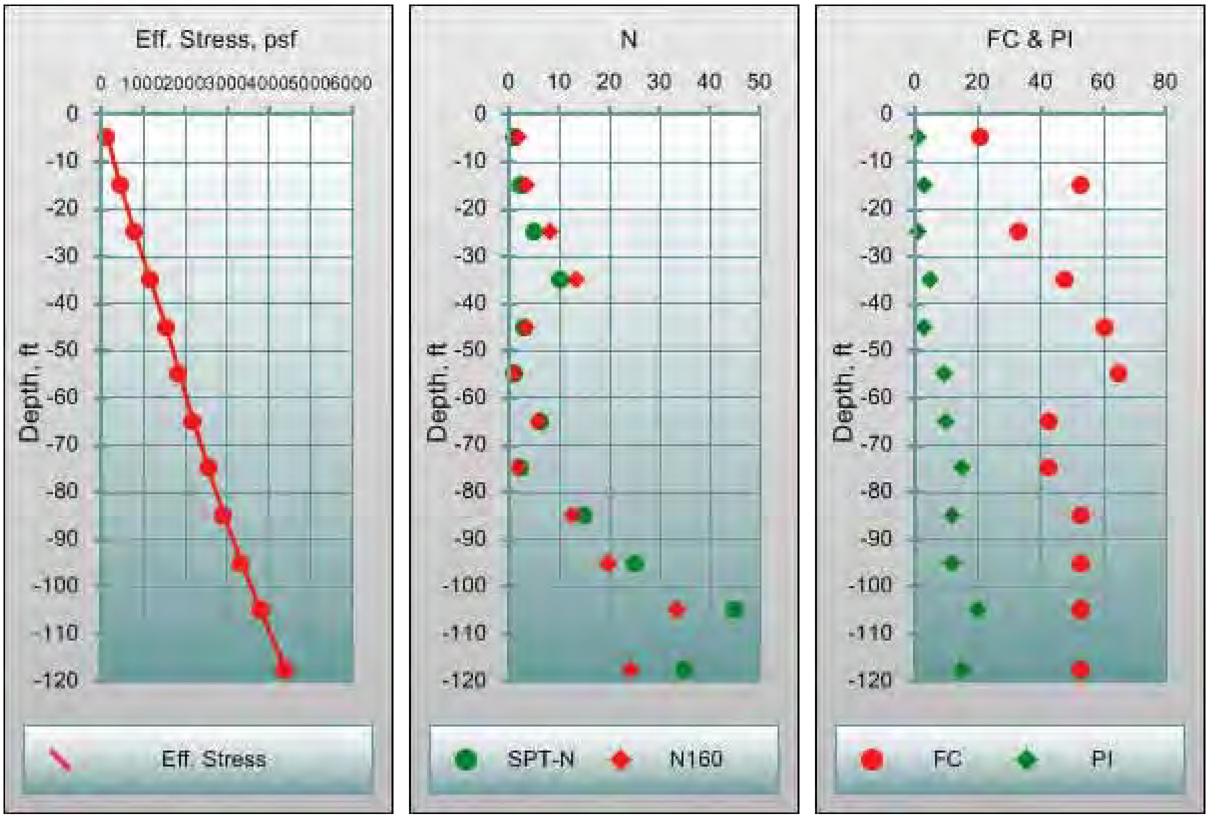
=== Soil Profile ===
Unit: ft
The number of soil layers: 12
GWT at top of layer: 1
GWT depth: 0.00
SPT Energy Ratio (%): 60.00
Amplification Factors: a= 0.1400 b= 0.0200
Elevation: 0.00
Ground Surface: Infinite Slope (%)= 0.2

Layer	Descpt.	Thickness (ft)	Unit Weight (lb/ft3)	Nm	N160	Vs ft/sec
1	Loose_silty_sand	10	90.00	1	1.7	330.0
2	Soft_sandy_silt	10	95.00	2	3.4	403.5
3	Soft_silt	10	100.00	5	8.2	526.3
4	Medium_dense_silty_sand	10	100.00	10	13.5	643.4
5	Soft_silty_sand	10	100.00	3	3.5	453.8
6	Loose_silty_sand	10	90.00	1	1.1	330.0
7	Soft_silty_sand	10	100.00	6	5.9	554.9
8	Loose_silty_sand	10	95.00	2	1.8	403.5
9	Medium_dense_sand	10	105.00	15	12.8	723.7
10	Medium_dense_silty_sand	10	105.00	25	19.9	839.3
11	Dense_sand	10	110.00	45	33.6	995.3
12	Dense_sand	15	110.00	35	24.3	925.3

Layer	FC (%)	PI	wc/LL	D50 (mm)	Ini. Eff. Stress (psf)	Ini. Total Stress (psf)
1	21	1	1	1128.0	138.0	450.00
2	53	3	0.9	1128.0	439.0	1375.00
3	33	1	1	1598.0	790.0	2350.00
4	47.5	5	0.9	1786.0	1166.0	3350.00

5	60.5	3	1	2068.0	1542.0	4350.00
6	65	9	0.9	2350.0	1868.0	5300.00
7	42.5	10	0.8	2726.0	2194.0	6250.00
8	42.5	15	1	3572.0	2545.0	7225.00
9	53	12	0.9	4700.0	2921.0	8225.00
10	53	12	0.9	3347.0	3347.0	9275.00
11	53	20	1	3773.0	3798.0	10350.00
12	53	15	0.9	4305.5	4393.0	11725.00

Soil Profile Plots



=== Susceptibility Evaluation ===

Threshold: 0.5
Weighting factors: B-I= 0.50 B-S= 0.50

Layer	PI	wc/LL	B-I	B-S	Suscep. Index	Potential
1	1.00	1.00	1.00	0.76	0.88	YES
2	3.00	0.90	0.96	0.63	0.80	YES
3	1.00	1.00	1.00	0.76	0.88	YES
4	5.00	0.90	0.62	0.63	0.62	YES
5	3.00	1.00	0.96	0.76	0.86	YES
6	9.00	0.90	0.09	0.59	0.34	NO
7	10.00	0.80	0.05	0.41	0.23	NO
8	15.00	1.00	0.01	0.37	0.19	NO
9	12.00	0.90	0.02	0.48	0.25	NO
10	12.00	0.90	0.02	0.48	0.25	NO
11	20.00	1.00	0.00	0.13	0.06	NO
12	15.00	0.90	0.01	0.31	0.16	NO

=== Initiation ===

Initiation - Multiple Scenario

Retrun Period (yrs) = 475
Models Selected :
Use All Deterministic Models.
--WSDOT Recommended--
Use NCEER, Boulanger & Idriss, and Cetin's model with weighting factors of 0.4, 0.4, and 0.2 respectively.

===== Mean Mw and FS ==============
---NCEER Model------------
--- PGA = 0.378 Mw = 6.58---------

Layer	(N1)60	CSR	CRR	FS	Nreq
1	1.70	0.552	0.077	0.14	30.0
2	3.40	0.506	0.105	0.21	29.4
3	8.18	0.451	0.155	0.34	28.5
4	13.47	0.397	0.230	0.58	27.3
5	3.51	0.342	0.106	0.31	25.6

===== Mean Mw and FS ==============
---Boulanger and Idriss Model------------
--- PGA = 0.378 Mw = 6.58---------

Layer	(N1)60	CSR	CRR	FS	Nreq
1	1.70	0.640	0.094	0.15	31.6
2	3.40	0.587	0.111	0.19	31.0
3	8.50	0.527	0.148	0.28	30.2
4	13.49	0.476	0.195	0.41	29.3
5	3.67	0.434	0.113	0.26	28.4

===== Mean Mw and FS ==============
---Cetin et al. Model------------
--- PGA = 0.378 Mw = 6.58---------

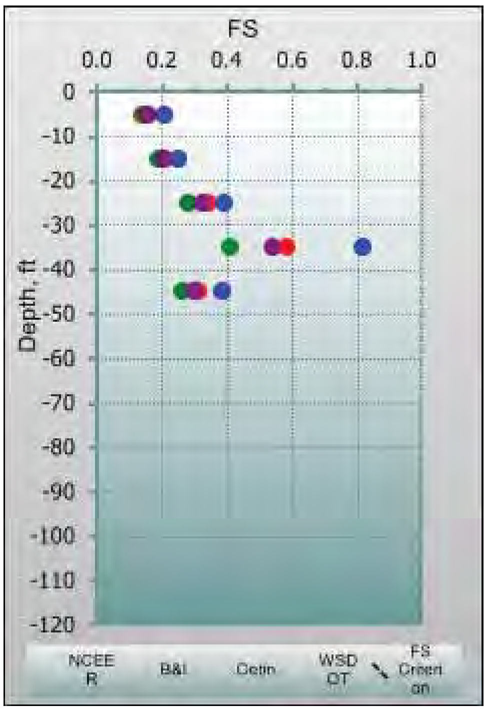
Layer	(N1)60	CSR	CRR	FS	Nreq
1	1.60	0.759	0.158	0.21	21.3
2	3.20	0.609	0.152	0.25	18.8
3	8.00	0.449	0.177	0.39	19.4
4	13.47	0.347	0.283	0.82	16.1
5	3.51	0.299	0.114	0.38	14.1

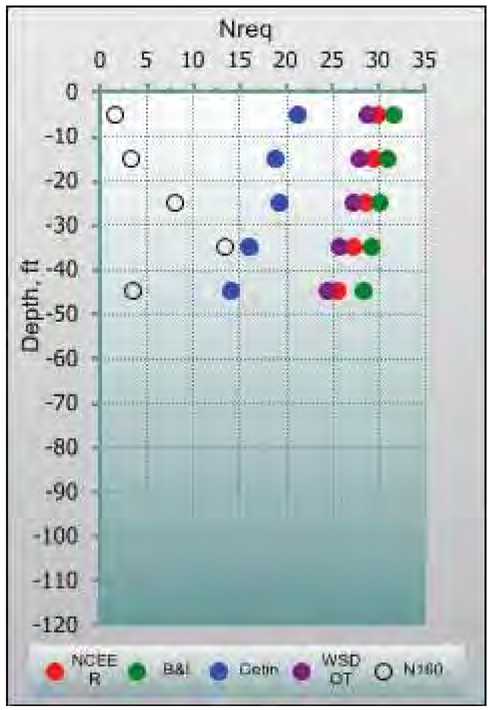
---WSDOT Recommended------------
--- PGA = 0.378 Mw = 6.58---------

Layer	(N1)60	CSR	CRR	FS	Nreq
1	1.70	0.628	0.100	0.16	28.9
2	3.40	0.559	0.117	0.21	27.9
3	8.18	0.481	0.157	0.33	27.4
4	13.47	0.418	0.227	0.54	25.9
5	3.51	0.370	0.111	0.30	24.4

Table of FS

#	Depth ft	NCEER	B&I	Cetin PL=0.60	WSDOT PL=0.60
1	-5.00	0.14	0.15	0.21	0.16
2	-15.00	0.21	0.19	0.25	0.21
3	-25.00	0.34	0.28	0.39	0.33
4	-35.00	0.58	0.41	0.82	0.54
5	-45.00	0.31	0.26	0.38	0.30



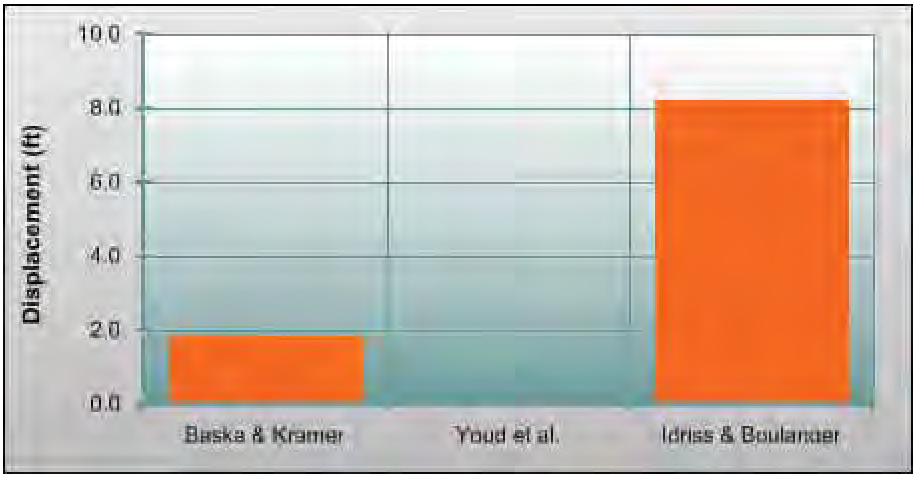


=== Effects ===

** Lateral Spreading **

>>>Multiple Scenario Results
Model Selected :
WSDOT Recommended (weighted average)
using models of Baska & Kramer and Youd et al.

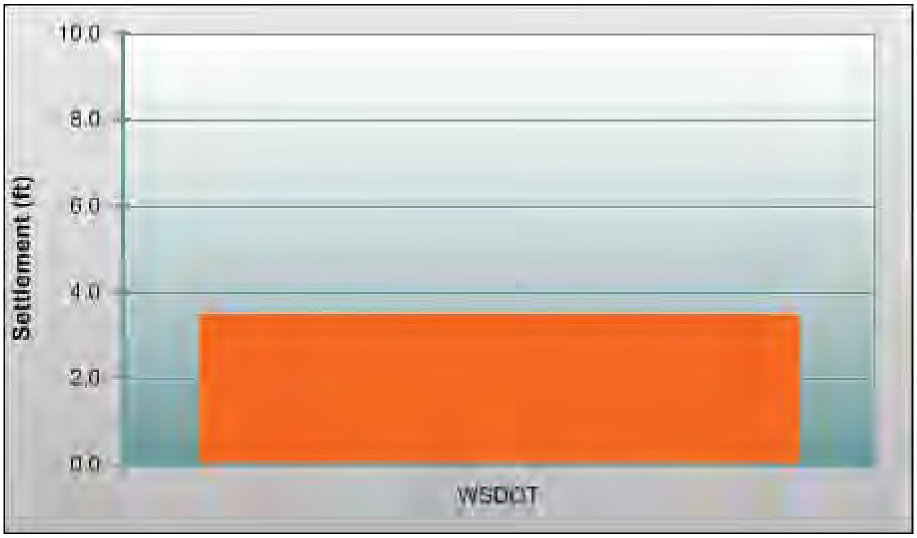
```
Baska & Kramer: 1.86 ft
Youd et al.: 0.00 ft
Idriss & Boulanger: 8.26 ft

----------------------------------------
Weighting factors: Baska and Kramer = 0.65
                   Youd et al.      = 0.35

 WSDOT Recommended: 1.21 ft
```




```
=== Effects ===
---------------------------------------------------


** Settlement **
----------------
>>>Multiple Scenario Results
Groud Surface Settlement MULTIPLE Scenario
Return Period (yrs) = 475
Model Selected :
   WSDOT Recommended (weighted average)
   using all deterministic models.
   -----------------------------------------
   Weighting factors = 0.25 for each model
-----------------------------------------


WSDOT Recommended:
=================
Total ground surface settlement = 3.52 ft
----------------------------------------------
```

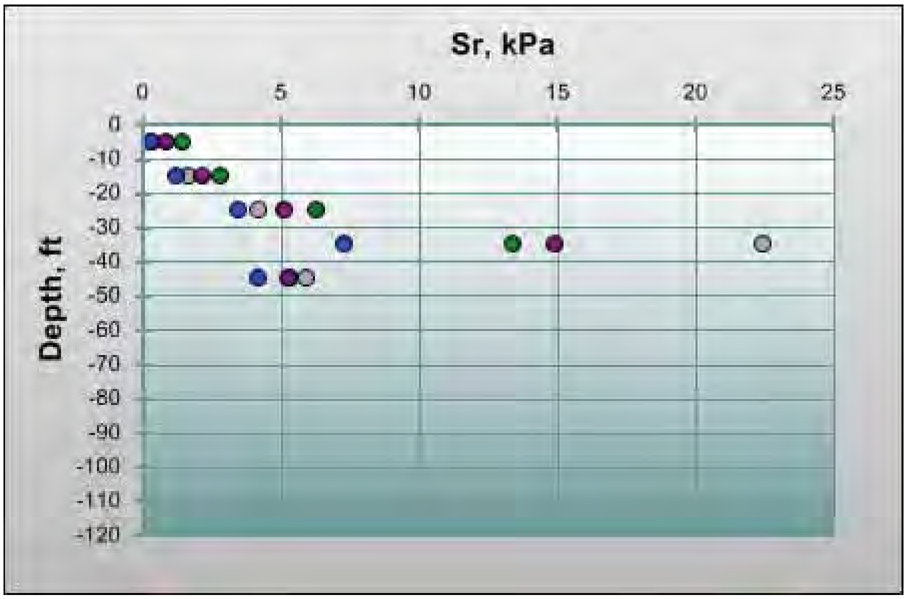
#	Depth ft	thickness ft	ev %	Weight	dh ft
1	5.00	10.0	10.142	1.00	1.01
2	15.00	10.0	9.038	1.00	0.90
3	25.00	10.0	4.369	1.00	0.44
4	35.00	10.0	2.660	1.00	0.27

```
  5    45.00      10.0  9.020    1.00    0.90
  6    55.00      10.0  0.001    0.00    0.00
  7    65.00      10.0  0.001    0.00    0.00
  8    75.00      10.0  0.001    0.00    0.00
  9    85.00      10.0  0.001    0.00    0.00
 10    95.00      10.0  0.001    0.00    0.00
 11   105.00      10.0  0.001    0.00    0.00
 12   117.50      15.0  0.001    0.00    0.00
----------------------------------------------
```




```
=== Effects ===
---------------------------------------------------


** Residual Strength **
-----------------------
====== Soil Layers Selected ==================
Layer 1
Layer 2

====== Models Selected =======================
Use recommended models:
  Kramer & Wang, Deterministic (KWD), w/ weighting factor = 0.5
  Idriss & Boulanger           (IDB), w/ weighting factor = 0.3
  Olson & Stark                (OLS), w/ weighting factor = 0.2
The residual strength is estimated as:
  Residual Strength =
    0.5*(Kramer & Wang) + 0.3*(Idriss & Boulanger) + 0.2*(Olson & Stark)

--------------------------------------------------------

###### Unweighted Residual Strength ####################

Kramer & Wang Deterministic Model:
   Layer 1:  Sr =    29 psf =   1.4 kPa = 0.014 atm
   Layer 2:  Sr =    59 psf =   2.8 kPa = 0.028 atm
------------------------------------------------------
```

```
Idriss & Boulanger Model:
   Layer 1:  Sr =     7 psf =   0.3 kPa = 0.003 atm
   Layer 2:  Sr =    34 psf =   1.6 kPa = 0.016 atm
------------------------------------------------------
Olson & Stark Model:
   Layer 1:  Sr =     6 psf =   0.3 kPa = 0.003 atm
   Layer 2:  Sr =    24 psf =   1.2 kPa = 0.012 atm
------------------------------------------------------
WSDOT Recommended Model:
   Layer 1:  Sr =    18 psf =   0.9 kPa = 0.008 atm
   Layer 2:  Sr =    44 psf =   2.1 kPa = 0.021 atm
------------------------------------------------------
```



Liquefaction Hazard Evaluation Report
by WSLiq Program beta (May, 2009)

Site Name: Lockheed West Seattle
Site Location (N,W) = 47.583 , 122.367
Job No: 106-8945
Analyst: TetraTech
Date: 10/9/2011 3:58:28 PM

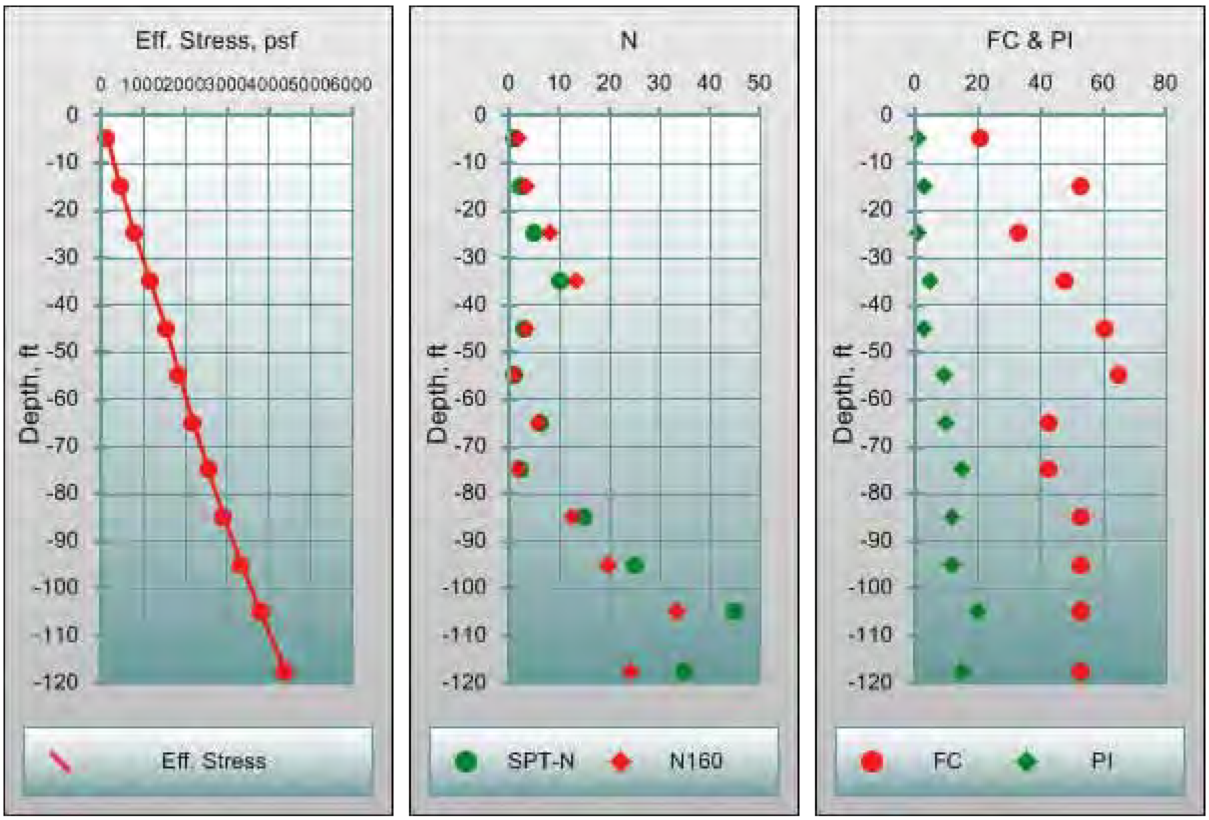
=== Soil Profile ===
Unit: ft
The number of soil layers: 12
GWT at top of layer: 1
GWT depth: 0.00
SPT Energy Ratio (%): 60.00
Amplification Factors: a= 0.1400 b= 0.0200
Elevation: 0.00
Ground Surface: Infinite Slope (%)= 0.2

Layer	Descpt.	Thickness (ft)	Unit Weight (lb/ft3)	Nm	N160	Vs ft/sec
1	Loose_silty_sand	10	90.00	1	1.7	330.0
2	Soft_sandy_silt	10	95.00	2	3.4	403.5
3	Soft_silt	10	100.00	5	8.2	526.3
4	Medium_dense_silty_sand	10	100.00	10	13.5	643.4
5	Soft_silty_sand	10	100.00	3	3.5	453.8
6	Loose_silty_sand	10	90.00	1	1.1	330.0
7	Soft_silty_sand	10	100.00	6	5.9	554.9
8	Loose_silty_sand	10	95.00	2	1.8	403.5
9	Medium_dense_sand	10	105.00	15	12.8	723.7
10	Medium_dense_silty_sand	10	105.00	25	19.9	839.3
11	Dense_sand	10	110.00	45	33.6	995.3
12	Dense_sand	15	110.00	35	24.3	925.3

Layer	FC (%)	PI	wc/LL	D50 (mm)	Ini. Eff. Stress (psf)	Ini. Total Stress (psf)
1	21	1	1	1128.0	138.0	450.00
2	53	3	0.9	1128.0	439.0	1375.00
3	33	1	1	1598.0	790.0	2350.00
4	47.5	5	0.9	1786.0	1166.0	3350.00

5	60.5	3	1	2068.0	1542.0	4350.00
6	65	9	0.9	2350.0	1868.0	5300.00
7	42.5	10	0.8	2726.0	2194.0	6250.00
8	42.5	15	1	3572.0	2545.0	7225.00
9	53	12	0.9	4700.0	2921.0	8225.00
10	53	12	0.9	3347.0	3347.0	9275.00
11	53	20	1	3773.0	3798.0	10350.00
12	53	15	0.9	4305.5	4393.0	11725.00

Soil Profile Plots



=== Susceptibility Evaluation ===

Threshold: 0.5

Weighting factors: B-I= 0.50 B-S= 0.50

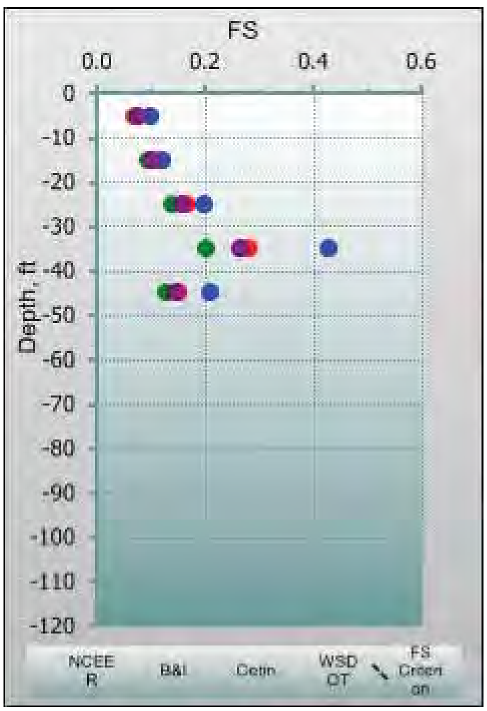
Layer	PI	wc/LL	B-I	B-S	Suscep. Index	Potential
1	1.00	1.00	1.00	0.76	0.88	YES
2	3.00	0.90	0.96	0.63	0.80	YES
3	1.00	1.00	1.00	0.76	0.88	YES
4	5.00	0.90	0.62	0.63	0.62	YES
5	3.00	1.00	0.96	0.76	0.86	YES
6	9.00	0.90	0.09	0.59	0.34	NO
7	10.00	0.80	0.05	0.41	0.23	NO
8	15.00	1.00	0.01	0.37	0.19	NO
9	12.00	0.90	0.02	0.48	0.25	NO
10	12.00	0.90	0.02	0.48	0.25	NO
11	20.00	1.00	0.00	0.13	0.06	NO
12	15.00	0.90	0.01	0.31	0.16	NO

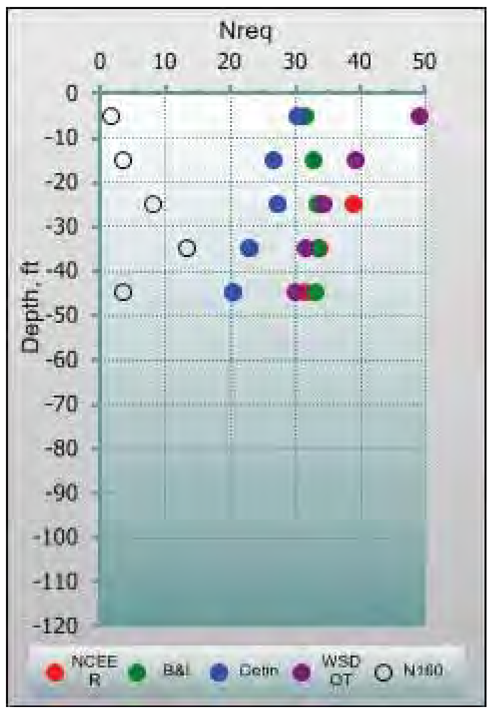
```
=== Initiation ===
---------------------------------------------------

Initiation - Multiple Scenario
-----------------------------------------
Retrun Period (yrs) = 2475
Models Selected :
Use All Deterministic Models.
--WSDOT Recommended--
   Use NCEER, Boulanger & Idriss, and
   Cetin's model with weighting factors
   of 0.4, 0.4, and 0.2 respectively.
-----------------------------------------


===== Mean Mw and FS ==============
---NCEER Model------------
--- PGA = 0.754  Mw = 6.71---------

Layer  (N1)60    CSR     CRR     FS     Nreq
-----  ------  ------  ------  ------  ------
    1    1.70   1.143   0.077    0.07    76.5
    2    3.40   1.048   0.105    0.10    52.4
    3    8.18   0.936   0.155    0.17    39.0
    4   13.47   0.822   0.230    0.28    33.7
    5    3.51   0.709   0.106    0.15    31.7


===== Mean Mw and FS ==============
---Boulanger and Idriss Model------------
--- PGA = 0.754  Mw = 6.71---------

Layer  (N1)60    CSR     CRR     FS     Nreq
-----  ------  ------  ------  ------  ------
    1    1.70   1.300   0.094    0.07    31.5
    2    3.40   1.195   0.111    0.09    32.8
    3    8.50   1.071   0.148    0.14    33.6
    4   13.49   0.968   0.195    0.20    33.6
    5    3.67   0.883   0.113    0.13    33.3


===== Mean Mw and FS ==============
---Cetin et al. Model------------
--- PGA = 0.754  Mw = 6.71---------

Layer  (N1)60    CSR     CRR     FS     Nreq
-----  ------  ------  ------  ------  ------
    1    1.60   1.504   0.148    0.10    30.3
    2    3.20   1.180   0.142    0.12    26.7
    3    8.00   0.837   0.165    0.20    27.3
    4   13.47   0.616   0.265    0.43    23.1
    5    3.51   0.513   0.107    0.21    20.5

---WSDOT Recommended------------
--- PGA = 0.754  Mw = 6.71---------
```

Layer	(N1)60	CSR	CRR	FS	Nreq
1	1.70	1.278	0.098	0.08	49.3
2	3.40	1.133	0.115	0.10	39.4
3	8.18	0.970	0.154	0.16	34.5
4	13.47	0.839	0.223	0.27	31.5
5	3.51	0.739	0.109	0.15	30.1

Table of FS

#	Depth ft	NCEER	B&I	Cetin PL=0.60	WSDOT PL=0.60
1	-5.00	0.07	0.07	0.10	0.08
2	-15.00	0.10	0.09	0.12	0.10
3	-25.00	0.17	0.14	0.20	0.16
4	-35.00	0.28	0.20	0.43	0.27
5	-45.00	0.15	0.13	0.21	0.15



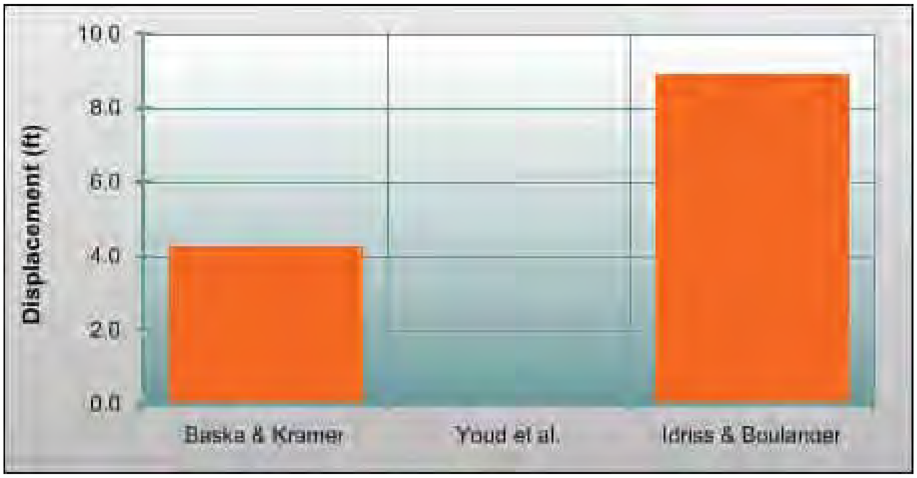


=== Effects ===

** Lateral Spreading **

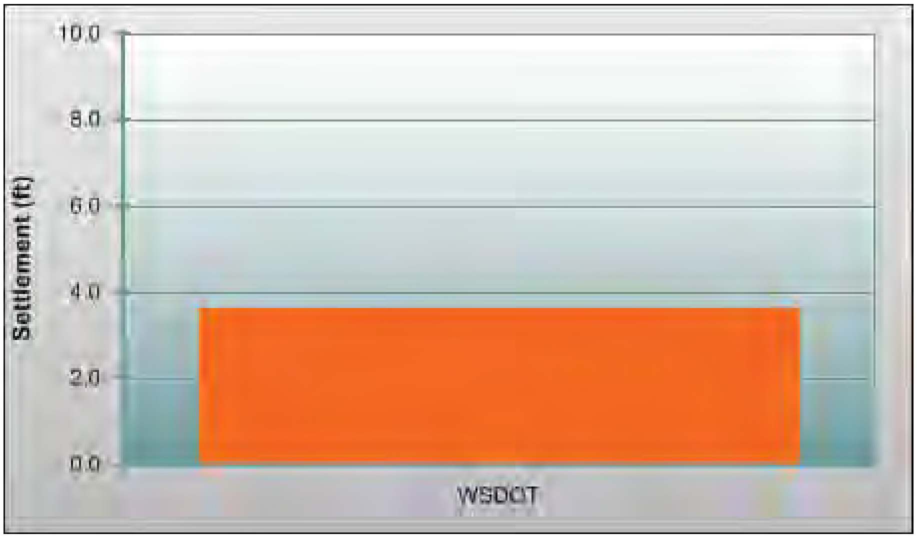
>>>Multiple Scenario Results
Model Selected :
WSDOT Recommended (weighted average)
using models of Baska & Kramer and Youd et al.

```
Baska & Kramer: 4.32 ft
Youd et al.: 0.00 ft
Idriss & Boulanger: 8.95 ft

----------------------------------------
Weighting factors: Baska and Kramer = 0.65
                   Youd et al.      = 0.35

 WSDOT Recommended: 2.81 ft
```



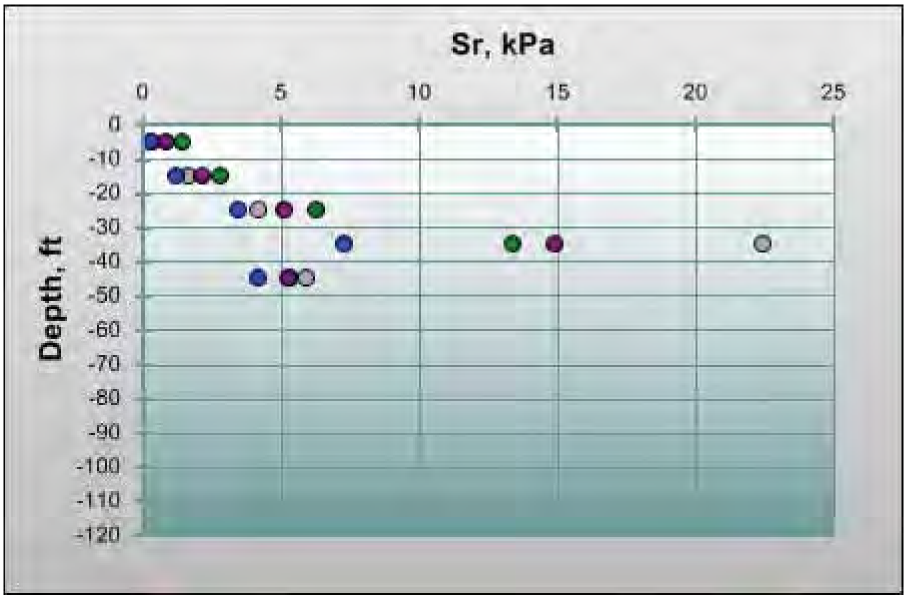

```
=== Effects ===
---------------------------------------------------


** Settlement **
----------------
>>>Multiple Scenario Results
Groud Surface Settlement MULTIPLE Scenario
Return Period (yrs) = 2475
Model Selected :
   WSDOT Recommended (weighted average)
   using all deterministic models.
   ----------------------------------------
   Weighting factors = 0.25 for each model
-----------------------------------------


WSDOT Recommended:
=================
Total ground surface settlement = 3.65 ft
----------------------------------------------
  #    Depth thickness    ev    Weight    dh
          ft        ft     %              ft
----------------------------------------------
  1     5.00      10.0  10.228    1.00    1.02
  2    15.00      10.0   9.419    1.00    0.94
  3    25.00      10.0   4.497    1.00    0.45
  4    35.00      10.0   2.997    1.00    0.30
```

```
  5    45.00      10.0  9.403    1.00    0.94
  6    55.00      10.0  0.001    0.00    0.00
  7    65.00      10.0  0.001    0.00    0.00
  8    75.00      10.0  0.001    0.00    0.00
  9    85.00      10.0  0.001    0.00    0.00
 10    95.00      10.0  0.001    0.00    0.00
 11   105.00      10.0  0.001    0.00    0.00
 12   117.50      15.0  0.001    0.00    0.00
----------------------------------------------
```




```
=== Effects ===
---------------------------------------------------


** Residual Strength **
-----------------------
====== Soil Layers Selected ==================
Layer 1
Layer 2

====== Models Selected =======================
Use recommended models:
  Kramer & Wang, Deterministic (KWD), w/ weighting factor = 0.5
  Idriss & Boulanger           (IDB), w/ weighting factor = 0.3
  Olson & Stark                (OLS), w/ weighting factor = 0.2
The residual strength is estimated as:
  Residual Strength =
    0.5*(Kramer & Wang) + 0.3*(Idriss & Boulanger) + 0.2*(Olson & Stark)

--------------------------------------------------------

###### Unweighted Residual Strength ####################

Kramer & Wang Deterministic Model:
   Layer 1:  Sr =    29 psf =   1.4 kPa = 0.014 atm
   Layer 2:  Sr =    59 psf =   2.8 kPa = 0.028 atm
-----------------------------------------------------
```

```
Idriss & Boulanger Model:
   Layer 1:  Sr =     7 psf =   0.3 kPa = 0.003 atm
   Layer 2:  Sr =    34 psf =   1.6 kPa = 0.016 atm
------------------------------------------------------
Olson & Stark Model:
   Layer 1:  Sr =     6 psf =   0.3 kPa = 0.003 atm
   Layer 2:  Sr =    24 psf =   1.2 kPa = 0.012 atm
------------------------------------------------------
WSDOT Recommended Model:
   Layer 1:  Sr =    18 psf =   0.9 kPa = 0.008 atm
   Layer 2:  Sr =    44 psf =   2.1 kPa = 0.021 atm
------------------------------------------------------
```



Liquefaction Hazard Evaluation Report
by WSLiq Program beta (May, 2009)

Site Name: Lockheed West Seattle
Site Location (N,W) = 47.583 , 122.367
Job No: 106-8945
Analyst: TetraTech
Date: 10/7/2011 9:15:51 AM

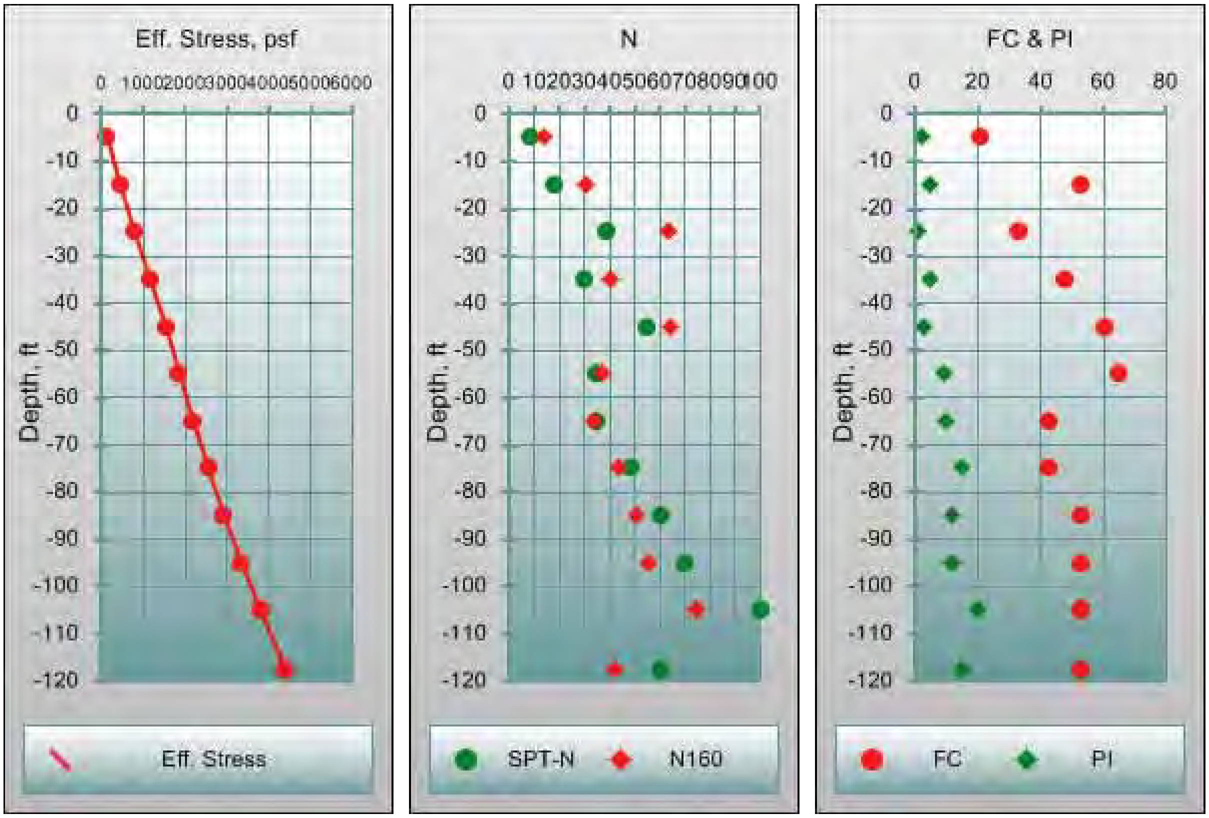
=== Soil Profile ===
Unit: ft
The number of soil layers: 12
GWT at top of layer: 1
GWT depth: 0.00
SPT Energy Ratio (%): 60.00
Amplification Factors: a= 0.1400 b= 0.0200
Elevation: 0.00
Ground Surface: Infinite Slope (%)= 0.2

Layer	Descpt.	Thickness (ft)	Unit Weight (lb/ft3)	Nm	N160	Vs ft/sec
1	Loose_silty_sand	10	90.00	8	13.6	603.1
2	Soft_sandy_silt	10	95.00	18	30.6	763.0
3	Soft_silt	10	100.00	39	63.8	954.8
4	Medium_dense_silty_sand	10	100.00	30	40.4	884.9
5	Soft_silty_sand	10	100.00	55	64.4	1054.9
6	Loose_silty_sand	10	90.00	35	37.3	925.3
7	Soft_silty_sand	10	100.00	35	34.4	925.3
8	Loose_silty_sand	10	95.00	48	43.8	1014.1
9	Medium_dense_sand	10	105.00	60	51.1	1081.9
10	Medium_dense_silty_sand	10	105.00	70	55.7	1131.3
11	Dense_sand	10	110.00	100	74.6	1254.6
12	Dense_sand	15	110.00	60	41.6	1081.9

Layer	FC (%)	PI	wc/LL	D50 (mm)	Ini. Eff. Stress (psf)	Ini. Total Stress (psf)
1	21	2	1	1128.0	138.0	450.00
2	53	5	0.9	1128.0	439.0	1375.00
3	33	1	1	1598.0	790.0	2350.00
4	47.5	5	0.9	1786.0	1166.0	3350.00

5	60.5	3	1	2068.0	1542.0	4350.00
6	65	9	0.9	2350.0	1868.0	5300.00
7	42.5	10	0.8	2726.0	2194.0	6250.00
8	42.5	15	1	3572.0	2545.0	7225.00
9	53	12	0.9	4700.0	2921.0	8225.00
10	53	12	0.9	3347.0	3347.0	9275.00
11	53	20	1	3773.0	3798.0	10350.00
12	53	15	0.9	4305.5	4393.0	11725.00

Soil Profile Plots



=== Susceptibility Evaluation ===

Threshold: 0.5

Weighting factors: B-I= 0.50   B-S= 0.50

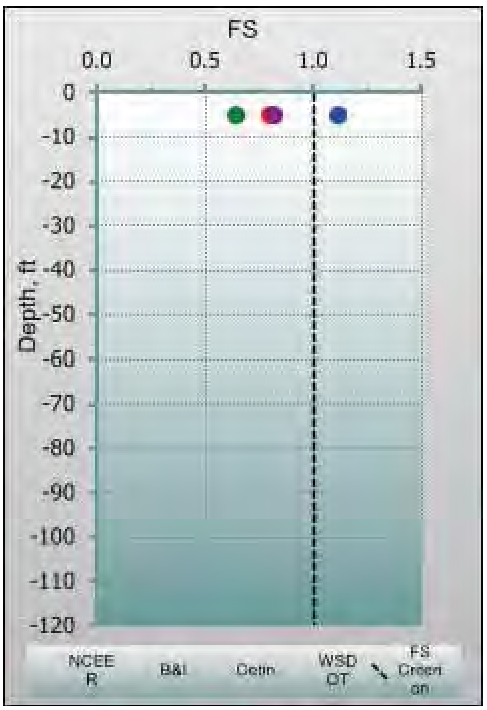
Layer	PI	wc/LL	B-I	B-S	Suscep. Index	Potential
1	2.00	1.00	1.00	0.76	0.88	YES
2	5.00	0.90	0.62	0.63	0.62	YES
3	1.00	1.00	1.00	0.76	0.88	YES
4	5.00	0.90	0.62	0.63	0.62	YES
5	3.00	1.00	0.96	0.76	0.86	YES
6	9.00	0.90	0.09	0.59	0.34	NO
7	10.00	0.80	0.05	0.41	0.23	NO
8	15.00	1.00	0.01	0.37	0.19	NO
9	12.00	0.90	0.02	0.48	0.25	NO
10	12.00	0.90	0.02	0.48	0.25	NO
11	20.00	1.00	0.00	0.13	0.06	NO
12	15.00	0.90	0.01	0.31	0.16	NO

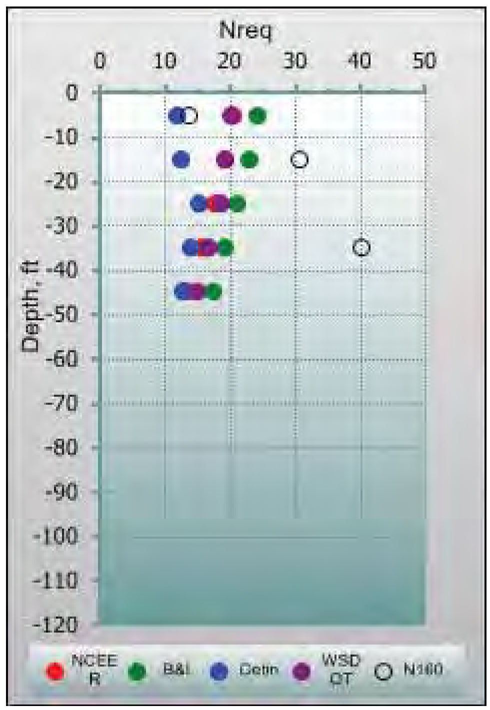
```
=== Initiation ===
---------------------------------------------------

Initiation - Multiple Scenario
-----------------------------------------
Retrun Period (yrs) = 108
Models Selected :
Use All Deterministic Models.
--WSDOT Recommended--
   Use NCEER, Boulanger & Idriss, and
   Cetin's model with weighting factors
   of 0.4, 0.4, and 0.2 respectively.
-----------------------------------------


===== Mean Mw and FS ==============
---NCEER Model------------
--- PGA = 0.176  Mw = 6.46---------

Layer  (N1)60    CSR     CRR     FS     Nreq
-----  ------  ------  ------  ------  ------
    1   13.60   0.247   0.198    0.80    20.6
    2   30.60   0.226   3.000   13.28    19.3
    3   63.83   0.202   3.000   14.87    17.6
    4   40.42   0.177   3.000   16.92    15.7
    5   64.43   0.153   3.000   19.62    13.5


===== Mean Mw and FS ==============
---Boulanger and Idriss Model------------
--- PGA = 0.176  Mw = 6.46---------

Layer  (N1)60    CSR     CRR     FS     Nreq
-----  ------  ------  ------  ------  ------
    1   13.60   0.291   0.186    0.64    24.3
    2   30.60   0.267   1.448    5.42    23.0
    3   46.00   0.239   3.000   12.54    21.2
    4   36.33   0.216   3.000   13.90    19.3
    5   46.00   0.197   3.000   15.23    17.6


===== Mean Mw and FS ==============
---Cetin et al. Model------------
--- PGA = 0.176  Mw = 6.46---------

Layer  (N1)60    CSR     CRR     FS     Nreq
-----  ------  ------  ------  ------  ------
    1   12.80   0.372   0.417    1.12    12.0
    2   28.80   0.354   1.652    4.67    12.4
    3   62.40   0.329   3.000    9.13    15.2
    4   40.42   0.302   2.773    9.19    14.1
    5   64.43   0.274   3.000   10.97    12.7

---WSDOT Recommended------------
--- PGA = 0.176  Mw = 6.46---------
```

Layer	(N1)60	CSR	CRR	FS	Nreq
1	13.60	0.289	0.237	0.82	20.3
2	30.60	0.268	2.109	7.87	19.4
3	63.83	0.242	3.000	12.39	18.5
4	40.42	0.218	2.955	13.58	16.8
5	64.43	0.195	3.000	15.41	15.0

Table of FS

#	Depth ft	NCEER	B&I	Cetin PL=0.60	WSDOT PL=0.60
1	-5.00	0.80	0.64	1.12	0.82
2	-15.00	13.28	5.42	4.67	7.87
3	-25.00	14.87	12.54	9.13	12.39
4	-35.00	16.92	13.90	9.19	13.58
5	-45.00	19.62	15.23	10.97	15.41



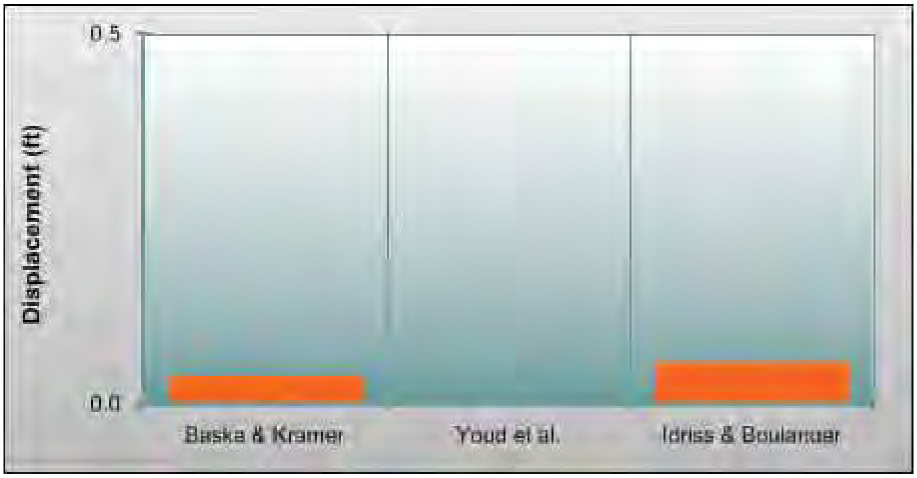


=== Effects ===

** Lateral Spreading **

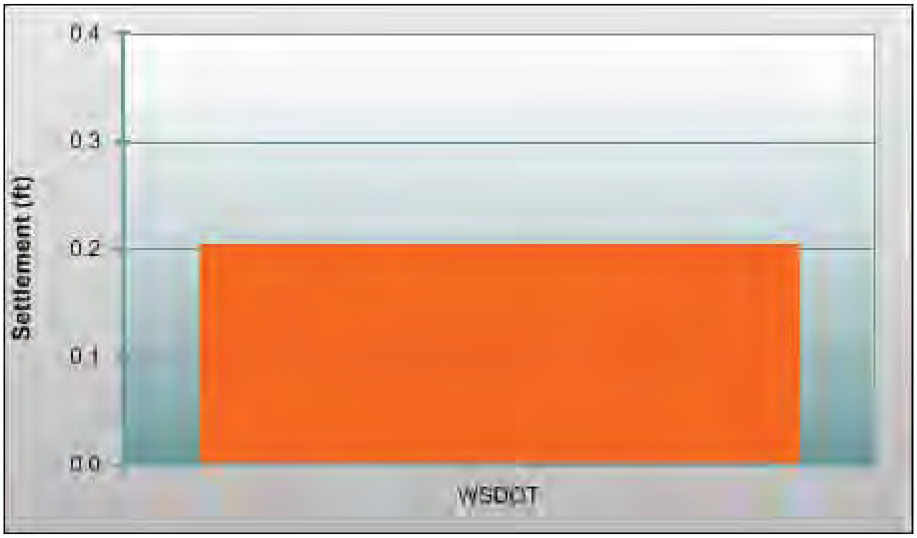
>>>Multiple Scenario Results
Model Selected :
WSDOT Recommended (weighted average)
using models of Baska & Kramer and Youd et al.

```
Baska & Kramer: 0.04 ft
Youd et al.: 0.00 ft
Idriss & Boulanger: 0.06 ft

----------------------------------------
Weighting factors: Baska and Kramer = 0.65
                   Youd et al.      = 0.35

 WSDOT Recommended: 0.03 ft
```



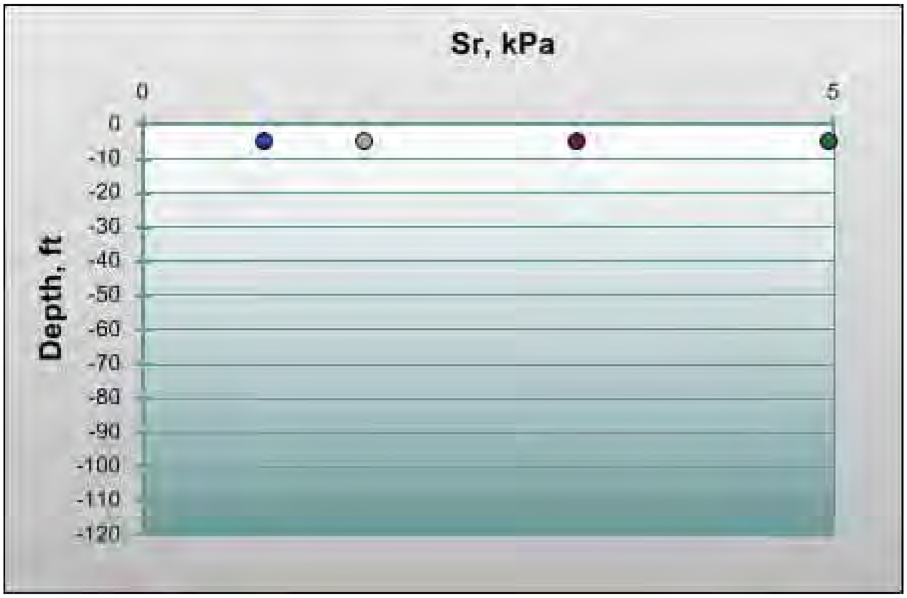

```
=== Effects ===
---------------------------------------------------


** Settlement **
----------------
>>>Multiple Scenario Results
Groud Surface Settlement MULTIPLE Scenario
Return Period (yrs) = 108
Model Selected :
   WSDOT Recommended (weighted average)
   using all deterministic models.
   -----------------------------------------
   Weighting factors = 0.25 for each model
-----------------------------------------


WSDOT Recommended:
=================
Total ground surface settlement = 0.21 ft
----------------------------------------------
  #    Depth thickness    ev    Weight    dh
          ft        ft     %              ft
----------------------------------------------
  1     5.00      10.0   2.037    1.00    0.20
  2    15.00      10.0   0.036    0.35    0.00
  3    25.00      10.0   0.001    0.00    0.00
  4    35.00      10.0   0.126    0.00    0.00
```

```
  5    45.00      10.0   0.001    0.00    0.00
  6    55.00      10.0   0.001    0.00    0.00
  7    65.00      10.0   0.001    0.00    0.00
  8    75.00      10.0   0.001    0.00    0.00
  9    85.00      10.0   0.001    0.00    0.00
 10    95.00      10.0   0.001    0.00    0.00
 11   105.00      10.0   0.001    0.00    0.00
 12   117.50      15.0   0.001    0.00    0.00
----------------------------------------------
```




```
=== Effects ===
---------------------------------------------------


** Residual Strength **
-----------------------
====== Soil Layers Selected ==================
Layer 1

====== Models Selected =======================
Use recommended models:
  Kramer & Wang, Deterministic (KWD), w/ weighting factor = 0.5
  Idriss & Boulanger           (IDB), w/ weighting factor = 0.3
  Olson & Stark                (OLS), w/ weighting factor = 0.2
The residual strength is estimated as:
  Residual Strength =
    0.5*(Kramer & Wang) + 0.3*(Idriss & Boulanger) + 0.2*(Olson & Stark)

--------------------------------------------------------

###### Unweighted Residual Strength ####################

Kramer & Wang Deterministic Model:
   Layer 1:  Sr =   104 psf =   5.0 kPa = 0.049 atm
------------------------------------------------------
Idriss & Boulanger Model:
   Layer 1:  Sr =    33 psf =   1.6 kPa = 0.016 atm
```

```
------------------------------------------------------
Olson & Stark Model:
   Layer 1:  Sr =    18 psf =   0.9 kPa = 0.009 atm
------------------------------------------------------
WSDOT Recommended Model:
   Layer 1:  Sr =    65 psf =   3.1 kPa = 0.031 atm
------------------------------------------------------
```



Liquefaction Hazard Evaluation Report
by WSLiq Program beta (May, 2009)

Site Name: Lockheed West Seattle
Site Location (N,W) = 47.583 , 122.367
Job No: 106-8945
Analyst: TetraTech
Date: 10/7/2011 9:17:23 AM

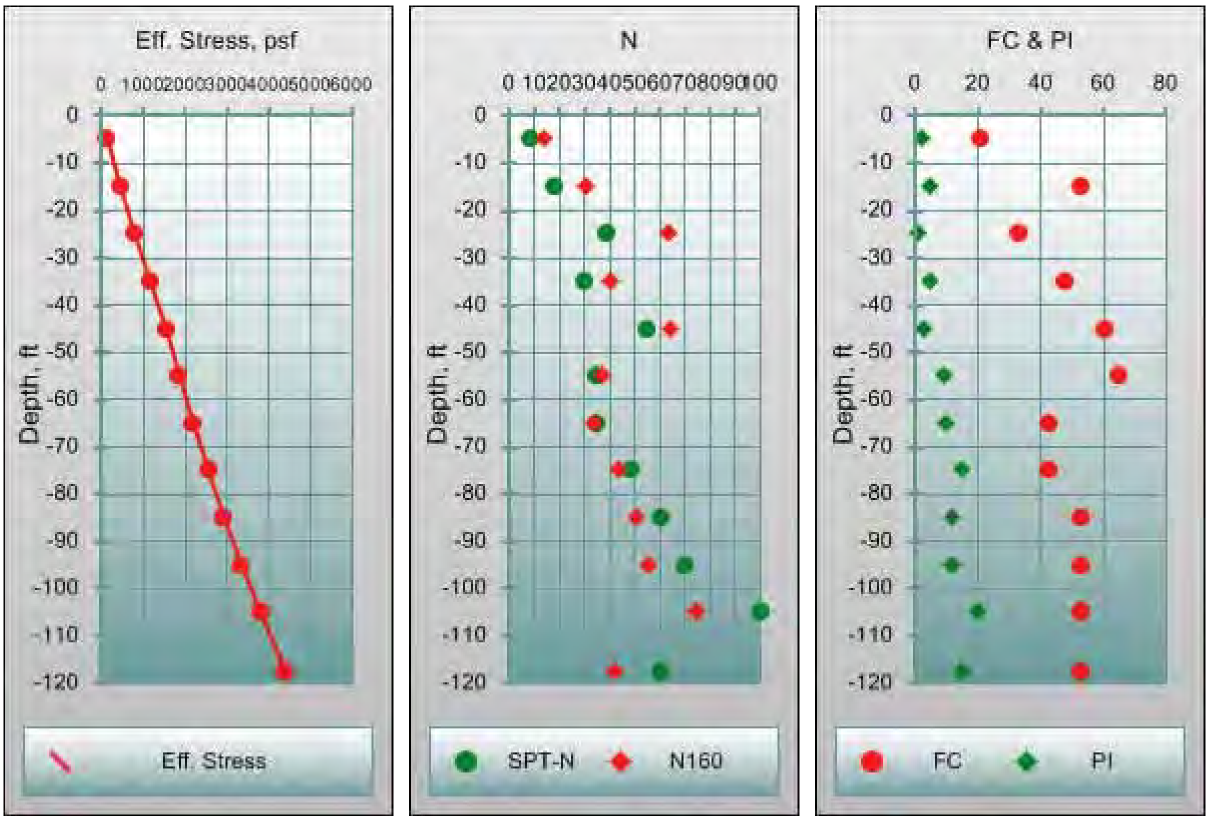
=== Soil Profile ===
Unit: ft
The number of soil layers: 12
GWT at top of layer: 1
GWT depth: 0.00
SPT Energy Ratio (%): 60.00
Amplification Factors: a= 0.1400 b= 0.0200
Elevation: 0.00
Ground Surface: Infinite Slope (%)= 0.2

Layer	Descpt.	Thickness (ft)	Unit Weight (lb/ft3)	Nm	N160	Vs ft/sec
1	Loose_silty_sand	10	90.00	8	13.6	603.1
2	Soft_sandy_silt	10	95.00	18	30.6	763.0
3	Soft_silt	10	100.00	39	63.8	954.8
4	Medium_dense_silty_sand	10	100.00	30	40.4	884.9
5	Soft_silty_sand	10	100.00	55	64.4	1054.9
6	Loose_silty_sand	10	90.00	35	37.3	925.3
7	Soft_silty_sand	10	100.00	35	34.4	925.3
8	Loose_silty_sand	10	95.00	48	43.8	1014.1
9	Medium_dense_sand	10	105.00	60	51.1	1081.9
10	Medium_dense_silty_sand	10	105.00	70	55.7	1131.3
11	Dense_sand	10	110.00	100	74.6	1254.6
12	Dense_sand	15	110.00	60	41.6	1081.9

Layer	FC (%)	PI	wc/LL	D50 (mm)	Ini. Eff. Stress (psf)	Ini. Total Stress (psf)
1	21	2	1	1128.0	138.0	450.00
2	53	5	0.9	1128.0	439.0	1375.00
3	33	1	1	1598.0	790.0	2350.00
4	47.5	5	0.9	1786.0	1166.0	3350.00

5	60.5	3	1	2068.0	1542.0	4350.00
6	65	9	0.9	2350.0	1868.0	5300.00
7	42.5	10	0.8	2726.0	2194.0	6250.00
8	42.5	15	1	3572.0	2545.0	7225.00
9	53	12	0.9	4700.0	2921.0	8225.00
10	53	12	0.9	3347.0	3347.0	9275.00
11	53	20	1	3773.0	3798.0	10350.00
12	53	15	0.9	4305.5	4393.0	11725.00

Soil Profile Plots



=== Susceptibility Evaluation ===

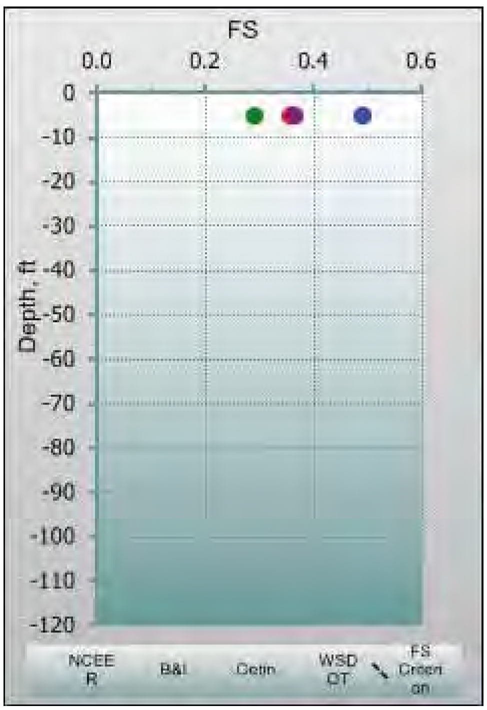
Threshold: 0.5

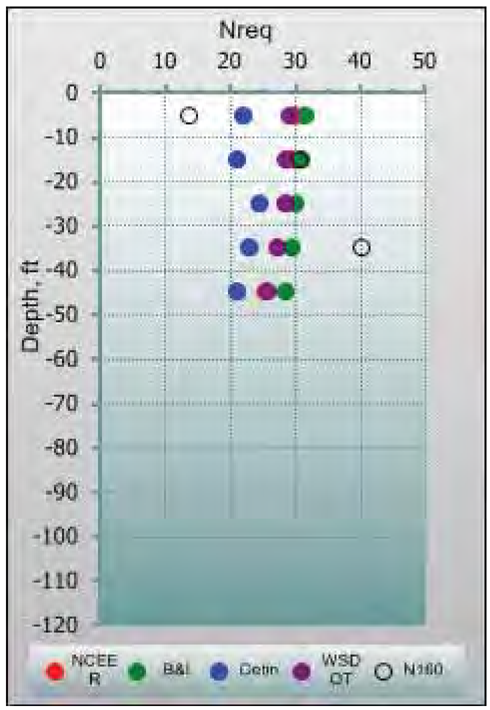
Weighting factors: B-I= 0.50   B-S= 0.50

Layer	PI	wc/LL	B-I	B-S	Suscep. Index	Potential
1	2.00	1.00	1.00	0.76	0.88	YES
2	5.00	0.90	0.62	0.63	0.62	YES
3	1.00	1.00	1.00	0.76	0.88	YES
4	5.00	0.90	0.62	0.63	0.62	YES
5	3.00	1.00	0.96	0.76	0.86	YES
6	9.00	0.90	0.09	0.59	0.34	NO
7	10.00	0.80	0.05	0.41	0.23	NO
8	15.00	1.00	0.01	0.37	0.19	NO
9	12.00	0.90	0.02	0.48	0.25	NO
10	12.00	0.90	0.02	0.48	0.25	NO
11	20.00	1.00	0.00	0.13	0.06	NO
12	15.00	0.90	0.01	0.31	0.16	NO

```
=== Initiation ===
---------------------------------------------------

Initiation - Multiple Scenario
-----------------------------------------
Retrun Period (yrs) = 475
Models Selected :
Use All Deterministic Models.
--WSDOT Recommended--
   Use NCEER, Boulanger & Idriss, and
   Cetin's model with weighting factors
   of 0.4, 0.4, and 0.2 respectively.
-----------------------------------------


===== Mean Mw and FS ==============
---NCEER Model------------
--- PGA = 0.378  Mw = 6.58---------

Layer  (N1)60    CSR     CRR     FS     Nreq
-----  ------  ------  ------  ------  ------
    1   13.60   0.552   0.198    0.36    30.0
    2   30.60   0.506   3.000    5.93    29.4
    3   63.83   0.451   3.000    6.65    28.5
    4   40.42   0.397   3.000    7.56    27.3
    5   64.43   0.342   3.000    8.77    25.6


===== Mean Mw and FS ==============
---Boulanger and Idriss Model------------
--- PGA = 0.378  Mw = 6.58---------

Layer  (N1)60    CSR     CRR     FS     Nreq
-----  ------  ------  ------  ------  ------
    1   13.60   0.640   0.186    0.29    31.6
    2   30.60   0.587   1.448    2.46    31.0
    3   46.00   0.527   3.000    5.70    30.2
    4   36.33   0.476   3.000    6.31    29.3
    5   46.00   0.434   3.000    6.91    28.4


===== Mean Mw and FS ==============
---Cetin et al. Model------------
--- PGA = 0.378  Mw = 6.58---------

Layer  (N1)60    CSR     CRR     FS     Nreq
-----  ------  ------  ------  ------  ------
    1   12.80   0.800   0.394    0.49    21.9
    2   28.80   0.761   1.562    2.05    21.3
    3   62.40   0.704   3.000    4.26    24.7
    4   40.42   0.643   2.765    4.30    23.1
    5   64.43   0.578   3.000    5.19    21.2

---WSDOT Recommended------------
--- PGA = 0.378  Mw = 6.58---------
```

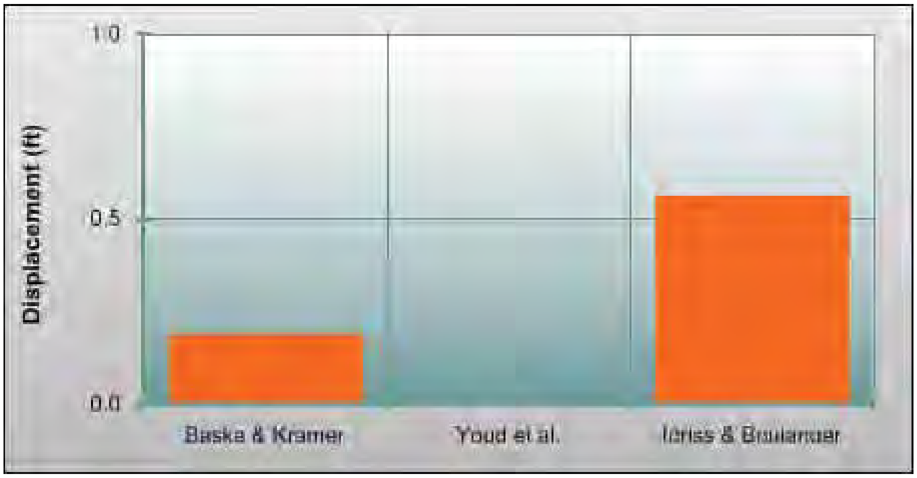
```
Layer   (N1)60    CSR     CRR     FS      Nreq
-----   ------  ------  ------  ------  ------
    1    13.60   0.637   0.233    0.37    29.0
    2    30.60   0.589   2.091    3.55    28.4
    3    63.83   0.532   3.000    5.64    28.4
    4    40.42   0.478   2.953    6.18    27.3
    5    64.43   0.426   3.000    7.04    25.9

  Table of FS
---------------------------------------
  #      Depth   NCEER     B&I     Cetin      WSDOT
            ft                   PL=0.60    PL=0.60
  1      -5.00    0.36    0.29      0.49       0.37
  2     -15.00    5.93    2.46      2.05       3.55
  3     -25.00    6.65    5.70      4.26       5.64
  4     -35.00    7.56    6.31      4.30       6.18
  5     -45.00    8.77    6.91      5.19       7.04
```





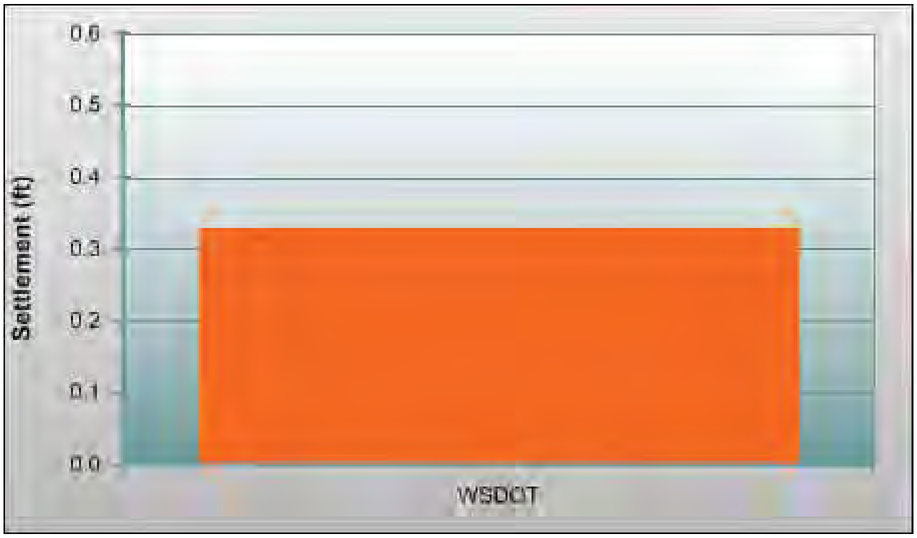

```
=== Effects ===
---------------------------------------------------


** Lateral Spreading **
-----------------------
>>>Multiple Scenario Results
Model Selected :
   WSDOT Recommended (weighted average)
   using models of Baska & Kramer and Youd et al.
-----------------------------------------
```

```
Baska & Kramer: 0.19 ft
Youd et al.: 0.00 ft
Idriss & Boulanger: 0.57 ft

----------------------------------------
Weighting factors: Baska and Kramer = 0.65
                   Youd et al.      = 0.35

 WSDOT Recommended: 0.12 ft
```



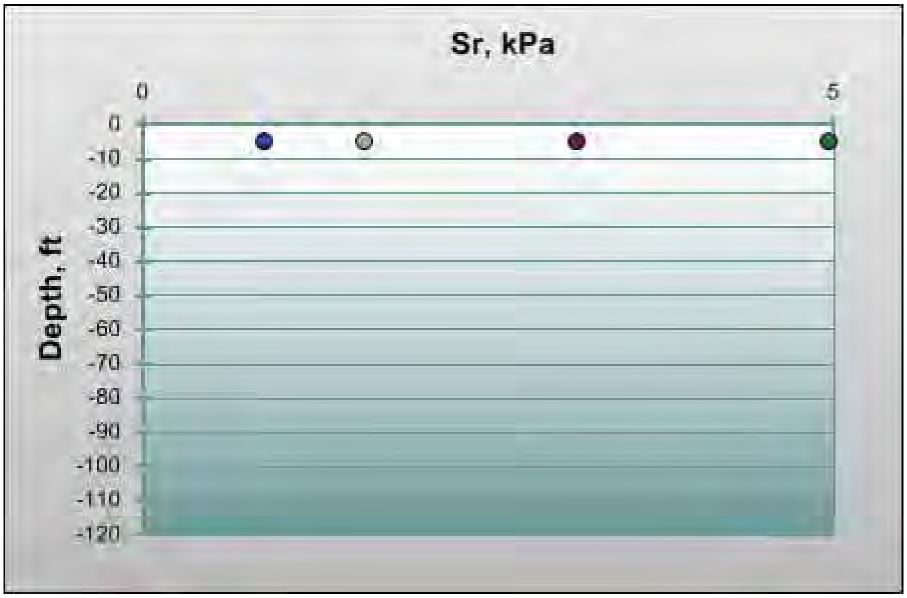

```
=== Effects ===
---------------------------------------------------


** Settlement **
----------------
>>>Multiple Scenario Results
Groud Surface Settlement MULTIPLE Scenario
Return Period (yrs) = 475
Model Selected :
   WSDOT Recommended (weighted average)
   using all deterministic models.
   -----------------------------------------
   Weighting factors = 0.25 for each model
-----------------------------------------


WSDOT Recommended:
=================
Total ground surface settlement = 0.33 ft
----------------------------------------------
  #    Depth thickness    ev    Weight    dh
          ft        ft     %              ft
----------------------------------------------
  1     5.00      10.0   3.042    1.00    0.30
  2    15.00      10.0   0.285    0.84    0.03
  3    25.00      10.0   0.001    0.00    0.00
  4    35.00      10.0   0.126    0.07    0.00
```

```
  5    45.00      10.0   0.001    0.00    0.00
  6    55.00      10.0   0.001    0.00    0.00
  7    65.00      10.0   0.001    0.00    0.00
  8    75.00      10.0   0.001    0.00    0.00
  9    85.00      10.0   0.001    0.00    0.00
 10    95.00      10.0   0.001    0.00    0.00
 11   105.00      10.0   0.001    0.00    0.00
 12   117.50      15.0   0.001    0.00    0.00
----------------------------------------------
```




```
=== Effects ===
---------------------------------------------------


** Residual Strength **
-----------------------
====== Soil Layers Selected ==================
Layer 1

====== Models Selected =======================
Use recommended models:
  Kramer & Wang, Deterministic (KWD), w/ weighting factor = 0.5
  Idriss & Boulanger           (IDB), w/ weighting factor = 0.3
  Olson & Stark                (OLS), w/ weighting factor = 0.2
The residual strength is estimated as:
  Residual Strength =
    0.5*(Kramer & Wang) + 0.3*(Idriss & Boulanger) + 0.2*(Olson & Stark)

--------------------------------------------------------

###### Unweighted Residual Strength ####################

Kramer & Wang Deterministic Model:
   Layer 1:  Sr =   104 psf =   5.0 kPa = 0.049 atm
------------------------------------------------------
Idriss & Boulanger Model:
   Layer 1:  Sr =    33 psf =   1.6 kPa = 0.016 atm
```

```
------------------------------------------------------
Olson & Stark Model:
   Layer 1:  Sr =    18 psf =   0.9 kPa = 0.009 atm
------------------------------------------------------
WSDOT Recommended Model:
   Layer 1:  Sr =    65 psf =   3.1 kPa = 0.031 atm
------------------------------------------------------
```



Liquefaction Hazard Evaluation Report
by WSLiq Program beta (May, 2009)

Site Name: Lockheed West Seattle
Site Location (N,W) = 47.583 , 122.367
Job No: 106-8945
Analyst: TetraTech
Date: 10/7/2011 9:18:24 AM

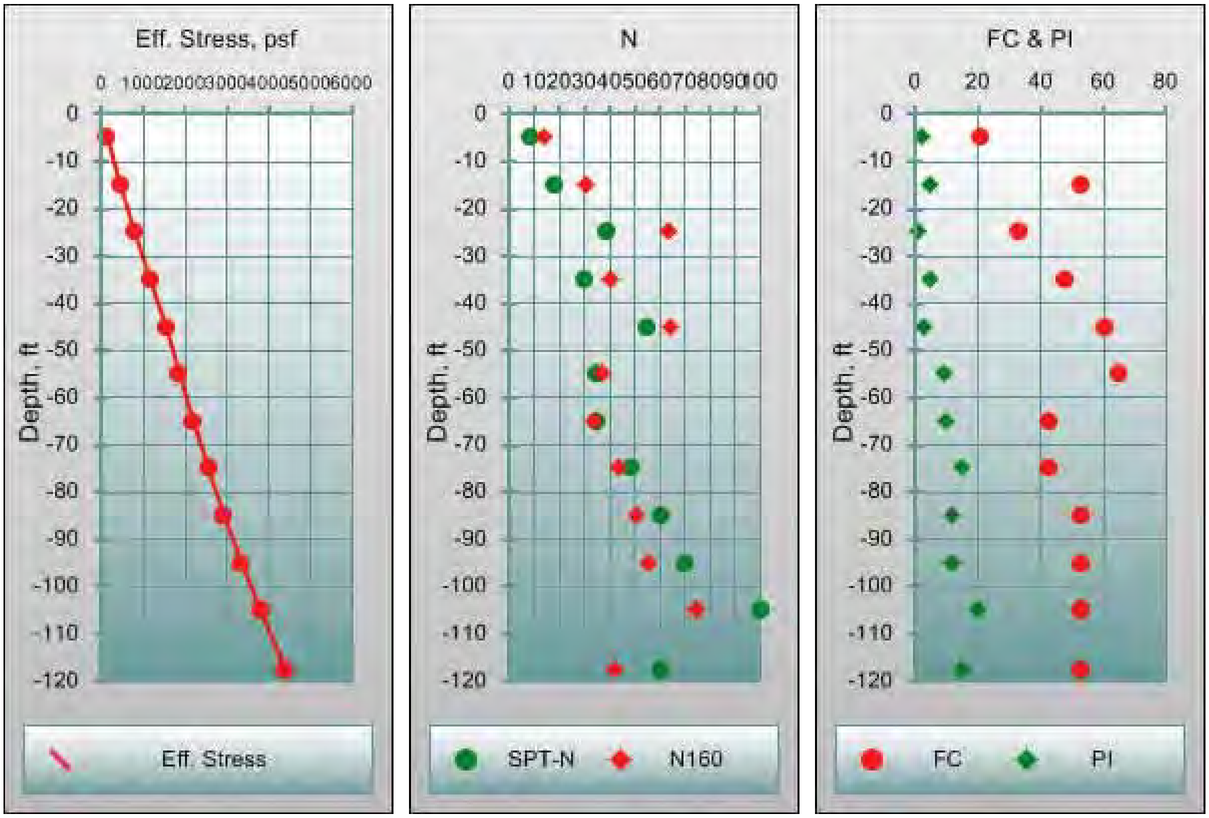
=== Soil Profile ===
Unit: ft
The number of soil layers: 12
GWT at top of layer: 1
GWT depth: 0.00
SPT Energy Ratio (%): 60.00
Amplification Factors: a= 0.1400 b= 0.0200
Elevation: 0.00
Ground Surface: Infinite Slope (%)= 0.2

Layer	Descpt.	Thickness (ft)	Unit Weight (lb/ft3)	Nm	N160	Vs ft/sec
1	Loose_silty_sand	10	90.00	8	13.6	603.1
2	Soft_sandy_silt	10	95.00	18	30.6	763.0
3	Soft_silt	10	100.00	39	63.8	954.8
4	Medium_dense_silty_sand	10	100.00	30	40.4	884.9
5	Soft_silty_sand	10	100.00	55	64.4	1054.9
6	Loose_silty_sand	10	90.00	35	37.3	925.3
7	Soft_silty_sand	10	100.00	35	34.4	925.3
8	Loose_silty_sand	10	95.00	48	43.8	1014.1
9	Medium_dense_sand	10	105.00	60	51.1	1081.9
10	Medium_dense_silty_sand	10	105.00	70	55.7	1131.3
11	Dense_sand	10	110.00	100	74.6	1254.6
12	Dense_sand	15	110.00	60	41.6	1081.9

Layer	FC (%)	PI	wc/LL	D50 (mm)	Ini. Eff. Stress (psf)	Ini. Total Stress (psf)
1	21	2	1	1128.0	138.0	450.00
2	53	5	0.9	1128.0	439.0	1375.00
3	33	1	1	1598.0	790.0	2350.00
4	47.5	5	0.9	1786.0	1166.0	3350.00

5	60.5	3	1	2068.0	1542.0	4350.00
6	65	9	0.9	2350.0	1868.0	5300.00
7	42.5	10	0.8	2726.0	2194.0	6250.00
8	42.5	15	1	3572.0	2545.0	7225.00
9	53	12	0.9	4700.0	2921.0	8225.00
10	53	12	0.9	3347.0	3347.0	9275.00
11	53	20	1	3773.0	3798.0	10350.00
12	53	15	0.9	4305.5	4393.0	11725.00

Soil Profile Plots



=== Susceptibility Evaluation ===

Threshold: 0.5

Weighting factors: B-I= 0.50   B-S= 0.50

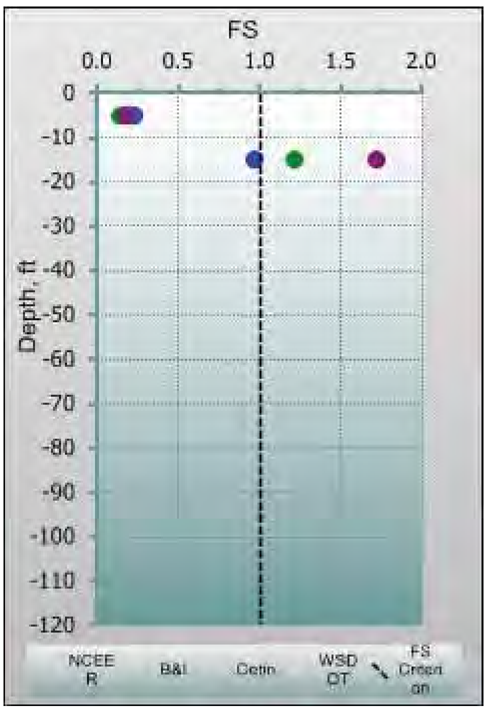
Layer	PI	wc/LL	B-I	B-S	Suscep. Index	Potential
1	2.00	1.00	1.00	0.76	0.88	YES
2	5.00	0.90	0.62	0.63	0.62	YES
3	1.00	1.00	1.00	0.76	0.88	YES
4	5.00	0.90	0.62	0.63	0.62	YES
5	3.00	1.00	0.96	0.76	0.86	YES
6	9.00	0.90	0.09	0.59	0.34	NO
7	10.00	0.80	0.05	0.41	0.23	NO
8	15.00	1.00	0.01	0.37	0.19	NO
9	12.00	0.90	0.02	0.48	0.25	NO
10	12.00	0.90	0.02	0.48	0.25	NO
11	20.00	1.00	0.00	0.13	0.06	NO
12	15.00	0.90	0.01	0.31	0.16	NO

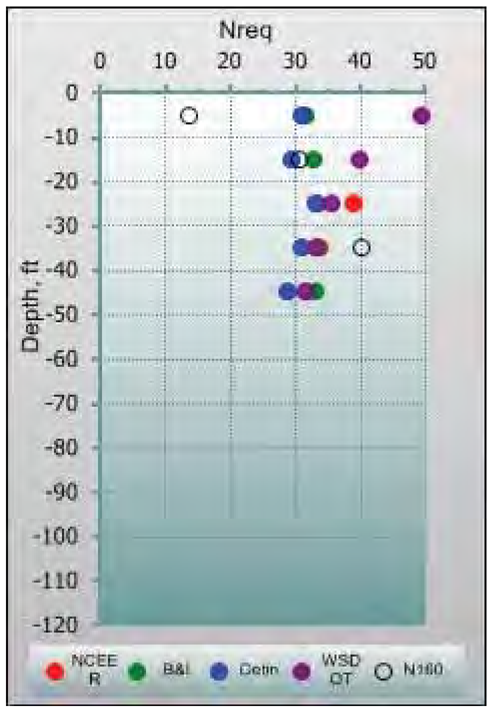
```
=== Initiation ===
---------------------------------------------------

Initiation - Multiple Scenario
-----------------------------------------
Retrun Period (yrs) = 2475
Models Selected :
Use All Deterministic Models.
--WSDOT Recommended--
   Use NCEER, Boulanger & Idriss, and
   Cetin's model with weighting factors
   of 0.4, 0.4, and 0.2 respectively.
-----------------------------------------


===== Mean Mw and FS ==============
---NCEER Model------------
--- PGA = 0.754  Mw = 6.71---------

Layer  (N1)60    CSR     CRR     FS     Nreq
-----  ------  ------  ------  ------  ------
    1   13.60   1.143   0.198    0.17    76.5
    2   30.60   1.048   3.000    2.86    52.4
    3   63.83   0.936   3.000    3.21    39.0
    4   40.42   0.822   3.000    3.65    33.7
    5   64.43   0.709   3.000    4.23    31.7


===== Mean Mw and FS ==============
---Boulanger and Idriss Model------------
--- PGA = 0.754  Mw = 6.71---------

Layer  (N1)60    CSR     CRR     FS     Nreq
-----  ------  ------  ------  ------  ------
    1   13.60   1.300   0.186    0.14    31.5
    2   30.60   1.195   1.448    1.21    32.8
    3   46.00   1.071   3.000    2.80    33.6
    4   36.33   0.968   3.000    3.10    33.6
    5   46.00   0.883   3.000    3.40    33.3


===== Mean Mw and FS ==============
---Cetin et al. Model------------
--- PGA = 0.754  Mw = 6.71---------

Layer  (N1)60    CSR     CRR     FS     Nreq
-----  ------  ------  ------  ------  ------
    1   12.80   1.593   0.369    0.23    31.0
    2   28.80   1.512   1.462    0.97    29.4
    3   62.40   1.393   3.000    2.15    33.3
    4   40.42   1.258   2.753    2.19    31.1
    5   64.43   1.107   3.000    2.71    28.8

---WSDOT Recommended------------
--- PGA = 0.754  Mw = 6.71---------
```

Layer	(N1)60	CSR	CRR	FS	Nreq
1	13.60	1.296	0.227	0.18	49.4
2	30.60	1.199	2.071	1.73	40.0
3	63.83	1.081	3.000	2.77	35.7
4	40.42	0.968	2.951	3.05	33.1
5	64.43	0.858	3.000	3.50	31.8

Table of FS

#	Depth ft	NCEER	B&I	Cetin PL=0.60	WSDOT PL=0.60
1	-5.00	0.17	0.14	0.23	0.18
2	-15.00	2.86	1.21	0.97	1.73
3	-25.00	3.21	2.80	2.15	2.77
4	-35.00	3.65	3.10	2.19	3.05
5	-45.00	4.23	3.40	2.71	3.50





=== Effects ===

** Lateral Spreading **

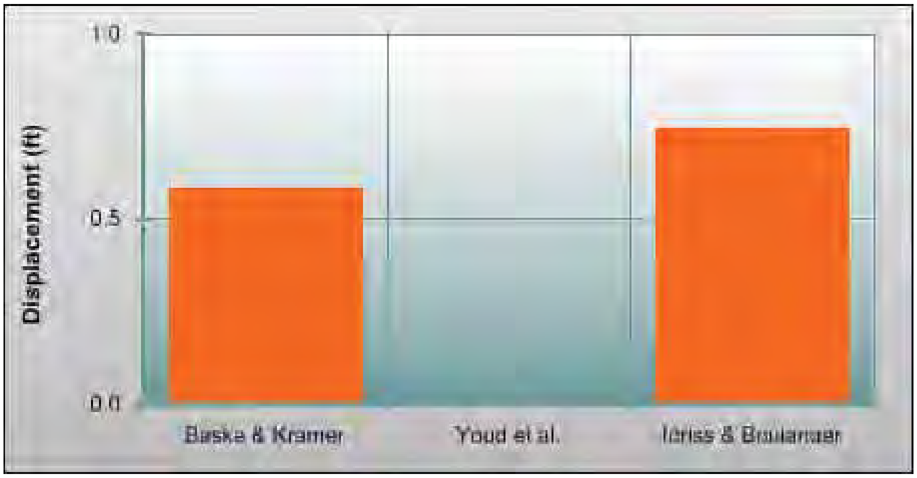
>>>Multiple Scenario Results

Model Selected :

WSDOT Recommended (weighted average)

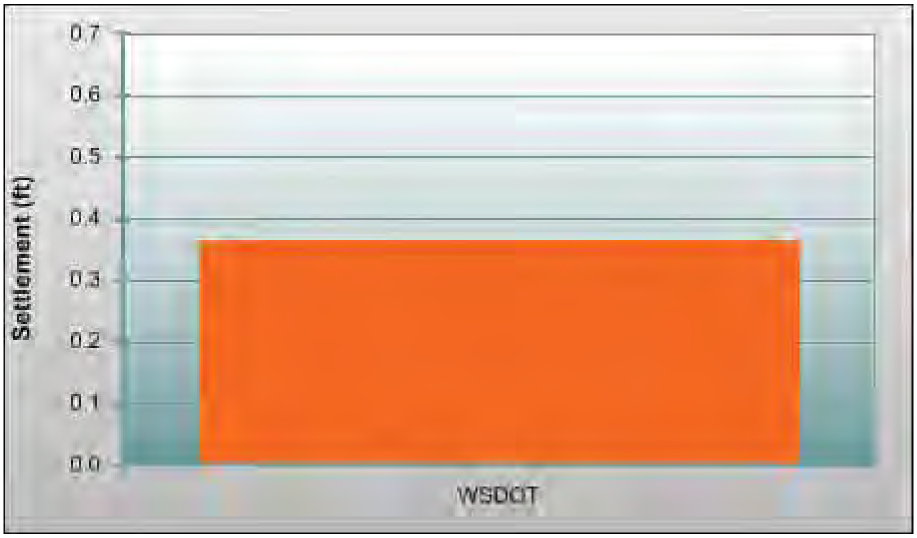
using models of Baska & Kramer and Youd et al.

```
Baska & Kramer: 0.59 ft
Youd et al.: 0.00 ft
Idriss & Boulanger: 0.75 ft

----------------------------------------
Weighting factors: Baska and Kramer = 0.65
                   Youd et al.      = 0.35

 WSDOT Recommended: 0.38 ft
```



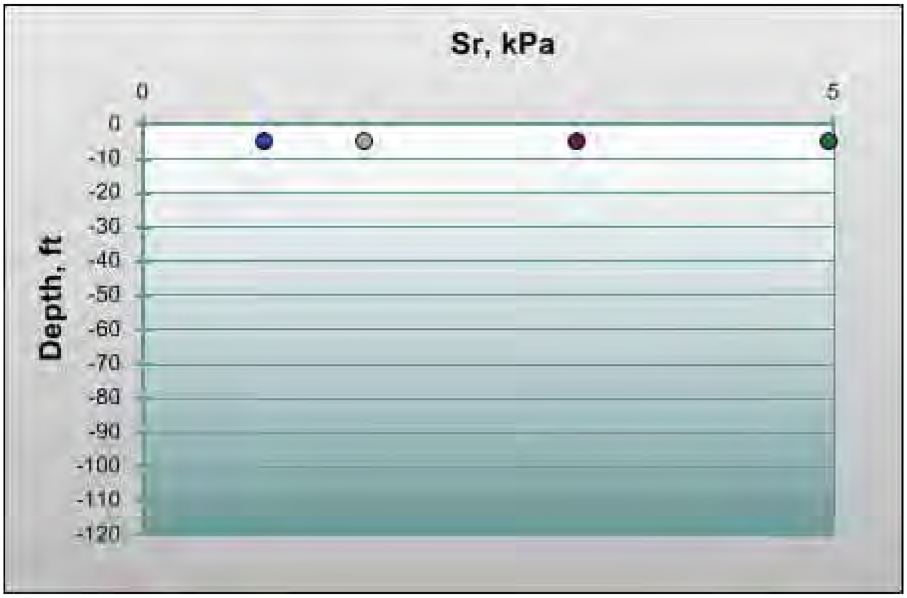

```
=== Effects ===
---------------------------------------------------


** Settlement **
----------------
>>>Multiple Scenario Results
Groud Surface Settlement MULTIPLE Scenario
Return Period (yrs) = 2475
Model Selected :
   WSDOT Recommended (weighted average)
   using all deterministic models.
   -----------------------------------------
   Weighting factors = 0.25 for each model
-----------------------------------------


WSDOT Recommended:
=================
Total ground surface settlement = 0.37 ft
----------------------------------------------
  #    Depth thickness    ev    Weight    dh
          ft        ft     %              ft
----------------------------------------------
  1     5.00      10.0   3.125    1.00    0.31
  2    15.00      10.0   0.443    1.00    0.04
  3    25.00      10.0   0.001    0.00    0.00
  4    35.00      10.0   0.126    0.82    0.01
```

```
  5    45.00       10.0   0.001    0.00    0.00
  6    55.00       10.0   0.001    0.00    0.00
  7    65.00       10.0   0.001    0.00    0.00
  8    75.00       10.0   0.001    0.00    0.00
  9    85.00       10.0   0.001    0.00    0.00
 10    95.00       10.0   0.001    0.00    0.00
 11   105.00       10.0   0.001    0.00    0.00
 12   117.50       15.0   0.001    0.00    0.00
----------------------------------------------
```




```
=== Effects ===
---------------------------------------------------


** Residual Strength **
-----------------------
====== Soil Layers Selected ==================
Layer 1

====== Models Selected =======================
Use recommended models:
  Kramer & Wang, Deterministic (KWD), w/ weighting factor = 0.5
  Idriss & Boulanger           (IDB), w/ weighting factor = 0.3
  Olson & Stark                (OLS), w/ weighting factor = 0.2
The residual strength is estimated as:
  Residual Strength =
    0.5*(Kramer & Wang) + 0.3*(Idriss & Boulanger) + 0.2*(Olson & Stark)

--------------------------------------------------------

###### Unweighted Residual Strength ####################

Kramer & Wang Deterministic Model:
   Layer 1:  Sr =   104 psf =   5.0 kPa = 0.049 atm
------------------------------------------------------
Idriss & Boulanger Model:
   Layer 1:  Sr =    33 psf =   1.6 kPa = 0.016 atm
```

```
------------------------------------------------------
Olson & Stark Model:
   Layer 1:  Sr =    18 psf =   0.9 kPa = 0.009 atm
------------------------------------------------------
WSDOT Recommended Model:
   Layer 1:  Sr =    65 psf =   3.1 kPa = 0.031 atm
------------------------------------------------------
```



ALTERNATIVE 2A2A

108 YEARS, 475 YEARS, 2,475 YEARS – LOWER-BOUND SPT

108 YEARS, 475 YEARS, 2,475 YEARS – UPPER-BOUND SPT

Liquefaction Hazard Evaluation Report
by WSLiq Program beta (May, 2009)

Site Name: Lockheed West Seattle
Site Location (N,W) = 47.583 , 122.367
Job No: 106-8945
Analyst: TetraTech
Date: 10/14/2011 10:41:47 AM

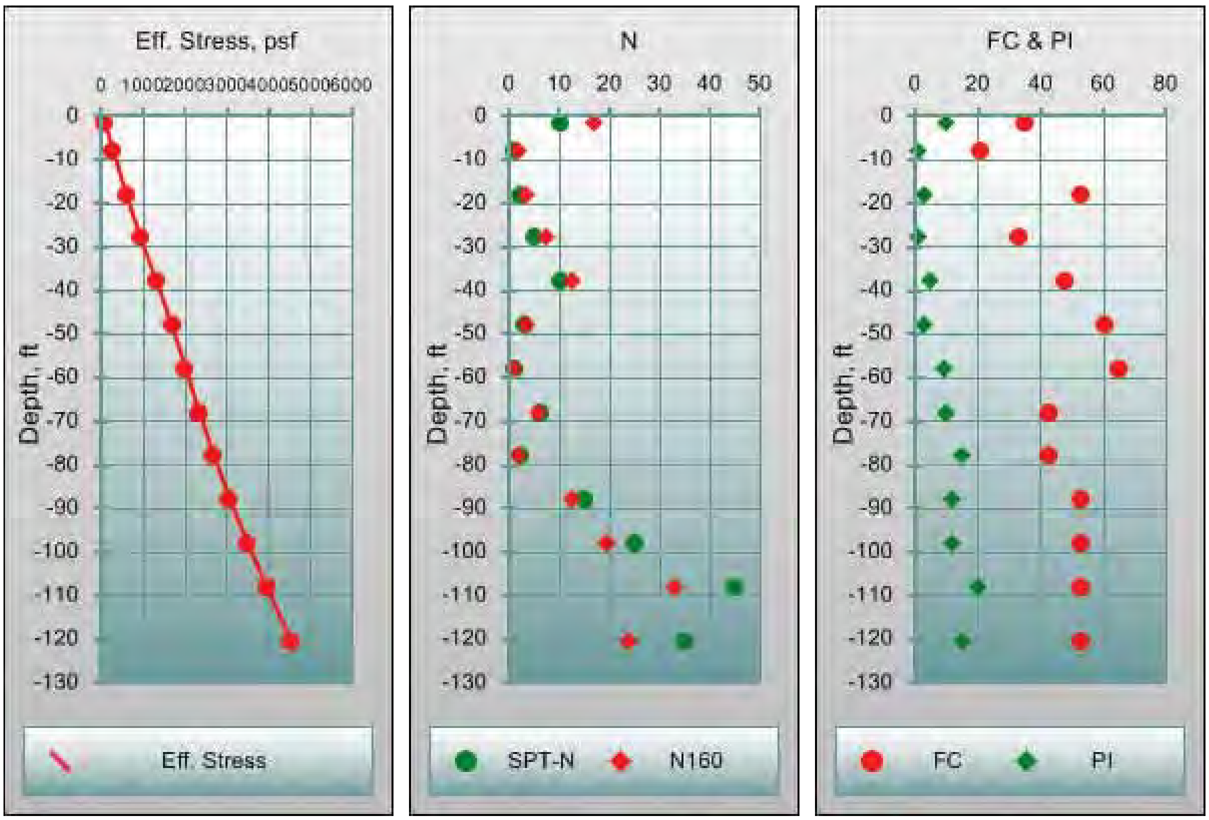
=== Soil Profile ===
Unit: ft
The number of soil layers: 13
GWT at top of layer: 1
GWT depth: 0.00
SPT Energy Ratio (%): 60.00
Amplification Factors: a= 0.1400 b= 0.0200
Elevation: 0.00
Ground Surface: Infinite Slope (%)= 0.2

Layer	Descpt.	Thickness (ft)	Unit Weight (lb/ft3)	Nm	N160	Vs ft/sec
1	Cap_layer	3	110.00	10	17.0	643.4
2	Loose_silty_sand	10	90.00	1	1.7	330.0
3	Soft_sandy_silt	10	95.00	2	3.4	403.5
4	Soft_silt	10	100.00	5	7.5	526.3
5	Medium_dense_silty_sand	10	100.00	10	12.7	643.4
6	Soft_silty_sand	10	100.00	3	3.4	453.8
7	Loose_silty_sand	10	90.00	1	1.0	330.0
8	Soft_silty_sand	10	100.00	6	5.7	554.9
9	Loose_silty_sand	10	95.00	2	1.8	403.5
10	Medium_dense_sand	10	105.00	15	12.5	723.7
11	Medium_dense_silty_sand	10	105.00	25	19.5	839.3
12	Dense_sand	10	110.00	45	33.0	995.3
13	Dense_sand	15	110.00	35	23.9	925.3

Layer	FC (%)	PI	wc/LL	D50 (mm)	Ini. Eff. Stress (psf)	Ini. Total Stress (psf)
1	35	10	0.9	3000	71.4	165.00
2	21	1	1	1128.0	280.8	780.00

3	53	3	0.9	1128.0	581.8	1705.00
4	33	1	1	1598.0	932.8	2680.00
5	47.5	5	0.9	1786.0	1308.8	3680.00
6	60.5	3	1	2068.0	1684.8	4680.00
7	65	9	.9	2350.0	2010.8	5630.00
8	42.5	10	0.8	2726.0	2336.8	6580.00
9	42.5	15	1	3572.0	2687.8	7555.00
10	53	12	0.9	4700.0	3063.8	8555.00
11	53	12	0.9	3347.0	3489.8	9605.00
12	53	20	1	3773.0	3940.8	10680.00
13	53	15	0.9	4305.5	4535.8	12055.00

Soil Profile Plots



=== Susceptibility Evaluation ===

Threshold: 0.5

Weighting factors: B-I= 0.50   B-S= 0.50

Layer	PI	wc/LL	B-I	B-S	Suscep. Index	Potential
1	10.00	0.90	0.05	0.56	0.31	NO
2	1.00	1.00	1.00	0.76	0.88	YES
3	3.00	0.90	0.96	0.63	0.80	YES
4	1.00	1.00	1.00	0.76	0.88	YES
5	5.00	0.90	0.62	0.63	0.62	YES
6	3.00	1.00	0.96	0.76	0.86	YES
7	9.00	0.90	0.09	0.59	0.34	NO
8	10.00	0.80	0.05	0.41	0.23	NO
9	15.00	1.00	0.01	0.37	0.19	NO

```
   10  12.00   0.90  0.02  0.48          0.25         NO
   11  12.00   0.90  0.02  0.48          0.25         NO
   12  20.00   1.00  0.00  0.13          0.06         NO
   13  15.00   0.90  0.01  0.31          0.16         NO


=== Initiation ===
---------------------------------------------------

Initiation - Multiple Scenario
-----------------------------------------
Retrun Period (yrs) = 108
Models Selected :
Use All Deterministic Models.
--WSDOT Recommended--
   Use NCEER, Boulanger & Idriss, and
   Cetin's model with weighting factors
   of 0.4, 0.4, and 0.2 respectively.
-----------------------------------------


===== Mean Mw and FS ==============
---NCEER Model------------
--- PGA = 0.176  Mw = 6.46---------

Layer  (N1)60    CSR     CRR     FS     Nreq
-----  ------  ------  ------  ------  ------
    2    1.70   0.207   0.077    0.37    18.0
    3    3.40   0.208   0.105    0.51    18.1
    4    7.53   0.190   0.148    0.78    16.7
    5   12.72   0.167   0.219    1.31    14.8
    6    3.36   0.144   0.105    0.73    12.7


===== Mean Mw and FS ==============
---Boulanger and Idriss Model------------
--- PGA = 0.176  Mw = 6.46---------

Layer  (N1)60    CSR     CRR     FS     Nreq
-----  ------  ------  ------  ------  ------
    2    1.70   0.245   0.094    0.38    21.8
    3    3.40   0.246   0.111    0.45    21.7
    4    7.96   0.227   0.143    0.63    20.2
    5   12.77   0.207   0.188    0.91    18.5
    6    3.47   0.190   0.112    0.59    16.9


===== Mean Mw and FS ==============
---Cetin et al. Model------------
--- PGA = 0.176  Mw = 6.46---------

Layer  (N1)60    CSR     CRR     FS     Nreq
-----  ------  ------  ------  ------  ------
    2    1.60   0.289   0.137    0.48    11.3
    3    3.20   0.251   0.149    0.59     9.4
    4    7.53   0.194   0.172    0.88     9.5
    5   12.72   0.159   0.271    1.71     7.2
```

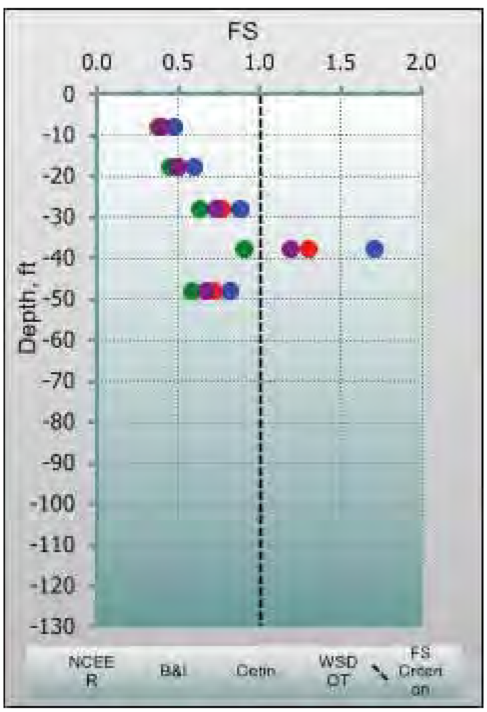
6	3.36	0.143	0.116	0.82	6.0

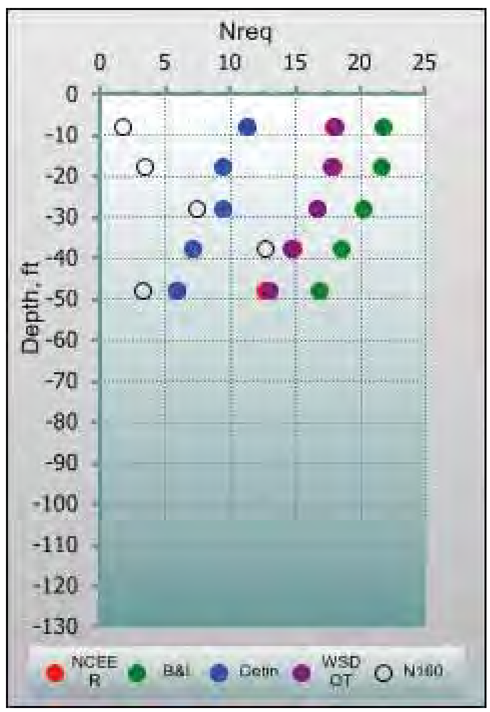
---WSDOT Recommended------------
--- PGA = 0.176 Mw = 6.46---------

Layer	(N1)60	CSR	CRR	FS	Nreq
2	1.70	0.239	0.096	0.40	18.2
3	3.40	0.232	0.116	0.50	17.8
4	7.53	0.206	0.151	0.73	16.7
5	12.72	0.181	0.217	1.19	14.8
6	3.36	0.162	0.110	0.68	13.0

Table of FS

#	Depth ft	NCEER	B&I	Cetin PL=0.60	WSDOT PL=0.60
2	-8.00	0.37	0.38	0.48	0.40
3	-18.00	0.51	0.45	0.59	0.50
4	-28.00	0.78	0.63	0.88	0.73
5	-38.00	1.31	0.91	1.71	1.19
6	-48.00	0.73	0.59	0.82	0.68



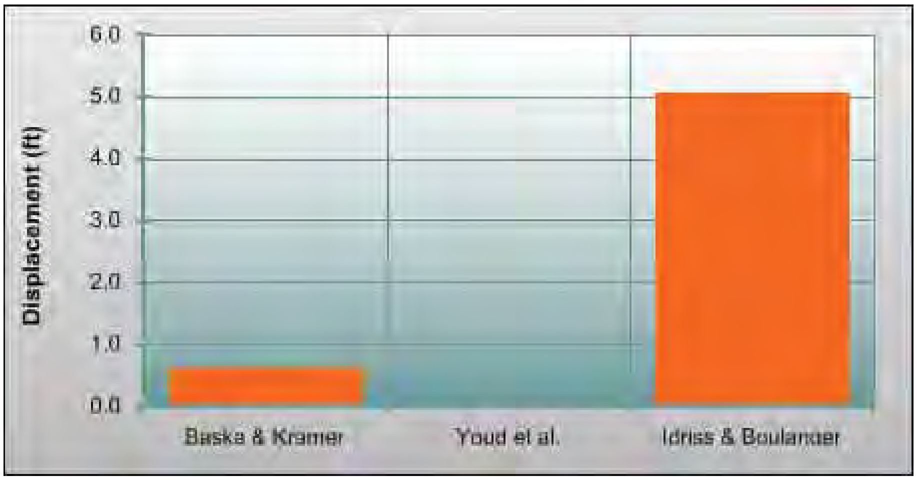


=== Effects ===

** Lateral Spreading **

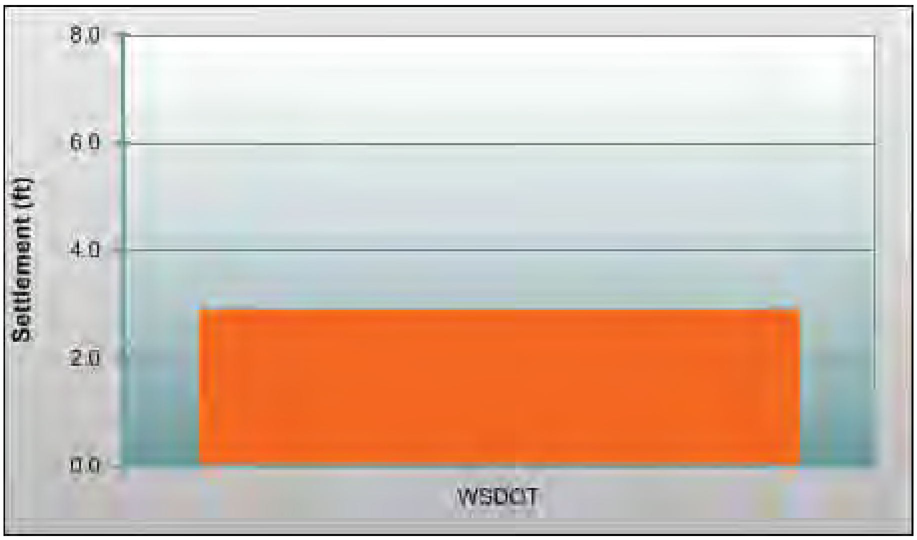
>>>Multiple Scenario Results

```
Model Selected :
   WSDOT Recommended (weighted average)
   using models of Baska & Kramer and Youd et al.
-----------------------------------------

Baska & Kramer: 0.62 ft
Youd et al.: 0.00 ft
Idriss & Boulanger: 5.08 ft

----------------------------------------
Weighting factors: Baska and Kramer = 0.65
                   Youd et al.      = 0.35

 WSDOT Recommended: 0.40 ft
```



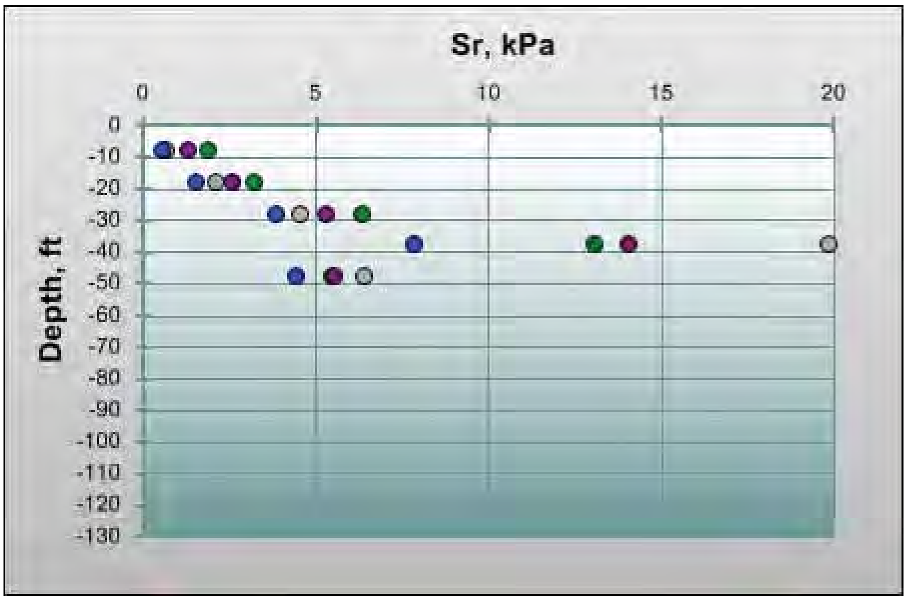

```
=== Effects ===
---------------------------------------------------


** Settlement **
----------------
>>>Multiple Scenario Results
Groud Surface Settlement MULTIPLE Scenario
Return Period (yrs) = 108
Model Selected :
   WSDOT Recommended (weighted average)
   using all deterministic models.
   -----------------------------------------
   Weighting factors = 0.25 for each model
-----------------------------------------


WSDOT Recommended:
=================
Total ground surface settlement = 2.94 ft
----------------------------------------------
  #    Depth thickness    ev    Weight    dh
          ft         ft     %              ft
----------------------------------------------
```

1	1.50	3.0	0.001	0.00	0.00
2	8.00	10.0	9.897	1.00	0.99
3	18.00	10.0	8.251	1.00	0.83
4	28.00	10.0	3.350	1.00	0.33
5	38.00	10.0	1.063	0.99	0.10
6	48.00	10.0	6.821	1.00	0.68
7	58.00	10.0	0.001	0.00	0.00
8	68.00	10.0	0.001	0.00	0.00
9	78.00	10.0	0.001	0.00	0.00
10	88.00	10.0	0.001	0.00	0.00
11	98.00	10.0	0.001	0.00	0.00
12	108.00	10.0	0.001	0.00	0.00
13	120.50	15.0	0.001	0.00	0.00




```
=== Effects ===
---------------------------------------------------


** Residual Strength **
-----------------------
====== Soil Layers Selected ==================
Layer 2
Layer 3

====== Models Selected =======================
Use recommended models:
  Kramer & Wang, Deterministic (KWD), w/ weighting factor = 0.5
  Idriss & Boulanger           (IDB), w/ weighting factor = 0.3
  Olson & Stark                (OLS), w/ weighting factor = 0.2
The residual strength is estimated as:
  Residual Strength =
    0.5*(Kramer & Wang) + 0.3*(Idriss & Boulanger) + 0.2*(Olson & Stark)

--------------------------------------------------------

###### Unweighted Residual Strength ####################
```

```
Kramer & Wang Deterministic Model:
   Layer 2:  Sr =    40 psf =   1.9 kPa = 0.019 atm
   Layer 3:  Sr =    67 psf =   3.2 kPa = 0.032 atm
------------------------------------------------------
Idriss & Boulanger Model:
   Layer 2:  Sr =    14 psf =   0.7 kPa = 0.007 atm
   Layer 3:  Sr =    44 psf =   2.1 kPa = 0.021 atm
------------------------------------------------------
Olson & Stark Model:
   Layer 2:  Sr =    12 psf =   0.6 kPa = 0.006 atm
   Layer 3:  Sr =    32 psf =   1.5 kPa = 0.015 atm
------------------------------------------------------
WSDOT Recommended Model:
   Layer 2:  Sr =    27 psf =   1.3 kPa = 0.013 atm
   Layer 3:  Sr =    53 psf =   2.6 kPa = 0.025 atm
------------------------------------------------------
```



Liquefaction Hazard Evaluation Report
by WSLiq Program beta (May, 2009)

Site Name: Lockheed West Seattle
Site Location (N,W) = 47.583 , 122.367
Job No: 106-8945
Analyst: TetraTech
Date: 10/14/2011 11:12:51 AM

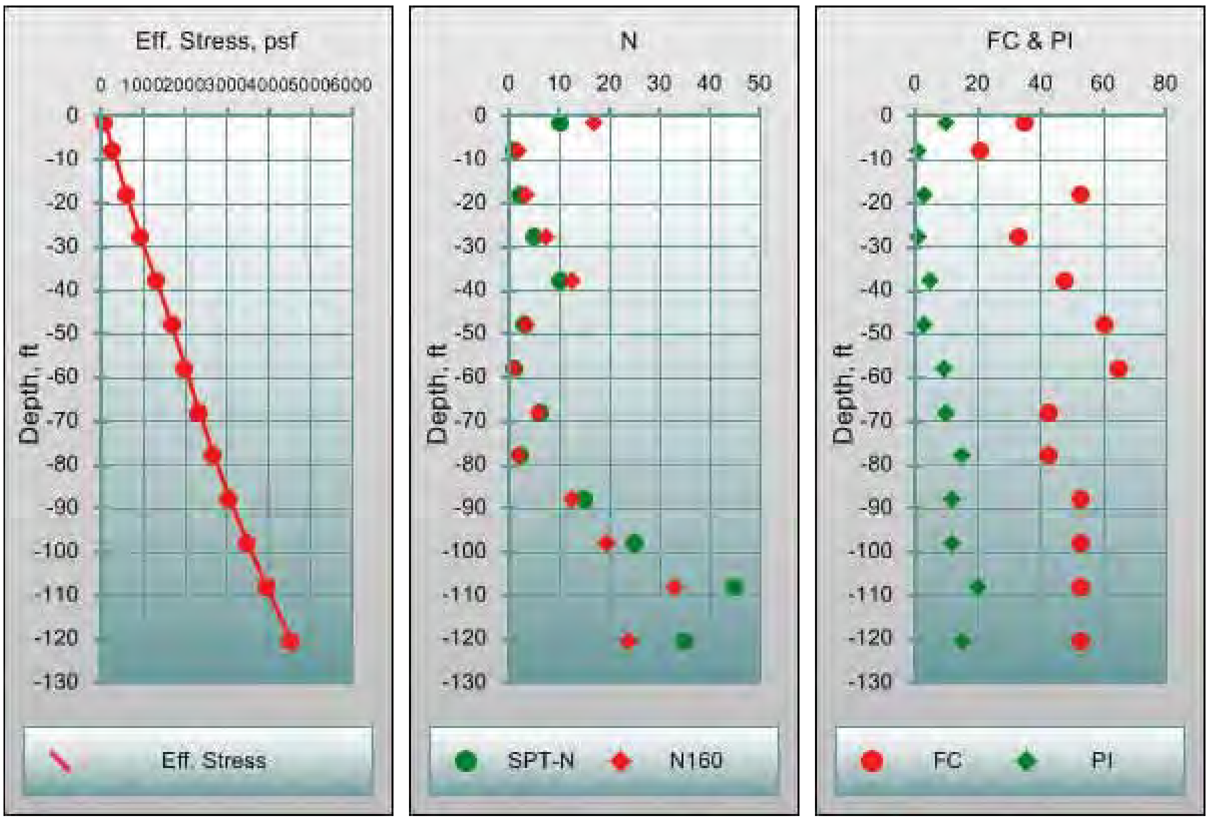
=== Soil Profile ===
Unit: ft
The number of soil layers: 13
GWT at top of layer: 1
GWT depth: 0.00
SPT Energy Ratio (%): 60.00
Amplification Factors: a= 0.1400 b= 0.0200
Elevation: 0.00
Ground Surface: Infinite Slope (%)= 0.2

Layer	Descpt.	Thickness (ft)	Unit Weight (lb/ft3)	Nm	N160	Vs ft/sec
1	Cap_layer	3	110.00	10	17.0	643.4
2	Loose_silty_sand	10	90.00	1	1.7	330.0
3	Soft_sandy_silt	10	95.00	2	3.4	403.5
4	Soft_silt	10	100.00	5	7.5	526.3
5	Medium_dense_silty_sand	10	100.00	10	12.7	643.4
6	Soft_silty_sand	10	100.00	3	3.4	453.8
7	Loose_silty_sand	10	90.00	1	1.0	330.0
8	Soft_silty_sand	10	100.00	6	5.7	554.9
9	Loose_silty_sand	10	95.00	2	1.8	403.5
10	Medium_dense_sand	10	105.00	15	12.5	723.7
11	Medium_dense_silty_sand	10	105.00	25	19.5	839.3
12	Dense_sand	10	110.00	45	33.0	995.3
13	Dense_sand	15	110.00	35	23.9	925.3

Layer	FC (%)	PI	wc/LL	D50 (mm)	Ini. Eff. Stress (psf)	Ini. Total Stress (psf)
1	35	10	0.9	3000	71.4	165.00
2	21	1	1	1128.0	280.8	780.00

3	53	3	0.9	1128.0	581.8	1705.00
4	33	1	1	1598.0	932.8	2680.00
5	47.5	5	0.9	1786.0	1308.8	3680.00
6	60.5	3	1	2068.0	1684.8	4680.00
7	65	9	.9	2350.0	2010.8	5630.00
8	42.5	10	0.8	2726.0	2336.8	6580.00
9	42.5	15	1	3572.0	2687.8	7555.00
10	53	12	0.9	4700.0	3063.8	8555.00
11	53	12	0.9	3347.0	3489.8	9605.00
12	53	20	1	3773.0	3940.8	10680.00
13	53	15	0.9	4305.5	4535.8	12055.00

Soil Profile Plots



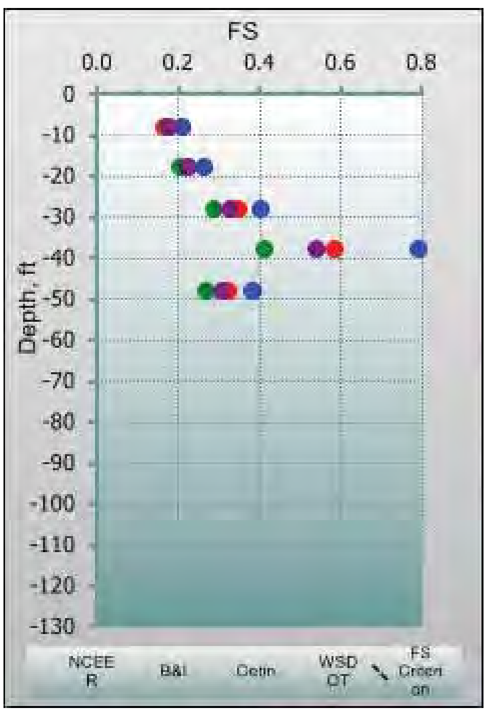
=== Susceptibility Evaluation ===

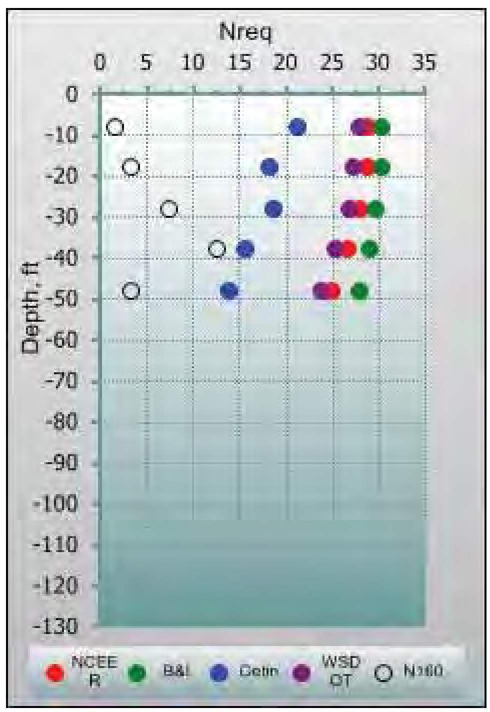
Threshold: 0.5
Weighting factors: B-I= 0.50   B-S= 0.50

Layer	PI	wc/LL	B-I	B-S	Suscep. Index	Potential
1	10.00	0.90	0.05	0.56	0.31	NO
2	1.00	1.00	1.00	0.76	0.88	YES
3	3.00	0.90	0.96	0.63	0.80	YES
4	1.00	1.00	1.00	0.76	0.88	YES
5	5.00	0.90	0.62	0.63	0.62	YES
6	3.00	1.00	0.96	0.76	0.86	YES
7	9.00	0.90	0.09	0.59	0.34	NO
8	10.00	0.80	0.05	0.41	0.23	NO
9	15.00	1.00	0.01	0.37	0.19	NO

```
   10  12.00   0.90  0.02  0.48          0.25         NO
   11  12.00   0.90  0.02  0.48          0.25         NO
   12  20.00   1.00  0.00  0.13          0.06         NO
   13  15.00   0.90  0.01  0.31          0.16         NO


=== Initiation ===
---------------------------------------------------

Initiation - Multiple Scenario
-----------------------------------------
Retrun Period (yrs) = 475
Models Selected :
Use All Deterministic Models.
--WSDOT Recommended--
   Use NCEER, Boulanger & Idriss, and
   Cetin's model with weighting factors
   of 0.4, 0.4, and 0.2 respectively.
-----------------------------------------


===== Mean Mw and FS ==============
---NCEER Model------------
--- PGA = 0.378  Mw = 6.58---------

Layer  (N1)60    CSR     CRR     FS     Nreq
-----  ------  ------  ------  ------  ------
    2    1.70   0.464   0.077    0.17    28.8
    3    3.40   0.466   0.105    0.23    28.8
    4    7.53   0.426   0.148    0.35    28.0
    5   12.72   0.375   0.219    0.58    26.7
    6    3.36   0.323   0.105    0.32    24.9


===== Mean Mw and FS ==============
---Boulanger and Idriss Model------------
--- PGA = 0.378  Mw = 6.58---------

Layer  (N1)60    CSR     CRR     FS     Nreq
-----  ------  ------  ------  ------  ------
    2    1.70   0.538   0.094    0.17    30.4
    3    3.40   0.541   0.111    0.21    30.4
    4    7.96   0.499   0.143    0.29    29.8
    5   12.77   0.456   0.188    0.41    29.0
    6    3.47   0.418   0.112    0.27    28.1


===== Mean Mw and FS ==============
---Cetin et al. Model------------
--- PGA = 0.378  Mw = 6.58---------

Layer  (N1)60    CSR     CRR     FS     Nreq
-----  ------  ------  ------  ------  ------
    2    1.60   0.619   0.130    0.21    21.2
    3    3.20   0.530   0.141    0.27    18.2
    4    7.53   0.402   0.162    0.40    18.6
    5   12.72   0.323   0.256    0.79    15.7
```

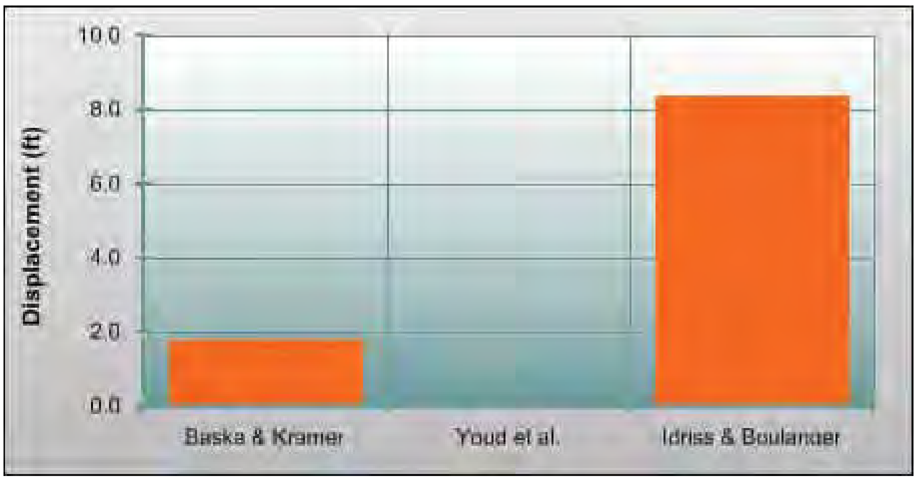
```
    6    3.36   0.287   0.110    0.38    14.0

---WSDOT Recommended------------
--- PGA = 0.378  Mw = 6.58---------

Layer  (N1)60    CSR     CRR     FS     Nreq
-----  ------  ------  ------  ------  ------
    2    1.70   0.525   0.094    0.18    27.9
    3    3.40   0.509   0.115    0.23    27.3
    4    7.53   0.450   0.149    0.33    26.8
    5   12.72   0.397   0.214    0.54    25.4
    6    3.36   0.354   0.109    0.31    24.0

  Table of FS
---------------------------------------
  #     Depth   NCEER     B&I     Cetin     WSDOT
          ft                     PL=0.60   PL=0.60
  2     -8.00    0.17    0.17      0.21      0.18
  3    -18.00    0.23    0.21      0.27      0.23
  4    -28.00    0.35    0.29      0.40      0.33
  5    -38.00    0.58    0.41      0.79      0.54
  6    -48.00    0.32    0.27      0.38      0.31
```





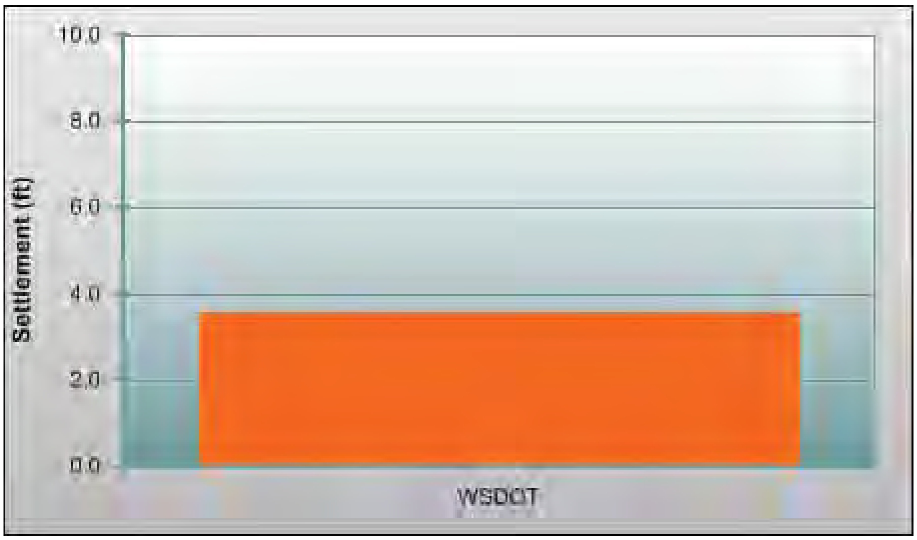

```
=== Effects ===
---------------------------------------------------


** Lateral Spreading **
-----------------------
>>>Multiple Scenario Results
```

```
Model Selected :
   WSDOT Recommended (weighted average)
   using models of Baska & Kramer and Youd et al.
-----------------------------------------

Baska & Kramer: 1.79 ft
Youd et al.: 0.00 ft
Idriss & Boulanger: 8.41 ft

----------------------------------------
Weighting factors: Baska and Kramer = 0.65
                   Youd et al.      = 0.35

 WSDOT Recommended: 1.17 ft
```



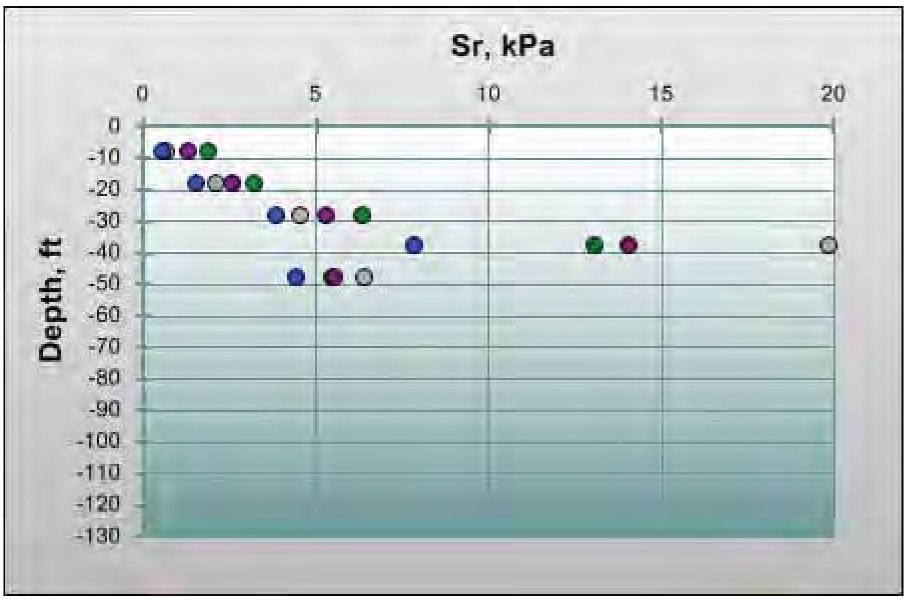

```
=== Effects ===
---------------------------------------------------


** Settlement **
----------------
>>>Multiple Scenario Results
Groud Surface Settlement MULTIPLE Scenario
Return Period (yrs) = 475
Model Selected :
   WSDOT Recommended (weighted average)
   using all deterministic models.
   -----------------------------------------
   Weighting factors = 0.25 for each model
-----------------------------------------


WSDOT Recommended:
=================
Total ground surface settlement = 3.62 ft
----------------------------------------------
  #    Depth thickness    ev    Weight    dh
          ft        ft     %              ft
----------------------------------------------
```

1	1.50	3.0	0.001	0.00	0.00
2	8.00	10.0	10.162	1.00	1.02
3	18.00	10.0	9.368	1.00	0.94
4	28.00	10.0	4.601	1.00	0.46
5	38.00	10.0	2.780	1.00	0.28
6	48.00	10.0	9.241	1.00	0.92
7	58.00	10.0	0.001	0.00	0.00
8	68.00	10.0	0.001	0.00	0.00
9	78.00	10.0	0.001	0.00	0.00
10	88.00	10.0	0.001	0.00	0.00
11	98.00	10.0	0.001	0.00	0.00
12	108.00	10.0	0.001	0.00	0.00
13	120.50	15.0	0.001	0.00	0.00




```
=== Effects ===
---------------------------------------------------


** Residual Strength **
-----------------------
====== Soil Layers Selected ==================
Layer 2
Layer 3

====== Models Selected =======================
Use recommended models:
  Kramer & Wang, Deterministic (KWD), w/ weighting factor = 0.5
  Idriss & Boulanger           (IDB), w/ weighting factor = 0.3
  Olson & Stark                (OLS), w/ weighting factor = 0.2
The residual strength is estimated as:
  Residual Strength =
    0.5*(Kramer & Wang) + 0.3*(Idriss & Boulanger) + 0.2*(Olson & Stark)

--------------------------------------------------------

###### Unweighted Residual Strength ####################
```

```
Kramer & Wang Deterministic Model:
   Layer 2:  Sr =    40 psf =   1.9 kPa = 0.019 atm
   Layer 3:  Sr =    67 psf =   3.2 kPa = 0.032 atm
------------------------------------------------------
Idriss & Boulanger Model:
   Layer 2:  Sr =    14 psf =   0.7 kPa = 0.007 atm
   Layer 3:  Sr =    44 psf =   2.1 kPa = 0.021 atm
------------------------------------------------------
Olson & Stark Model:
   Layer 2:  Sr =    12 psf =   0.6 kPa = 0.006 atm
   Layer 3:  Sr =    32 psf =   1.5 kPa = 0.015 atm
------------------------------------------------------
WSDOT Recommended Model:
   Layer 2:  Sr =    27 psf =   1.3 kPa = 0.013 atm
   Layer 3:  Sr =    53 psf =   2.6 kPa = 0.025 atm
------------------------------------------------------
```



Liquefaction Hazard Evaluation Report
by WSLiq Program beta (May, 2009)

Site Name: Lockheed West Seattle
Site Location (N,W) = 47.583 , 122.367
Job No: 106-8945
Analyst: TetraTech
Date: 10/14/2011 11:16:58 AM

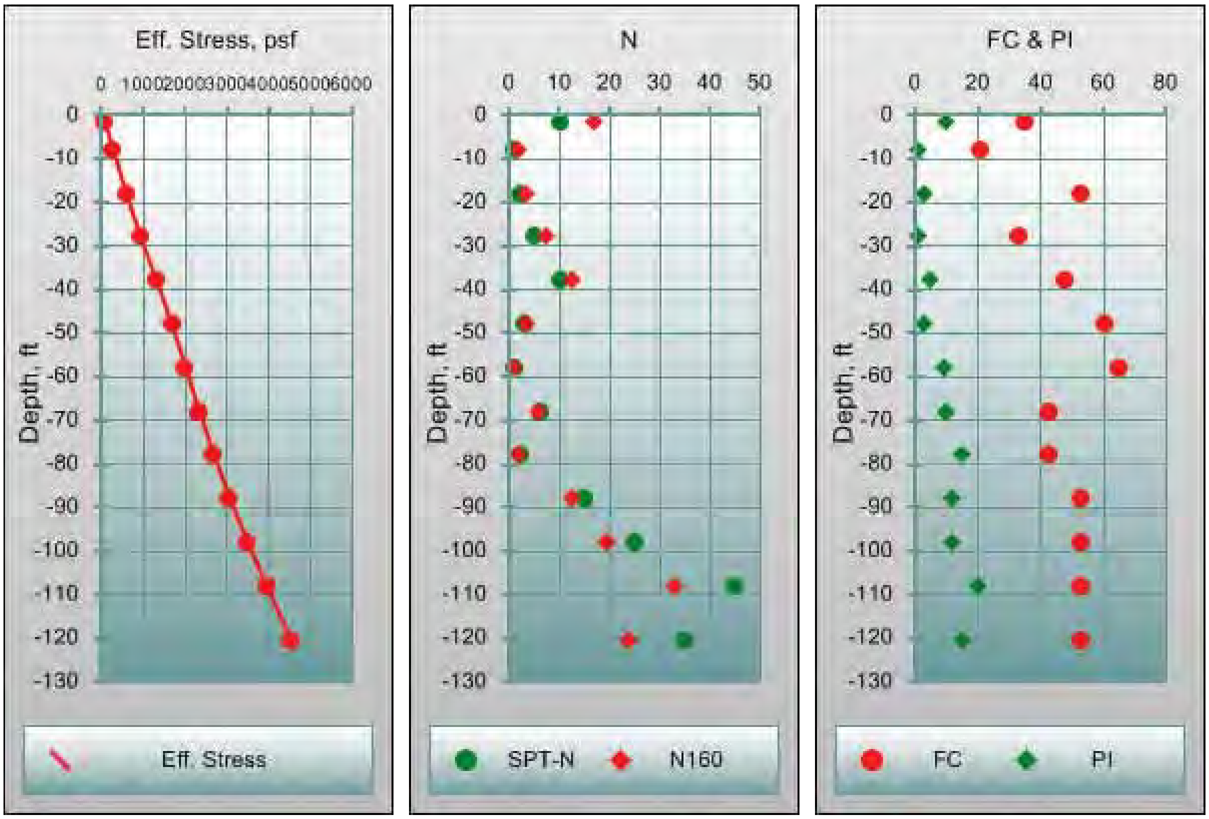
=== Soil Profile ===
Unit: ft
The number of soil layers: 13
GWT at top of layer: 1
GWT depth: 0.00
SPT Energy Ratio (%): 60.00
Amplification Factors: a= 0.1400 b= 0.0200
Elevation: 0.00
Ground Surface: Infinite Slope (%)= 0.2

Layer	Descpt.	Thickness (ft)	Unit Weight (lb/ft3)	Nm	N160	Vs ft/sec
1	Cap_layer	3	110.00	10	17.0	643.4
2	Loose_silty_sand	10	90.00	1	1.7	330.0
3	Soft_sandy_silt	10	95.00	2	3.4	403.5
4	Soft_silt	10	100.00	5	7.5	526.3
5	Medium_dense_silty_sand	10	100.00	10	12.7	643.4
6	Soft_silty_sand	10	100.00	3	3.4	453.8
7	Loose_silty_sand	10	90.00	1	1.0	330.0
8	Soft_silty_sand	10	100.00	6	5.7	554.9
9	Loose_silty_sand	10	95.00	2	1.8	403.5
10	Medium_dense_sand	10	105.00	15	12.5	723.7
11	Medium_dense_silty_sand	10	105.00	25	19.5	839.3
12	Dense_sand	10	110.00	45	33.0	995.3
13	Dense_sand	15	110.00	35	23.9	925.3

Layer	FC (%)	PI	wc/LL	D50 (mm)	Ini. Eff. Stress (psf)	Ini. Total Stress (psf)
1	35	10	0.9	3000	71.4	165.00
2	21	1	1	1128.0	280.8	780.00

3	53	3	0.9	1128.0	581.8	1705.00
4	33	1	1	1598.0	932.8	2680.00
5	47.5	5	0.9	1786.0	1308.8	3680.00
6	60.5	3	1	2068.0	1684.8	4680.00
7	65	9	.9	2350.0	2010.8	5630.00
8	42.5	10	0.8	2726.0	2336.8	6580.00
9	42.5	15	1	3572.0	2687.8	7555.00
10	53	12	0.9	4700.0	3063.8	8555.00
11	53	12	0.9	3347.0	3489.8	9605.00
12	53	20	1	3773.0	3940.8	10680.00
13	53	15	0.9	4305.5	4535.8	12055.00

Soil Profile Plots



=== Susceptibility Evaluation ===

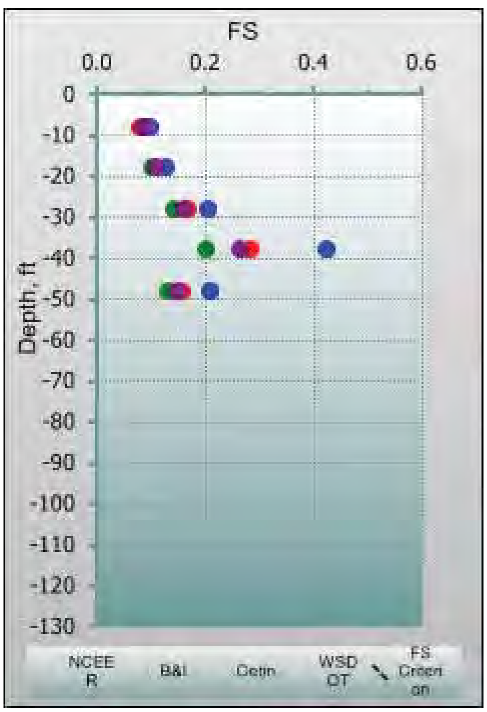
Threshold: 0.5

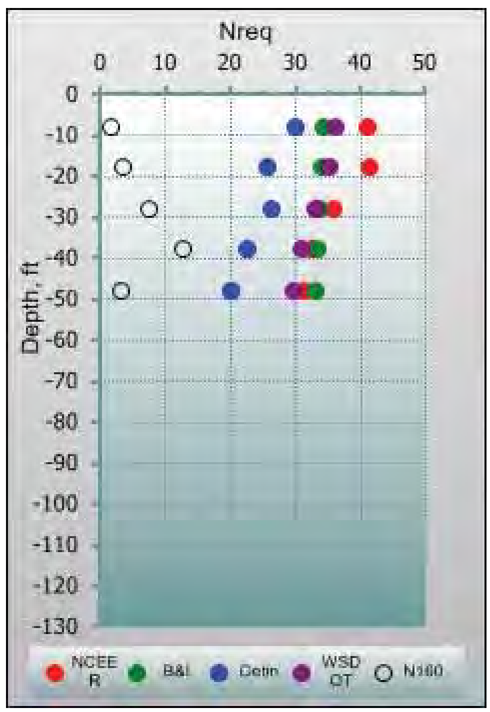
Weighting factors: B-I= 0.50 B-S= 0.50

Layer	PI	wc/LL	B-I	B-S	Suscep. Index	Potential
1	10.00	0.90	0.05	0.56	0.31	NO
2	1.00	1.00	1.00	0.76	0.88	YES
3	3.00	0.90	0.96	0.63	0.80	YES
4	1.00	1.00	1.00	0.76	0.88	YES
5	5.00	0.90	0.62	0.63	0.62	YES
6	3.00	1.00	0.96	0.76	0.86	YES
7	9.00	0.90	0.09	0.59	0.34	NO
8	10.00	0.80	0.05	0.41	0.23	NO
9	15.00	1.00	0.01	0.37	0.19	NO

```
   10  12.00   0.90  0.02  0.48          0.25         NO
   11  12.00   0.90  0.02  0.48          0.25         NO
   12  20.00   1.00  0.00  0.13          0.06         NO
   13  15.00   0.90  0.01  0.31          0.16         NO


=== Initiation ===
---------------------------------------------------

Initiation - Multiple Scenario
-----------------------------------------
Retrun Period (yrs) = 2475
Models Selected :
Use All Deterministic Models.
--WSDOT Recommended--
   Use NCEER, Boulanger & Idriss, and
   Cetin's model with weighting factors
   of 0.4, 0.4, and 0.2 respectively.
-----------------------------------------


===== Mean Mw and FS ==============
---NCEER Model------------
--- PGA = 0.754  Mw = 6.71---------

Layer  (N1)60    CSR     CRR     FS     Nreq
-----  ------  ------  ------  ------  ------
    2    1.70   0.961   0.077    0.08    41.1
    3    3.40   0.965   0.105    0.11    41.5
    4    7.53   0.882   0.148    0.17    35.8
    5   12.72   0.776   0.219    0.28    32.7
    6    3.36   0.669   0.105    0.16    31.4


===== Mean Mw and FS ==============
---Boulanger and Idriss Model------------
--- PGA = 0.754  Mw = 6.71---------

Layer  (N1)60    CSR     CRR     FS     Nreq
-----  ------  ------  ------  ------  ------
    2    1.70   1.094   0.094    0.09    34.5
    3    3.40   1.100   0.111    0.10    34.0
    4    7.96   1.015   0.143    0.14    33.9
    5   12.77   0.927   0.188    0.20    33.6
    6    3.47   0.850   0.112    0.13    33.2


===== Mean Mw and FS ==============
---Cetin et al. Model------------
--- PGA = 0.754  Mw = 6.71---------

Layer  (N1)60    CSR     CRR     FS     Nreq
-----  ------  ------  ------  ------  ------
    2    1.60   1.221   0.122    0.10    30.2
    3    3.20   1.018   0.132    0.13    25.9
    4    7.53   0.739   0.152    0.21    26.4
    5   12.72   0.567   0.240    0.42    22.5
```

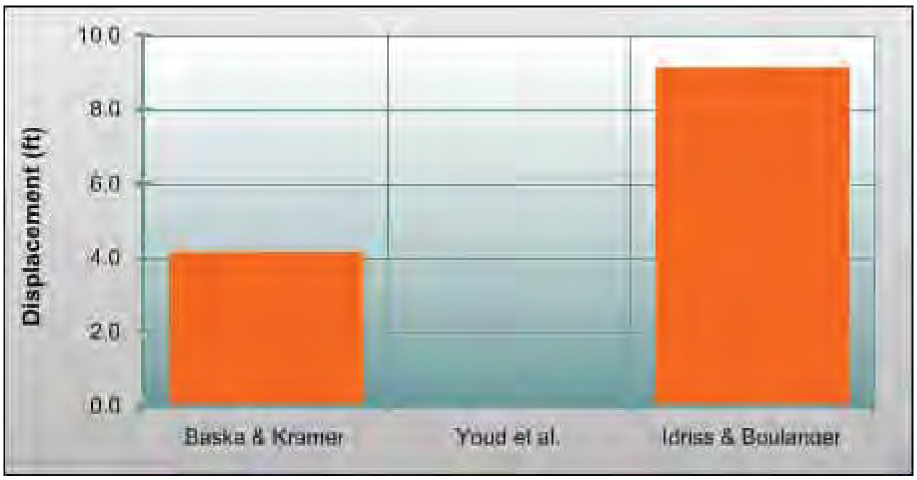
```
    6     3.36    0.491   0.103    0.21    20.3

---WSDOT Recommended------------
--- PGA = 0.754  Mw = 6.71---------

Layer  (N1)60    CSR     CRR      FS     Nreq
-----  ------  ------  ------  ------  ------
    2    1.70   1.066   0.093    0.09    36.3
    3    3.40   1.029   0.113    0.11    35.3
    4    7.53   0.907   0.147    0.16    33.1
    5   12.72   0.795   0.210    0.26    31.0
    6    3.36   0.706   0.107    0.15    29.9

  Table of FS
---------------------------------------
  #      Depth   NCEER     B&I      Cetin      WSDOT
            ft                     PL=0.60    PL=0.60
  2      -8.00    0.08    0.09       0.10       0.09
  3     -18.00    0.11    0.10       0.13       0.11
  4     -28.00    0.17    0.14       0.21       0.16
  5     -38.00    0.28    0.20       0.42       0.26
  6     -48.00    0.16    0.13       0.21       0.15
```





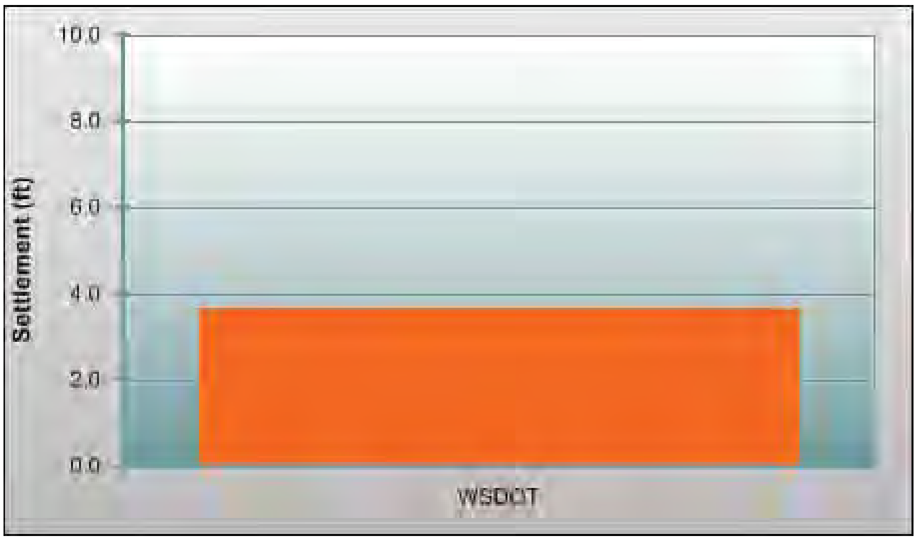

```
=== Effects ===
---------------------------------------------------


** Lateral Spreading **
-----------------------
>>>Multiple Scenario Results
```

```
Model Selected :
   WSDOT Recommended (weighted average)
   using models of Baska & Kramer and Youd et al.
-----------------------------------------

Baska & Kramer: 4.16 ft
Youd et al.: 0.00 ft
Idriss & Boulanger: 9.15 ft

----------------------------------------
Weighting factors: Baska and Kramer = 0.65
                   Youd et al.      = 0.35

 WSDOT Recommended: 2.71 ft
```



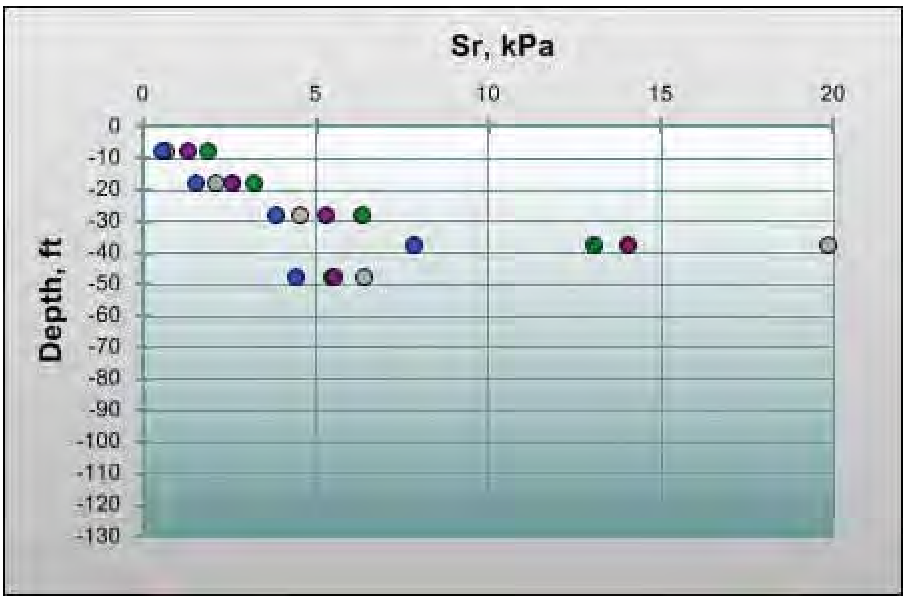

```
=== Effects ===
---------------------------------------------------


** Settlement **
----------------
>>>Multiple Scenario Results
Groud Surface Settlement MULTIPLE Scenario
Return Period (yrs) = 2475
Model Selected :
   WSDOT Recommended (weighted average)
   using all deterministic models.
   -----------------------------------------
   Weighting factors = 0.25 for each model
-----------------------------------------


WSDOT Recommended:
=================
Total ground surface settlement = 3.71 ft
----------------------------------------------
  #    Depth thickness    ev    Weight    dh
          ft        ft     %              ft
----------------------------------------------
```

1	1.50	3.0	0.001	0.00	0.00
2	8.00	10.0	10.233	1.00	1.02
3	18.00	10.0	9.435	1.00	0.94
4	28.00	10.0	4.828	1.00	0.48
5	38.00	10.0	3.196	1.00	0.32
6	48.00	10.0	9.434	1.00	0.94
7	58.00	10.0	0.001	0.00	0.00
8	68.00	10.0	0.001	0.00	0.00
9	78.00	10.0	0.001	0.00	0.00
10	88.00	10.0	0.001	0.00	0.00
11	98.00	10.0	0.001	0.00	0.00
12	108.00	10.0	0.001	0.00	0.00
13	120.50	15.0	0.001	0.00	0.00




```
=== Effects ===
---------------------------------------------------


** Residual Strength **
-----------------------
====== Soil Layers Selected ==================
Layer 2
Layer 3

====== Models Selected =======================
Use recommended models:
  Kramer & Wang, Deterministic (KWD), w/ weighting factor = 0.5
  Idriss & Boulanger           (IDB), w/ weighting factor = 0.3
  Olson & Stark                (OLS), w/ weighting factor = 0.2
The residual strength is estimated as:
  Residual Strength =
    0.5*(Kramer & Wang) + 0.3*(Idriss & Boulanger) + 0.2*(Olson & Stark)

--------------------------------------------------------

###### Unweighted Residual Strength ####################
```

```
Kramer & Wang Deterministic Model:
   Layer 2:  Sr =    40 psf =   1.9 kPa = 0.019 atm
   Layer 3:  Sr =    67 psf =   3.2 kPa = 0.032 atm
-------------------------------------------------------
Idriss & Boulanger Model:
   Layer 2:  Sr =    14 psf =   0.7 kPa = 0.007 atm
   Layer 3:  Sr =    44 psf =   2.1 kPa = 0.021 atm
-------------------------------------------------------
Olson & Stark Model:
   Layer 2:  Sr =    12 psf =   0.6 kPa = 0.006 atm
   Layer 3:  Sr =    32 psf =   1.5 kPa = 0.015 atm
-------------------------------------------------------
WSDOT Recommended Model:
   Layer 2:  Sr =    27 psf =   1.3 kPa = 0.013 atm
   Layer 3:  Sr =    53 psf =   2.6 kPa = 0.025 atm
-------------------------------------------------------
```



Liquefaction Hazard Evaluation Report
by WSLiq Program beta (May, 2009)

Site Name: Lockheed West Seattle
Site Location (N,W) = 47.583 , 122.367
Job No: 106-8945
Analyst: TetraTech
Date: 10/14/2011 12:24:46 PM

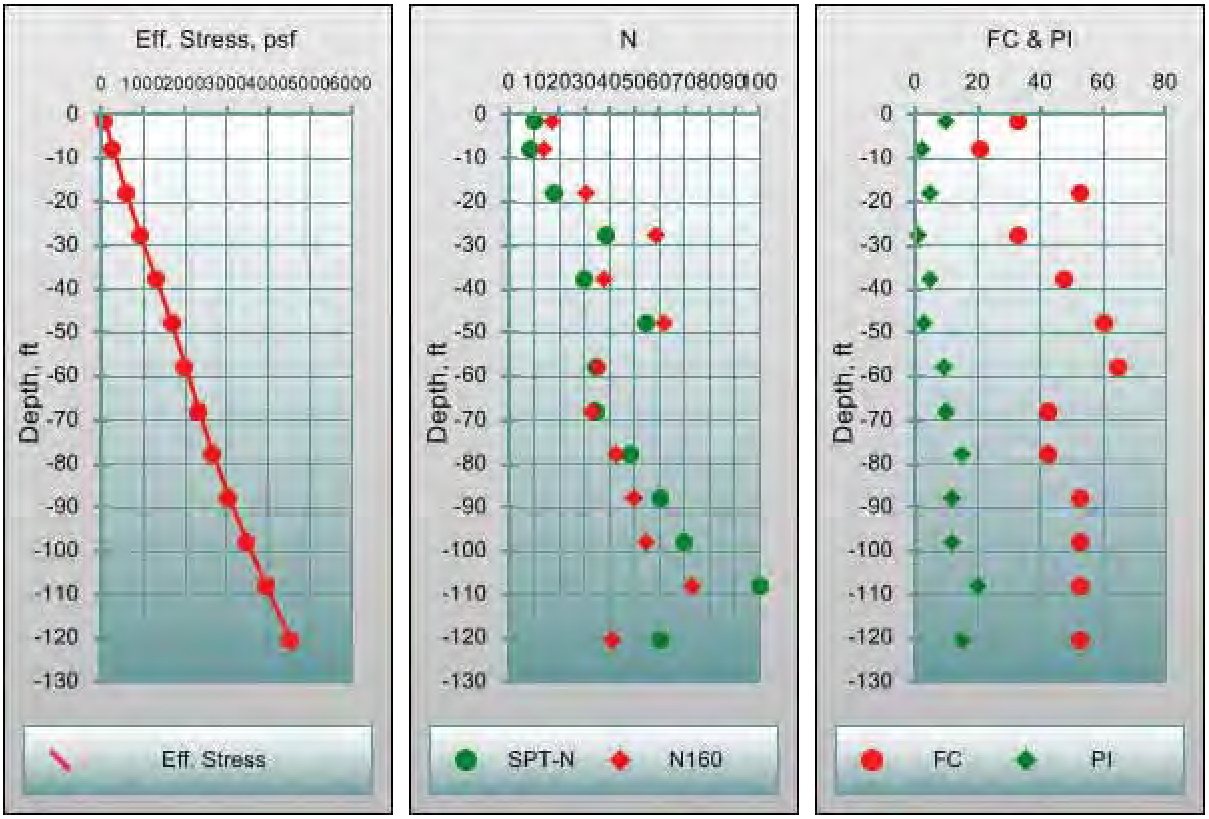
=== Soil Profile ===
Unit: ft
The number of soil layers: 13
GWT at top of layer: 1
GWT depth: 0.00
SPT Energy Ratio (%): 60.00
Amplification Factors: a= 0.1400 b= 0.0200
Elevation: 0.00
Ground Surface: Infinite Slope (%)= 0.2

Layer	Descpt.	Thickness (ft)	Unit Weight (lb/ft3)	Nm	N160	Vs ft/sec
1	Cap_layer	3	110.00	10	17.0	643.4
2	Loose_silty_sand	10	90.00	8	13.6	603.1
3	Soft_sandy_silt	10	95.00	18	30.6	763.0
4	Soft_silt	10	100.00	39	58.7	954.8
5	Medium_dense_silty_sand	10	100.00	30	38.1	884.9
6	Soft_silty_sand	10	100.00	55	61.6	1054.9
7	Loose_silty_sand	10	90.00	35	35.9	925.3
8	Soft_silty_sand	10	100.00	35	33.3	925.3
9	Loose_silty_sand	10	95.00	48	42.6	1014.1
10	Medium_dense_sand	10	105.00	60	49.9	1081.9
11	Medium_dense_silty_sand	10	105.00	70	54.5	1131.3
12	Dense_sand	10	110.00	100	73.3	1254.6
13	Dense_sand	15	110.00	60	41.0	1081.9

Layer	FC (%)	PI	wc/LL	D50 (mm)	Ini. Eff. Stress (psf)	Ini. Total Stress (psf)
1	33	10	0.9	3000	71.4	165.00
2	21	2	1	1128.0	280.8	780.00

3	53	5	0.9	1128.0	581.8	1705.00
4	33	1	1	1598.0	932.8	2680.00
5	47.5	5	0.9	1786.0	1308.8	3680.00
6	60.5	3	1	2068.0	1684.8	4680.00
7	65	9	0.9	2350.0	2010.8	5630.00
8	42.5	10	0.8	2726.0	2336.8	6580.00
9	42.5	15	1	3572.0	2687.8	7555.00
10	53	12	0.9	4700.0	3063.8	8555.00
11	53	12	0.9	3347.0	3489.8	9605.00
12	53	20	1	3773.0	3940.8	10680.00
13	53	15	0.9	4305.5	4535.8	12055.00

Soil Profile Plots



=== Susceptibility Evaluation ===

Threshold: 0.5

Weighting factors: B-I= 0.50   B-S= 0.50

Layer	PI	wc/LL	B-I	B-S	Suscep. Index	Potential
1	10.00	0.90	0.05	0.56	0.31	NO
2	2.00	1.00	1.00	0.76	0.88	YES
3	5.00	0.90	0.62	0.63	0.62	YES
4	1.00	1.00	1.00	0.76	0.88	YES
5	5.00	0.90	0.62	0.63	0.62	YES
6	3.00	1.00	0.96	0.76	0.86	YES
7	9.00	0.90	0.09	0.59	0.34	NO
8	10.00	0.80	0.05	0.41	0.23	NO
9	15.00	1.00	0.01	0.37	0.19	NO

```
   10  12.00   0.90  0.02  0.48          0.25         NO
   11  12.00   0.90  0.02  0.48          0.25         NO
   12  20.00   1.00  0.00  0.13          0.06         NO
   13  15.00   0.90  0.01  0.31          0.16         NO


=== Initiation ===
---------------------------------------------------

Initiation - Multiple Scenario
-----------------------------------------
Retrun Period (yrs) = 108
Models Selected :
Use All Deterministic Models.
--WSDOT Recommended--
   Use NCEER, Boulanger & Idriss, and
   Cetin's model with weighting factors
   of 0.4, 0.4, and 0.2 respectively.
-----------------------------------------


===== Mean Mw and FS ==============
---NCEER Model------------
--- PGA = 0.176  Mw = 6.46---------

Layer  (N1)60    CSR     CRR     FS     Nreq
-----  ------  ------  ------  ------  ------
    2   13.60   0.207   0.198    0.96    18.0
    3   30.60   0.208   3.000   14.42    18.1
    4   58.74   0.190   3.000   15.77    16.7
    5   38.15   0.167   3.000   17.92    14.8
    6   61.64   0.144   3.000   20.78    12.7


===== Mean Mw and FS ==============
---Boulanger and Idriss Model------------
--- PGA = 0.176  Mw = 6.46---------

Layer  (N1)60    CSR     CRR     FS     Nreq
-----  ------  ------  ------  ------  ------
    2   13.60   0.245   0.186    0.76    21.8
    3   29.03   0.246   1.031    4.19    21.7
    4   46.00   0.227   3.000   13.24    20.2
    5   35.13   0.207   3.000   14.51    18.5
    6   46.00   0.190   3.000   15.83    16.9


===== Mean Mw and FS ==============
---Cetin et al. Model------------
--- PGA = 0.176  Mw = 6.46---------

Layer  (N1)60    CSR     CRR     FS     Nreq
-----  ------  ------  ------  ------  ------
    2   12.80   0.316   0.342    1.08    12.4
    3   28.80   0.329   1.528    4.65    12.4
    4   58.74   0.311   3.000    9.66    15.0
    5   38.15   0.284   2.446    8.63    13.7
```

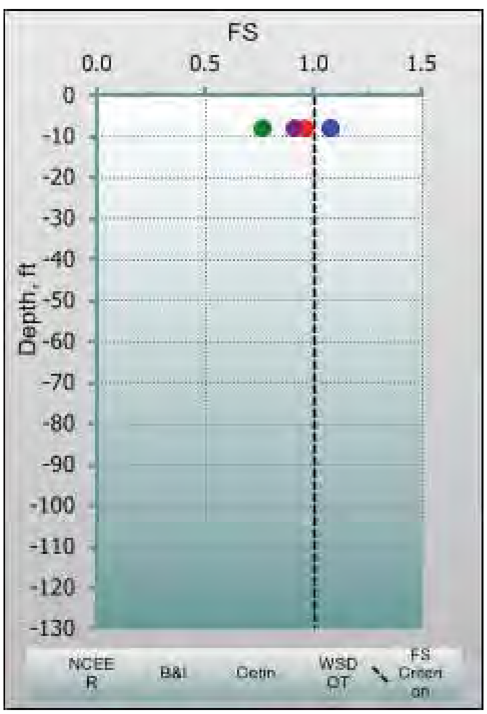
6	61.64	0.255	3.000	11.74	12.3

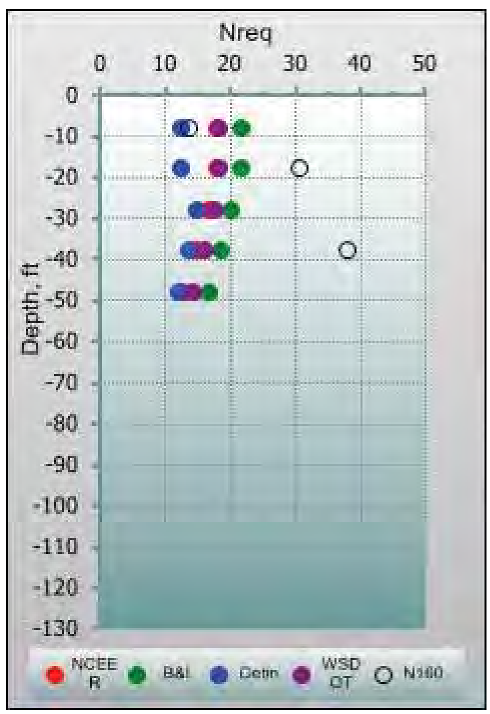
---WSDOT Recommended------------
--- PGA = 0.176 Mw = 6.46---------

Layer	(N1)60	CSR	CRR	FS	Nreq
2	13.60	0.244	0.222	0.91	18.4
3	30.60	0.247	1.918	7.76	18.4
4	58.74	0.229	3.000	13.11	17.8
5	38.15	0.206	2.889	14.00	16.1
6	61.64	0.185	3.000	16.24	14.3

Table of FS

#	Depth ft	NCEER	B&I	Cetin PL=0.60	WSDOT PL=0.60
2	-8.00	0.96	0.76	1.08	0.91
3	-18.00	14.42	4.19	4.65	7.76
4	-28.00	15.77	13.24	9.66	13.11
5	-38.00	17.92	14.51	8.63	14.00
6	-48.00	20.78	15.83	11.74	16.24



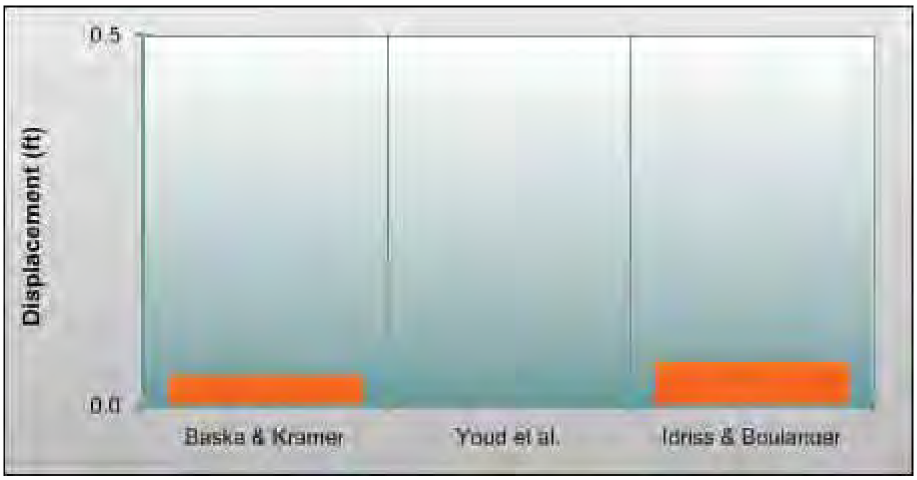


=== Effects ===

** Lateral Spreading **

>>>Multiple Scenario Results

```
Model Selected :
   WSDOT Recommended (weighted average)
   using models of Baska & Kramer and Youd et al.
-----------------------------------------

Baska & Kramer: 0.04 ft
Youd et al.: 0.00 ft
Idriss & Boulanger: 0.06 ft

----------------------------------------
Weighting factors: Baska and Kramer = 0.65
                   Youd et al.      = 0.35

 WSDOT Recommended: 0.03 ft
```




```
=== Effects ===
---------------------------------------------------


** Settlement **
----------------
>>>Multiple Scenario Results
Groud Surface Settlement MULTIPLE Scenario
Return Period (yrs) = 108
Model Selected :
   WSDOT Recommended (weighted average)
   using all deterministic models.
   -----------------------------------------
   Weighting factors = 0.25 for each model
-----------------------------------------


WSDOT Recommended:
=================
Total ground surface settlement = 0.17 ft
----------------------------------------------
  #    Depth thickness    ev    Weight    dh
          ft        ft     %              ft
----------------------------------------------
```

1	1.50	3.0	0.001	0.00	0.00
2	8.00	10.0	1.669	1.00	0.17
3	18.00	10.0	0.137	0.27	0.00
4	28.00	10.0	0.001	0.00	0.00
5	38.00	10.0	0.126	0.00	0.00
6	48.00	10.0	0.001	0.00	0.00
7	58.00	10.0	0.001	0.00	0.00
8	68.00	10.0	0.001	0.00	0.00
9	78.00	10.0	0.001	0.00	0.00
10	88.00	10.0	0.001	0.00	0.00
11	98.00	10.0	0.001	0.00	0.00
12	108.00	10.0	0.001	0.00	0.00
13	120.50	15.0	0.001	0.00	0.00


```
=== Effects ===
---------------------------------------------------


** Residual Strength **
-----------------------
====== Soil Layers Selected ==================
Layer 2

====== Models Selected =======================
Use recommended models:
  Kramer & Wang, Deterministic (KWD), w/ weighting factor = 0.5
  Idriss & Boulanger           (IDB), w/ weighting factor = 0.3
  Olson & Stark                (OLS), w/ weighting factor = 0.2
The residual strength is estimated as:
  Residual Strength =
    0.5*(Kramer & Wang) + 0.3*(Idriss & Boulanger) + 0.2*(Olson & Stark)

--------------------------------------------------------

###### Unweighted Residual Strength ####################
```

```
Kramer & Wang Deterministic Model:
   Layer 2:  Sr =   142 psf =   6.8 kPa = 0.067 atm
------------------------------------------------------
Idriss & Boulanger Model:
   Layer 2:  Sr =    68 psf =   3.3 kPa = 0.032 atm
------------------------------------------------------
Olson & Stark Model:
   Layer 2:  Sr =    37 psf =   1.8 kPa = 0.018 atm
------------------------------------------------------
WSDOT Recommended Model:
   Layer 2:  Sr =    99 psf =   4.7 kPa = 0.047 atm
------------------------------------------------------
```

Liquefaction Hazard Evaluation Report
by WSLiq Program beta (May, 2009)

Site Name: Lockheed West Seattle
Site Location (N,W) = 47.583 , 122.367
Job No: 106-8945
Analyst: TetraTech
Date: 10/14/2011 12:26:37 PM

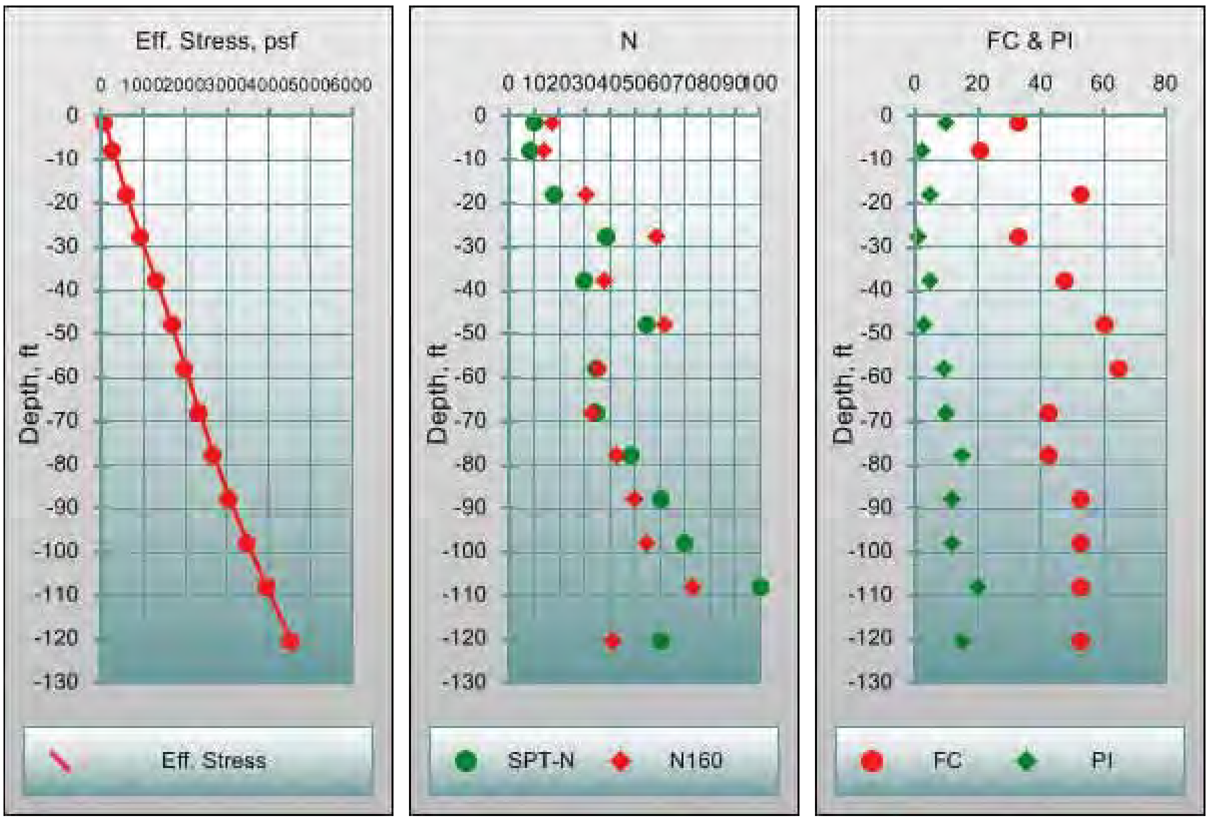
=== Soil Profile ===
Unit: ft
The number of soil layers: 13
GWT at top of layer: 1
GWT depth: 0.00
SPT Energy Ratio (%): 60.00
Amplification Factors: a= 0.1400 b= 0.0200
Elevation: 0.00
Ground Surface: Infinite Slope (%)= 0.2

Layer	Descpt.	Thickness (ft)	Unit Weight (lb/ft3)	Nm	N160	Vs ft/sec
1	Cap_layer	3	110.00	10	17.0	643.4
2	Loose_silty_sand	10	90.00	8	13.6	603.1
3	Soft_sandy_silt	10	95.00	18	30.6	763.0
4	Soft_silt	10	100.00	39	58.7	954.8
5	Medium_dense_silty_sand	10	100.00	30	38.1	884.9
6	Soft_silty_sand	10	100.00	55	61.6	1054.9
7	Loose_silty_sand	10	90.00	35	35.9	925.3
8	Soft_silty_sand	10	100.00	35	33.3	925.3
9	Loose_silty_sand	10	95.00	48	42.6	1014.1
10	Medium_dense_sand	10	105.00	60	49.9	1081.9
11	Medium_dense_silty_sand	10	105.00	70	54.5	1131.3
12	Dense_sand	10	110.00	100	73.3	1254.6
13	Dense_sand	15	110.00	60	41.0	1081.9

Layer	FC (%)	PI	wc/LL	D50 (mm)	Ini. Eff. Stress (psf)	Ini. Total Stress (psf)
1	33	10	0.9	3000	71.4	165.00
2	21	2	1	1128.0	280.8	780.00

3	53	5	0.9	1128.0	581.8	1705.00
4	33	1	1	1598.0	932.8	2680.00
5	47.5	5	0.9	1786.0	1308.8	3680.00
6	60.5	3	1	2068.0	1684.8	4680.00
7	65	9	0.9	2350.0	2010.8	5630.00
8	42.5	10	0.8	2726.0	2336.8	6580.00
9	42.5	15	1	3572.0	2687.8	7555.00
10	53	12	0.9	4700.0	3063.8	8555.00
11	53	12	0.9	3347.0	3489.8	9605.00
12	53	20	1	3773.0	3940.8	10680.00
13	53	15	0.9	4305.5	4535.8	12055.00

Soil Profile Plots



=== Susceptibility Evaluation ===

Threshold: 0.5

Weighting factors: B-I= 0.50 B-S= 0.50

Layer	PI	wc/LL	B-I	B-S	Suscep. Index	Potential
1	10.00	0.90	0.05	0.56	0.31	NO
2	2.00	1.00	1.00	0.76	0.88	YES
3	5.00	0.90	0.62	0.63	0.62	YES
4	1.00	1.00	1.00	0.76	0.88	YES
5	5.00	0.90	0.62	0.63	0.62	YES
6	3.00	1.00	0.96	0.76	0.86	YES
7	9.00	0.90	0.09	0.59	0.34	NO
8	10.00	0.80	0.05	0.41	0.23	NO
9	15.00	1.00	0.01	0.37	0.19	NO

10	12.00	0.90	0.02	0.48	0.25	NO
11	12.00	0.90	0.02	0.48	0.25	NO
12	20.00	1.00	0.00	0.13	0.06	NO
13	15.00	0.90	0.01	0.31	0.16	NO

=== Initiation ===

Initiation - Multiple Scenario

Retrun Period (yrs) = 475
Models Selected :
Use All Deterministic Models.
--WSDOT Recommended--
Use NCEER, Boulanger & Idriss, and
Cetin's model with weighting factors
of 0.4, 0.4, and 0.2 respectively.

===== Mean Mw and FS ==============
---NCEER Model------------
--- PGA = 0.378 Mw = 6.58---------

Layer	(N1)60	CSR	CRR	FS	Nreq
2	13.60	0.464	0.198	0.43	28.8
3	30.60	0.466	3.000	6.44	28.8
4	58.74	0.426	3.000	7.05	28.0
5	38.15	0.375	3.000	8.01	26.7
6	61.64	0.323	3.000	9.29	24.9

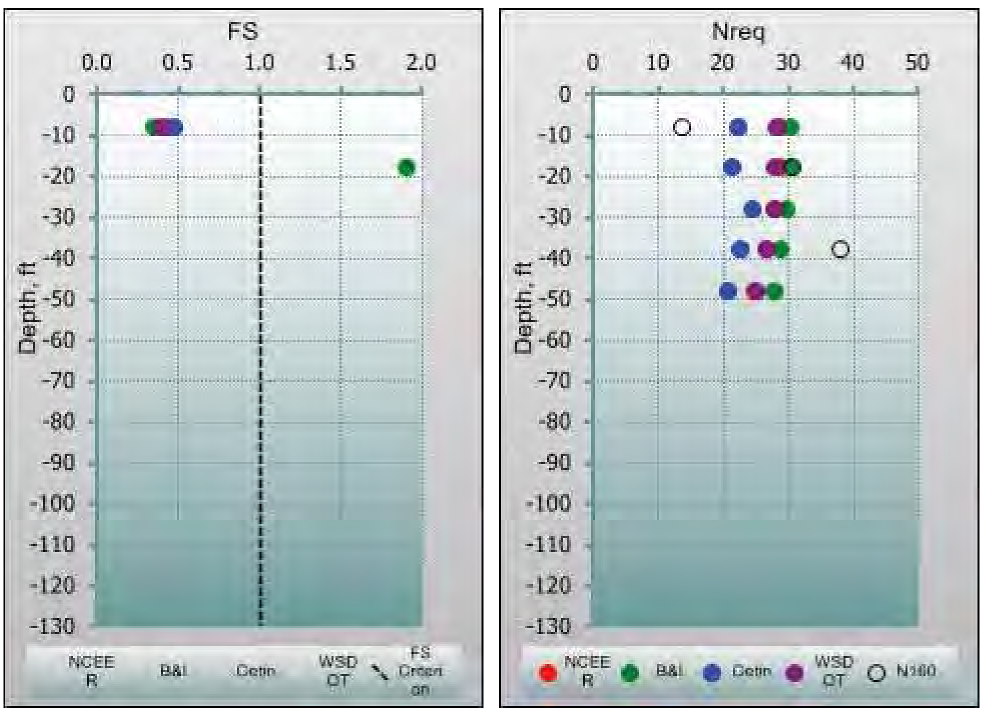
===== Mean Mw and FS ==============
---Boulanger and Idriss Model------------
--- PGA = 0.378 Mw = 6.58---------

Layer	(N1)60	CSR	CRR	FS	Nreq
2	13.60	0.538	0.186	0.35	30.4
3	29.03	0.541	1.031	1.91	30.4
4	46.00	0.499	3.000	6.01	29.8
5	35.13	0.456	3.000	6.58	29.0
6	46.00	0.418	3.000	7.18	28.1

===== Mean Mw and FS ==============
---Cetin et al. Model------------
--- PGA = 0.378 Mw = 6.58---------

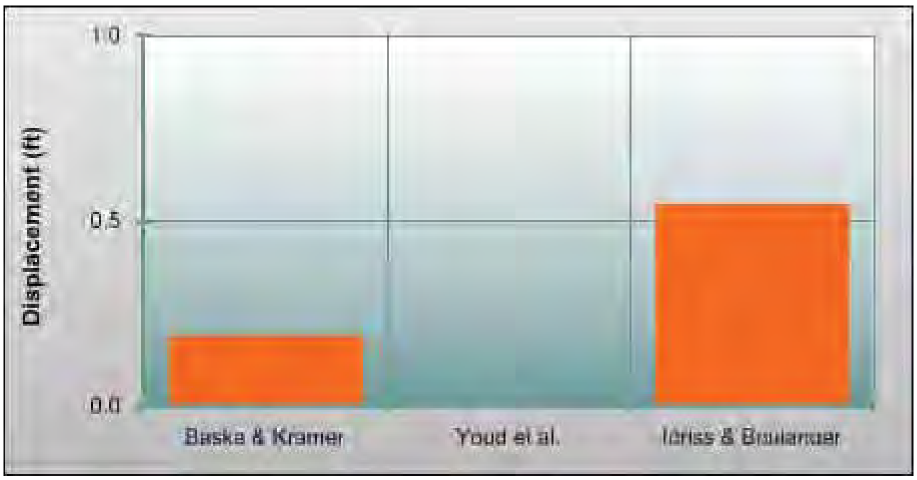
Layer	(N1)60	CSR	CRR	FS	Nreq
2	12.80	0.679	0.323	0.48	22.3
3	28.80	0.705	1.445	2.05	21.3
4	58.74	0.665	3.000	4.51	24.5
5	38.15	0.602	2.369	3.93	22.7

```
    6   61.64   0.537   3.000    5.59    20.7

---WSDOT Recommended------------
--- PGA = 0.378  Mw = 6.58---------

Layer  (N1)60    CSR     CRR     FS     Nreq
-----  ------  ------  ------  ------  ------
    2   13.60   0.537   0.218    0.41    28.1
    3   30.60   0.544   1.901    3.50    27.9
    4   58.74   0.503   3.000    5.97    28.0
    5   38.15   0.452   2.874    6.35    26.8
    6   61.64   0.404   3.000    7.43    25.3

  Table of FS
---------------------------------------
  #     Depth   NCEER     B&I     Cetin      WSDOT
           ft                   PL=0.60    PL=0.60
  2     -8.00    0.43    0.35      0.48       0.41
  3    -18.00    6.44    1.91      2.05       3.50
  4    -28.00    7.05    6.01      4.51       5.97
  5    -38.00    8.01    6.58      3.93       6.35
  6    -48.00    9.29    7.18      5.59       7.43
```



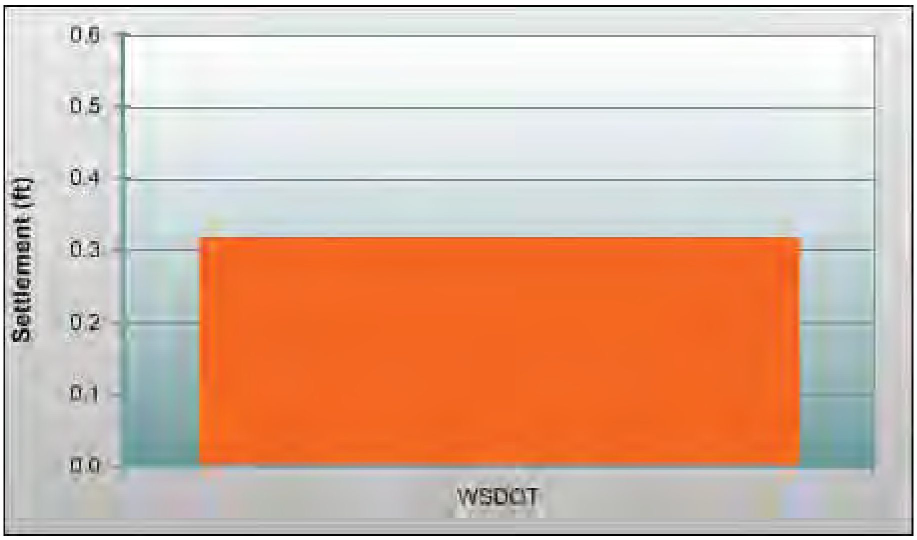

```
=== Effects ===
---------------------------------------------------


** Lateral Spreading **
-----------------------
>>>Multiple Scenario Results
```

```
Model Selected :
   WSDOT Recommended (weighted average)
   using models of Baska & Kramer and Youd et al.
-----------------------------------------

Baska & Kramer: 0.19 ft
Youd et al.: 0.00 ft
Idriss & Boulanger: 0.55 ft

----------------------------------------
Weighting factors: Baska and Kramer = 0.65
                   Youd et al.      = 0.35

 WSDOT Recommended: 0.12 ft
```




```
=== Effects ===
---------------------------------------------------


** Settlement **
----------------
>>>Multiple Scenario Results
Groud Surface Settlement MULTIPLE Scenario
Return Period (yrs) = 475
Model Selected :
   WSDOT Recommended (weighted average)
   using all deterministic models.
   -----------------------------------------
   Weighting factors = 0.25 for each model
-----------------------------------------


WSDOT Recommended:
=================
Total ground surface settlement = 0.32 ft
----------------------------------------------
  #    Depth thickness    ev    Weight    dh
          ft        ft     %              ft
----------------------------------------------
```

1	1.50	3.0	0.001	0.00	0.00
2	8.00	10.0	2.966	1.00	0.30
3	18.00	10.0	0.260	0.83	0.02
4	28.00	10.0	0.001	0.00	0.00
5	38.00	10.0	0.126	0.15	0.00
6	48.00	10.0	0.001	0.00	0.00
7	58.00	10.0	0.001	0.00	0.00
8	68.00	10.0	0.001	0.00	0.00
9	78.00	10.0	0.001	0.00	0.00
10	88.00	10.0	0.001	0.00	0.00
11	98.00	10.0	0.001	0.00	0.00
12	108.00	10.0	0.001	0.00	0.00
13	120.50	15.0	0.001	0.00	0.00




```
=== Effects ===
---------------------------------------------------


** Residual Strength **
-----------------------
====== Soil Layers Selected ==================
Layer 2

====== Models Selected =======================
Use recommended models:
  Kramer & Wang, Deterministic (KWD), w/ weighting factor = 0.5
  Idriss & Boulanger           (IDB), w/ weighting factor = 0.3
  Olson & Stark                (OLS), w/ weighting factor = 0.2
The residual strength is estimated as:
  Residual Strength =
    0.5*(Kramer & Wang) + 0.3*(Idriss & Boulanger) + 0.2*(Olson & Stark)

--------------------------------------------------------

###### Unweighted Residual Strength ####################
```

```
Kramer & Wang Deterministic Model:
   Layer 2:  Sr =   142 psf =   6.8 kPa = 0.067 atm
------------------------------------------------------
Idriss & Boulanger Model:
   Layer 2:  Sr =    68 psf =   3.3 kPa = 0.032 atm
------------------------------------------------------
Olson & Stark Model:
   Layer 2:  Sr =    37 psf =   1.8 kPa = 0.018 atm
------------------------------------------------------
WSDOT Recommended Model:
   Layer 2:  Sr =    99 psf =   4.7 kPa = 0.047 atm
------------------------------------------------------
```

Liquefaction Hazard Evaluation Report
by WSLiq Program beta (May, 2009)

Site Name: Lockheed West Seattle
Site Location (N,W) = 47.583 , 122.367
Job No: 106-8945
Analyst: TetraTech
Date: 10/14/2011 12:29:10 PM

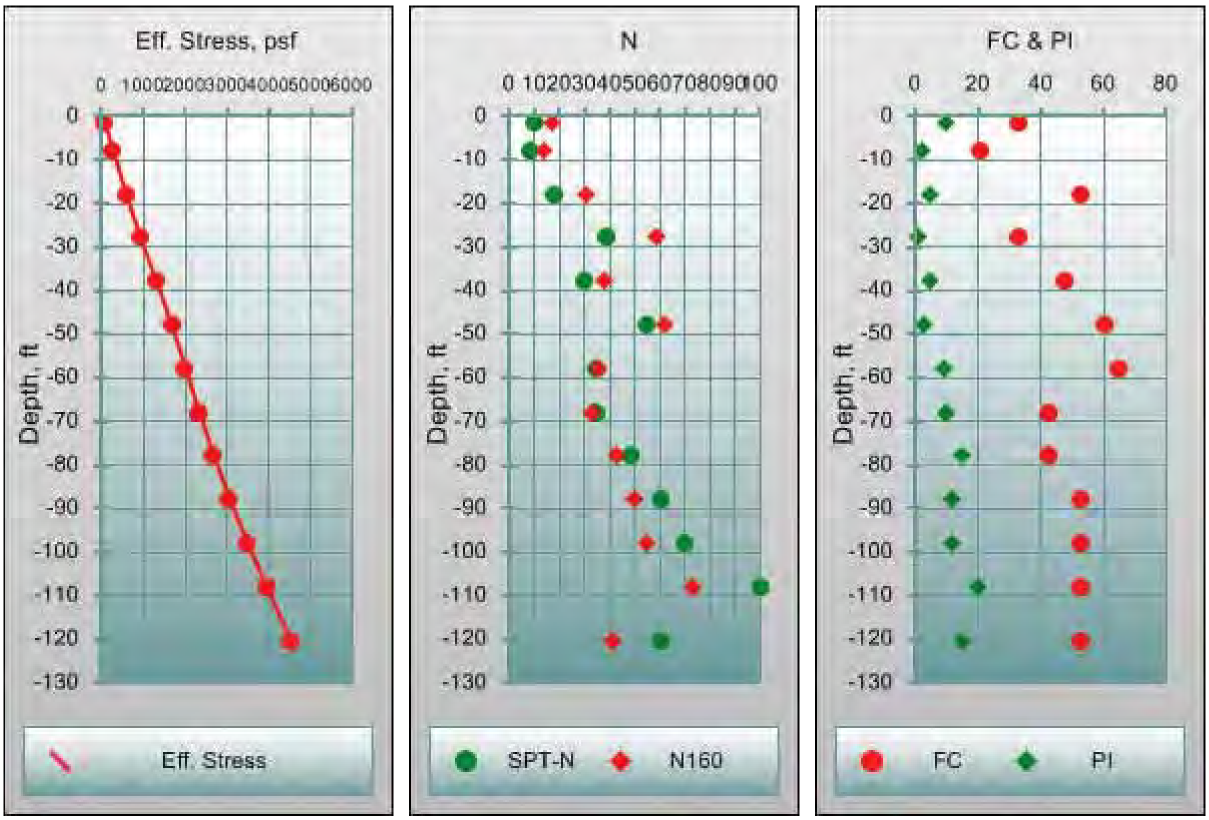
=== Soil Profile ===
Unit: ft
The number of soil layers: 13
GWT at top of layer: 1
GWT depth: 0.00
SPT Energy Ratio (%): 60.00
Amplification Factors: a= 0.1400 b= 0.0200
Elevation: 0.00
Ground Surface: Infinite Slope (%)= 0.2

Layer	Descpt.	Thickness (ft)	Unit Weight (lb/ft3)	Nm	N160	Vs ft/sec
1	Cap_layer	3	110.00	10	17.0	643.4
2	Loose_silty_sand	10	90.00	8	13.6	603.1
3	Soft_sandy_silt	10	95.00	18	30.6	763.0
4	Soft_silt	10	100.00	39	58.7	954.8
5	Medium_dense_silty_sand	10	100.00	30	38.1	884.9
6	Soft_silty_sand	10	100.00	55	61.6	1054.9
7	Loose_silty_sand	10	90.00	35	35.9	925.3
8	Soft_silty_sand	10	100.00	35	33.3	925.3
9	Loose_silty_sand	10	95.00	48	42.6	1014.1
10	Medium_dense_sand	10	105.00	60	49.9	1081.9
11	Medium_dense_silty_sand	10	105.00	70	54.5	1131.3
12	Dense_sand	10	110.00	100	73.3	1254.6
13	Dense_sand	15	110.00	60	41.0	1081.9

Layer	FC (%)	PI	wc/LL	D50 (mm)	Ini. Eff. Stress (psf)	Ini. Total Stress (psf)
1	33	10	0.9	3000	71.4	165.00
2	21	2	1	1128.0	280.8	780.00

3	53	5	0.9	1128.0	581.8	1705.00
4	33	1	1	1598.0	932.8	2680.00
5	47.5	5	0.9	1786.0	1308.8	3680.00
6	60.5	3	1	2068.0	1684.8	4680.00
7	65	9	0.9	2350.0	2010.8	5630.00
8	42.5	10	0.8	2726.0	2336.8	6580.00
9	42.5	15	1	3572.0	2687.8	7555.00
10	53	12	0.9	4700.0	3063.8	8555.00
11	53	12	0.9	3347.0	3489.8	9605.00
12	53	20	1	3773.0	3940.8	10680.00
13	53	15	0.9	4305.5	4535.8	12055.00

Soil Profile Plots



=== Susceptibility Evaluation ===

Threshold: 0.5

Weighting factors: B-I= 0.50 B-S= 0.50

Layer	PI	wc/LL	B-I	B-S	Suscep. Index	Potential
1	10.00	0.90	0.05	0.56	0.31	NO
2	2.00	1.00	1.00	0.76	0.88	YES
3	5.00	0.90	0.62	0.63	0.62	YES
4	1.00	1.00	1.00	0.76	0.88	YES
5	5.00	0.90	0.62	0.63	0.62	YES
6	3.00	1.00	0.96	0.76	0.86	YES
7	9.00	0.90	0.09	0.59	0.34	NO
8	10.00	0.80	0.05	0.41	0.23	NO
9	15.00	1.00	0.01	0.37	0.19	NO

```
   10  12.00   0.90  0.02  0.48          0.25         NO
   11  12.00   0.90  0.02  0.48          0.25         NO
   12  20.00   1.00  0.00  0.13          0.06         NO
   13  15.00   0.90  0.01  0.31          0.16         NO


=== Initiation ===
---------------------------------------------------

Initiation - Multiple Scenario
-----------------------------------------
Retrun Period (yrs) = 2475
Models Selected :
Use All Deterministic Models.
--WSDOT Recommended--
   Use NCEER, Boulanger & Idriss, and
   Cetin's model with weighting factors
   of 0.4, 0.4, and 0.2 respectively.
-----------------------------------------


===== Mean Mw and FS ==============
---NCEER Model------------
--- PGA = 0.754  Mw = 6.71---------

Layer  (N1)60    CSR     CRR     FS     Nreq
-----  ------  ------  ------  ------  ------
    2   13.60   0.961   0.198    0.21    41.1
    3   30.60   0.965   3.000    3.11    41.5
    4   58.74   0.882   3.000    3.40    35.8
    5   38.15   0.776   3.000    3.87    32.7
    6   61.64   0.669   3.000    4.48    31.4


===== Mean Mw and FS ==============
---Boulanger and Idriss Model------------
--- PGA = 0.754  Mw = 6.71---------

Layer  (N1)60    CSR     CRR     FS     Nreq
-----  ------  ------  ------  ------  ------
    2   13.60   1.094   0.186    0.17    34.5
    3   29.03   1.100   1.031    0.94    34.0
    4   46.00   1.015   3.000    2.96    33.9
    5   35.13   0.927   3.000    3.24    33.6
    6   46.00   0.850   3.000    3.53    33.2


===== Mean Mw and FS ==============
---Cetin et al. Model------------
--- PGA = 0.754  Mw = 6.71---------

Layer  (N1)60    CSR     CRR     FS     Nreq
-----  ------  ------  ------  ------  ------
    2   12.80   1.352   0.303    0.22    31.4
    3   28.80   1.400   1.352    0.97    29.4
    4   58.74   1.309   3.000    2.29    33.1
    5   38.15   1.167   2.274    1.95    30.6
```

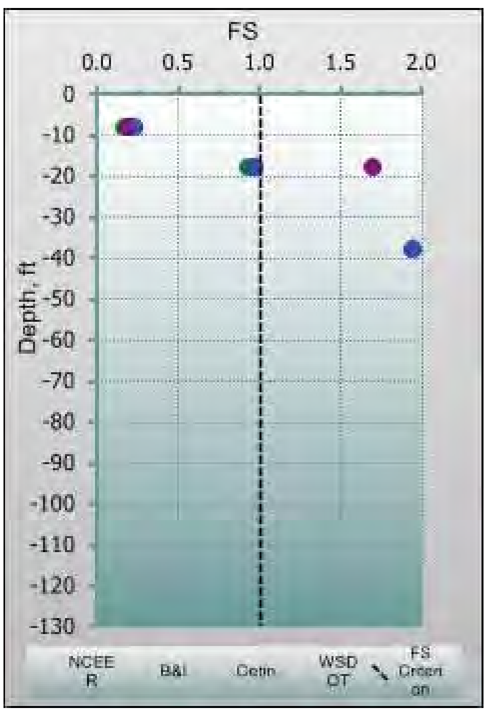
6	61.64	1.016	3.000	2.95	28.1

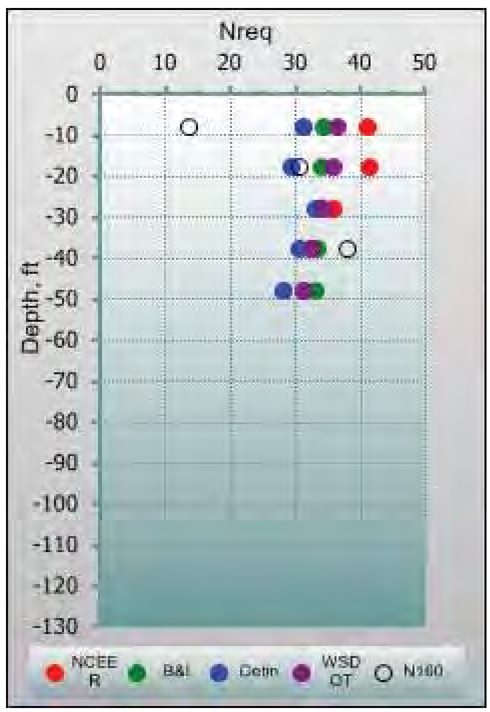
---WSDOT Recommended------------
--- PGA = 0.754 Mw = 6.71---------

Layer	(N1)60	CSR	CRR	FS	Nreq
2	13.60	1.093	0.214	0.20	36.5
3	30.60	1.106	1.883	1.70	36.0
4	58.74	1.021	3.000	2.94	34.5
5	38.15	0.915	2.855	3.12	32.6
6	61.64	0.811	3.000	3.70	31.4

Table of FS

#	Depth ft	NCEER	B&I	Cetin PL=0.60	WSDOT PL=0.60
2	-8.00	0.21	0.17	0.22	0.20
3	-18.00	3.11	0.94	0.97	1.70
4	-28.00	3.40	2.96	2.29	2.94
5	-38.00	3.87	3.24	1.95	3.12
6	-48.00	4.48	3.53	2.95	3.70



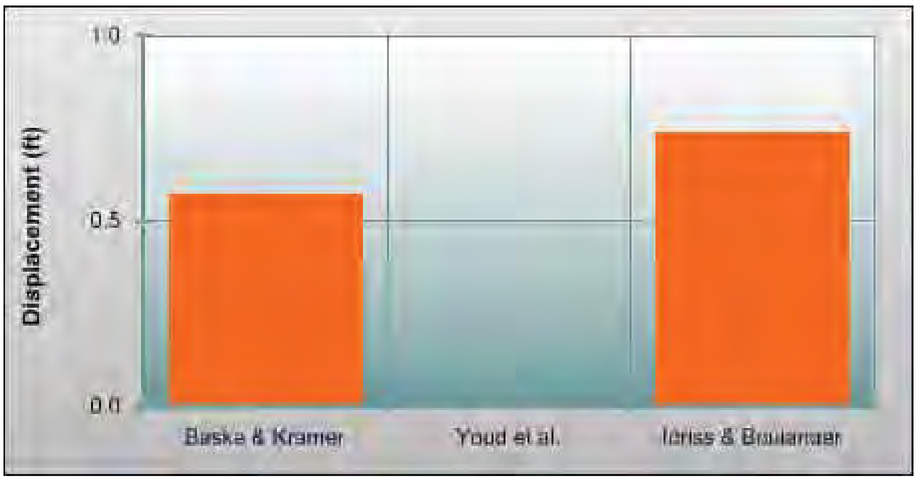


=== Effects ===

** Lateral Spreading **

>>>Multiple Scenario Results

```
Model Selected :
   WSDOT Recommended (weighted average)
   using models of Baska & Kramer and Youd et al.
-----------------------------------------

Baska & Kramer: 0.58 ft
Youd et al.: 0.00 ft
Idriss & Boulanger: 0.75 ft

----------------------------------------
Weighting factors: Baska and Kramer = 0.65
                   Youd et al.      = 0.35

 WSDOT Recommended: 0.37 ft
```




```
=== Effects ===
---------------------------------------------------


** Settlement **
----------------
>>>Multiple Scenario Results
Groud Surface Settlement MULTIPLE Scenario
Return Period (yrs) = 2475
Model Selected :
   WSDOT Recommended (weighted average)
   using all deterministic models.
   -----------------------------------------
   Weighting factors = 0.25 for each model
-----------------------------------------


WSDOT Recommended:
=================
Total ground surface settlement = 0.37 ft
----------------------------------------------
  #    Depth thickness    ev    Weight    dh
          ft        ft     %              ft
----------------------------------------------
```

1	1.50	3.0	0.001	0.00	0.00
2	8.00	10.0	3.126	1.00	0.31
3	18.00	10.0	0.439	1.00	0.04
4	28.00	10.0	0.001	0.00	0.00
5	38.00	10.0	0.126	0.91	0.01
6	48.00	10.0	0.001	0.00	0.00
7	58.00	10.0	0.001	0.00	0.00
8	68.00	10.0	0.001	0.00	0.00
9	78.00	10.0	0.001	0.00	0.00
10	88.00	10.0	0.001	0.00	0.00
11	98.00	10.0	0.001	0.00	0.00
12	108.00	10.0	0.001	0.00	0.00
13	120.50	15.0	0.001	0.00	0.00


```
=== Effects ===
---------------------------------------------------


** Residual Strength **
-----------------------
====== Soil Layers Selected ==================
Layer 2

====== Models Selected =======================
Use recommended models:
  Kramer & Wang, Deterministic (KWD), w/ weighting factor = 0.5
  Idriss & Boulanger           (IDB), w/ weighting factor = 0.3
  Olson & Stark                (OLS), w/ weighting factor = 0.2
The residual strength is estimated as:
  Residual Strength =
    0.5*(Kramer & Wang) + 0.3*(Idriss & Boulanger) + 0.2*(Olson & Stark)

--------------------------------------------------------

###### Unweighted Residual Strength ####################
```

```
Kramer & Wang Deterministic Model:
   Layer 2:  Sr =   142 psf =   6.8 kPa = 0.067 atm
------------------------------------------------------
Idriss & Boulanger Model:
   Layer 2:  Sr =    68 psf =   3.3 kPa = 0.032 atm
------------------------------------------------------
Olson & Stark Model:
   Layer 2:  Sr =    37 psf =   1.8 kPa = 0.018 atm
------------------------------------------------------
WSDOT Recommended Model:
   Layer 2:  Sr =    99 psf =   4.7 kPa = 0.047 atm
------------------------------------------------------
```

ALTERNATIVE 3A1

108 YEARS, 475 YEARS, 2,475 YEARS – LOWER-BOUND SPT

108 YEARS, 475 YEARS, 2,475 YEARS – UPPER-BOUND SPT

Liquefaction Hazard Evaluation Report
by WSLiq Program beta (May, 2009)

Site Name: Lockheed West Seattle
Site Location (N,W) = 47.583 , 122.367
Job No: 106-8945
Analyst: TetraTech
Date: 10/14/2011 11:35:51 AM

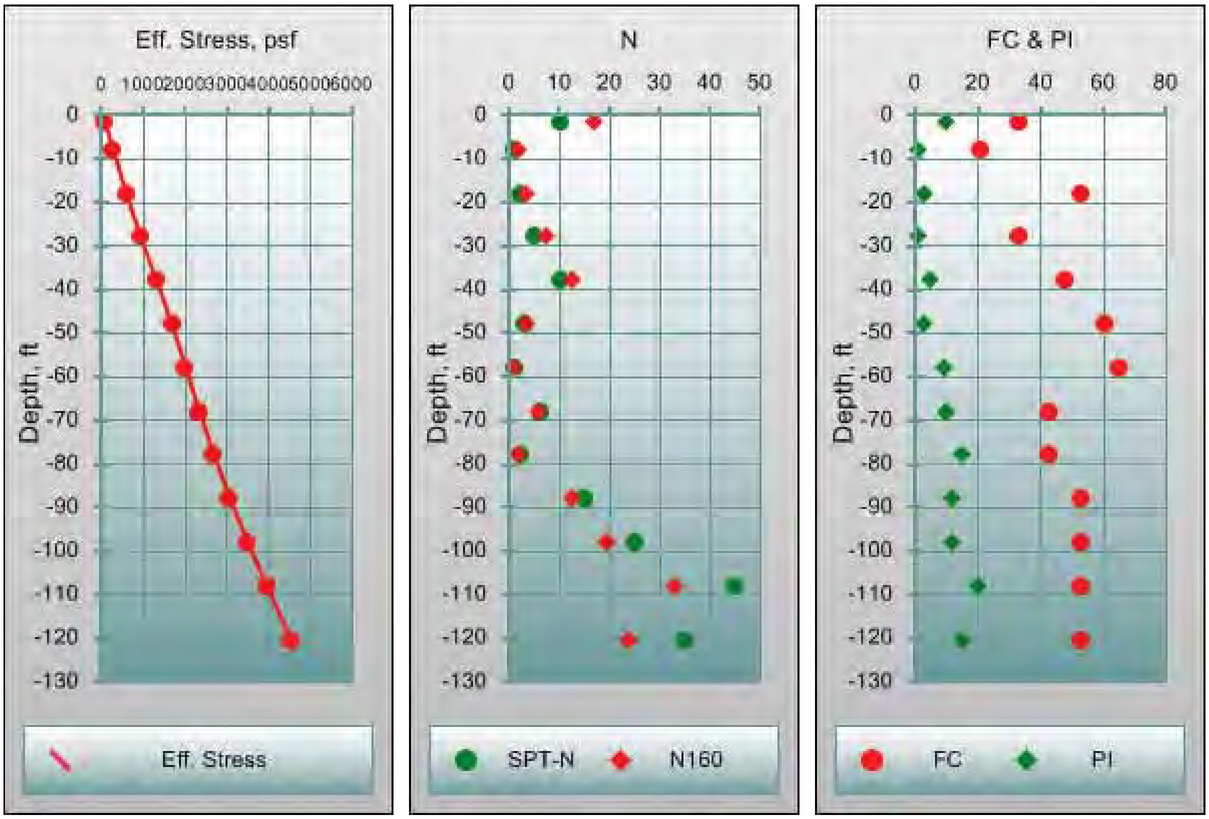
=== Soil Profile ===
Unit: ft
The number of soil layers: 13
GWT at top of layer: 1
GWT depth: 0.00
SPT Energy Ratio (%): 60.00
Amplification Factors: a= 0.1400 b= 0.0200
Elevation: 0.00
Ground Surface: Infinite Slope (%)= 0.2

Layer	Descpt.	Thickness (ft)	Unit Weight (lb/ft3)	Nm	N160	Vs ft/sec
1	Cap_layer	3	110.00	10	17.0	643.4
2	Loose_silty_sand	7	90.00	1	1.7	330.0
3	Soft_sandy_silt	10	95.00	2	3.4	403.5
4	Soft_silt	10	100.00	5	7.9	526.3
5	Medium_dense_silty_sand	10	100.00	10	13.1	643.4
6	Soft_silty_sand	10	100.00	3	3.4	453.8
7	Loose_silty_sand	10	90.00	1	1.0	330.0
8	Soft_silty_sand	10	100.00	6	5.8	554.9
9	Loose_silty_sand	10	95.00	2	1.8	403.5
10	Medium_dense_sand	10	105.00	15	12.6	723.7
11	Medium_dense_silty_sand	10	105.00	25	19.7	839.3
12	Dense_sand	10	110.00	45	33.3	995.3
13	Dense_sand	15	110.00	35	24.1	925.3

Layer	FC (%)	PI	wc/LL	D50 (mm)	Ini. Eff. Stress (psf)	Ini. Total Stress (psf)
1	33	10	0.9	3000	71.4	165.00
2	21	1	1	1128.0	239.4	645.00

3	53	3	0.9	1128.0	499.0	1435.00
4	33	1	1	1598.0	850.0	2410.00
5	47.5	5	0.9	1786.0	1226.0	3410.00
6	60.5	3	1	2068.0	1602.0	4410.00
7	65	9	0.9	2350.0	1928.0	5360.00
8	42.5	10	0.8	2726.0	2254.0	6310.00
9	42.5	15	1	3572.0	2605.0	7285.00
10	53	12	0.9	4700.0	2981.0	8285.00
11	53	12	0.9	3347.0	3407.0	9335.00
12	53	20	1	3773.0	3858.0	10410.00
13	53	15	0.9	4305.5	4453.0	11785.00

Soil Profile Plots



=== Susceptibility Evaluation ===

Threshold: 0.5

Weighting factors: B-I= 0.50   B-S= 0.50

Layer	PI	wc/LL	B-I	B-S	Suscep. Index	Potential
1	10.00	0.90	0.05	0.56	0.31	NO
2	1.00	1.00	1.00	0.76	0.88	YES
3	3.00	0.90	0.96	0.63	0.80	YES
4	1.00	1.00	1.00	0.76	0.88	YES
5	5.00	0.90	0.62	0.63	0.62	YES
6	3.00	1.00	0.96	0.76	0.86	YES
7	9.00	0.90	0.09	0.59	0.34	NO
8	10.00	0.80	0.05	0.41	0.23	NO
9	15.00	1.00	0.01	0.37	0.19	NO

```
   10  12.00   0.90  0.02  0.48          0.25         NO
   11  12.00   0.90  0.02  0.48          0.25         NO
   12  20.00   1.00  0.00  0.13          0.06         NO
   13  15.00   0.90  0.01  0.31          0.16         NO


=== Initiation ===
---------------------------------------------------

Initiation - Multiple Scenario
-----------------------------------------
Retrun Period (yrs) = 108
Models Selected :
Use All Deterministic Models.
--WSDOT Recommended--
   Use NCEER, Boulanger & Idriss, and
   Cetin's model with weighting factors
   of 0.4, 0.4, and 0.2 respectively.
-----------------------------------------


===== Mean Mw and FS ==============
---NCEER Model------------
--- PGA = 0.176  Mw = 6.46---------

Layer  (N1)60    CSR     CRR     FS     Nreq
-----  ------  ------  ------  ------  ------
    2    1.70   0.202   0.077    0.38    17.6
    3    3.40   0.207   0.105    0.51    18.0
    4    7.89   0.192   0.152    0.79    16.9
    5   13.14   0.172   0.225    1.31    15.2
    6    3.45   0.149   0.106    0.71    13.2


===== Mean Mw and FS ==============
---Boulanger and Idriss Model------------
--- PGA = 0.176  Mw = 6.46---------

Layer  (N1)60    CSR     CRR     FS     Nreq
-----  ------  ------  ------  ------  ------
    2    1.70   0.239   0.094    0.39    21.4
    3    3.40   0.245   0.111    0.45    21.7
    4    8.35   0.228   0.146    0.64    20.4
    5   13.18   0.209   0.192    0.92    18.8
    6    3.58   0.192   0.112    0.59    17.2


===== Mean Mw and FS ==============
---Cetin et al. Model------------
--- PGA = 0.176  Mw = 6.46---------

Layer  (N1)60    CSR     CRR     FS     Nreq
-----  ------  ------  ------  ------  ------
    2    1.60   0.290   0.144    0.50    10.8
    3    3.20   0.272   0.155    0.57     9.9
    4    7.89   0.216   0.181    0.84    10.5
    5   13.14   0.173   0.286    1.65     8.0
```

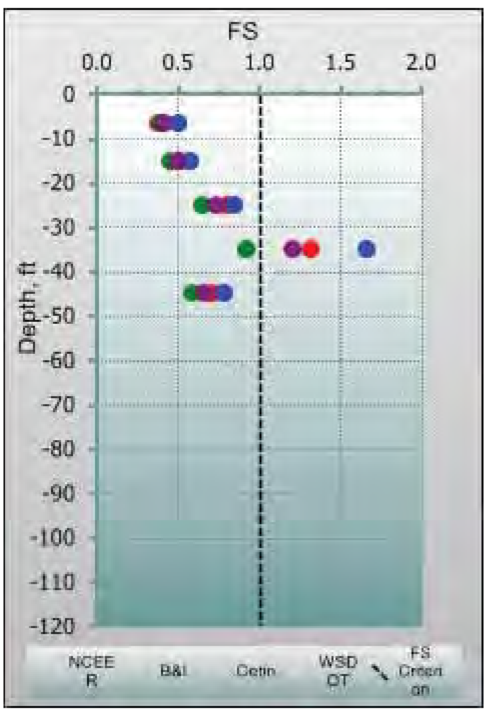
6	3.45	0.151	0.119	0.79	6.5

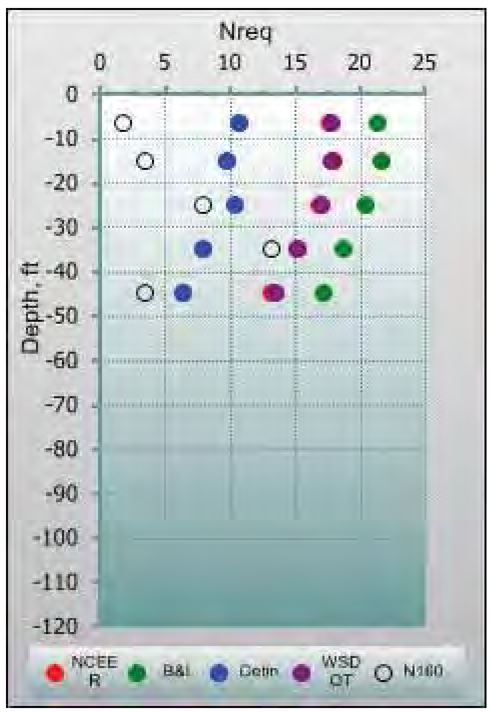
---WSDOT Recommended------------
--- PGA = 0.176 Mw = 6.46---------

Layer	(N1)60	CSR	CRR	FS	Nreq
2	1.70	0.235	0.097	0.41	17.8
3	3.40	0.236	0.118	0.50	17.9
4	7.89	0.211	0.156	0.74	17.0
5	13.14	0.187	0.224	1.20	15.2
6	3.45	0.167	0.111	0.67	13.4

Table of FS

#	Depth ft	NCEER	B&I	Cetin PL=0.60	WSDOT PL=0.60
2	-6.50	0.38	0.39	0.50	0.41
3	-15.00	0.51	0.45	0.57	0.50
4	-25.00	0.79	0.64	0.84	0.74
5	-35.00	1.31	0.92	1.65	1.20
6	-45.00	0.71	0.59	0.79	0.67



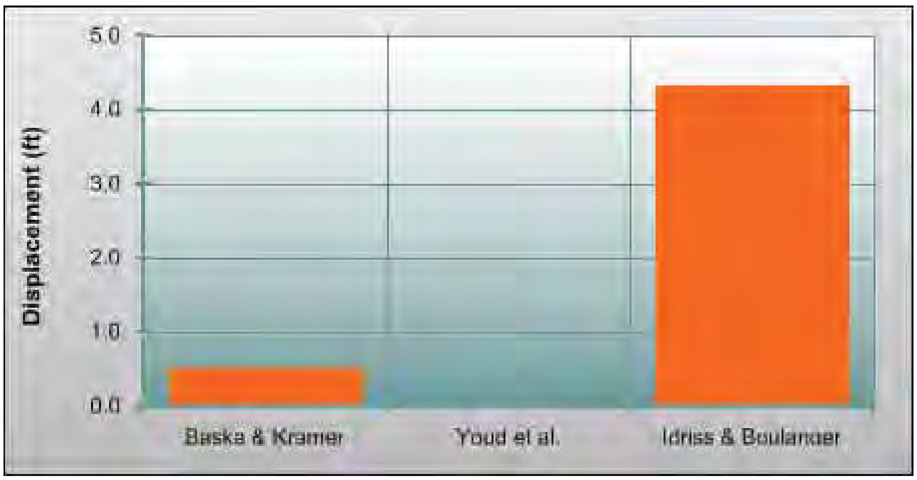


=== Effects ===

** Lateral Spreading **

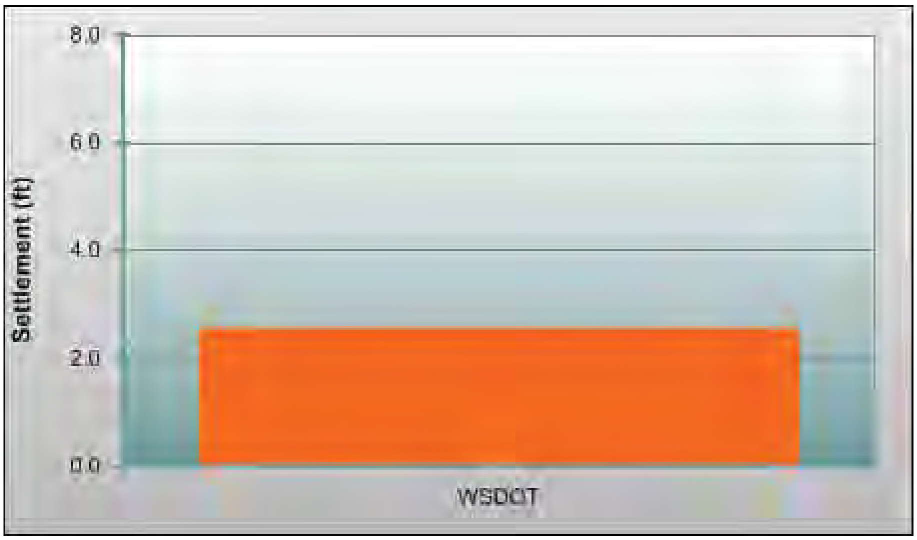
>>>Multiple Scenario Results

```
Model Selected :
   WSDOT Recommended (weighted average)
   using models of Baska & Kramer and Youd et al.
-----------------------------------------

Baska & Kramer: 0.53 ft
Youd et al.: 0.00 ft
Idriss & Boulanger: 4.33 ft

----------------------------------------
Weighting factors: Baska and Kramer = 0.65
                   Youd et al.      = 0.35

 WSDOT Recommended: 0.34 ft
```



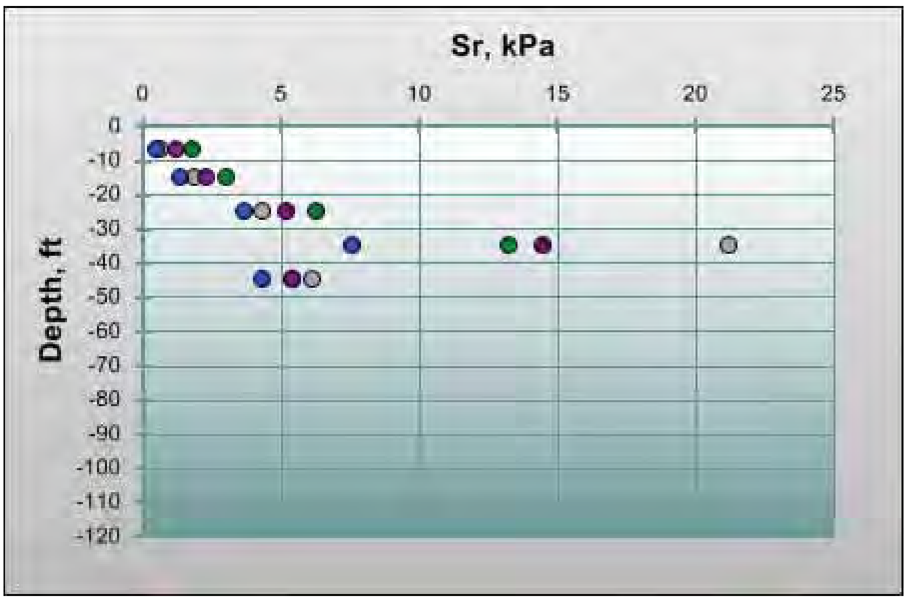

```
=== Effects ===
---------------------------------------------------


** Settlement **
----------------
>>>Multiple Scenario Results
Groud Surface Settlement MULTIPLE Scenario
Return Period (yrs) = 108
Model Selected :
   WSDOT Recommended (weighted average)
   using all deterministic models.
   -----------------------------------------
   Weighting factors = 0.25 for each model
-----------------------------------------


WSDOT Recommended:
=================
Total ground surface settlement = 2.59 ft
----------------------------------------------
  #    Depth thickness    ev    Weight    dh
          ft        ft     %              ft
----------------------------------------------
```

1	1.50	3.0	0.001	0.00	0.00
2	6.50	7.0	9.887	1.00	0.69
3	15.00	10.0	8.249	1.00	0.82
4	25.00	10.0	3.201	1.00	0.32
5	35.00	10.0	1.042	0.99	0.10
6	45.00	10.0	6.508	1.00	0.65
7	55.00	10.0	0.001	0.00	0.00
8	65.00	10.0	0.001	0.00	0.00
9	75.00	10.0	0.001	0.00	0.00
10	85.00	10.0	0.001	0.00	0.00
11	95.00	10.0	0.001	0.00	0.00
12	105.00	10.0	0.001	0.00	0.00
13	117.50	15.0	0.001	0.00	0.00




```
=== Effects ===
---------------------------------------------------


** Residual Strength **
-----------------------
====== Soil Layers Selected ==================
Layer 2
Layer 3

====== Models Selected =======================
Use recommended models:
  Kramer & Wang, Deterministic (KWD), w/ weighting factor = 0.5
  Idriss & Boulanger           (IDB), w/ weighting factor = 0.3
  Olson & Stark                (OLS), w/ weighting factor = 0.2
The residual strength is estimated as:
  Residual Strength =
    0.5*(Kramer & Wang) + 0.3*(Idriss & Boulanger) + 0.2*(Olson & Stark)

--------------------------------------------------------

###### Unweighted Residual Strength ####################
```

```
Kramer & Wang Deterministic Model:
   Layer 2:  Sr =    37 psf =   1.8 kPa = 0.018 atm
   Layer 3:  Sr =    63 psf =   3.0 kPa = 0.030 atm
------------------------------------------------------
Idriss & Boulanger Model:
   Layer 2:  Sr =    12 psf =   0.6 kPa = 0.006 atm
   Layer 3:  Sr =    38 psf =   1.8 kPa = 0.018 atm
------------------------------------------------------
Olson & Stark Model:
   Layer 2:  Sr =    10 psf =   0.5 kPa = 0.005 atm
   Layer 3:  Sr =    28 psf =   1.3 kPa = 0.013 atm
------------------------------------------------------
WSDOT Recommended Model:
   Layer 2:  Sr =    24 psf =   1.2 kPa = 0.011 atm
   Layer 3:  Sr =    48 psf =   2.3 kPa = 0.023 atm
------------------------------------------------------
```



Liquefaction Hazard Evaluation Report
by WSLiq Program beta (May, 2009)

Site Name: Lockheed West Seattle
Site Location (N,W) = 47.583 , 122.367
Job No: 106-8945
Analyst: TetraTech
Date: 10/14/2011 11:38:58 AM

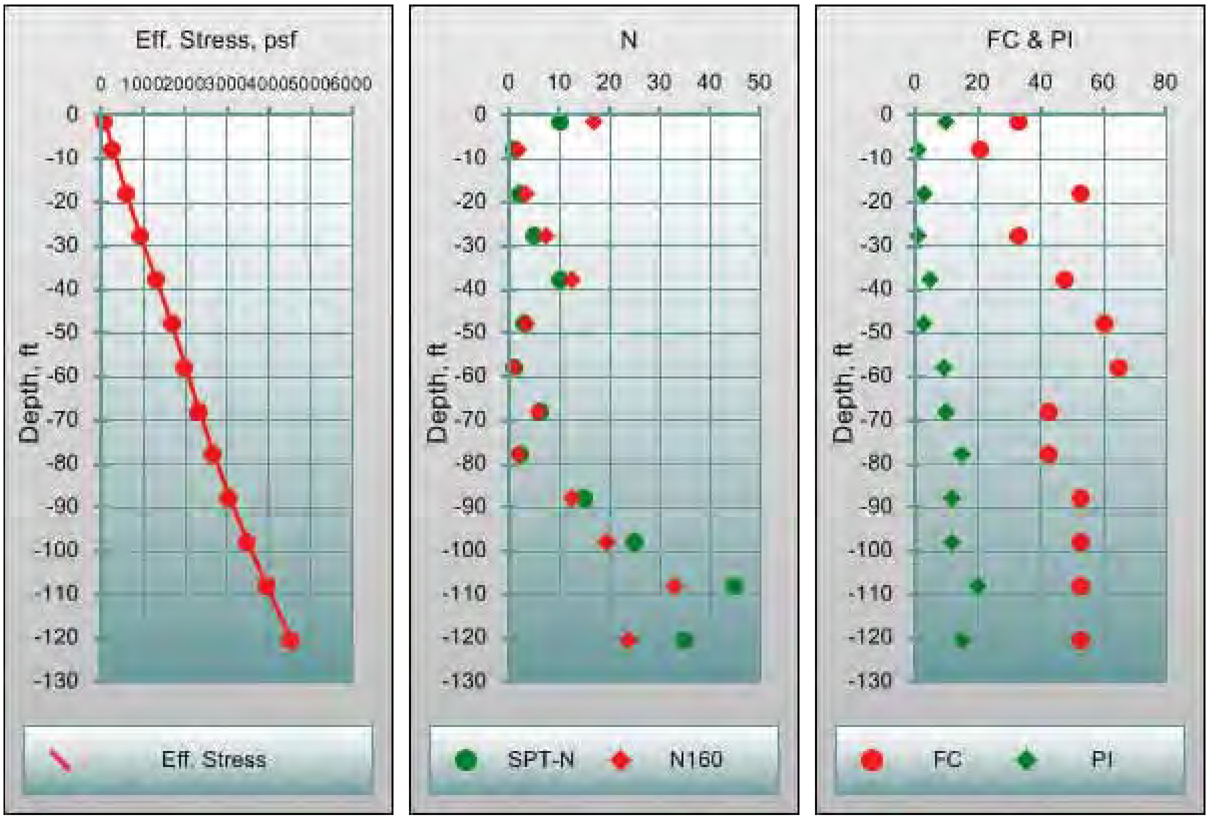
=== Soil Profile ===
Unit: ft
The number of soil layers: 13
GWT at top of layer: 1
GWT depth: 0.00
SPT Energy Ratio (%): 60.00
Amplification Factors: a= 0.1400 b= 0.0200
Elevation: 0.00
Ground Surface: Infinite Slope (%)= 0.2

Layer	Descpt.	Thickness (ft)	Unit Weight (lb/ft3)	Nm	N160	Vs ft/sec
1	Cap_layer	3	110.00	10	17.0	643.4
2	Loose_silty_sand	7	90.00	1	1.7	330.0
3	Soft_sandy_silt	10	95.00	2	3.4	403.5
4	Soft_silt	10	100.00	5	7.9	526.3
5	Medium_dense_silty_sand	10	100.00	10	13.1	643.4
6	Soft_silty_sand	10	100.00	3	3.4	453.8
7	Loose_silty_sand	10	90.00	1	1.0	330.0
8	Soft_silty_sand	10	100.00	6	5.8	554.9
9	Loose_silty_sand	10	95.00	2	1.8	403.5
10	Medium_dense_sand	10	105.00	15	12.6	723.7
11	Medium_dense_silty_sand	10	105.00	25	19.7	839.3
12	Dense_sand	10	110.00	45	33.3	995.3
13	Dense_sand	15	110.00	35	24.1	925.3

Layer	FC (%)	PI	wc/LL	D50 (mm)	Ini. Eff. Stress (psf)	Ini. Total Stress (psf)
1	33	10	0.9	3000	71.4	165.00
2	21	1	1	1128.0	239.4	645.00

3	53	3	0.9	1128.0	499.0	1435.00
4	33	1	1	1598.0	850.0	2410.00
5	47.5	5	0.9	1786.0	1226.0	3410.00
6	60.5	3	1	2068.0	1602.0	4410.00
7	65	9	0.9	2350.0	1928.0	5360.00
8	42.5	10	0.8	2726.0	2254.0	6310.00
9	42.5	15	1	3572.0	2605.0	7285.00
10	53	12	0.9	4700.0	2981.0	8285.00
11	53	12	0.9	3347.0	3407.0	9335.00
12	53	20	1	3773.0	3858.0	10410.00
13	53	15	0.9	4305.5	4453.0	11785.00

Soil Profile Plots



=== Susceptibility Evaluation ===

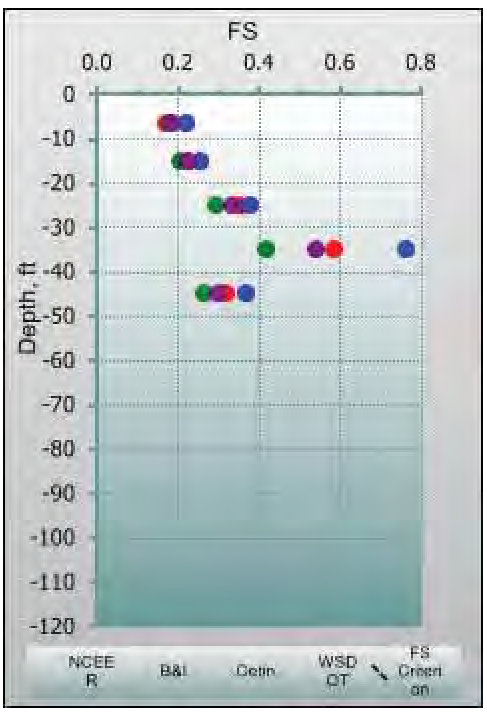
Threshold: 0.5

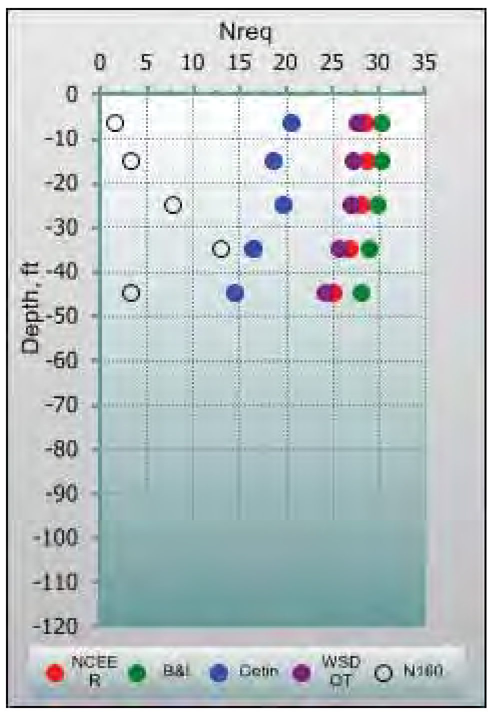
Weighting factors: B-I= 0.50 B-S= 0.50

Layer	PI	wc/LL	B-I	B-S	Suscep. Index	Potential
1	10.00	0.90	0.05	0.56	0.31	NO
2	1.00	1.00	1.00	0.76	0.88	YES
3	3.00	0.90	0.96	0.63	0.80	YES
4	1.00	1.00	1.00	0.76	0.88	YES
5	5.00	0.90	0.62	0.63	0.62	YES
6	3.00	1.00	0.96	0.76	0.86	YES
7	9.00	0.90	0.09	0.59	0.34	NO
8	10.00	0.80	0.05	0.41	0.23	NO
9	15.00	1.00	0.01	0.37	0.19	NO

```
   10  12.00   0.90  0.02  0.48          0.25         NO
   11  12.00   0.90  0.02  0.48          0.25         NO
   12  20.00   1.00  0.00  0.13          0.06         NO
   13  15.00   0.90  0.01  0.31          0.16         NO


=== Initiation ===
---------------------------------------------------

Initiation - Multiple Scenario
-----------------------------------------
Retrun Period (yrs) = 475
Models Selected :
Use All Deterministic Models.
--WSDOT Recommended--
   Use NCEER, Boulanger & Idriss, and
   Cetin's model with weighting factors
   of 0.4, 0.4, and 0.2 respectively.
-----------------------------------------


===== Mean Mw and FS ==============
---NCEER Model------------
--- PGA = 0.378  Mw = 6.58---------

Layer  (N1)60    CSR     CRR     FS     Nreq
-----  ------  ------  ------  ------  ------
    2    1.70   0.453   0.077    0.17    28.6
    3    3.40   0.464   0.105    0.23    28.8
    4    7.89   0.430   0.152    0.35    28.1
    5   13.14   0.384   0.225    0.59    26.9
    6    3.45   0.334   0.106    0.32    25.3


===== Mean Mw and FS ==============
---Boulanger and Idriss Model------------
--- PGA = 0.378  Mw = 6.58---------

Layer  (N1)60    CSR     CRR     FS     Nreq
-----  ------  ------  ------  ------  ------
    2    1.70   0.525   0.094    0.18    30.3
    3    3.40   0.539   0.111    0.21    30.4
    4    8.35   0.502   0.146    0.29    29.8
    5   13.18   0.460   0.192    0.42    29.1
    6    3.58   0.424   0.112    0.27    28.2


===== Mean Mw and FS ==============
---Cetin et al. Model------------
--- PGA = 0.378  Mw = 6.58---------

Layer  (N1)60    CSR     CRR     FS     Nreq
-----  ------  ------  ------  ------  ------
    2    1.60   0.622   0.136    0.22    20.7
    3    3.20   0.579   0.147    0.25    18.7
    4    7.89   0.452   0.172    0.38    19.7
    5   13.14   0.355   0.271    0.76    16.5
```

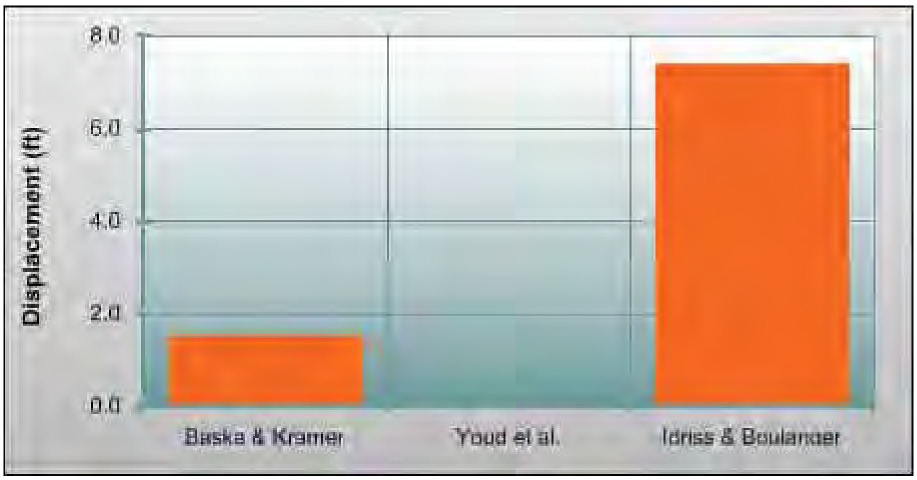
```
    6     3.45    0.307    0.113     0.37     14.5

---WSDOT Recommended------------
--- PGA = 0.378  Mw = 6.58---------

Layer   (N1)60    CSR      CRR      FS      Nreq
-----   ------  ------   ------   ------   ------
    2     1.70    0.516    0.096     0.19     27.7
    3     3.40    0.517    0.116     0.22     27.4
    4     7.89    0.463    0.154     0.33     27.1
    5    13.14    0.409    0.221     0.54     25.7
    6     3.45    0.364    0.110     0.30     24.3

  Table of FS
---------------------------------------
  #      Depth    NCEER      B&I     Cetin      WSDOT
           ft                       PL=0.60    PL=0.60
  2      -6.50     0.17     0.18      0.22       0.19
  3     -15.00     0.23     0.21      0.25       0.22
  4     -25.00     0.35     0.29      0.38       0.33
  5     -35.00     0.59     0.42      0.76       0.54
  6     -45.00     0.32     0.27      0.37       0.30
```





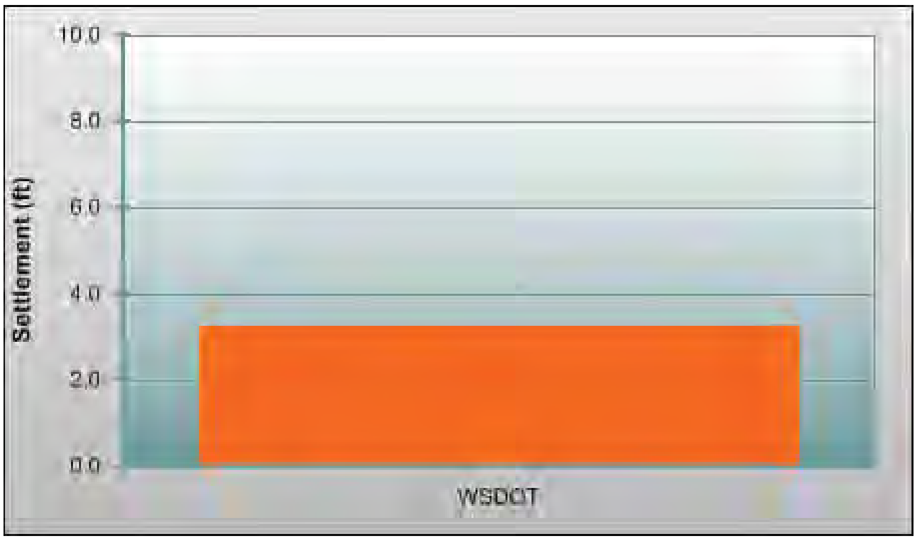

```
=== Effects ===
---------------------------------------------------

** Lateral Spreading **
-----------------------
>>>Multiple Scenario Results
```

```
Model Selected :
   WSDOT Recommended (weighted average)
   using models of Baska & Kramer and Youd et al.
-----------------------------------------

Baska & Kramer: 1.55 ft
Youd et al.: 0.00 ft
Idriss & Boulanger: 7.42 ft

----------------------------------------
Weighting factors: Baska and Kramer = 0.65
                   Youd et al.      = 0.35

 WSDOT Recommended: 1.01 ft
```



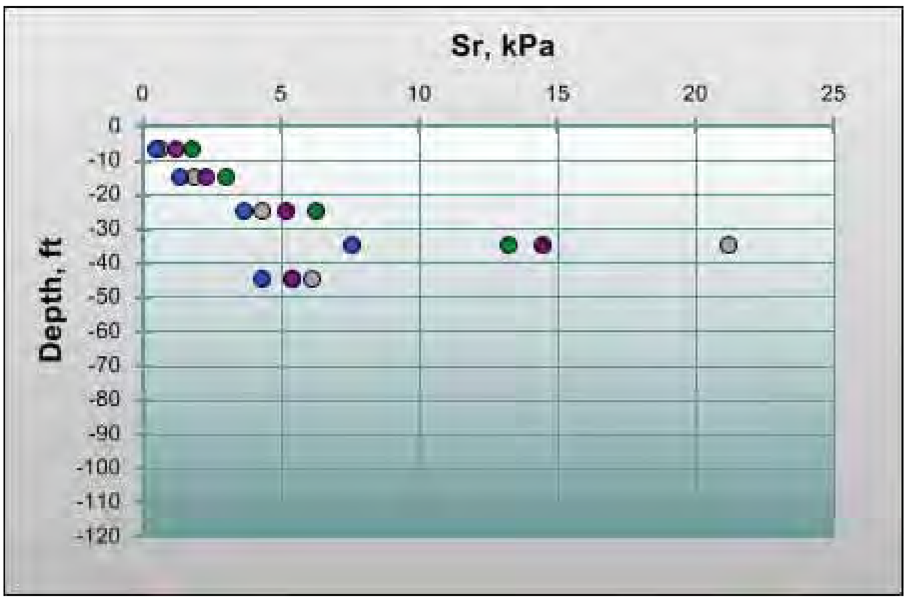

```
=== Effects ===
---------------------------------------------------


** Settlement **
----------------
>>>Multiple Scenario Results
Groud Surface Settlement MULTIPLE Scenario
Return Period (yrs) = 475
Model Selected :
   WSDOT Recommended (weighted average)
   using all deterministic models.
   -----------------------------------------
   Weighting factors = 0.25 for each model
-----------------------------------------


WSDOT Recommended:
=================
Total ground surface settlement = 3.29 ft
----------------------------------------------
  #    Depth thickness    ev    Weight    dh
          ft        ft     %              ft
----------------------------------------------
```

1	1.50	3.0	0.001	0.00	0.00
2	6.50	7.0	10.157	1.00	0.71
3	15.00	10.0	9.367	1.00	0.94
4	25.00	10.0	4.462	1.00	0.45
5	35.00	10.0	2.709	1.00	0.27
6	45.00	10.0	9.231	1.00	0.92
7	55.00	10.0	0.001	0.00	0.00
8	65.00	10.0	0.001	0.00	0.00
9	75.00	10.0	0.001	0.00	0.00
10	85.00	10.0	0.001	0.00	0.00
11	95.00	10.0	0.001	0.00	0.00
12	105.00	10.0	0.001	0.00	0.00
13	117.50	15.0	0.001	0.00	0.00




```
=== Effects ===
----------------------------------------------------


** Residual Strength **
-----------------------
====== Soil Layers Selected ==================
Layer 2
Layer 3

====== Models Selected =======================
Use recommended models:
  Kramer & Wang, Deterministic (KWD), w/ weighting factor = 0.5
  Idriss & Boulanger           (IDB), w/ weighting factor = 0.3
  Olson & Stark                (OLS), w/ weighting factor = 0.2
The residual strength is estimated as:
  Residual Strength =
    0.5*(Kramer & Wang) + 0.3*(Idriss & Boulanger) + 0.2*(Olson & Stark)

---------------------------------------------------------

###### Unweighted Residual Strength ####################
```

```
Kramer & Wang Deterministic Model:
   Layer 2:  Sr =    37 psf =   1.8 kPa = 0.018 atm
   Layer 3:  Sr =    63 psf =   3.0 kPa = 0.030 atm
------------------------------------------------------
Idriss & Boulanger Model:
   Layer 2:  Sr =    12 psf =   0.6 kPa = 0.006 atm
   Layer 3:  Sr =    38 psf =   1.8 kPa = 0.018 atm
------------------------------------------------------
Olson & Stark Model:
   Layer 2:  Sr =    10 psf =   0.5 kPa = 0.005 atm
   Layer 3:  Sr =    28 psf =   1.3 kPa = 0.013 atm
------------------------------------------------------
WSDOT Recommended Model:
   Layer 2:  Sr =    24 psf =   1.2 kPa = 0.011 atm
   Layer 3:  Sr =    48 psf =   2.3 kPa = 0.023 atm
------------------------------------------------------
```



Liquefaction Hazard Evaluation Report
by WSLiq Program beta (May, 2009)

Site Name: Lockheed West Seattle
Site Location (N,W) = 47.583 , 122.367
Job No: 106-8945
Analyst: TetraTech
Date: 10/14/2011 11:42:34 AM

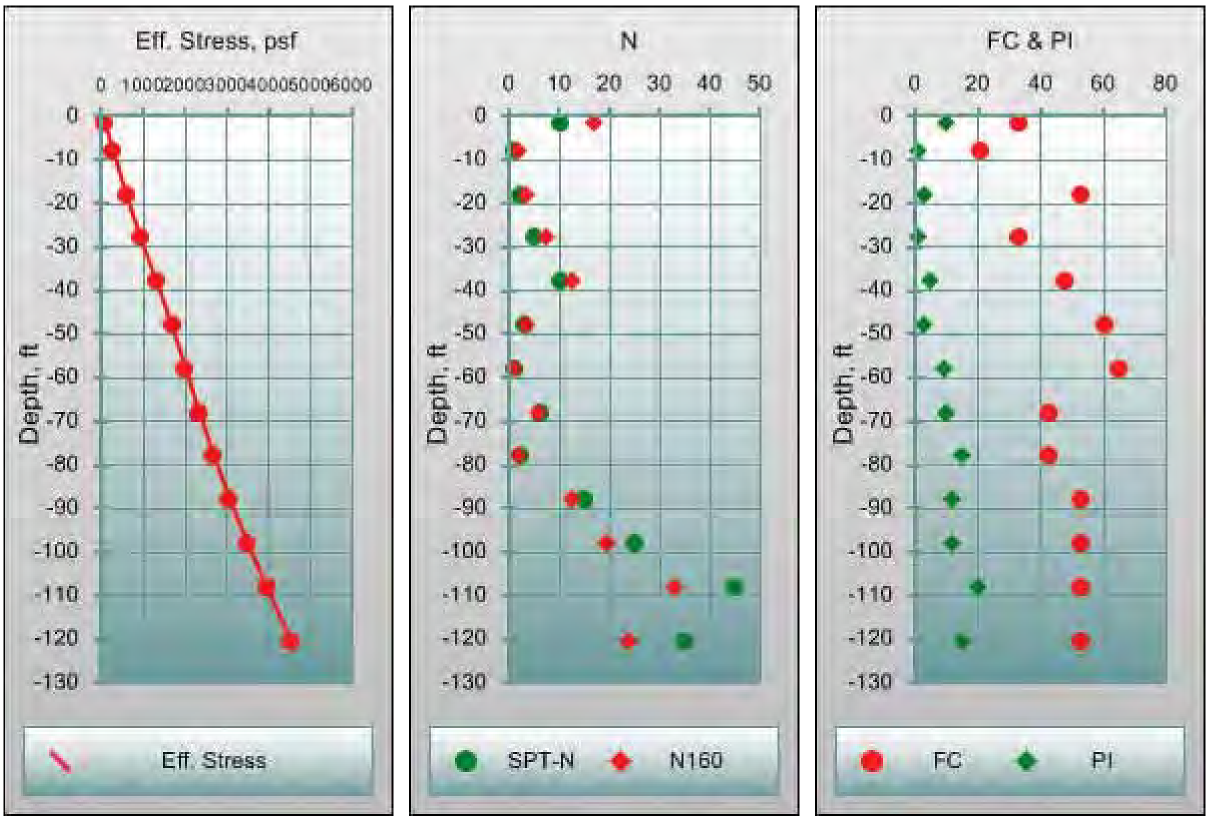
=== Soil Profile ===
Unit: ft
The number of soil layers: 13
GWT at top of layer: 1
GWT depth: 0.00
SPT Energy Ratio (%): 60.00
Amplification Factors: a= 0.1400 b= 0.0200
Elevation: 0.00
Ground Surface: Infinite Slope (%)= 0.2

Layer	Descpt.	Thickness (ft)	Unit Weight (lb/ft3)	Nm	N160	Vs ft/sec
1	Cap_layer	3	110.00	10	17.0	643.4
2	Loose_silty_sand	7	90.00	1	1.7	330.0
3	Soft_sandy_silt	10	95.00	2	3.4	403.5
4	Soft_silt	10	100.00	5	7.9	526.3
5	Medium_dense_silty_sand	10	100.00	10	13.1	643.4
6	Soft_silty_sand	10	100.00	3	3.4	453.8
7	Loose_silty_sand	10	90.00	1	1.0	330.0
8	Soft_silty_sand	10	100.00	6	5.8	554.9
9	Loose_silty_sand	10	95.00	2	1.8	403.5
10	Medium_dense_sand	10	105.00	15	12.6	723.7
11	Medium_dense_silty_sand	10	105.00	25	19.7	839.3
12	Dense_sand	10	110.00	45	33.3	995.3
13	Dense_sand	15	110.00	35	24.1	925.3

Layer	FC (%)	PI	wc/LL	D50 (mm)	Ini. Eff. Stress (psf)	Ini. Total Stress (psf)
1	33	10	0.9	3000	71.4	165.00
2	21	1	1	1128.0	239.4	645.00

3	53	3	0.9	1128.0	499.0	1435.00
4	33	1	1	1598.0	850.0	2410.00
5	47.5	5	0.9	1786.0	1226.0	3410.00
6	60.5	3	1	2068.0	1602.0	4410.00
7	65	9	0.9	2350.0	1928.0	5360.00
8	42.5	10	0.8	2726.0	2254.0	6310.00
9	42.5	15	1	3572.0	2605.0	7285.00
10	53	12	0.9	4700.0	2981.0	8285.00
11	53	12	0.9	3347.0	3407.0	9335.00
12	53	20	1	3773.0	3858.0	10410.00
13	53	15	0.9	4305.5	4453.0	11785.00

Soil Profile Plots



=== Susceptibility Evaluation ===

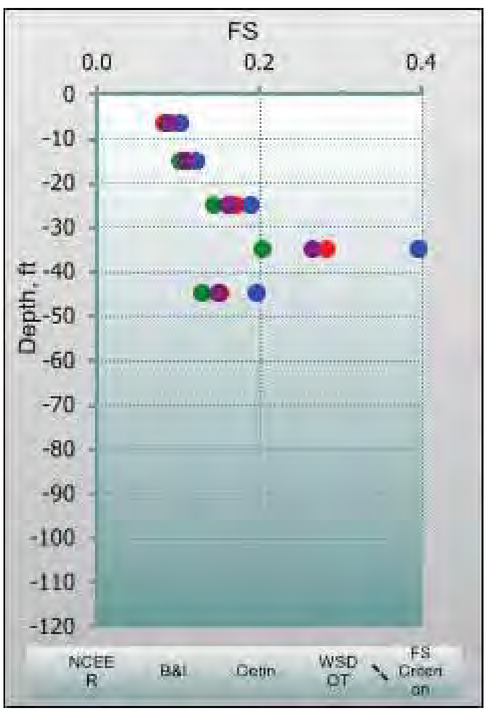
Threshold: 0.5

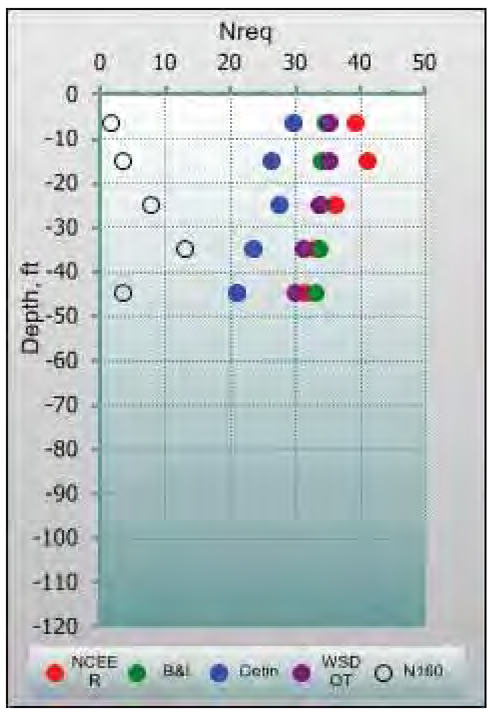
Weighting factors: B-I= 0.50 B-S= 0.50

Layer	PI	wc/LL	B-I	B-S	Suscep. Index	Potential
1	10.00	0.90	0.05	0.56	0.31	NO
2	1.00	1.00	1.00	0.76	0.88	YES
3	3.00	0.90	0.96	0.63	0.80	YES
4	1.00	1.00	1.00	0.76	0.88	YES
5	5.00	0.90	0.62	0.63	0.62	YES
6	3.00	1.00	0.96	0.76	0.86	YES
7	9.00	0.90	0.09	0.59	0.34	NO
8	10.00	0.80	0.05	0.41	0.23	NO
9	15.00	1.00	0.01	0.37	0.19	NO

```
   10  12.00   0.90  0.02  0.48          0.25         NO
   11  12.00   0.90  0.02  0.48          0.25         NO
   12  20.00   1.00  0.00  0.13          0.06         NO
   13  15.00   0.90  0.01  0.31          0.16         NO


=== Initiation ===
---------------------------------------------------

Initiation - Multiple Scenario
-----------------------------------------
Retrun Period (yrs) = 2475
Models Selected :
Use All Deterministic Models.
--WSDOT Recommended--
   Use NCEER, Boulanger & Idriss, and
   Cetin's model with weighting factors
   of 0.4, 0.4, and 0.2 respectively.
-----------------------------------------


===== Mean Mw and FS ==============
---NCEER Model------------
--- PGA = 0.754  Mw = 6.71---------

Layer  (N1)60    CSR     CRR     FS     Nreq
-----  ------  ------  ------  ------  ------
    2    1.70   0.938   0.077    0.08    39.2
    3    3.40   0.962   0.105    0.11    41.2
    4    7.89   0.892   0.152    0.17    36.3
    5   13.14   0.796   0.225    0.28    33.0
    6    3.45   0.692   0.106    0.15    31.6


===== Mean Mw and FS ==============
---Boulanger and Idriss Model------------
--- PGA = 0.754  Mw = 6.71---------

Layer  (N1)60    CSR     CRR     FS     Nreq
-----  ------  ------  ------  ------  ------
    2    1.70   1.068   0.094    0.09    34.6
    3    3.40   1.097   0.111    0.10    34.2
    4    8.35   1.021   0.146    0.14    34.0
    5   13.18   0.937   0.192    0.20    33.7
    6    3.58   0.861   0.112    0.13    33.3


===== Mean Mw and FS ==============
---Cetin et al. Model------------
--- PGA = 0.754  Mw = 6.71---------

Layer  (N1)60    CSR     CRR     FS     Nreq
-----  ------  ------  ------  ------  ------
    2    1.60   1.232   0.127    0.10    29.7
    3    3.20   1.126   0.137    0.12    26.5
    4    7.89   0.850   0.161    0.19    27.7
    5   13.14   0.639   0.253    0.40    23.7
```

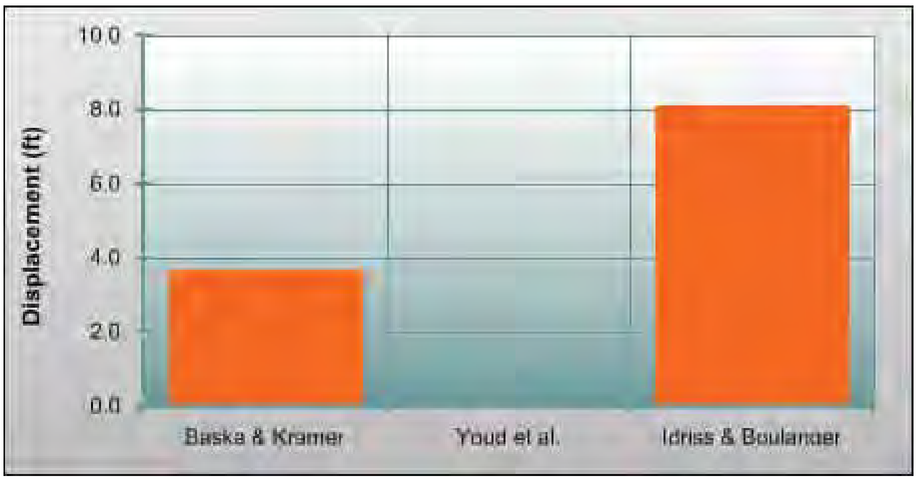
```
    6     3.45    0.534    0.105     0.20     21.0

---WSDOT Recommended------------
--- PGA = 0.754  Mw = 6.71---------

Layer  (N1)60    CSR      CRR      FS      Nreq
-----  ------  ------   ------   ------   ------
    2     1.70   1.049    0.094    0.09     35.5
    3     3.40   1.049    0.114    0.11     35.5
    4     7.89   0.935    0.151    0.16     33.7
    5    13.14   0.821    0.218    0.26     31.4
    6     3.45   0.728    0.108    0.15     30.2

  Table of FS
---------------------------------------
  #     Depth   NCEER     B&I     Cetin     WSDOT
          ft                     PL=0.60   PL=0.60
  2     -6.50    0.08    0.09      0.10      0.09
  3    -15.00    0.11    0.10      0.12      0.11
  4    -25.00    0.17    0.14      0.19      0.16
  5    -35.00    0.28    0.20      0.40      0.26
  6    -45.00    0.15    0.13      0.20      0.15
```





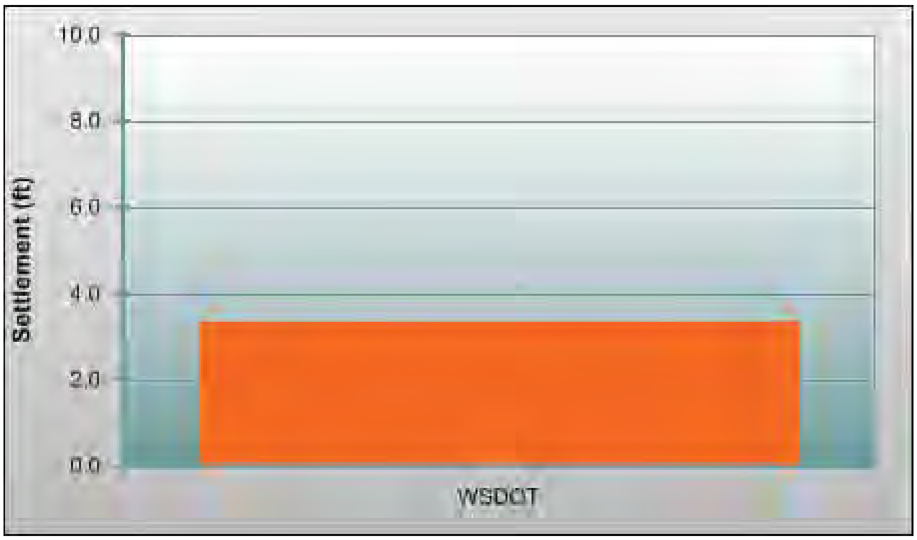

```
=== Effects ===
---------------------------------------------------


** Lateral Spreading **
-----------------------
>>>Multiple Scenario Results
```

```
Model Selected :
   WSDOT Recommended (weighted average)
   using models of Baska & Kramer and Youd et al.
-----------------------------------------

Baska & Kramer: 3.68 ft
Youd et al.: 0.00 ft
Idriss & Boulanger: 8.11 ft

----------------------------------------
Weighting factors: Baska and Kramer = 0.65
                   Youd et al.      = 0.35

 WSDOT Recommended: 2.39 ft
```



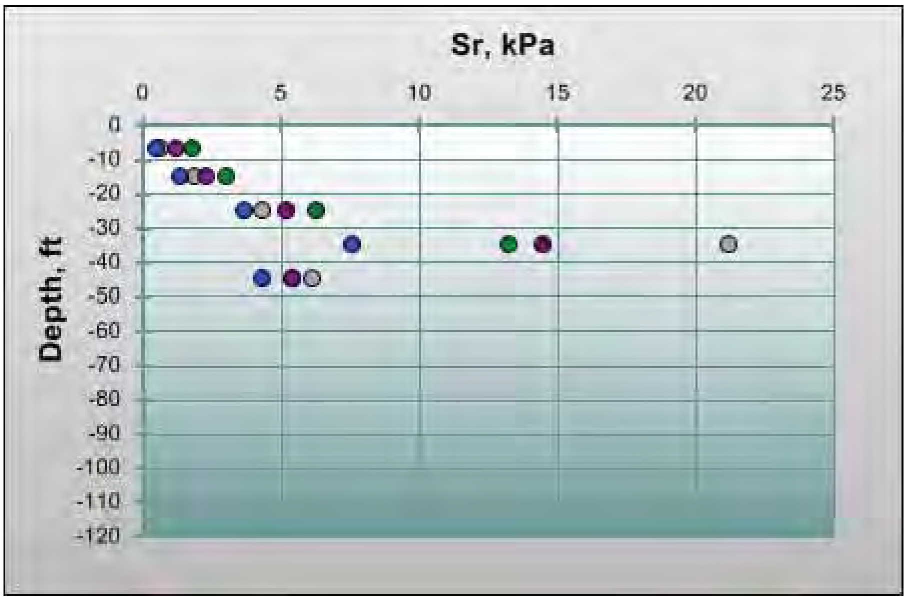

```
=== Effects ===
---------------------------------------------------


** Settlement **
----------------
>>>Multiple Scenario Results
Groud Surface Settlement MULTIPLE Scenario
Return Period (yrs) = 2475
Model Selected :
   WSDOT Recommended (weighted average)
   using all deterministic models.
   -----------------------------------------
   Weighting factors = 0.25 for each model
-----------------------------------------


WSDOT Recommended:
=================
Total ground surface settlement = 3.37 ft
----------------------------------------------
  #    Depth thickness    ev    Weight    dh
          ft        ft     %              ft
----------------------------------------------
```

```
  1     1.50       3.0   0.001    0.00    0.00
  2     6.50       7.0  10.232    1.00    0.72
  3    15.00      10.0   9.435    1.00    0.94
  4    25.00      10.0   4.658    1.00    0.47
  5    35.00      10.0   3.036    1.00    0.30
  6    45.00      10.0   9.416    1.00    0.94
  7    55.00      10.0   0.001    0.00    0.00
  8    65.00      10.0   0.001    0.00    0.00
  9    75.00      10.0   0.001    0.00    0.00
 10    85.00      10.0   0.001    0.00    0.00
 11    95.00      10.0   0.001    0.00    0.00
 12   105.00      10.0   0.001    0.00    0.00
 13   117.50      15.0   0.001    0.00    0.00
----------------------------------------------
```




```
=== Effects ===
---------------------------------------------------


** Residual Strength **
-----------------------
====== Soil Layers Selected ==================
Layer 2
Layer 3

====== Models Selected ======================
Use recommended models:
  Kramer & Wang, Deterministic (KWD), w/ weighting factor = 0.5
  Idriss & Boulanger           (IDB), w/ weighting factor = 0.3
  Olson & Stark                (OLS), w/ weighting factor = 0.2
The residual strength is estimated as:
  Residual Strength =
    0.5*(Kramer & Wang) + 0.3*(Idriss & Boulanger) + 0.2*(Olson & Stark)

--------------------------------------------------------

###### Unweighted Residual Strength ####################
```

```
Kramer & Wang Deterministic Model:
   Layer 2:  Sr =    37 psf =   1.8 kPa = 0.018 atm
   Layer 3:  Sr =    63 psf =   3.0 kPa = 0.030 atm
------------------------------------------------------
Idriss & Boulanger Model:
   Layer 2:  Sr =    12 psf =   0.6 kPa = 0.006 atm
   Layer 3:  Sr =    38 psf =   1.8 kPa = 0.018 atm
------------------------------------------------------
Olson & Stark Model:
   Layer 2:  Sr =    10 psf =   0.5 kPa = 0.005 atm
   Layer 3:  Sr =    28 psf =   1.3 kPa = 0.013 atm
------------------------------------------------------
WSDOT Recommended Model:
   Layer 2:  Sr =    24 psf =   1.2 kPa = 0.011 atm
   Layer 3:  Sr =    48 psf =   2.3 kPa = 0.023 atm
------------------------------------------------------
```



Liquefaction Hazard Evaluation Report
by WSLiq Program beta (May, 2009)

Site Name: Lockheed West Seattle
Site Location (N,W) = 47.583 , 122.367
Job No: 106-8945
Analyst: TetraTech
Date: 10/14/2011 12:58:48 PM

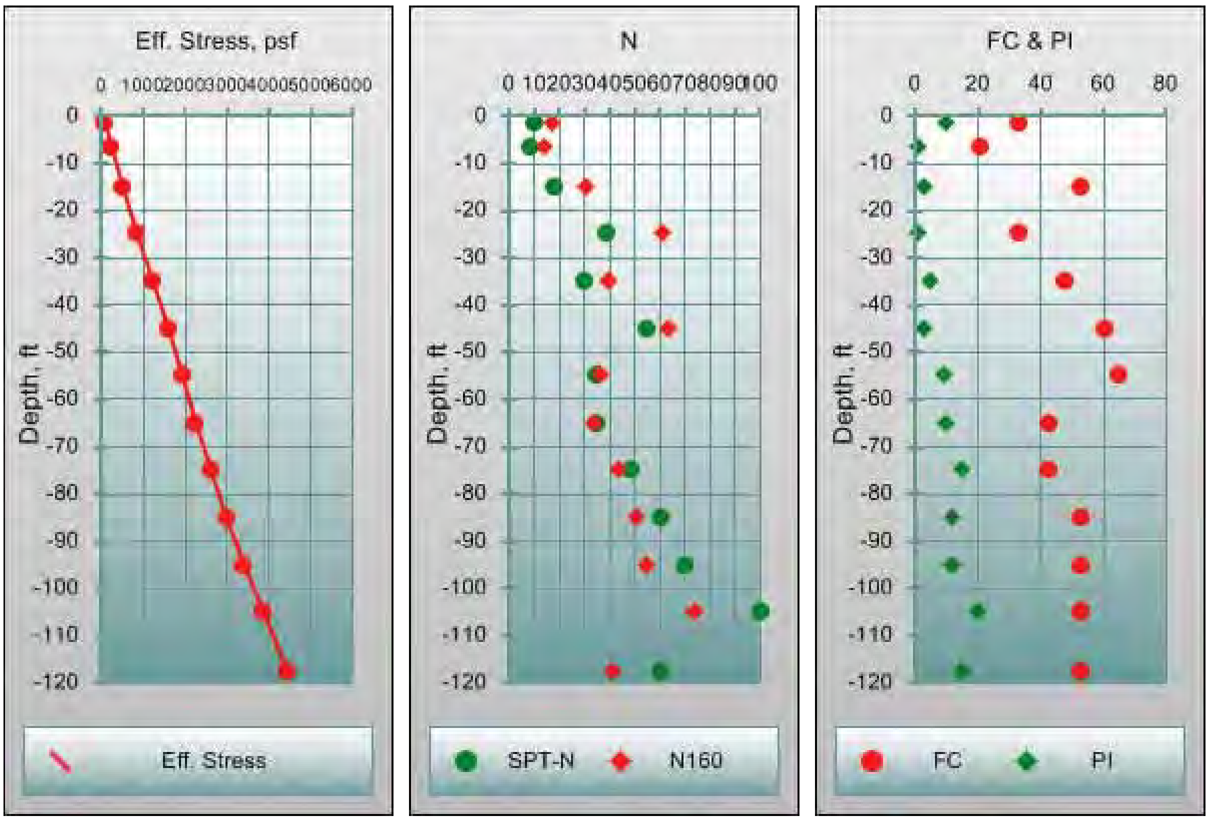
=== Soil Profile ===
Unit: ft
The number of soil layers: 13
GWT at top of layer: 1
GWT depth: 0.00
SPT Energy Ratio (%): 60.00
Amplification Factors: a= 0.1400 b= 0.0200
Elevation: 0.00
Ground Surface: Infinite Slope (%)= 0.2

Layer	Descpt.	Thickness (ft)	Unit Weight (lb/ft3)	Nm	N160	Vs ft/sec
1	Cap_layer	3	110.00	10	17.0	643.4
2	Loose_silty_sand	7	90.00	8	13.6	603.1
3	Soft_sandy_silt	10	95.00	18	30.6	763.0
4	Soft_silt	10	100.00	39	61.5	954.8
5	Medium_dense_silty_sand	10	100.00	30	39.4	884.9
6	Soft_silty_sand	10	100.00	55	63.2	1054.9
7	Loose_silty_sand	10	90.00	35	36.7	925.3
8	Soft_silty_sand	10	100.00	35	33.9	925.3
9	Loose_silty_sand	10	95.00	48	43.3	1014.1
10	Medium_dense_sand	10	105.00	60	50.6	1081.9
11	Medium_dense_silty_sand	10	105.00	70	55.2	1131.3
12	Dense_sand	10	110.00	100	74.1	1254.6
13	Dense_sand	15	110.00	60	41.4	1081.9

Layer	FC (%)	PI	wc/LL	D50 (mm)	Ini. Eff. Stress (psf)	Ini. Total Stress (psf)
1	33	10	0.9	3000	71.4	165.00
2	21	1	1	1128.0	239.4	645.00

3	53	3	0.9	1128.0	499.0	1435.00
4	33	1	1	1598.0	850.0	2410.00
5	47.5	5	0.9	1786.0	1226.0	3410.00
6	60.5	3	1	2068.0	1602.0	4410.00
7	65	9	0.9	2350.0	1928.0	5360.00
8	42.5	10	0.8	2726.0	2254.0	6310.00
9	42.5	15	1	3572.0	2605.0	7285.00
10	53	12	0.9	4700.0	2981.0	8285.00
11	53	12	0.9	3347.0	3407.0	9335.00
12	53	20	1	3773.0	3858.0	10410.00
13	53	15	0.9	4305.5	4453.0	11785.00

Soil Profile Plots




```
=== Susceptibility Evaluation ===
-------------------------------------------------------
Threshold: 0.5
Weighting factors: B-I= 0.50   B-S= 0.50
-------------------------------------------------------
Layer      PI  wc/LL    B-I    B-S  Suscep. Index  Potential
    1  10.00    0.90  0.05  0.56          0.31          NO
    2   1.00    1.00  1.00  0.76          0.88         YES
    3   3.00    0.90  0.96  0.63          0.80         YES
    4   1.00    1.00  1.00  0.76          0.88         YES
    5   5.00    0.90  0.62  0.63          0.62         YES
    6   3.00    1.00  0.96  0.76          0.86         YES
    7   9.00    0.90  0.09  0.59          0.34          NO
    8  10.00    0.80  0.05  0.41          0.23          NO
    9  15.00    1.00  0.01  0.37          0.19          NO
```

10	12.00	0.90	0.02	0.48	0.25	NO
11	12.00	0.90	0.02	0.48	0.25	NO
12	20.00	1.00	0.00	0.13	0.06	NO
13	15.00	0.90	0.01	0.31	0.16	NO

=== Initiation ===

Initiation - Multiple Scenario

Retrun Period (yrs) = 108
Models Selected :
Use All Deterministic Models.
--WSDOT Recommended--
Use NCEER, Boulanger & Idriss, and
Cetin's model with weighting factors
of 0.4, 0.4, and 0.2 respectively.

===== Mean Mw and FS ==============
---NCEER Model------------
--- PGA = 0.176 Mw = 6.46---------

Layer	(N1)60	CSR	CRR	FS	Nreq
2	13.60	0.202	0.198	0.98	17.6
3	30.60	0.207	3.000	14.46	18.0
4	61.54	0.192	3.000	15.60	16.9
5	39.41	0.172	3.000	17.48	15.2
6	63.21	0.149	3.000	20.11	13.2

===== Mean Mw and FS ==============
---Boulanger and Idriss Model------------
--- PGA = 0.176 Mw = 6.46---------

Layer	(N1)60	CSR	CRR	FS	Nreq
2	13.60	0.239	0.186	0.78	21.4
3	30.33	0.245	1.360	5.54	21.7
4	46.00	0.228	3.000	13.16	20.4
5	35.81	0.209	3.000	14.35	18.8
6	46.00	0.192	3.000	15.61	17.2

===== Mean Mw and FS ==============
---Cetin et al. Model------------
--- PGA = 0.176 Mw = 6.46---------

Layer	(N1)60	CSR	CRR	FS	Nreq
2	12.80	0.307	0.358	1.16	11.5
3	28.80	0.325	1.594	4.90	11.8
4	61.54	0.314	3.000	9.56	14.9
5	39.41	0.293	2.642	9.00	13.9

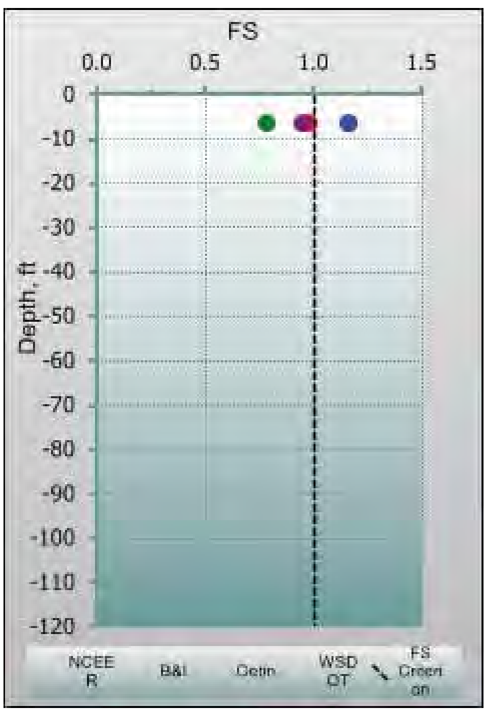
6	63.21	0.269	3.000	11.17	12.7

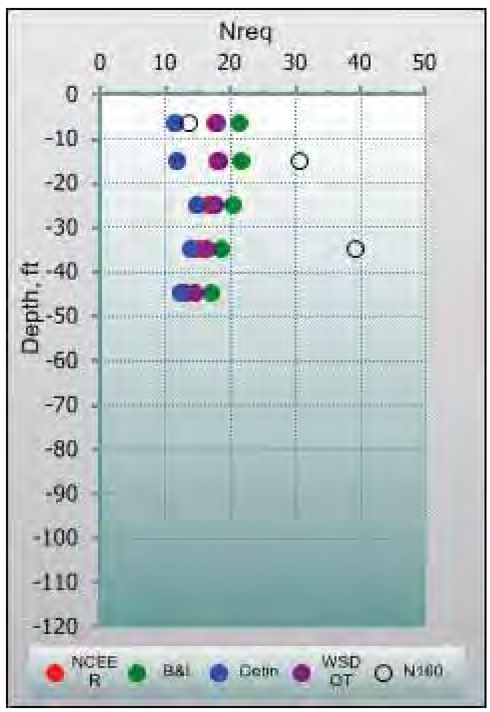
---WSDOT Recommended------------
--- PGA = 0.176 Mw = 6.46---------

Layer	(N1)60	CSR	CRR	FS	Nreq
2	13.60	0.238	0.225	0.95	17.9
3	30.60	0.246	2.063	8.38	18.3
4	61.54	0.231	3.000	12.99	17.9
5	39.41	0.211	2.928	13.88	16.4
6	63.21	0.190	3.000	15.77	14.7

Table of FS

#	Depth ft	NCEER	B&I	Cetin PL=0.60	WSDOT PL=0.60
2	-6.50	0.98	0.78	1.16	0.95
3	-15.00	14.46	5.54	4.90	8.38
4	-25.00	15.60	13.16	9.56	12.99
5	-35.00	17.48	14.35	9.00	13.88
6	-45.00	20.11	15.61	11.17	15.77



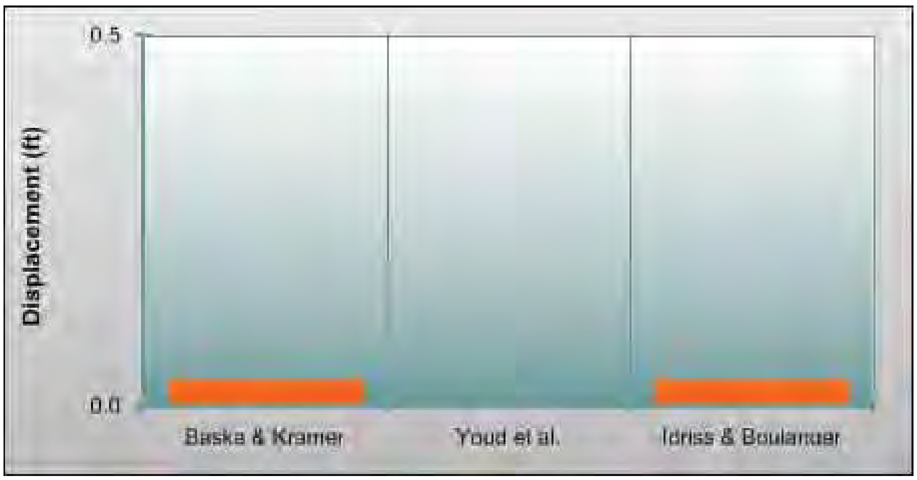


=== Effects ===

** Lateral Spreading **

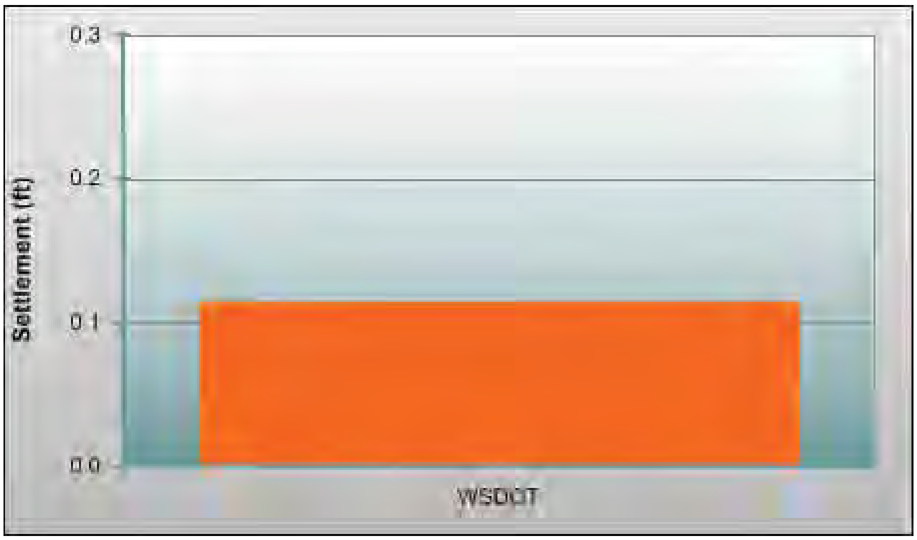
>>>Multiple Scenario Results

```
Model Selected :
   WSDOT Recommended (weighted average)
   using models of Baska & Kramer and Youd et al.
-----------------------------------------

Baska & Kramer: 0.04 ft
Youd et al.: 0.00 ft
Idriss & Boulanger: 0.04 ft

----------------------------------------
Weighting factors: Baska and Kramer = 0.65
                   Youd et al.      = 0.35

 WSDOT Recommended: 0.02 ft
```



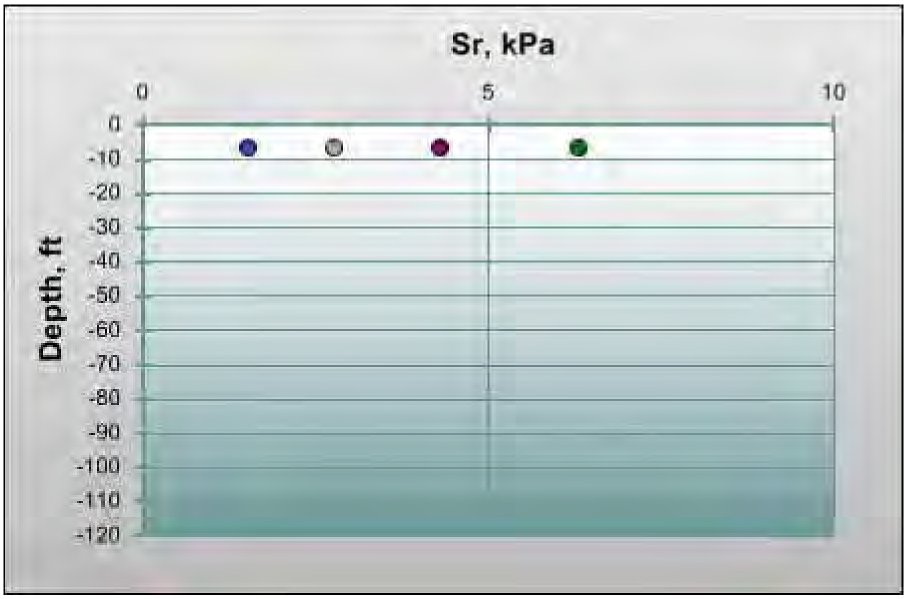

```
=== Effects ===
---------------------------------------------------


** Settlement **
----------------
>>>Multiple Scenario Results
Groud Surface Settlement MULTIPLE Scenario
Return Period (yrs) = 108
Model Selected :
   WSDOT Recommended (weighted average)
   using all deterministic models.
   -----------------------------------------
   Weighting factors = 0.25 for each model
-----------------------------------------


WSDOT Recommended:
=================
Total ground surface settlement = 0.11 ft
----------------------------------------------
  #    Depth thickness    ev    Weight    dh
          ft        ft     %              ft
----------------------------------------------
```

```
  1     1.50       3.0  0.001    0.00    0.00
  2     6.50       7.0  1.625    1.00    0.11
  3    15.00      10.0  0.137    0.24    0.00
  4    25.00      10.0  0.001    0.00    0.00
  5    35.00      10.0  0.126    0.00    0.00
  6    45.00      10.0  0.001    0.00    0.00
  7    55.00      10.0  0.001    0.00    0.00
  8    65.00      10.0  0.001    0.00    0.00
  9    75.00      10.0  0.001    0.00    0.00
 10    85.00      10.0  0.001    0.00    0.00
 11    95.00      10.0  0.001    0.00    0.00
 12   105.00      10.0  0.001    0.00    0.00
 13   117.50      15.0  0.001    0.00    0.00
----------------------------------------------
```




```
=== Effects ===
---------------------------------------------------


** Residual Strength **
-----------------------
====== Soil Layers Selected ==================
Layer 2

====== Models Selected ======================
Use recommended models:
  Kramer & Wang, Deterministic (KWD), w/ weighting factor = 0.5
  Idriss & Boulanger           (IDB), w/ weighting factor = 0.3
  Olson & Stark                (OLS), w/ weighting factor = 0.2
The residual strength is estimated as:
  Residual Strength =
    0.5*(Kramer & Wang) + 0.3*(Idriss & Boulanger) + 0.2*(Olson & Stark)

--------------------------------------------------------

###### Unweighted Residual Strength ####################
```

```
Kramer & Wang Deterministic Model:
   Layer 2:  Sr =   132 psf =   6.3 kPa = 0.062 atm
------------------------------------------------------
Idriss & Boulanger Model:
   Layer 2:  Sr =    58 psf =   2.8 kPa = 0.027 atm
------------------------------------------------------
Olson & Stark Model:
   Layer 2:  Sr =    32 psf =   1.5 kPa = 0.015 atm
------------------------------------------------------
WSDOT Recommended Model:
   Layer 2:  Sr =    90 psf =   4.3 kPa = 0.042 atm
------------------------------------------------------
```



Liquefaction Hazard Evaluation Report
by WSLiq Program beta (May, 2009)

Site Name: Lockheed West Seattle
Site Location (N,W) = 47.583 , 122.367
Job No: 106-8945
Analyst: TetraTech
Date: 10/14/2011 1:00:46 PM

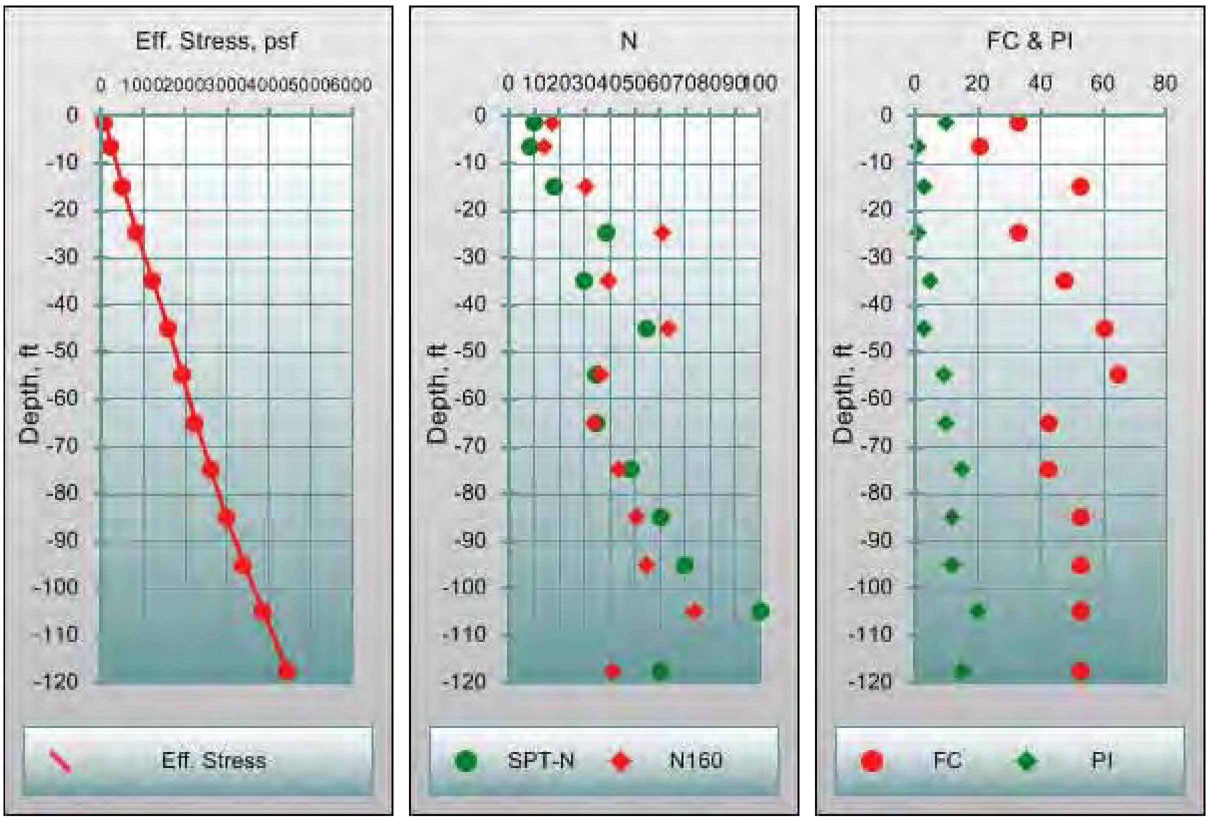
=== Soil Profile ===
Unit: ft
The number of soil layers: 13
GWT at top of layer: 1
GWT depth: 0.00
SPT Energy Ratio (%): 60.00
Amplification Factors: a= 0.1400 b= 0.0200
Elevation: 0.00
Ground Surface: Infinite Slope (%)= 0.2

Layer	Descpt.	Thickness (ft)	Unit Weight (lb/ft3)	Nm	N160	Vs ft/sec
1	Cap_layer	3	110.00	10	17.0	643.4
2	Loose_silty_sand	7	90.00	8	13.6	603.1
3	Soft_sandy_silt	10	95.00	18	30.6	763.0
4	Soft_silt	10	100.00	39	61.5	954.8
5	Medium_dense_silty_sand	10	100.00	30	39.4	884.9
6	Soft_silty_sand	10	100.00	55	63.2	1054.9
7	Loose_silty_sand	10	90.00	35	36.7	925.3
8	Soft_silty_sand	10	100.00	35	33.9	925.3
9	Loose_silty_sand	10	95.00	48	43.3	1014.1
10	Medium_dense_sand	10	105.00	60	50.6	1081.9
11	Medium_dense_silty_sand	10	105.00	70	55.2	1131.3
12	Dense_sand	10	110.00	100	74.1	1254.6
13	Dense_sand	15	110.00	60	41.4	1081.9

Layer	FC (%)	PI	wc/LL	D50 (mm)	Ini. Eff. Stress (psf)	Ini. Total Stress (psf)
1	33	10	0.9	3000	71.4	165.00
2	21	1	1	1128.0	239.4	645.00

3	53	3	0.9	1128.0	499.0	1435.00
4	33	1	1	1598.0	850.0	2410.00
5	47.5	5	0.9	1786.0	1226.0	3410.00
6	60.5	3	1	2068.0	1602.0	4410.00
7	65	9	0.9	2350.0	1928.0	5360.00
8	42.5	10	0.8	2726.0	2254.0	6310.00
9	42.5	15	1	3572.0	2605.0	7285.00
10	53	12	0.9	4700.0	2981.0	8285.00
11	53	12	0.9	3347.0	3407.0	9335.00
12	53	20	1	3773.0	3858.0	10410.00
13	53	15	0.9	4305.5	4453.0	11785.00

Soil Profile Plots



=== Susceptibility Evaluation ===

Threshold: 0.5

Weighting factors: B-I= 0.50   B-S= 0.50

Layer	PI	wc/LL	B-I	B-S	Suscep. Index	Potential
1	10.00	0.90	0.05	0.56	0.31	NO
2	1.00	1.00	1.00	0.76	0.88	YES
3	3.00	0.90	0.96	0.63	0.80	YES
4	1.00	1.00	1.00	0.76	0.88	YES
5	5.00	0.90	0.62	0.63	0.62	YES
6	3.00	1.00	0.96	0.76	0.86	YES
7	9.00	0.90	0.09	0.59	0.34	NO
8	10.00	0.80	0.05	0.41	0.23	NO
9	15.00	1.00	0.01	0.37	0.19	NO

10	12.00	0.90	0.02	0.48	0.25	NO
11	12.00	0.90	0.02	0.48	0.25	NO
12	20.00	1.00	0.00	0.13	0.06	NO
13	15.00	0.90	0.01	0.31	0.16	NO

=== Initiation ===

Initiation - Multiple Scenario

Retrun Period (yrs) = 475
Models Selected :
Use All Deterministic Models.
--WSDOT Recommended--
Use NCEER, Boulanger & Idriss, and
Cetin's model with weighting factors
of 0.4, 0.4, and 0.2 respectively.

===== Mean Mw and FS ==============
---NCEER Model------------
--- PGA = 0.378 Mw = 6.58---------

Layer	(N1)60	CSR	CRR	FS	Nreq
2	13.60	0.453	0.198	0.44	28.6
3	30.60	0.464	3.000	6.46	28.8
4	61.54	0.430	3.000	6.97	28.1
5	39.41	0.384	3.000	7.81	26.9
6	63.21	0.334	3.000	8.99	25.3

===== Mean Mw and FS ==============
---Boulanger and Idriss Model------------
--- PGA = 0.378 Mw = 6.58---------

Layer	(N1)60	CSR	CRR	FS	Nreq
2	13.60	0.525	0.186	0.35	30.3
3	30.33	0.539	1.360	2.52	30.4
4	46.00	0.502	3.000	5.98	29.8
5	35.81	0.460	3.000	6.52	29.1
6	46.00	0.424	3.000	7.08	28.2

===== Mean Mw and FS ==============
---Cetin et al. Model------------
--- PGA = 0.378 Mw = 6.58---------

Layer	(N1)60	CSR	CRR	FS	Nreq
2	12.80	0.660	0.338	0.51	21.5
3	28.80	0.699	1.508	2.16	20.7
4	61.54	0.673	3.000	4.46	24.4
5	39.41	0.625	2.598	4.15	22.9

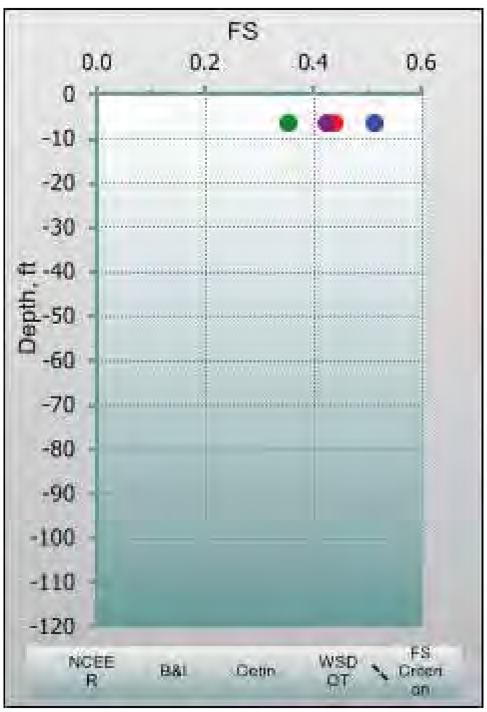
6	63.21	0.567	3.000	5.29	21.2

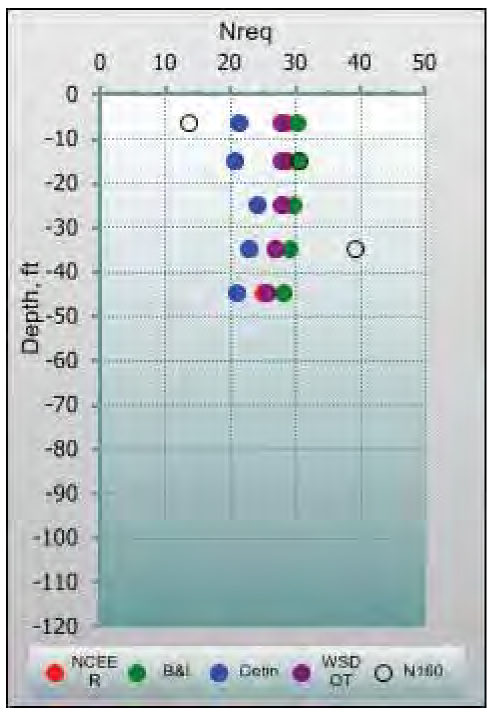
---WSDOT Recommended------------
--- PGA = 0.378 Mw = 6.58---------

Layer	(N1)60	CSR	CRR	FS	Nreq
2	13.60	0.523	0.221	0.42	27.8
3	30.60	0.541	2.045	3.78	27.8
4	61.54	0.507	3.000	5.91	28.1
5	39.41	0.463	2.920	6.31	27.0
6	63.21	0.416	3.000	7.20	25.6

Table of FS

#	Depth ft	NCEER	B&I	Cetin PL=0.60	WSDOT PL=0.60
2	-6.50	0.44	0.35	0.51	0.42
3	-15.00	6.46	2.52	2.16	3.78
4	-25.00	6.97	5.98	4.46	5.91
5	-35.00	7.81	6.52	4.15	6.31
6	-45.00	8.99	7.08	5.29	7.20



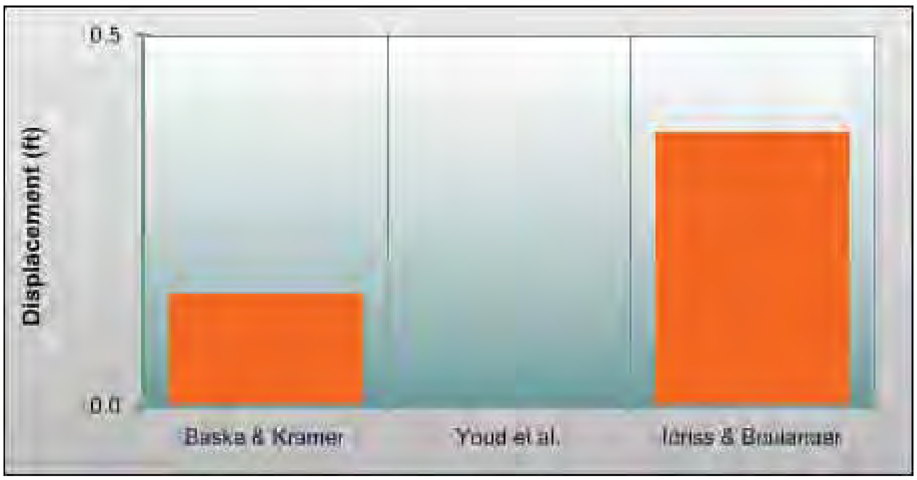


=== Effects ===

** Lateral Spreading **

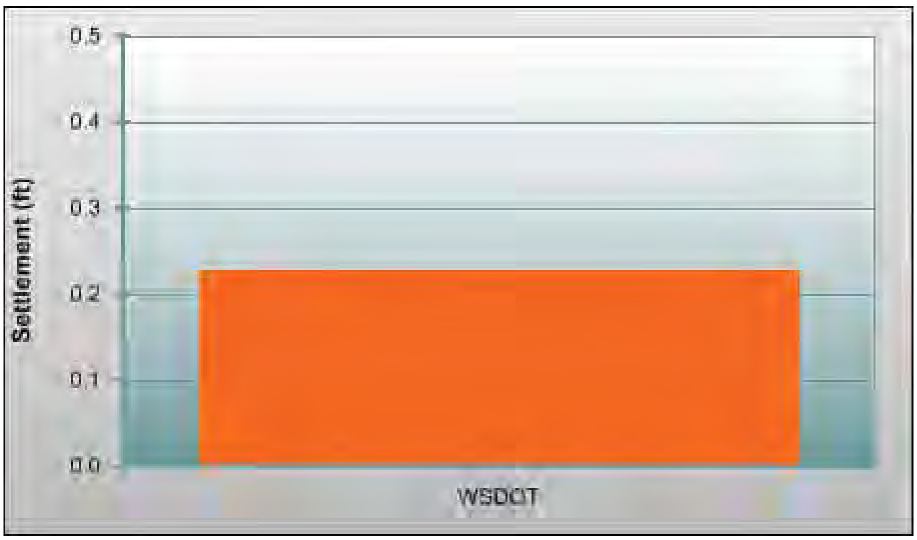
>>>Multiple Scenario Results

```
Model Selected :
   WSDOT Recommended (weighted average)
   using models of Baska & Kramer and Youd et al.
-----------------------------------------

Baska & Kramer: 0.15 ft
Youd et al.: 0.00 ft
Idriss & Boulanger: 0.37 ft

----------------------------------------
Weighting factors: Baska and Kramer = 0.65
                   Youd et al.      = 0.35

 WSDOT Recommended: 0.10 ft
```



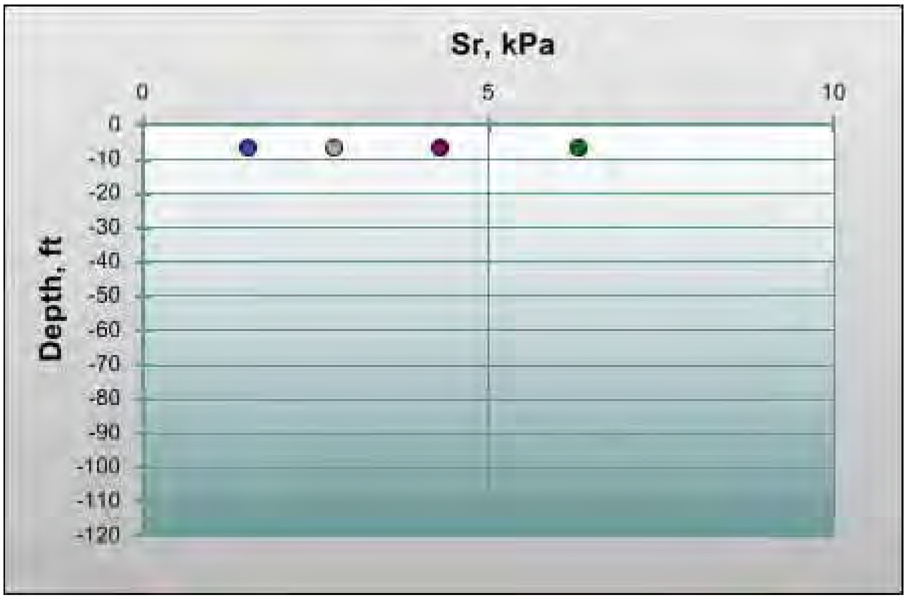

```
=== Effects ===
---------------------------------------------------


** Settlement **
----------------
>>>Multiple Scenario Results
Groud Surface Settlement MULTIPLE Scenario
Return Period (yrs) = 475
Model Selected :
   WSDOT Recommended (weighted average)
   using all deterministic models.
   -----------------------------------------
   Weighting factors = 0.25 for each model
-----------------------------------------


WSDOT Recommended:
=================
Total ground surface settlement = 0.23 ft
----------------------------------------------
  #    Depth thickness    ev    Weight    dh
          ft        ft     %              ft
----------------------------------------------
```

1	1.50	3.0	0.001	0.00	0.00
2	6.50	7.0	2.951	1.00	0.21
3	15.00	10.0	0.259	0.80	0.02
4	25.00	10.0	0.001	0.00	0.00
5	35.00	10.0	0.126	0.10	0.00
6	45.00	10.0	0.001	0.00	0.00
7	55.00	10.0	0.001	0.00	0.00
8	65.00	10.0	0.001	0.00	0.00
9	75.00	10.0	0.001	0.00	0.00
10	85.00	10.0	0.001	0.00	0.00
11	95.00	10.0	0.001	0.00	0.00
12	105.00	10.0	0.001	0.00	0.00
13	117.50	15.0	0.001	0.00	0.00




```
=== Effects ===
---------------------------------------------------


** Residual Strength **
-----------------------
====== Soil Layers Selected ==================
Layer 2

====== Models Selected =======================
Use recommended models:
  Kramer & Wang, Deterministic (KWD), w/ weighting factor = 0.5
  Idriss & Boulanger           (IDB), w/ weighting factor = 0.3
  Olson & Stark                (OLS), w/ weighting factor = 0.2
The residual strength is estimated as:
  Residual Strength =
    0.5*(Kramer & Wang) + 0.3*(Idriss & Boulanger) + 0.2*(Olson & Stark)

--------------------------------------------------------

###### Unweighted Residual Strength ####################
```

```
Kramer & Wang Deterministic Model:
   Layer 2:  Sr =   132 psf =   6.3 kPa = 0.062 atm
------------------------------------------------------
Idriss & Boulanger Model:
   Layer 2:  Sr =    58 psf =   2.8 kPa = 0.027 atm
------------------------------------------------------
Olson & Stark Model:
   Layer 2:  Sr =    32 psf =   1.5 kPa = 0.015 atm
------------------------------------------------------
WSDOT Recommended Model:
   Layer 2:  Sr =    90 psf =   4.3 kPa = 0.042 atm
------------------------------------------------------
```



Liquefaction Hazard Evaluation Report
by WSLiq Program beta (May, 2009)

Site Name: Lockheed West Seattle
Site Location (N,W) = 47.583 , 122.367
Job No: 106-8945
Analyst: TetraTech
Date: 10/14/2011 1:02:10 PM

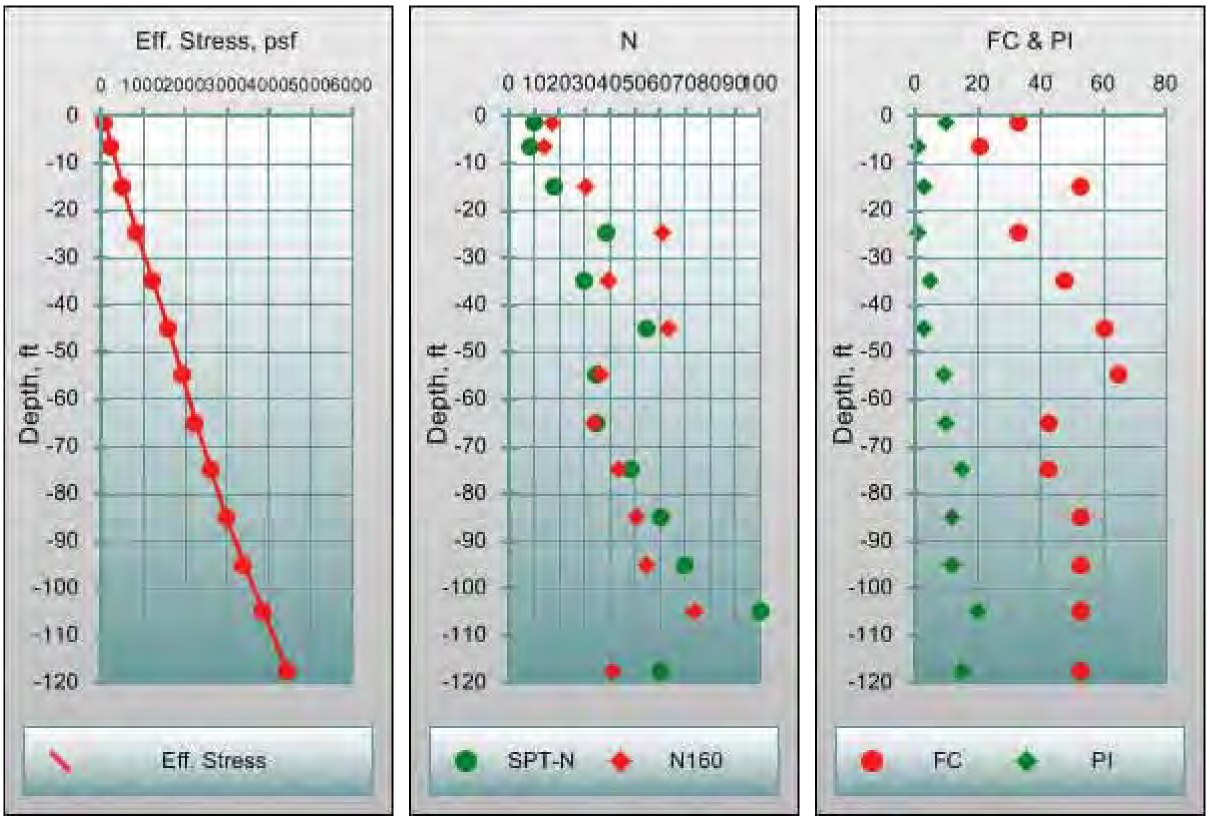
=== Soil Profile ===
Unit: ft
The number of soil layers: 13
GWT at top of layer: 1
GWT depth: 0.00
SPT Energy Ratio (%): 60.00
Amplification Factors: a= 0.1400 b= 0.0200
Elevation: 0.00
Ground Surface: Infinite Slope (%)= 0.2

Layer	Descpt.	Thickness (ft)	Unit Weight (lb/ft3)	Nm	N160	Vs ft/sec
1	Cap_layer	3	110.00	10	17.0	643.4
2	Loose_silty_sand	7	90.00	8	13.6	603.1
3	Soft_sandy_silt	10	95.00	18	30.6	763.0
4	Soft_silt	10	100.00	39	61.5	954.8
5	Medium_dense_silty_sand	10	100.00	30	39.4	884.9
6	Soft_silty_sand	10	100.00	55	63.2	1054.9
7	Loose_silty_sand	10	90.00	35	36.7	925.3
8	Soft_silty_sand	10	100.00	35	33.9	925.3
9	Loose_silty_sand	10	95.00	48	43.3	1014.1
10	Medium_dense_sand	10	105.00	60	50.6	1081.9
11	Medium_dense_silty_sand	10	105.00	70	55.2	1131.3
12	Dense_sand	10	110.00	100	74.1	1254.6
13	Dense_sand	15	110.00	60	41.4	1081.9

Layer	FC (%)	PI	wc/LL	D50 (mm)	Ini. Eff. Stress (psf)	Ini. Total Stress (psf)
1	33	10	0.9	3000	71.4	165.00
2	21	1	1	1128.0	239.4	645.00

3	53	3	0.9	1128.0	499.0	1435.00
4	33	1	1	1598.0	850.0	2410.00
5	47.5	5	0.9	1786.0	1226.0	3410.00
6	60.5	3	1	2068.0	1602.0	4410.00
7	65	9	0.9	2350.0	1928.0	5360.00
8	42.5	10	0.8	2726.0	2254.0	6310.00
9	42.5	15	1	3572.0	2605.0	7285.00
10	53	12	0.9	4700.0	2981.0	8285.00
11	53	12	0.9	3347.0	3407.0	9335.00
12	53	20	1	3773.0	3858.0	10410.00
13	53	15	0.9	4305.5	4453.0	11785.00

Soil Profile Plots




```
=== Susceptibility Evaluation ===
-------------------------------------------------------
Threshold: 0.5
Weighting factors: B-I= 0.50  B-S= 0.50
-------------------------------------------------------
Layer      PI  wc/LL   B-I   B-S  Suscep. Index  Potential
    1  10.00   0.90  0.05  0.56          0.31         NO
    2   1.00   1.00  1.00  0.76          0.88        YES
    3   3.00   0.90  0.96  0.63          0.80        YES
    4   1.00   1.00  1.00  0.76          0.88        YES
    5   5.00   0.90  0.62  0.63          0.62        YES
    6   3.00   1.00  0.96  0.76          0.86        YES
    7   9.00   0.90  0.09  0.59          0.34         NO
    8  10.00   0.80  0.05  0.41          0.23         NO
    9  15.00   1.00  0.01  0.37          0.19         NO
```

```
   10  12.00   0.90  0.02  0.48          0.25         NO
   11  12.00   0.90  0.02  0.48          0.25         NO
   12  20.00   1.00  0.00  0.13          0.06         NO
   13  15.00   0.90  0.01  0.31          0.16         NO


=== Initiation ===
---------------------------------------------------

Initiation - Multiple Scenario
-----------------------------------------
Retrun Period (yrs) = 2475
Models Selected :
Use All Deterministic Models.
--WSDOT Recommended--
   Use NCEER, Boulanger & Idriss, and
   Cetin's model with weighting factors
   of 0.4, 0.4, and 0.2 respectively.
-----------------------------------------


===== Mean Mw and FS ==============
---NCEER Model------------
--- PGA = 0.754  Mw = 6.71---------

Layer  (N1)60    CSR     CRR     FS     Nreq
-----  ------  ------  ------  ------  ------
    2   13.60   0.938   0.198    0.21    39.2
    3   30.60   0.962   3.000    3.12    41.2
    4   61.54   0.892   3.000    3.36    36.3
    5   39.41   0.796   3.000    3.77    33.0
    6   63.21   0.692   3.000    4.34    31.6


===== Mean Mw and FS ==============
---Boulanger and Idriss Model------------
--- PGA = 0.754  Mw = 6.71---------

Layer  (N1)60    CSR     CRR     FS     Nreq
-----  ------  ------  ------  ------  ------
    2   13.60   1.068   0.186    0.17    34.6
    3   30.33   1.097   1.360    1.24    34.2
    4   46.00   1.021   3.000    2.94    34.0
    5   35.81   0.937   3.000    3.20    33.7
    6   46.00   0.861   3.000    3.48    33.3


===== Mean Mw and FS ==============
---Cetin et al. Model------------
--- PGA = 0.754  Mw = 6.71---------

Layer  (N1)60    CSR     CRR     FS     Nreq
-----  ------  ------  ------  ------  ------
    2   12.80   1.315   0.316    0.24    30.5
    3   28.80   1.390   1.411    1.02    28.8
    4   61.54   1.331   3.000    2.25    33.0
    5   39.41   1.224   2.541    2.08    31.0
```

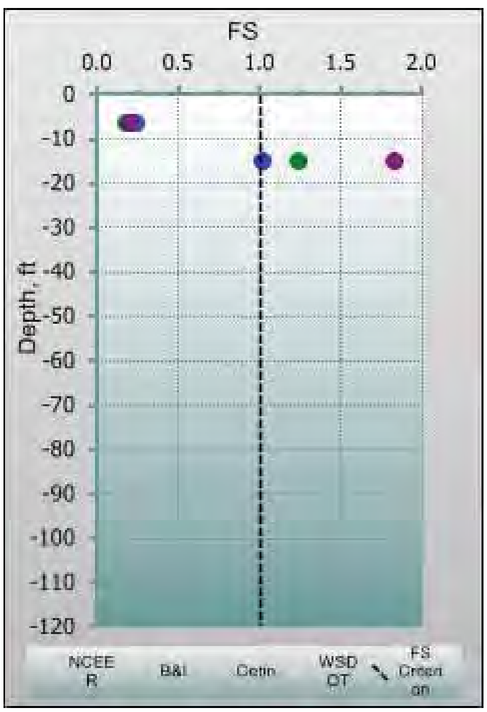
6	63.21	1.088	3.000	2.76	28.7

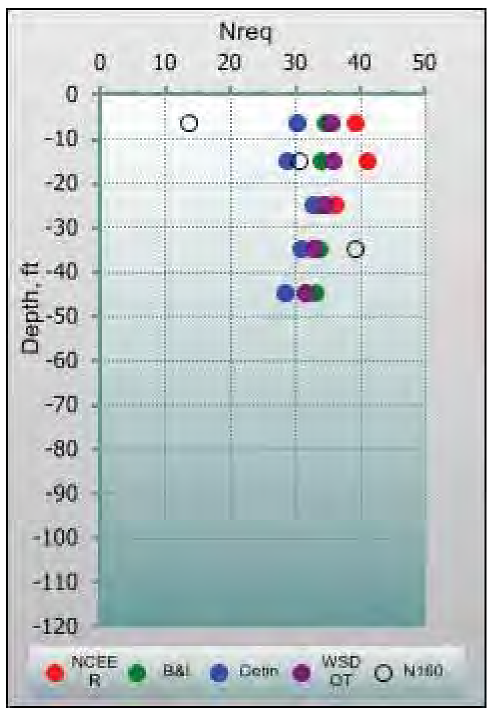
---WSDOT Recommended------------
--- PGA = 0.754 Mw = 6.71---------

Layer	(N1)60	CSR	CRR	FS	Nreq
2	13.60	1.066	0.217	0.20	35.6
3	30.60	1.101	2.026	1.84	35.9
4	61.54	1.031	3.000	2.91	34.7
5	39.41	0.938	2.908	3.10	32.9
6	63.21	0.839	3.000	3.58	31.7

Table of FS

#	Depth ft	NCEER	B&I	Cetin PL=0.60	WSDOT PL=0.60
2	-6.50	0.21	0.17	0.24	0.20
3	-15.00	3.12	1.24	1.02	1.84
4	-25.00	3.36	2.94	2.25	2.91
5	-35.00	3.77	3.20	2.08	3.10
6	-45.00	4.34	3.48	2.76	3.58



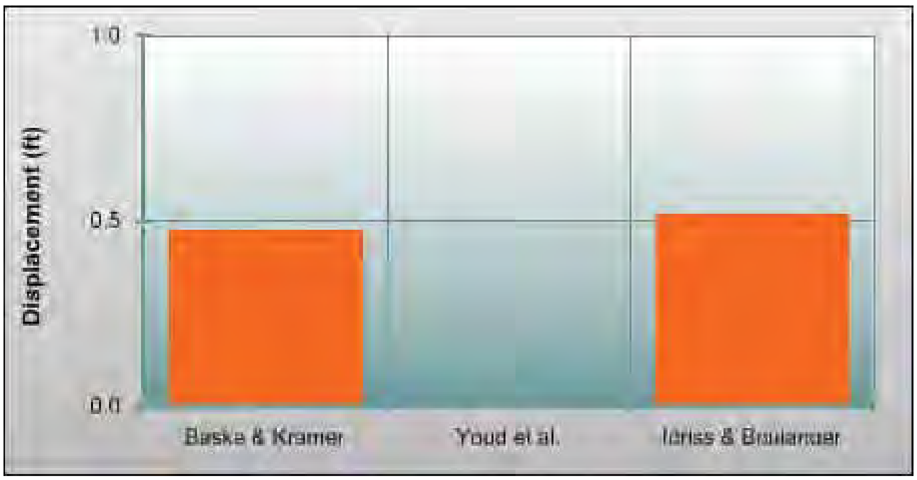


=== Effects ===

** Lateral Spreading **

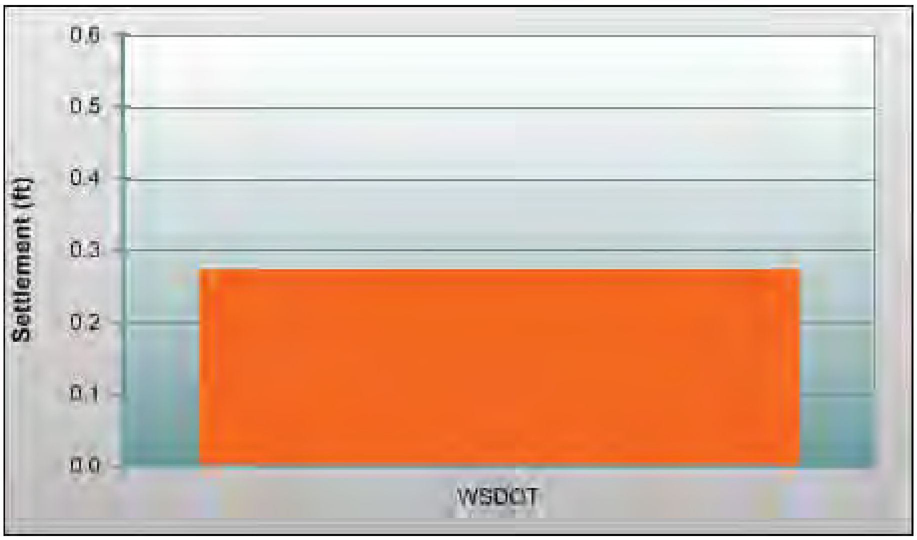
>>>Multiple Scenario Results

```
Model Selected :
   WSDOT Recommended (weighted average)
   using models of Baska & Kramer and Youd et al.
-----------------------------------------

Baska & Kramer: 0.48 ft
Youd et al.: 0.00 ft
Idriss & Boulanger: 0.52 ft

----------------------------------------
Weighting factors: Baska and Kramer = 0.65
                   Youd et al.      = 0.35

 WSDOT Recommended: 0.31 ft
```




```
=== Effects ===
---------------------------------------------------


** Settlement **
----------------
>>>Multiple Scenario Results
Groud Surface Settlement MULTIPLE Scenario
Return Period (yrs) = 2475
Model Selected :
   WSDOT Recommended (weighted average)
   using all deterministic models.
   -----------------------------------------
   Weighting factors = 0.25 for each model
-----------------------------------------


WSDOT Recommended:
=================
Total ground surface settlement = 0.27 ft
----------------------------------------------
  #    Depth thickness    ev    Weight    dh
          ft        ft     %              ft
----------------------------------------------
```

1	1.50	3.0	0.001	0.00	0.00
2	6.50	7.0	3.126	1.00	0.22
3	15.00	10.0	0.439	1.00	0.04
4	25.00	10.0	0.001	0.00	0.00
5	35.00	10.0	0.126	0.88	0.01
6	45.00	10.0	0.001	0.00	0.00
7	55.00	10.0	0.001	0.00	0.00
8	65.00	10.0	0.001	0.00	0.00
9	75.00	10.0	0.001	0.00	0.00
10	85.00	10.0	0.001	0.00	0.00
11	95.00	10.0	0.001	0.00	0.00
12	105.00	10.0	0.001	0.00	0.00
13	117.50	15.0	0.001	0.00	0.00



=== Effects ===

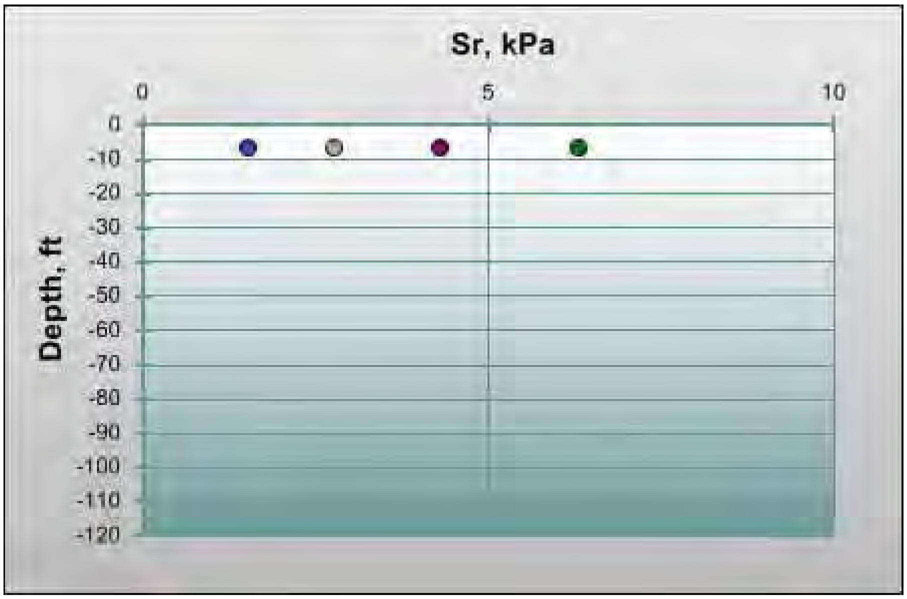
** Residual Strength **

====== Soil Layers Selected ==================
Layer 2

====== Models Selected =======================
Use recommended models:
  Kramer & Wang, Deterministic (KWD), w/ weighting factor = 0.5
  Idriss & Boulanger   (IDB), w/ weighting factor = 0.3
  Olson & Stark   (OLS), w/ weighting factor = 0.2
The residual strength is estimated as:
  Residual Strength =
    0.5*(Kramer & Wang) + 0.3*(Idriss & Boulanger) + 0.2*(Olson & Stark)

Unweighted Residual Strength

```
Kramer & Wang Deterministic Model:
   Layer 2:  Sr =   132 psf =   6.3 kPa = 0.062 atm
------------------------------------------------------
Idriss & Boulanger Model:
   Layer 2:  Sr =    58 psf =   2.8 kPa = 0.027 atm
------------------------------------------------------
Olson & Stark Model:
   Layer 2:  Sr =    32 psf =   1.5 kPa = 0.015 atm
------------------------------------------------------
WSDOT Recommended Model:
   Layer 2:  Sr =    90 psf =   4.3 kPa = 0.042 atm
------------------------------------------------------
```



ALTERNATIVE 3C

108 YEARS, 475 YEARS, 2,475 YEARS – LOWER-BOUND SPT

108 YEARS, 475 YEARS, 2,475 YEARS – UPPER-BOUND SPT

Liquefaction Hazard Evaluation Report
by WSLiq Program beta (May, 2009)

Site Name: Lockheed West Seattle
Site Location (N,W) = 47.583 , 122.367
Job No: 106-8945
Analyst: TetraTech
Date: 10/14/2011 11:51:36 AM

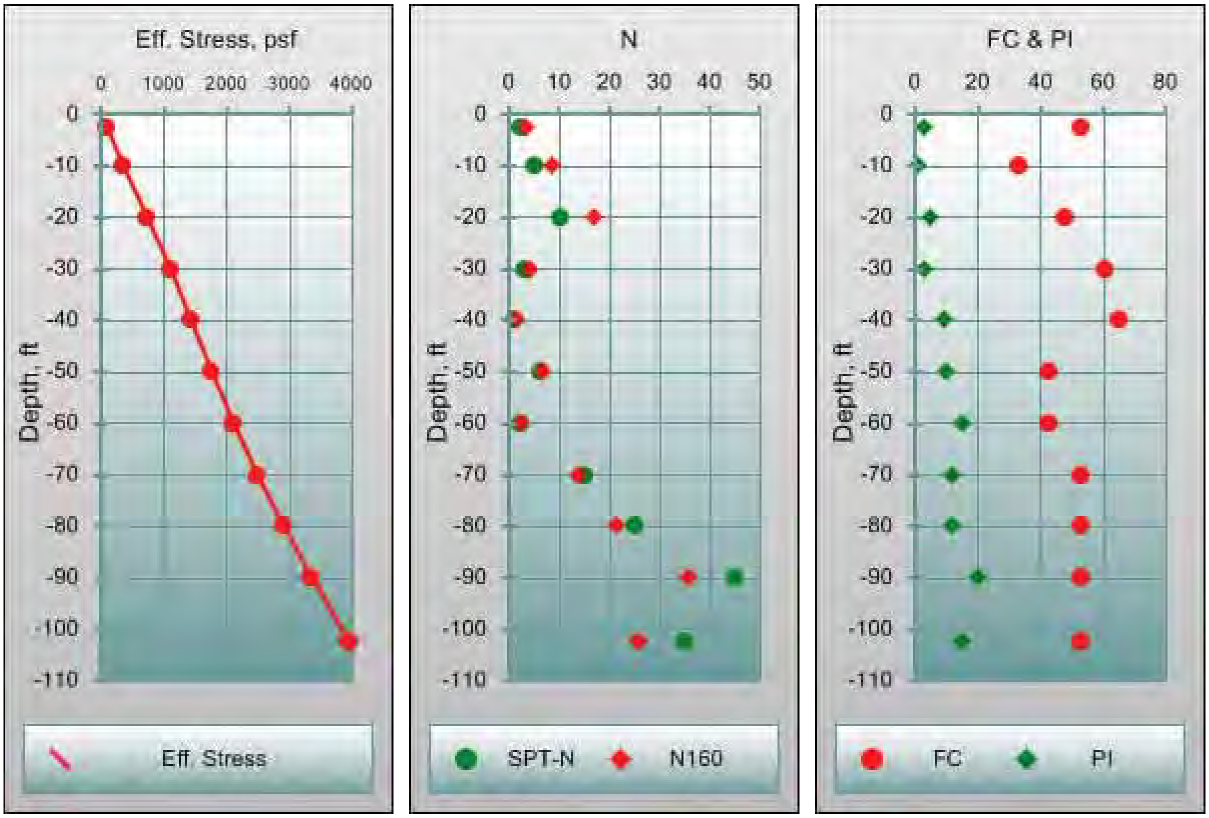
=== Soil Profile ===
Unit: ft
The number of soil layers: 11
GWT at top of layer: 1
GWT depth: 0.00
SPT Energy Ratio (%): 60.00
Amplification Factors: a= 0.1400 b= 0.0200
Elevation: 0.00
Ground Surface: Infinite Slope (%)= 0.2

Layer	Descpt.	Thickness (ft)	Unit Weight (lb/ft3)	Nm	N160	Vs ft/sec
1	Soft_sandy_silt	5	95.00	2	3.4	403.5
2	Soft_silt	10	100.00	5	8.5	526.3
3	Medium_dense_silty_sand	10	100.00	10	17.0	643.4
4	Soft_silty_sand	10	100.00	3	4.2	453.8
5	Loose_silty_sand	10	90.00	1	1.2	330.0
6	Soft_silty_sand	10	100.00	6	6.6	554.9
7	Loose_silty_sand	10	95.00	2	2.0	403.5
8	Medium_dense_sand	10	105.00	15	13.9	723.7
9	Medium_dense_silty_sand	10	105.00	25	21.3	839.3
10	Dense_sand	10	110.00	45	35.7	995.3
11	Dense_sand	15	110.00	35	25.6	925.3

Layer	FC (%)	PI	wc/LL	D50 (mm)	Ini. Eff. Stress (psf)	Ini. Total Stress (psf)
1	53	3	0.9	1128.0	81.5	237.50
2	33	1	1	1598.0	351.0	975.00
3	47.5	5	0.9	1786.0	727.0	1975.00
4	60.5	3	1	2068.0	1103.0	2975.00
5	65	9	0.9	2350.0	1429.0	3925.00
6	42.5	10	0.8	2726.0	1755.0	4875.00

7	42.5	15	1	3572.0	2106.0	5850.00
8	53	12	0.9	4700.0	2482.0	6850.00
9	53	12	0.9	3347.0	2908.0	7900.00
10	53	20	1	3773.0	3359.0	8975.00
11	53	15	0.9	4305.5	3954.0	10350.00

Soil Profile Plots



=== Susceptibility Evaluation ===

Threshold: 0.5

Weighting factors: B-I= 0.50   B-S= 0.50

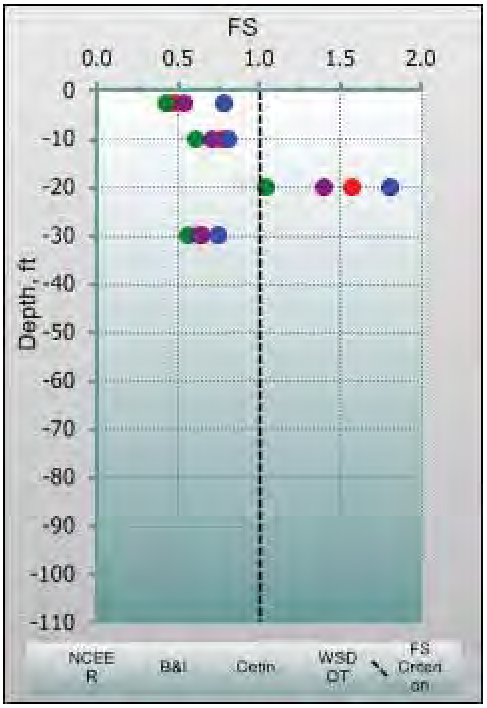
Layer	PI	wc/LL	B-I	B-S	Suscep. Index	Potential
1	3.00	0.90	0.96	0.63	0.80	YES
2	1.00	1.00	1.00	0.76	0.88	YES
3	5.00	0.90	0.62	0.63	0.62	YES
4	3.00	1.00	0.96	0.76	0.86	YES
5	9.00	0.90	0.09	0.59	0.34	NO
6	10.00	0.80	0.05	0.41	0.23	NO
7	15.00	1.00	0.01	0.37	0.19	NO
8	12.00	0.90	0.02	0.48	0.25	NO
9	12.00	0.90	0.02	0.48	0.25	NO
10	20.00	1.00	0.00	0.13	0.06	NO
11	15.00	0.90	0.01	0.31	0.16	NO

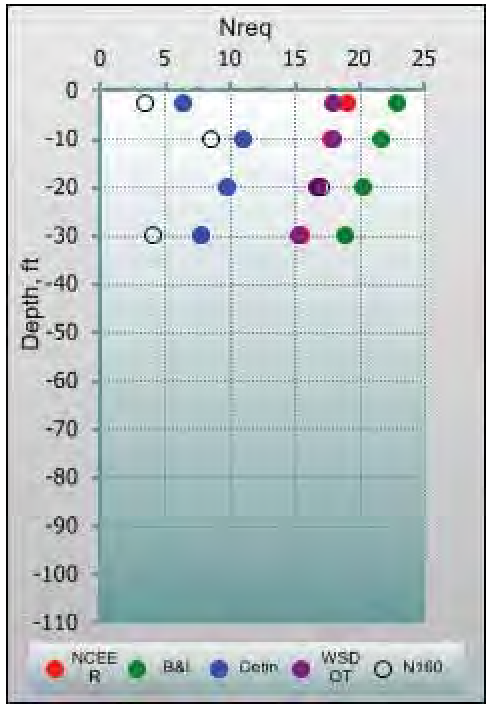
=== Initiation ===

```
Initiation - Multiple Scenario
-----------------------------------------
Retrun Period (yrs) = 108
Models Selected :
Use All Deterministic Models.
--WSDOT Recommended--
   Use NCEER, Boulanger & Idriss, and
   Cetin's model with weighting factors
   of 0.4, 0.4, and 0.2 respectively.
-----------------------------------------


===== Mean Mw and FS ==============
---NCEER Model------------
--- PGA = 0.176  Mw = 6.46---------

Layer  (N1)60    CSR     CRR     FS     Nreq
-----  ------  ------  ------  ------  ------
    1    3.40   0.223   0.105    0.47    19.1
    2    8.50   0.205   0.159    0.78    17.9
    3   17.00   0.191   0.300    1.57    16.8
    4    4.16   0.175   0.113    0.64    15.5


===== Mean Mw and FS ==============
---Boulanger and Idriss Model------------
--- PGA = 0.176  Mw = 6.46---------

Layer  (N1)60    CSR     CRR     FS     Nreq
-----  ------  ------  ------  ------  ------
    1    3.40   0.263   0.111    0.42    22.9
    2    8.50   0.243   0.148    0.61    21.6
    3   16.55   0.225   0.236    1.05    20.3
    4    4.50   0.210   0.119    0.57    19.0


===== Mean Mw and FS ==============
---Cetin et al. Model------------
--- PGA = 0.176  Mw = 6.46---------

Layer  (N1)60    CSR     CRR     FS     Nreq
-----  ------  ------  ------  ------  ------
    1    3.20   0.327   0.257    0.78     6.4
    2    8.00   0.288   0.234    0.81    11.0
    3   16.00   0.237   0.428    1.81     9.9
    4    4.16   0.189   0.141    0.75     7.8

---WSDOT Recommended------------
--- PGA = 0.176  Mw = 6.46---------

Layer  (N1)60    CSR     CRR     FS     Nreq
-----  ------  ------  ------  ------  ------
    1    3.40   0.260   0.138    0.53    18.1
    2    8.50   0.237   0.170    0.72    18.0
    3   17.00   0.214   0.300    1.40    16.8
    4    4.16   0.192   0.121    0.63    15.4
```

Table of FS

#	Depth ft	NCEER	B&I	Cetin PL=0.60	WSDOT PL=0.60
1	-2.50	0.47	0.42	0.78	0.53
2	-10.00	0.78	0.61	0.81	0.72
3	-20.00	1.57	1.05	1.81	1.40
4	-30.00	0.64	0.57	0.75	0.63





=== Effects ===

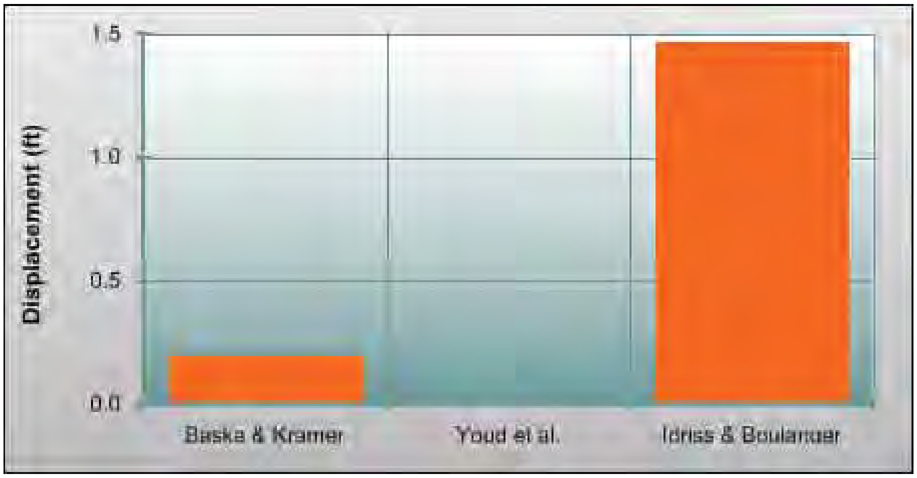
** Lateral Spreading **

>>>Multiple Scenario Results
Model Selected :
WSDOT Recommended (weighted average)
using models of Baska & Kramer and Youd et al.

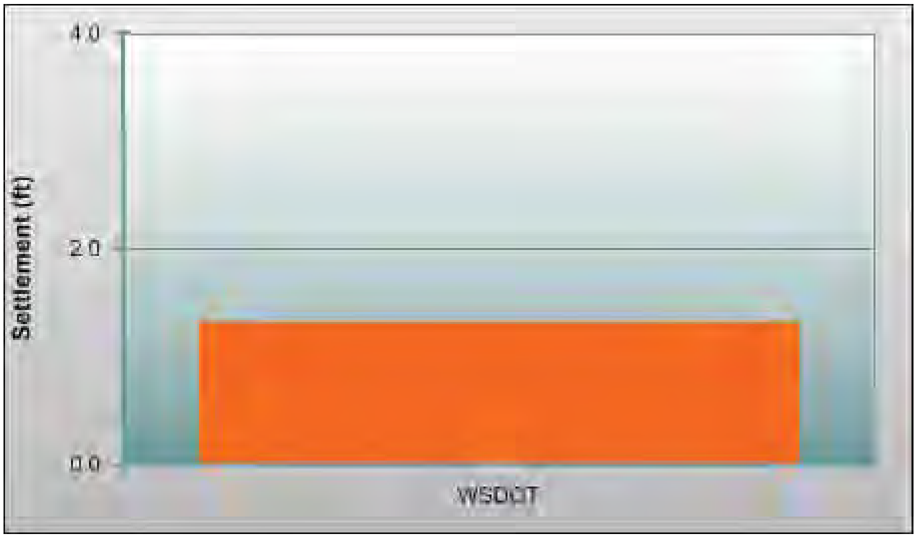
Baska & Kramer: 0.20 ft
Youd et al.: 0.00 ft
Idriss & Boulanger: 1.47 ft

Weighting factors: Baska and Kramer = 0.65
Youd et al. = 0.35

WSDOT Recommended: 0.13 ft

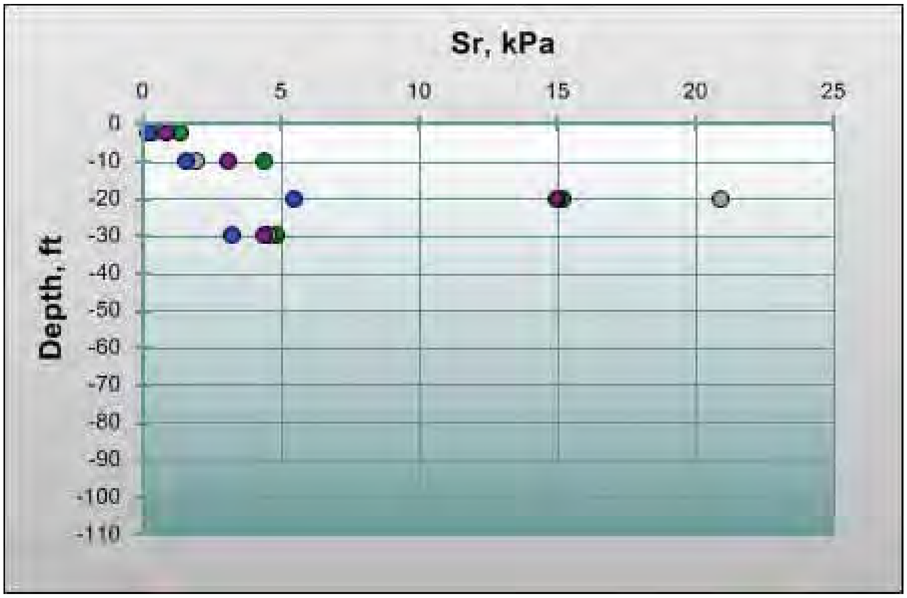



```
=== Effects ===
----------------------------------------------------


** Settlement **
----------------
>>>Multiple Scenario Results
Groud Surface Settlement MULTIPLE Scenario
Return Period (yrs) = 108
Model Selected :
   WSDOT Recommended (weighted average)
   using all deterministic models.
   -----------------------------------------
   Weighting factors = 0.25 for each model
-----------------------------------------


WSDOT Recommended:
=================
Total ground surface settlement = 1.34 ft
----------------------------------------------
  #    Depth thickness    ev    Weight    dh
          ft        ft     %              ft
----------------------------------------------
  1     2.50       5.0   8.519    1.00    0.43
  2    10.00      10.0   3.091    1.00    0.31
  3    20.00      10.0   0.617    0.99    0.06
  4    30.00      10.0   5.426    1.00    0.54
  5    40.00      10.0   0.001    0.00    0.00
  6    50.00      10.0   0.001    0.00    0.00
  7    60.00      10.0   0.001    0.00    0.00
  8    70.00      10.0   0.001    0.00    0.00
  9    80.00      10.0   0.001    0.00    0.00
 10    90.00      10.0   0.001    0.00    0.00
 11   102.50      15.0   0.001    0.00    0.00
----------------------------------------------
```




```
=== Effects ===
---------------------------------------------------


** Residual Strength **
-----------------------
====== Soil Layers Selected ==================
Layer 1
Layer 2

====== Models Selected =======================
Use recommended models:
  Kramer & Wang, Deterministic (KWD), w/ weighting factor = 0.5
  Idriss & Boulanger           (IDB), w/ weighting factor = 0.3
  Olson & Stark                (OLS), w/ weighting factor = 0.2
The residual strength is estimated as:
  Residual Strength =
    0.5*(Kramer & Wang) + 0.3*(Idriss & Boulanger) + 0.2*(Olson & Stark)

--------------------------------------------------------

###### Unweighted Residual Strength ####################

Kramer & Wang Deterministic Model:
   Layer 1:  Sr =    28 psf =   1.4 kPa = 0.013 atm
   Layer 2:  Sr =    92 psf =   4.4 kPa = 0.043 atm
------------------------------------------------------
Idriss & Boulanger Model:
   Layer 1:  Sr =     6 psf =   0.3 kPa = 0.003 atm
   Layer 2:  Sr =    40 psf =   1.9 kPa = 0.019 atm
------------------------------------------------------
Olson & Stark Model:
   Layer 1:  Sr =     5 psf =   0.2 kPa = 0.002 atm
   Layer 2:  Sr =    33 psf =   1.6 kPa = 0.016 atm
------------------------------------------------------
WSDOT Recommended Model:
   Layer 1:  Sr =    17 psf =   0.8 kPa = 0.008 atm
```

```
   Layer 2:  Sr =    64 psf =   3.1 kPa = 0.030 atm
------------------------------------------------------
```



Liquefaction Hazard Evaluation Report
by WSLiq Program beta (May, 2009)

Site Name: Lockheed West Seattle
Site Location (N,W) = 47.583 , 122.367
Job No: 106-8945
Analyst: TetraTech
Date: 10/14/2011 11:53:43 AM

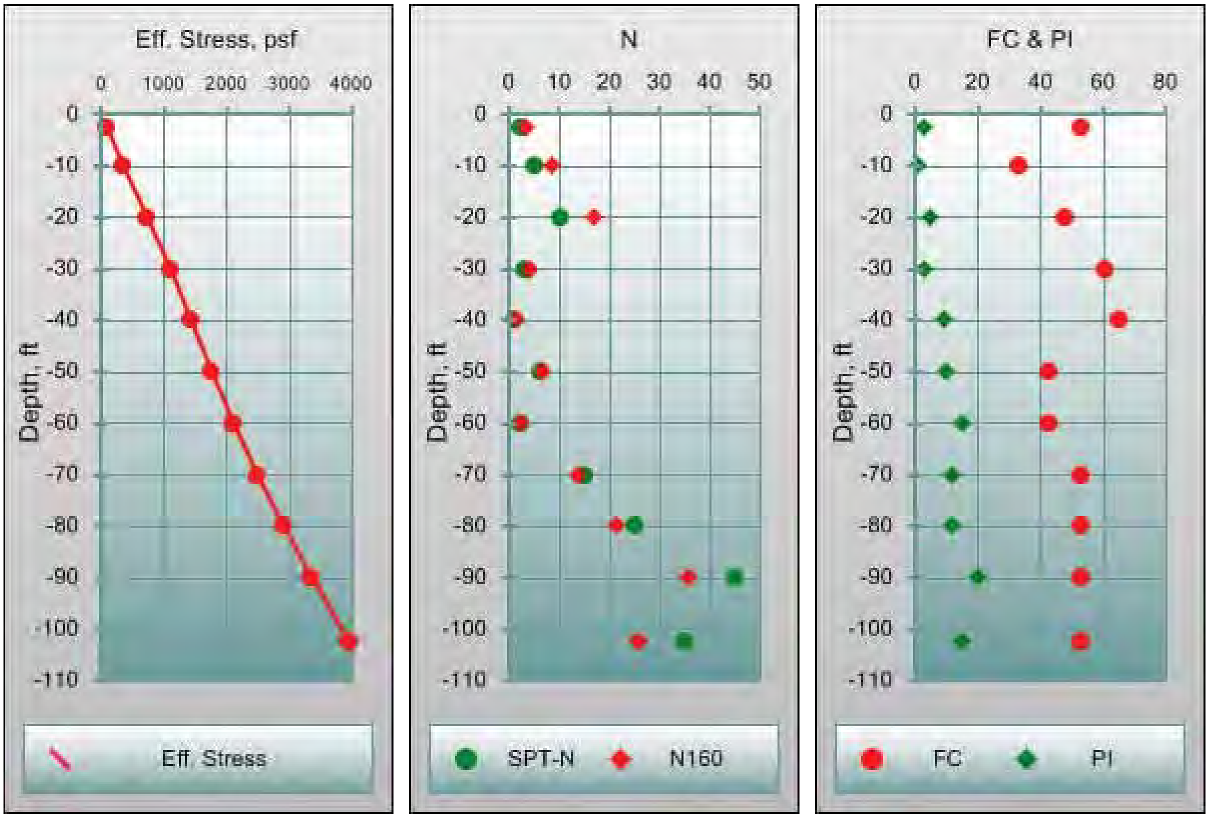
=== Soil Profile ===
Unit: ft
The number of soil layers: 11
GWT at top of layer: 1
GWT depth: 0.00
SPT Energy Ratio (%): 60.00
Amplification Factors: a= 0.1400 b= 0.0200
Elevation: 0.00
Ground Surface: Infinite Slope (%)= 0.2

Layer	Descpt.	Thickness (ft)	Unit Weight (lb/ft3)	Nm	N160	Vs ft/sec
1	Soft_sandy_silt	5	95.00	2	3.4	403.5
2	Soft_silt	10	100.00	5	8.5	526.3
3	Medium_dense_silty_sand	10	100.00	10	17.0	643.4
4	Soft_silty_sand	10	100.00	3	4.2	453.8
5	Loose_silty_sand	10	90.00	1	1.2	330.0
6	Soft_silty_sand	10	100.00	6	6.6	554.9
7	Loose_silty_sand	10	95.00	2	2.0	403.5
8	Medium_dense_sand	10	105.00	15	13.9	723.7
9	Medium_dense_silty_sand	10	105.00	25	21.3	839.3
10	Dense_sand	10	110.00	45	35.7	995.3
11	Dense_sand	15	110.00	35	25.6	925.3

Layer	FC (%)	PI	wc/LL	D50 (mm)	Ini. Eff. Stress (psf)	Ini. Total Stress (psf)
1	53	3	0.9	1128.0	81.5	237.50
2	33	1	1	1598.0	351.0	975.00
3	47.5	5	0.9	1786.0	727.0	1975.00
4	60.5	3	1	2068.0	1103.0	2975.00
5	65	9	0.9	2350.0	1429.0	3925.00
6	42.5	10	0.8	2726.0	1755.0	4875.00

7	42.5	15	1	3572.0	2106.0	5850.00
8	53	12	0.9	4700.0	2482.0	6850.00
9	53	12	0.9	3347.0	2908.0	7900.00
10	53	20	1	3773.0	3359.0	8975.00
11	53	15	0.9	4305.5	3954.0	10350.00

Soil Profile Plots



=== Susceptibility Evaluation ===

Threshold: 0.5

Weighting factors: B-I= 0.50 B-S= 0.50

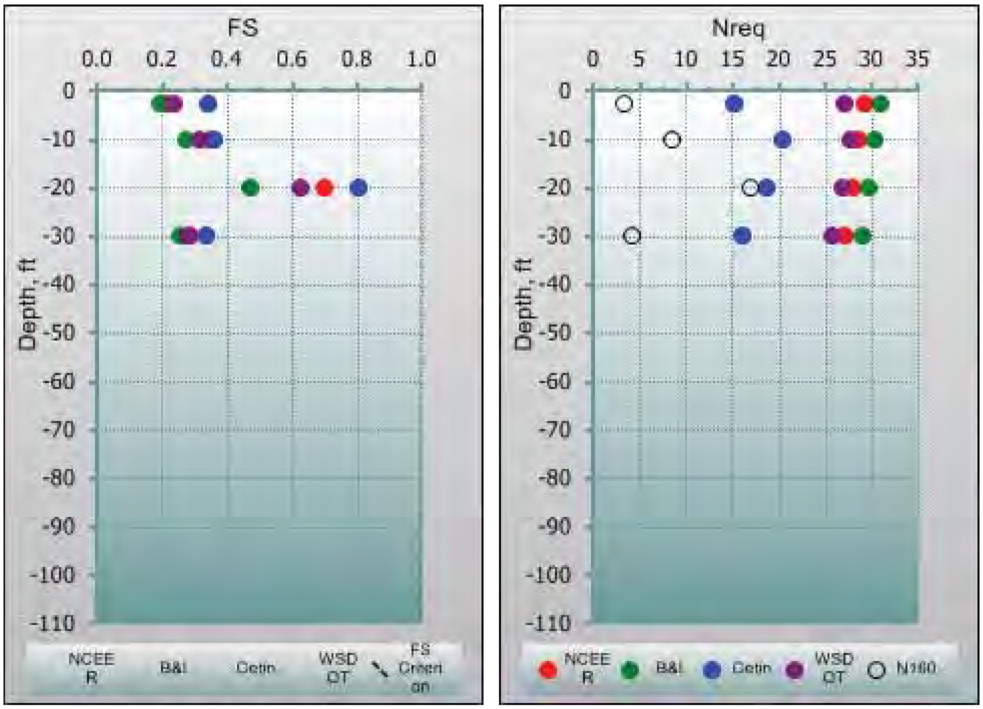
Layer	PI	wc/LL	B-I	B-S	Suscep. Index	Potential
1	3.00	0.90	0.96	0.63	0.80	YES
2	1.00	1.00	1.00	0.76	0.88	YES
3	5.00	0.90	0.62	0.63	0.62	YES
4	3.00	1.00	0.96	0.76	0.86	YES
5	9.00	0.90	0.09	0.59	0.34	NO
6	10.00	0.80	0.05	0.41	0.23	NO
7	15.00	1.00	0.01	0.37	0.19	NO
8	12.00	0.90	0.02	0.48	0.25	NO
9	12.00	0.90	0.02	0.48	0.25	NO
10	20.00	1.00	0.00	0.13	0.06	NO
11	15.00	0.90	0.01	0.31	0.16	NO

=== Initiation ===

```
Initiation - Multiple Scenario
-----------------------------------------
Retrun Period (yrs) = 475
Models Selected :
Use All Deterministic Models.
--WSDOT Recommended--
   Use NCEER, Boulanger & Idriss, and
   Cetin's model with weighting factors
   of 0.4, 0.4, and 0.2 respectively.
-----------------------------------------


===== Mean Mw and FS ==============
---NCEER Model------------
--- PGA = 0.378  Mw = 6.58---------

Layer  (N1)60    CSR     CRR     FS     Nreq
-----  ------  ------  ------  ------  ------
    1    3.40   0.499   0.105    0.21    29.3
    2    8.50   0.459   0.159    0.35    28.7
    3   17.00   0.427   0.300    0.70    28.0
    4    4.16   0.392   0.113    0.29    27.2


===== Mean Mw and FS ==============
---Boulanger and Idriss Model------------
--- PGA = 0.378  Mw = 6.58---------

Layer  (N1)60    CSR     CRR     FS     Nreq
-----  ------  ------  ------  ------  ------
    1    3.40   0.577   0.111    0.19    30.9
    2    8.50   0.534   0.148    0.28    30.4
    3   16.55   0.496   0.236    0.48    29.8
    4    4.50   0.462   0.119    0.26    29.2


===== Mean Mw and FS ==============
---Cetin et al. Model------------
--- PGA = 0.378  Mw = 6.58---------

Layer  (N1)60    CSR     CRR     FS     Nreq
-----  ------  ------  ------  ------  ------
    1    3.20   0.704   0.243    0.35    15.3
    2    8.00   0.617   0.221    0.36    20.5
    3   16.00   0.500   0.404    0.81    18.8
    4    4.16   0.393   0.133    0.34    16.1

---WSDOT Recommended------------
--- PGA = 0.378  Mw = 6.58---------

Layer  (N1)60    CSR     CRR     FS     Nreq
-----  ------  ------  ------  ------  ------
    1    3.40   0.571   0.135    0.24    27.1
    2    8.50   0.521   0.167    0.32    27.7
    3   17.00   0.469   0.295    0.63    26.9
    4    4.16   0.420   0.119    0.28    25.8
```

Table of FS

#	Depth ft	NCEER	B&I	Cetin PL=0.60	WSDOT PL=0.60
1	-2.50	0.21	0.19	0.35	0.24
2	-10.00	0.35	0.28	0.36	0.32
3	-20.00	0.70	0.48	0.81	0.63
4	-30.00	0.29	0.26	0.34	0.28



=== Effects ===

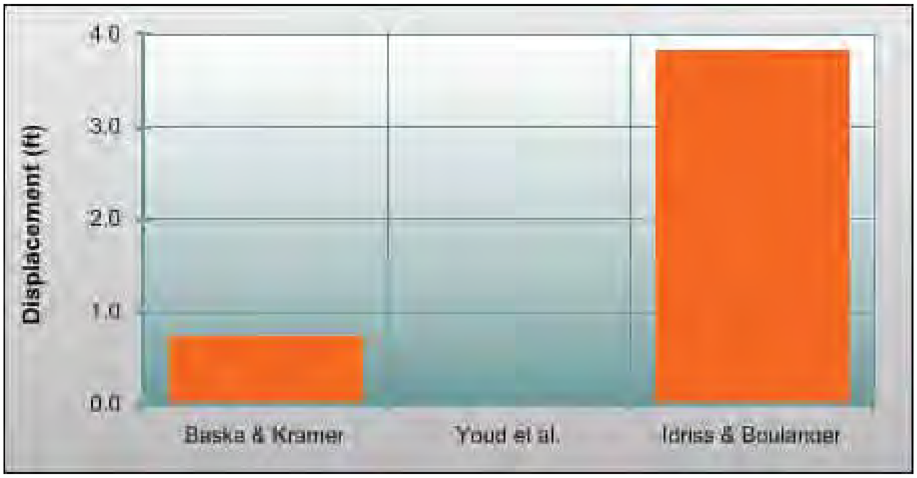
** Lateral Spreading **

>>>Multiple Scenario Results
Model Selected :
WSDOT Recommended (weighted average)
using models of Baska & Kramer and Youd et al.

Baska & Kramer: 0.74 ft
Youd et al.: 0.00 ft
Idriss & Boulanger: 3.85 ft

Weighting factors: Baska and Kramer = 0.65
Youd et al. = 0.35

WSDOT Recommended: 0.48 ft



=== Effects ===

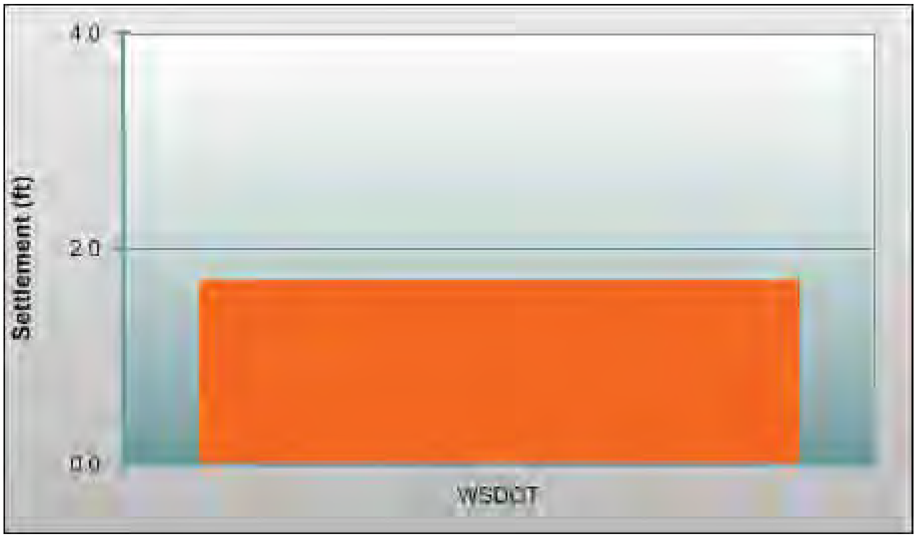
** Settlement **

>>>Multiple Scenario Results
Groud Surface Settlement MULTIPLE Scenario
Return Period (yrs) = 475
Model Selected :
   WSDOT Recommended (weighted average)
   using all deterministic models.

   Weighting factors = 0.25 for each model

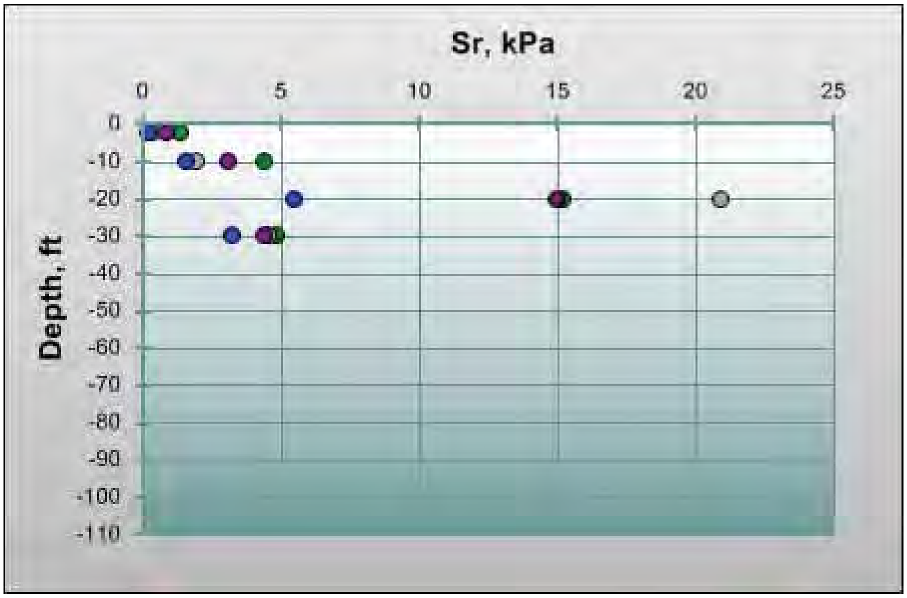
WSDOT Recommended:
=================
Total ground surface settlement = 1.72 ft

#	Depth ft	thickness ft	ev %	Weight	dh ft
1	2.50	5.0	9.141	1.00	0.46
2	10.00	10.0	4.205	1.00	0.42
3	20.00	10.0	1.978	1.00	0.20
4	30.00	10.0	6.489	1.00	0.65
5	40.00	10.0	0.001	0.00	0.00
6	50.00	10.0	0.001	0.00	0.00
7	60.00	10.0	0.001	0.00	0.00
8	70.00	10.0	0.001	0.00	0.00
9	80.00	10.0	0.001	0.00	0.00
10	90.00	10.0	0.001	0.00	0.00
11	102.50	15.0	0.001	0.00	0.00




```
=== Effects ===
---------------------------------------------------


** Residual Strength **
-----------------------
====== Soil Layers Selected ==================
Layer 1
Layer 2

====== Models Selected =======================
Use recommended models:
  Kramer & Wang, Deterministic (KWD), w/ weighting factor = 0.5
  Idriss & Boulanger           (IDB), w/ weighting factor = 0.3
  Olson & Stark                (OLS), w/ weighting factor = 0.2
The residual strength is estimated as:
  Residual Strength =
    0.5*(Kramer & Wang) + 0.3*(Idriss & Boulanger) + 0.2*(Olson & Stark)

--------------------------------------------------------

###### Unweighted Residual Strength ####################

Kramer & Wang Deterministic Model:
   Layer 1:  Sr =    28 psf =   1.4 kPa = 0.013 atm
   Layer 2:  Sr =    92 psf =   4.4 kPa = 0.043 atm
------------------------------------------------------
Idriss & Boulanger Model:
   Layer 1:  Sr =     6 psf =   0.3 kPa = 0.003 atm
   Layer 2:  Sr =    40 psf =   1.9 kPa = 0.019 atm
------------------------------------------------------
Olson & Stark Model:
   Layer 1:  Sr =     5 psf =   0.2 kPa = 0.002 atm
   Layer 2:  Sr =    33 psf =   1.6 kPa = 0.016 atm
------------------------------------------------------
WSDOT Recommended Model:
   Layer 1:  Sr =    17 psf =   0.8 kPa = 0.008 atm
```

```
   Layer 2:  Sr =    64 psf =   3.1 kPa = 0.030 atm
-----------------------------------------------------
```



Liquefaction Hazard Evaluation Report
by WSLiq Program beta (May, 2009)

Site Name: Lockheed West Seattle
Site Location (N,W) = 47.583 , 122.367
Job No: 106-8945
Analyst: TetraTech
Date: 10/14/2011 11:55:11 AM

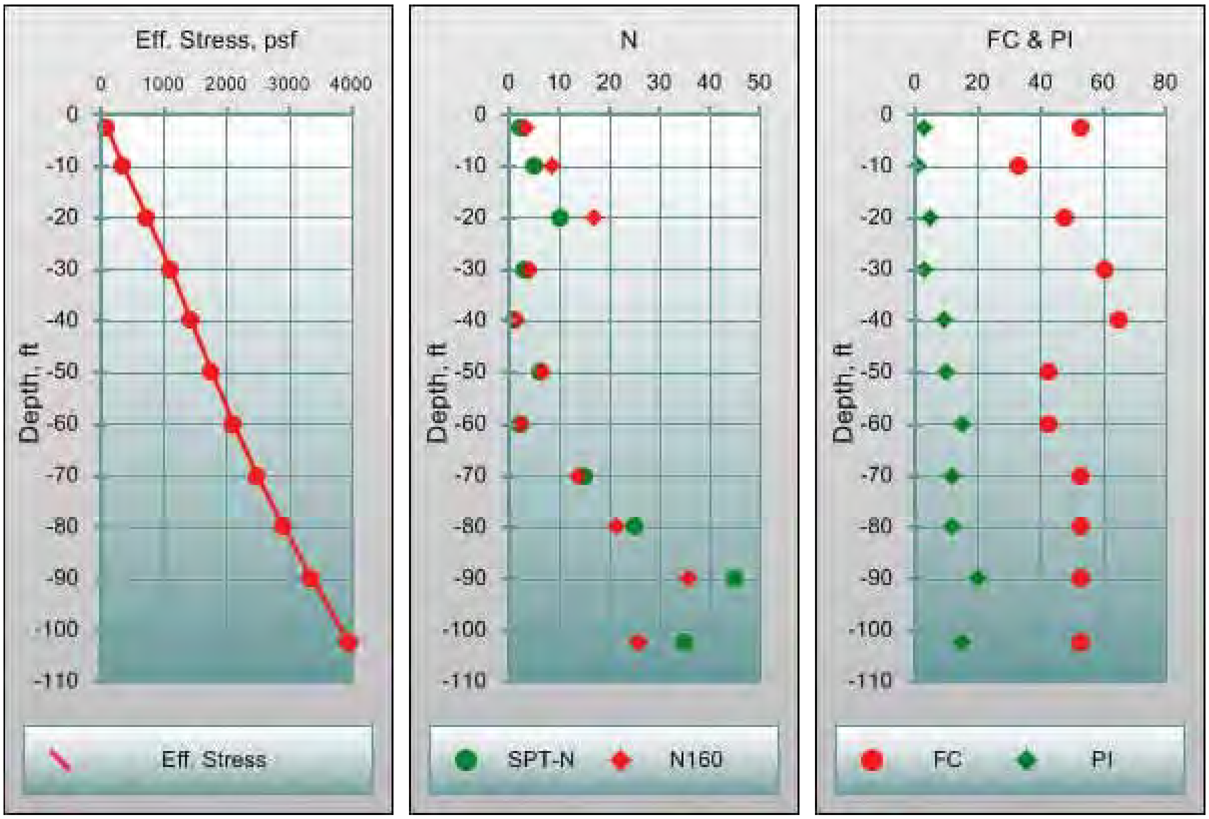
=== Soil Profile ===
Unit: ft
The number of soil layers: 11
GWT at top of layer: 1
GWT depth: 0.00
SPT Energy Ratio (%): 60.00
Amplification Factors: a= 0.1400 b= 0.0200
Elevation: 0.00
Ground Surface: Infinite Slope (%)= 0.2

Layer	Descpt.	Thickness (ft)	Unit Weight (lb/ft3)	Nm	N160	Vs ft/sec
1	Soft_sandy_silt	5	95.00	2	3.4	403.5
2	Soft_silt	10	100.00	5	8.5	526.3
3	Medium_dense_silty_sand	10	100.00	10	17.0	643.4
4	Soft_silty_sand	10	100.00	3	4.2	453.8
5	Loose_silty_sand	10	90.00	1	1.2	330.0
6	Soft_silty_sand	10	100.00	6	6.6	554.9
7	Loose_silty_sand	10	95.00	2	2.0	403.5
8	Medium_dense_sand	10	105.00	15	13.9	723.7
9	Medium_dense_silty_sand	10	105.00	25	21.3	839.3
10	Dense_sand	10	110.00	45	35.7	995.3
11	Dense_sand	15	110.00	35	25.6	925.3

Layer	FC (%)	PI	wc/LL	D50 (mm)	Ini. Eff. Stress (psf)	Ini. Total Stress (psf)
1	53	3	0.9	1128.0	81.5	237.50
2	33	1	1	1598.0	351.0	975.00
3	47.5	5	0.9	1786.0	727.0	1975.00
4	60.5	3	1	2068.0	1103.0	2975.00
5	65	9	0.9	2350.0	1429.0	3925.00
6	42.5	10	0.8	2726.0	1755.0	4875.00

7	42.5	15	1	3572.0	2106.0	5850.00
8	53	12	0.9	4700.0	2482.0	6850.00
9	53	12	0.9	3347.0	2908.0	7900.00
10	53	20	1	3773.0	3359.0	8975.00
11	53	15	0.9	4305.5	3954.0	10350.00

Soil Profile Plots



=== Susceptibility Evaluation ===

Threshold: 0.5

Weighting factors: B-I= 0.50 B-S= 0.50

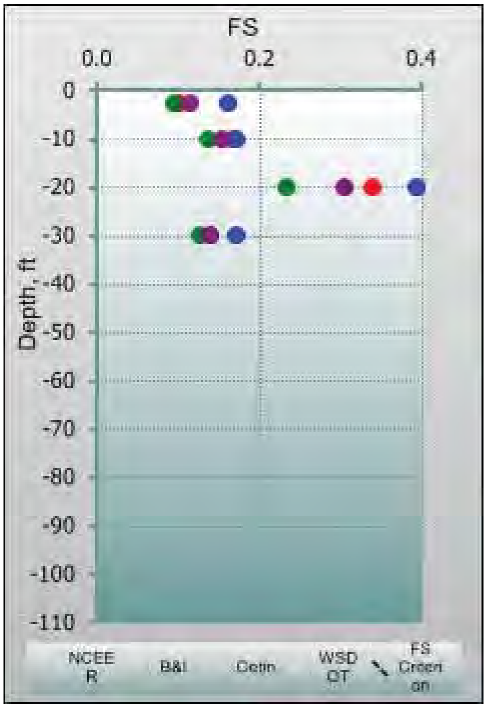
Layer	PI	wc/LL	B-I	B-S	Suscep. Index	Potential
1	3.00	0.90	0.96	0.63	0.80	YES
2	1.00	1.00	1.00	0.76	0.88	YES
3	5.00	0.90	0.62	0.63	0.62	YES
4	3.00	1.00	0.96	0.76	0.86	YES
5	9.00	0.90	0.09	0.59	0.34	NO
6	10.00	0.80	0.05	0.41	0.23	NO
7	15.00	1.00	0.01	0.37	0.19	NO
8	12.00	0.90	0.02	0.48	0.25	NO
9	12.00	0.90	0.02	0.48	0.25	NO
10	20.00	1.00	0.00	0.13	0.06	NO
11	15.00	0.90	0.01	0.31	0.16	NO

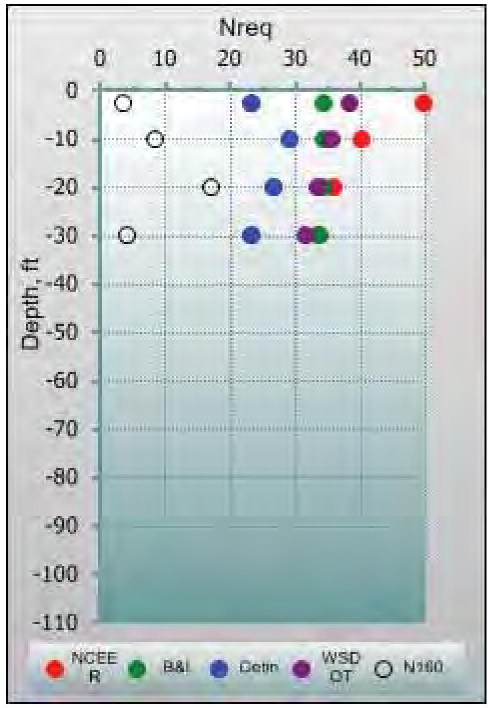
=== Initiation ===

```
Initiation - Multiple Scenario
-----------------------------------------
Retrun Period (yrs) = 2475
Models Selected :
Use All Deterministic Models.
--WSDOT Recommended--
   Use NCEER, Boulanger & Idriss, and
   Cetin's model with weighting factors
   of 0.4, 0.4, and 0.2 respectively.
-----------------------------------------


===== Mean Mw and FS ==============
---NCEER Model------------
--- PGA = 0.754  Mw = 6.71---------

Layer  (N1)60    CSR     CRR     FS     Nreq
-----  ------  ------  ------  ------  ------
    1    3.40   1.033   0.105    0.10    50.0
    2    8.50   0.952   0.159    0.17    40.3
    3   17.00   0.884   0.300    0.34    35.9
    4    4.16   0.813   0.113    0.14    33.4


===== Mean Mw and FS ==============
---Boulanger and Idriss Model------------
--- PGA = 0.754  Mw = 6.71---------

Layer  (N1)60    CSR     CRR     FS     Nreq
-----  ------  ------  ------  ------  ------
    1    3.40   1.172   0.111    0.09    34.3
    2    8.50   1.085   0.148    0.14    34.5
    3   16.55   1.008   0.236    0.23    34.3
    4    4.50   0.940   0.119    0.13    33.9


===== Mean Mw and FS ==============
---Cetin et al. Model------------
--- PGA = 0.754  Mw = 6.71---------

Layer  (N1)60    CSR     CRR     FS     Nreq
-----  ------  ------  ------  ------  ------
    1    3.20   1.399   0.227    0.16    23.4
    2    8.00   1.216   0.207    0.17    29.0
    3   16.00   0.961   0.378    0.39    26.6
    4    4.16   0.725   0.125    0.17    23.2

---WSDOT Recommended------------
--- PGA = 0.754  Mw = 6.71---------

Layer  (N1)60    CSR     CRR     FS     Nreq
-----  ------  ------  ------  ------  ------
    1    3.40   1.162   0.132    0.11    38.4
    2    8.50   1.058   0.164    0.16    35.7
    3   17.00   0.949   0.290    0.31    33.4
    4    4.16   0.846   0.118    0.14    31.6
```

Table of FS

#	Depth ft	NCEER	B&I	Cetin PL=0.60	WSDOT PL=0.60
1	-2.50	0.10	0.09	0.16	0.11
2	-10.00	0.17	0.14	0.17	0.16
3	-20.00	0.34	0.23	0.39	0.31
4	-30.00	0.14	0.13	0.17	0.14





=== Effects ===

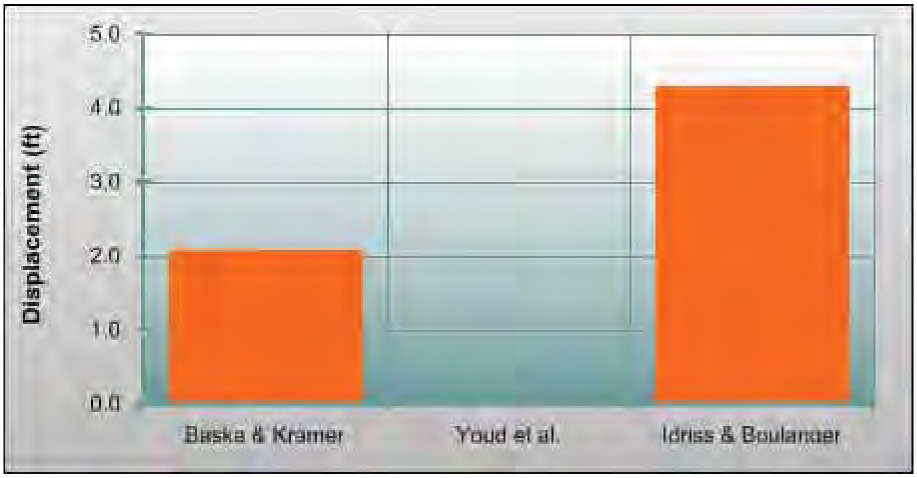
** Lateral Spreading **

\>>>Multiple Scenario Results
Model Selected :
WSDOT Recommended (weighted average)
using models of Baska & Kramer and Youd et al.

Baska & Kramer: 2.09 ft
Youd et al.: 0.00 ft
Idriss & Boulanger: 4.31 ft

Weighting factors: Baska and Kramer = 0.65
Youd et al. = 0.35

WSDOT Recommended: 1.36 ft



=== Effects ===

** Settlement **

>>>Multiple Scenario Results
Groud Surface Settlement MULTIPLE Scenario
Return Period (yrs) = 2475
Model Selected :
   WSDOT Recommended (weighted average)
   using all deterministic models.

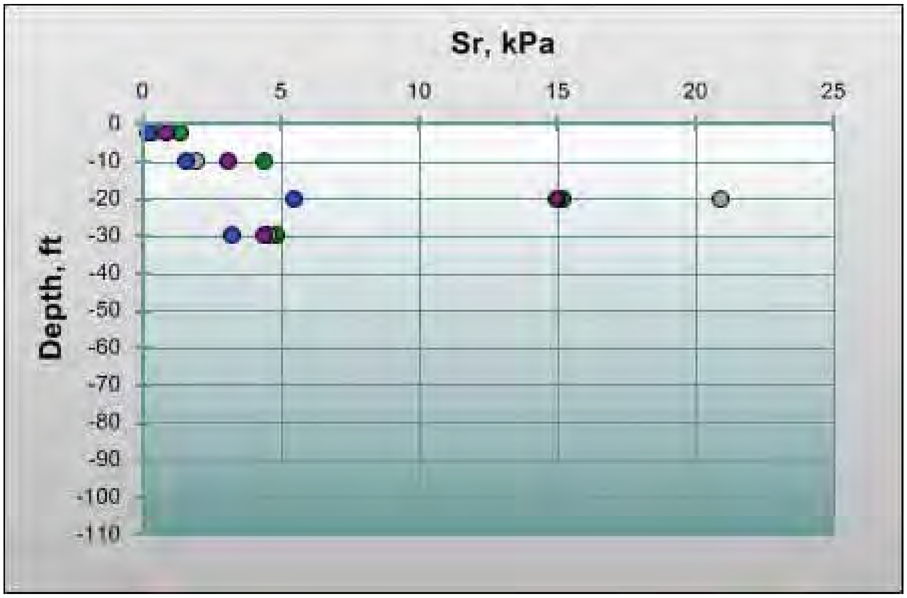
   Weighting factors = 0.25 for each model

WSDOT Recommended:
=================
Total ground surface settlement = 1.82 ft

#	Depth ft	thickness ft	ev %	Weight	dh ft
1	2.50	5.0	9.381	1.00	0.47
2	10.00	10.0	4.446	1.00	0.44
3	20.00	10.0	2.427	1.00	0.24
4	30.00	10.0	6.647	1.00	0.66
5	40.00	10.0	0.001	0.00	0.00
6	50.00	10.0	0.001	0.00	0.00
7	60.00	10.0	0.001	0.00	0.00
8	70.00	10.0	0.001	0.00	0.00
9	80.00	10.0	0.001	0.00	0.00
10	90.00	10.0	0.001	0.00	0.00
11	102.50	15.0	0.001	0.00	0.00


```
=== Effects ===
---------------------------------------------------


** Residual Strength **
-----------------------
====== Soil Layers Selected ==================
Layer 1
Layer 2

====== Models Selected =======================
Use recommended models:
  Kramer & Wang, Deterministic (KWD), w/ weighting factor = 0.5
  Idriss & Boulanger           (IDB), w/ weighting factor = 0.3
  Olson & Stark                (OLS), w/ weighting factor = 0.2
The residual strength is estimated as:
  Residual Strength =
    0.5*(Kramer & Wang) + 0.3*(Idriss & Boulanger) + 0.2*(Olson & Stark)

--------------------------------------------------------

###### Unweighted Residual Strength ####################

Kramer & Wang Deterministic Model:
   Layer 1:  Sr =    28 psf =   1.4 kPa = 0.013 atm
   Layer 2:  Sr =    92 psf =   4.4 kPa = 0.043 atm
------------------------------------------------------
Idriss & Boulanger Model:
   Layer 1:  Sr =     6 psf =   0.3 kPa = 0.003 atm
   Layer 2:  Sr =    40 psf =   1.9 kPa = 0.019 atm
------------------------------------------------------
Olson & Stark Model:
   Layer 1:  Sr =     5 psf =   0.2 kPa = 0.002 atm
   Layer 2:  Sr =    33 psf =   1.6 kPa = 0.016 atm
------------------------------------------------------
WSDOT Recommended Model:
   Layer 1:  Sr =    17 psf =   0.8 kPa = 0.008 atm
```

```
   Layer 2:  Sr =    64 psf =   3.1 kPa = 0.030 atm
------------------------------------------------------
```



Liquefaction Hazard Evaluation Report
by WSLiq Program beta (May, 2009)

Site Name: Lockheed West Seattle
Site Location (N,W) = 47.583 , 122.367
Job No: 106-8945
Analyst: TetraTech
Date: 10/14/2011 1:27:13 PM

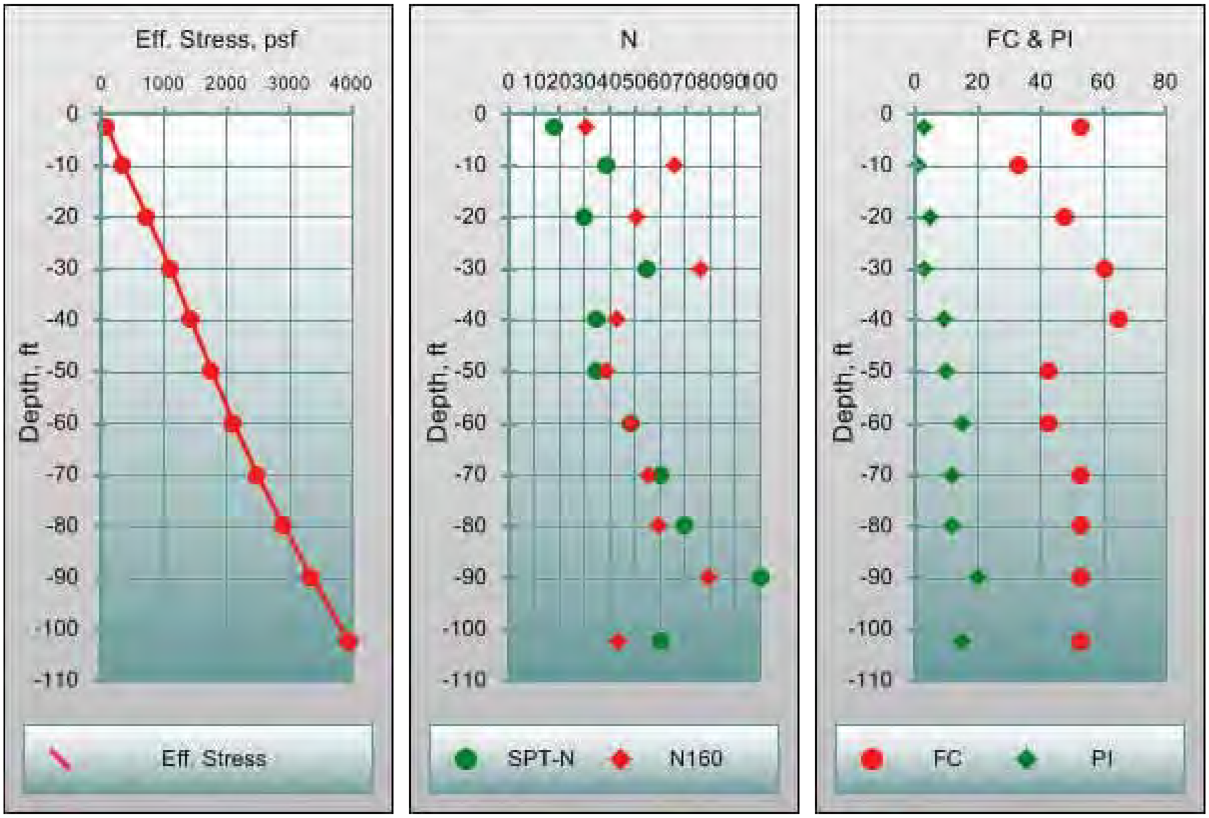
=== Soil Profile ===
Unit: ft
The number of soil layers: 11
GWT at top of layer: 1
GWT depth: 0.00
SPT Energy Ratio (%): 60.00
Amplification Factors: a= 0.1400 b= 0.0200
Elevation: 0.00
Ground Surface: Infinite Slope (%)= 0.2

Layer	Descpt.	Thickness (ft)	Unit Weight (lb/ft3)	Nm	N160	Vs ft/sec
1	Soft_sandy_silt	5	95.00	18	30.6	763.0
2	Soft_silt	10	100.00	39	66.3	954.8
3	Medium_dense_silty_sand	10	100.00	30	51.0	884.9
4	Soft_silty_sand	10	100.00	55	76.2	1054.9
5	Loose_silty_sand	10	90.00	35	42.6	925.3
6	Soft_silty_sand	10	100.00	35	38.4	925.3
7	Loose_silty_sand	10	95.00	48	48.1	1014.1
8	Medium_dense_sand	10	105.00	60	55.4	1081.9
9	Medium_dense_silty_sand	10	105.00	70	59.7	1131.3
10	Dense_sand	10	110.00	100	79.4	1254.6
11	Dense_sand	15	110.00	60	43.9	1081.9

Layer	FC (%)	PI	wc/LL	D50 (mm)	Ini. Eff. Stress (psf)	Ini. Total Stress (psf)
1	53	3	0.9	1128.0	81.5	237.50
2	33	1	1	1598.0	351.0	975.00
3	47.5	5	0.9	1786.0	727.0	1975.00
4	60.5	3	1	2068.0	1103.0	2975.00
5	65	9	0.9	2350.0	1429.0	3925.00
6	42.5	10	0.8	2726.0	1755.0	4875.00

7	42.5	15	1	3572.0	2106.0	5850.00
8	53	12	0.9	4700.0	2482.0	6850.00
9	53	12	0.9	3347.0	2908.0	7900.00
10	53	20	1	3773.0	3359.0	8975.00
11	53	15	0.9	4305.5	3954.0	10350.00

Soil Profile Plots



=== Susceptibility Evaluation ===

Threshold: 0.5

Weighting factors: B-I= 0.50 B-S= 0.50

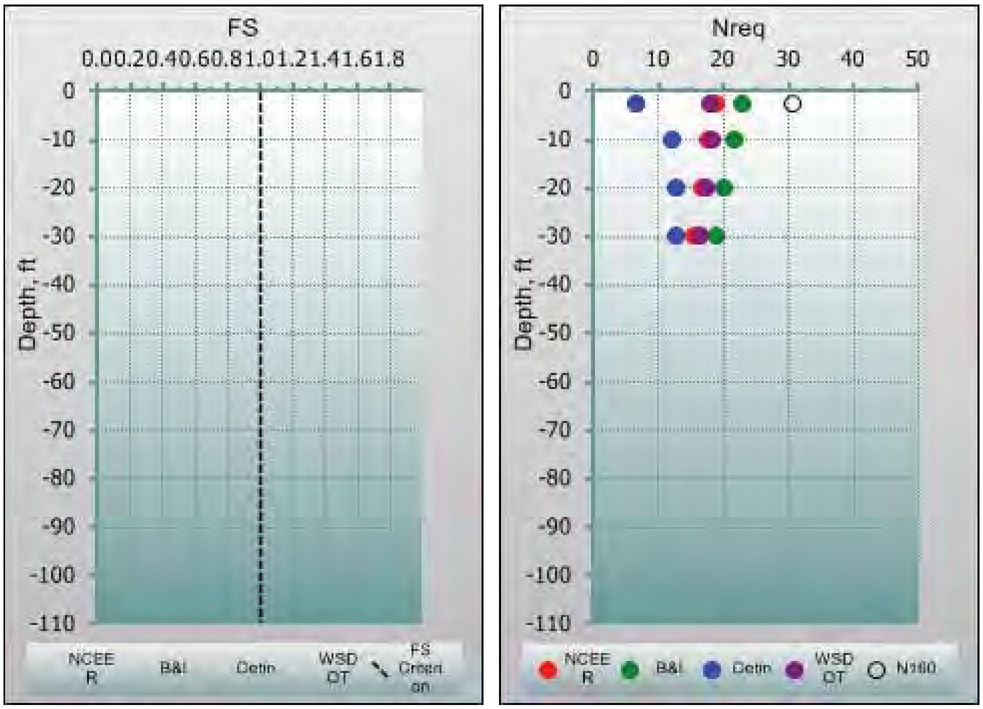
Layer	PI	wc/LL	B-I	B-S	Suscep. Index	Potential
1	3.00	0.90	0.96	0.63	0.80	YES
2	1.00	1.00	1.00	0.76	0.88	YES
3	5.00	0.90	0.62	0.63	0.62	YES
4	3.00	1.00	0.96	0.76	0.86	YES
5	9.00	0.90	0.09	0.59	0.34	NO
6	10.00	0.80	0.05	0.41	0.23	NO
7	15.00	1.00	0.01	0.37	0.19	NO
8	12.00	0.90	0.02	0.48	0.25	NO
9	12.00	0.90	0.02	0.48	0.25	NO
10	20.00	1.00	0.00	0.13	0.06	NO
11	15.00	0.90	0.01	0.31	0.16	NO

=== Initiation ===

```
Initiation - Multiple Scenario
-----------------------------------------
Retrun Period (yrs) = 108
Models Selected :
Use All Deterministic Models.
--WSDOT Recommended--
   Use NCEER, Boulanger & Idriss, and
   Cetin's model with weighting factors
   of 0.4, 0.4, and 0.2 respectively.
-----------------------------------------


===== Mean Mw and FS ==============
---NCEER Model------------
--- PGA = 0.176  Mw = 6.46---------

Layer  (N1)60    CSR     CRR     FS     Nreq
-----  ------  ------  ------  ------  ------
    1   30.60   0.223   3.000   13.46    19.1
    2   66.30   0.205   3.000   14.61    17.9
    3   51.00   0.191   3.000   15.74    16.8
    4   76.18   0.175   3.000   17.11    15.5


===== Mean Mw and FS ==============
---Boulanger and Idriss Model------------
--- PGA = 0.176  Mw = 6.46---------

Layer  (N1)60    CSR     CRR     FS     Nreq
-----  ------  ------  ------  ------  ------
    1   30.60   0.263   1.448    5.51    22.9
    2   46.00   0.243   3.000   12.36    21.6
    3   41.00   0.225   3.000   13.32    20.3
    4   46.00   0.210   3.000   14.29    19.0


===== Mean Mw and FS ==============
---Cetin et al. Model------------
--- PGA = 0.176  Mw = 6.46---------

Layer  (N1)60    CSR     CRR     FS     Nreq
-----  ------  ------  ------  ------  ------
    1   28.80   0.333   2.453    7.37     6.6
    2   62.40   0.317   3.000    9.45    12.1
    3   48.00   0.310   3.000    9.69    12.9
    4   76.18   0.306   3.000    9.82    12.9

---WSDOT Recommended------------
--- PGA = 0.176  Mw = 6.46---------

Layer  (N1)60    CSR     CRR     FS     Nreq
-----  ------  ------  ------  ------  ------
    1   30.60   0.261   2.270    8.70    18.1
    2   66.30   0.243   3.000   12.36    18.2
    3   51.00   0.228   3.000   13.14    17.4
    4   76.18   0.215   3.000   13.94    16.4
```

Table of FS

#	Depth ft	NCEER	B&I	Cetin PL=0.60	WSDOT PL=0.60
1	-2.50	13.46	5.51	7.37	8.70
2	-10.00	14.61	12.36	9.45	12.36
3	-20.00	15.74	13.32	9.69	13.14
4	-30.00	17.11	14.29	9.82	13.94



=== Effects ===

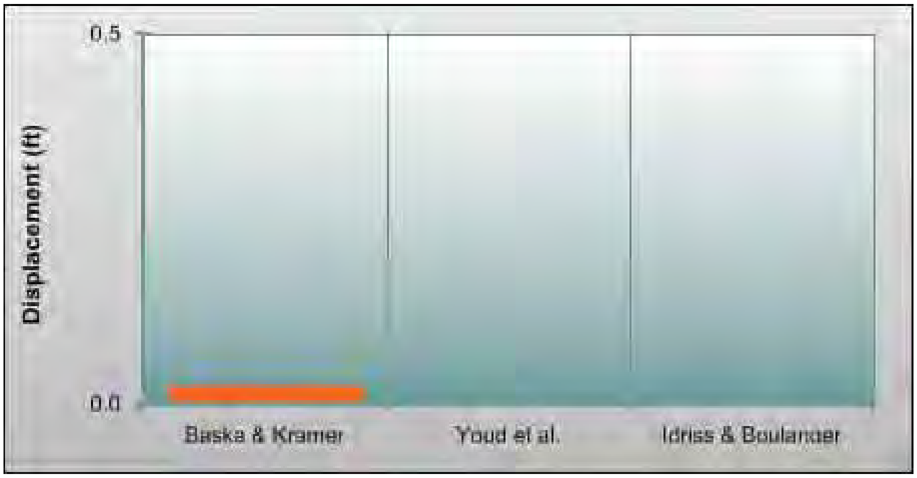
** Lateral Spreading **

>>>Multiple Scenario Results
Model Selected :
WSDOT Recommended (weighted average)
using models of Baska & Kramer and Youd et al.

Baska & Kramer: 0.03 ft
Youd et al.: 0.00 ft (Notice: T15 = 0)
Idriss & Boulanger: 0.00 ft

Weighting factors: Baska and Kramer = 0.65
Youd et al. = 0.35

WSDOT Recommended: 0.02 ft



=== Effects ===

** Settlement **

>>>Multiple Scenario Results
Groud Surface Settlement MULTIPLE Scenario
Return Period (yrs) = 108
Model Selected :
   Use all deterministic models.

Tokimatsu & Seed
=================
Total ground surface settlement = 0.00 ft

#	Depth ft	thickness ft	ev %	Weight	dh ft
1	2.50	5.0	0.001	0.00	0.00
2	10.00	10.0	0.001	0.00	0.00
3	20.00	10.0	0.001	0.00	0.00
4	30.00	10.0	0.001	0.00	0.00
5	40.00	10.0	0.001	0.00	0.00
6	50.00	10.0	0.001	0.00	0.00
7	60.00	10.0	0.001	0.00	0.00
8	70.00	10.0	0.001	0.00	0.00
9	80.00	10.0	0.001	0.00	0.00
10	90.00	10.0	0.001	0.00	0.00
11	102.50	15.0	0.001	0.00	0.00

Ishihara & Yoshimine
=================
Total ground surface settlement = 0.00 ft

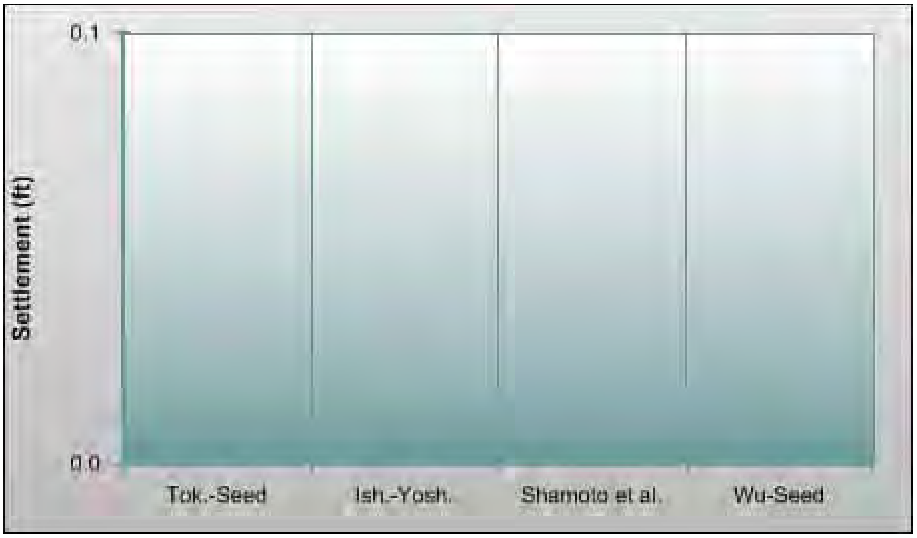
#	Depth ft	thickness ft	ev %	Weight	dh ft
1	2.50	5.0	0.001	0.00	0.00
2	10.00	10.0	0.001	0.00	0.00
3	20.00	10.0	0.001	0.00	0.00
4	30.00	10.0	0.001	0.00	0.00
5	40.00	10.0	0.001	0.00	0.00
6	50.00	10.0	0.001	0.00	0.00
7	60.00	10.0	0.001	0.00	0.00
8	70.00	10.0	0.001	0.00	0.00
9	80.00	10.0	0.001	0.00	0.00
10	90.00	10.0	0.001	0.00	0.00
11	102.50	15.0	0.001	0.00	0.00

Shamoto et al.
=================
Total ground surface settlement = 0.00 ft

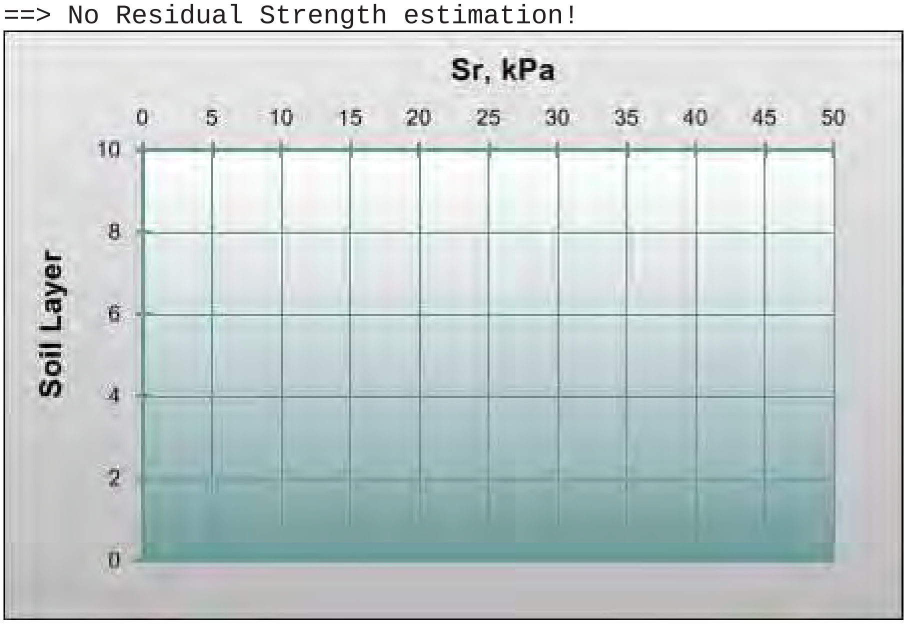
#	Depth ft	thickness ft	ev %	Weight	dh ft
1	2.50	5.0	0.121	0.02	0.00
2	10.00	10.0	0.000	0.00	0.00
3	20.00	10.0	0.000	0.00	0.00
4	30.00	10.0	0.000	0.00	0.00
5	40.00	10.0	0.000	0.00	0.00
6	50.00	10.0	0.000	0.00	0.00
7	60.00	10.0	0.000	0.00	0.00
8	70.00	10.0	0.000	0.00	0.00
9	80.00	10.0	0.000	0.00	0.00
10	90.00	10.0	0.000	0.00	0.00
11	102.50	15.0	0.000	0.00	0.00

Wu & Seed
=================
Total ground surface settlement = 0.00 ft

#	Depth ft	thickness ft	ev %	Weight	dh ft
1	2.50	5.0	0.007	0.04	0.00
2	10.00	10.0	0.000	0.00	0.00
3	20.00	10.0	0.000	0.00	0.00
4	30.00	10.0	0.000	0.00	0.00
5	40.00	10.0	0.000	0.00	0.00
6	50.00	10.0	0.000	0.00	0.00
7	60.00	10.0	0.000	0.00	0.00
8	70.00	10.0	0.000	0.00	0.00
9	80.00	10.0	0.000	0.00	0.00
10	90.00	10.0	0.000	0.00	0.00
11	102.50	15.0	0.000	0.00	0.00




```
=== Effects ===
----------------------------------------------------


** Residual Strength **
-----------------------
All soil layers that are suspcetible to liquefaction
have N1,60 > 20.
==> No Residual Strength estimation!
```



Liquefaction Hazard Evaluation Report
by WSLiq Program beta (May, 2009)

Site Name: Lockheed West Seattle
Site Location (N,W) = 47.583 , 122.367
Job No: 106-8945
Analyst: TetraTech
Date: 10/14/2011 1:28:58 PM

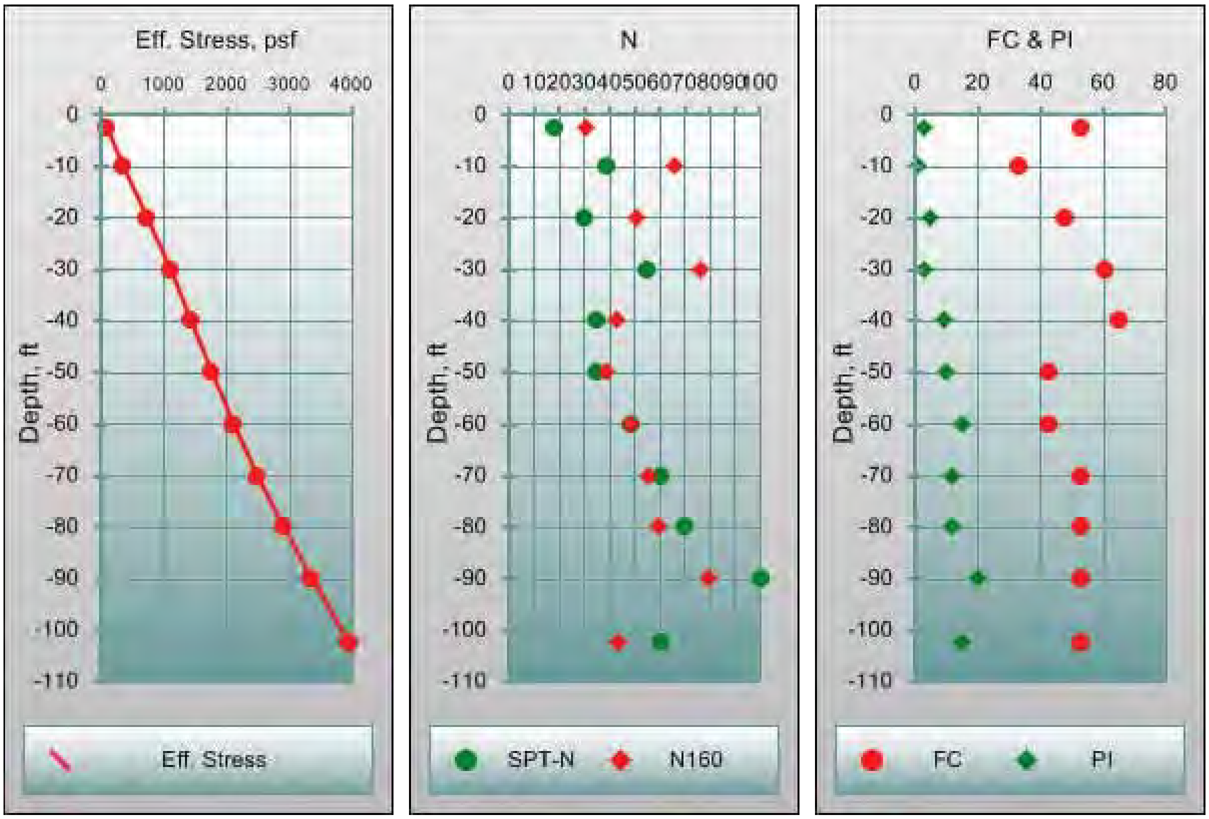
=== Soil Profile ===
Unit: ft
The number of soil layers: 11
GWT at top of layer: 1
GWT depth: 0.00
SPT Energy Ratio (%): 60.00
Amplification Factors: a= 0.1400 b= 0.0200
Elevation: 0.00
Ground Surface: Infinite Slope (%)= 0.2

Layer	Descpt.	Thickness (ft)	Unit Weight (lb/ft3)	Nm	N160	Vs ft/sec
1	Soft_sandy_silt	5	95.00	18	30.6	763.0
2	Soft_silt	10	100.00	39	66.3	954.8
3	Medium_dense_silty_sand	10	100.00	30	51.0	884.9
4	Soft_silty_sand	10	100.00	55	76.2	1054.9
5	Loose_silty_sand	10	90.00	35	42.6	925.3
6	Soft_silty_sand	10	100.00	35	38.4	925.3
7	Loose_silty_sand	10	95.00	48	48.1	1014.1
8	Medium_dense_sand	10	105.00	60	55.4	1081.9
9	Medium_dense_silty_sand	10	105.00	70	59.7	1131.3
10	Dense_sand	10	110.00	100	79.4	1254.6
11	Dense_sand	15	110.00	60	43.9	1081.9

Layer	FC (%)	PI	wc/LL	D50 (mm)	Ini. Eff. Stress (psf)	Ini. Total Stress (psf)
1	53	3	0.9	1128.0	81.5	237.50
2	33	1	1	1598.0	351.0	975.00
3	47.5	5	0.9	1786.0	727.0	1975.00
4	60.5	3	1	2068.0	1103.0	2975.00
5	65	9	0.9	2350.0	1429.0	3925.00
6	42.5	10	0.8	2726.0	1755.0	4875.00

7	42.5	15	1	3572.0	2106.0	5850.00
8	53	12	0.9	4700.0	2482.0	6850.00
9	53	12	0.9	3347.0	2908.0	7900.00
10	53	20	1	3773.0	3359.0	8975.00
11	53	15	0.9	4305.5	3954.0	10350.00

Soil Profile Plots



=== Susceptibility Evaluation ===

Threshold: 0.5

Weighting factors: B-I= 0.50 B-S= 0.50

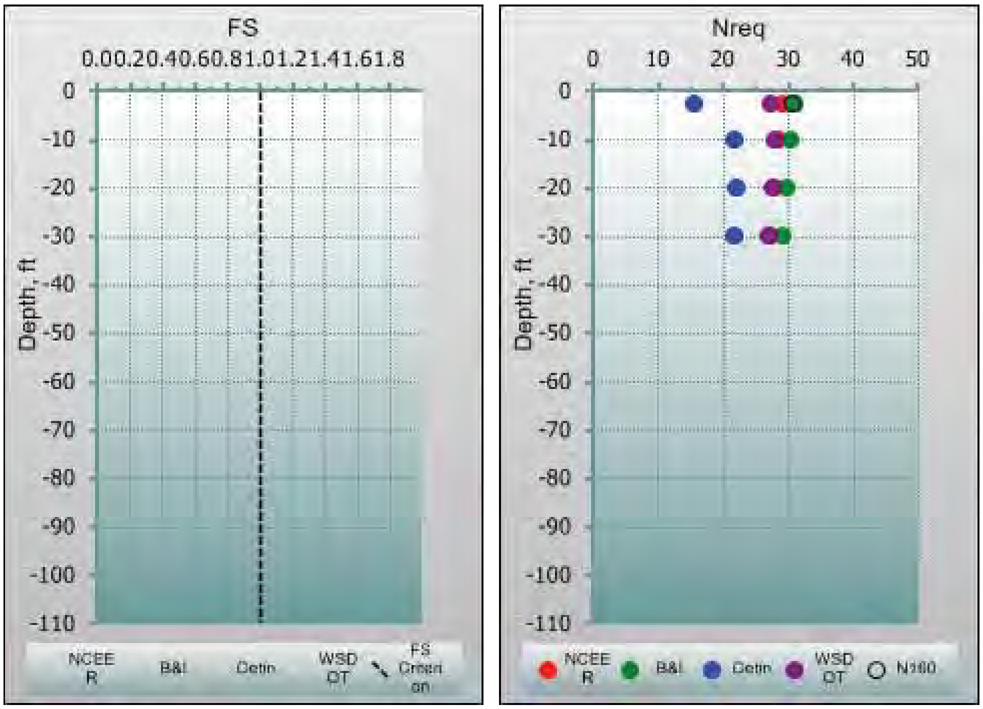
Layer	PI	wc/LL	B-I	B-S	Suscep. Index	Potential
1	3.00	0.90	0.96	0.63	0.80	YES
2	1.00	1.00	1.00	0.76	0.88	YES
3	5.00	0.90	0.62	0.63	0.62	YES
4	3.00	1.00	0.96	0.76	0.86	YES
5	9.00	0.90	0.09	0.59	0.34	NO
6	10.00	0.80	0.05	0.41	0.23	NO
7	15.00	1.00	0.01	0.37	0.19	NO
8	12.00	0.90	0.02	0.48	0.25	NO
9	12.00	0.90	0.02	0.48	0.25	NO
10	20.00	1.00	0.00	0.13	0.06	NO
11	15.00	0.90	0.01	0.31	0.16	NO

=== Initiation ===

```
Initiation - Multiple Scenario
-----------------------------------------
Retrun Period (yrs) = 475
Models Selected :
Use All Deterministic Models.
--WSDOT Recommended--
   Use NCEER, Boulanger & Idriss, and
   Cetin's model with weighting factors
   of 0.4, 0.4, and 0.2 respectively.
-----------------------------------------


===== Mean Mw and FS ==============
---NCEER Model------------
--- PGA = 0.378  Mw = 6.58---------

Layer  (N1)60    CSR     CRR     FS     Nreq
-----  ------  ------  ------  ------  ------
    1   30.60   0.499   3.000    6.02    29.3
    2   66.30   0.459   3.000    6.53    28.7
    3   51.00   0.427   3.000    7.03    28.0
    4   76.18   0.392   3.000    7.65    27.2


===== Mean Mw and FS ==============
---Boulanger and Idriss Model------------
--- PGA = 0.378  Mw = 6.58---------

Layer  (N1)60    CSR     CRR     FS     Nreq
-----  ------  ------  ------  ------  ------
    1   30.60   0.577   1.448    2.51    30.9
    2   46.00   0.534   3.000    5.62    30.4
    3   41.00   0.496   3.000    6.05    29.8
    4   46.00   0.462   3.000    6.49    29.2


===== Mean Mw and FS ==============
---Cetin et al. Model------------
--- PGA = 0.378  Mw = 6.58---------

Layer  (N1)60    CSR     CRR     FS     Nreq
-----  ------  ------  ------  ------  ------
    1   28.80   0.716   2.376    3.32    15.5
    2   62.40   0.682   3.000    4.40    21.6
    3   48.00   0.666   3.000    4.51    22.0
    4   76.18   0.656   3.000    4.57    21.6

---WSDOT Recommended------------
--- PGA = 0.378  Mw = 6.58---------

Layer  (N1)60    CSR     CRR     FS     Nreq
-----  ------  ------  ------  ------  ------
    1   30.60   0.573   2.254    3.93    27.2
    2   66.30   0.534   3.000    5.62    28.0
    3   51.00   0.502   3.000    5.98    27.5
    4   76.18   0.473   3.000    6.34    26.9
```

Table of FS

#	Depth ft	NCEER	B&I	Cetin PL=0.60	WSDOT PL=0.60
1	-2.50	6.02	2.51	3.32	3.93
2	-10.00	6.53	5.62	4.40	5.62
3	-20.00	7.03	6.05	4.51	5.98
4	-30.00	7.65	6.49	4.57	6.34



=== Effects ===

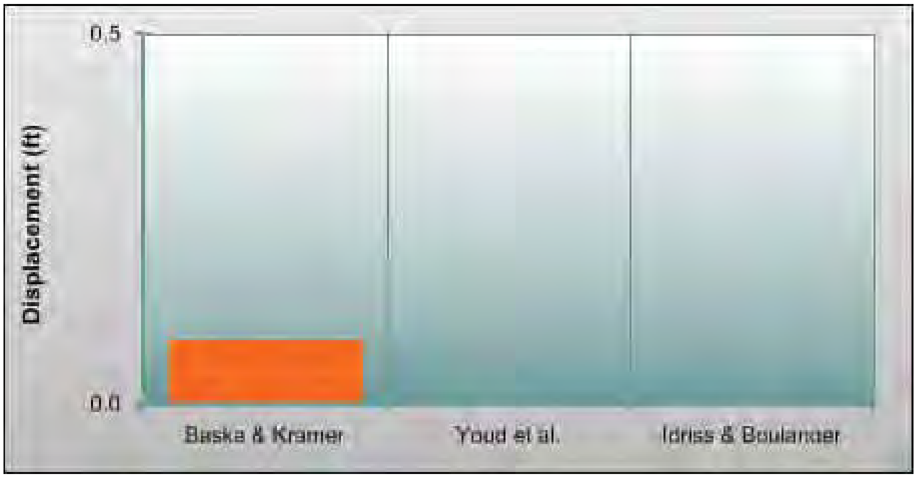
** Lateral Spreading **

>>>Multiple Scenario Results
Model Selected :
   WSDOT Recommended (weighted average)
   using models of Baska & Kramer and Youd et al.

Baska & Kramer: 0.09 ft
Youd et al.: 0.00 ft (Notice: T15 = 0)
Idriss & Boulanger: 0.00 ft

Weighting factors: Baska and Kramer = 0.65
                   Youd et al.   = 0.35

WSDOT Recommended: 0.06 ft



=== Effects ===

** Settlement **

>>>Multiple Scenario Results
Groud Surface Settlement MULTIPLE Scenario
Return Period (yrs) = 475
Model Selected :
Use all deterministic models.

Tokimatsu & Seed
=================
Total ground surface settlement = 0.00 ft

#	Depth ft	thickness ft	ev %	Weight	dh ft
1	2.50	5.0	0.001	0.16	0.00
2	10.00	10.0	0.001	0.00	0.00
3	20.00	10.0	0.001	0.00	0.00
4	30.00	10.0	0.001	0.00	0.00
5	40.00	10.0	0.001	0.00	0.00
6	50.00	10.0	0.001	0.00	0.00
7	60.00	10.0	0.001	0.00	0.00
8	70.00	10.0	0.001	0.00	0.00
9	80.00	10.0	0.001	0.00	0.00
10	90.00	10.0	0.001	0.00	0.00
11	102.50	15.0	0.001	0.00	0.00

Ishihara & Yoshimine
=================
Total ground surface settlement = 0.00 ft

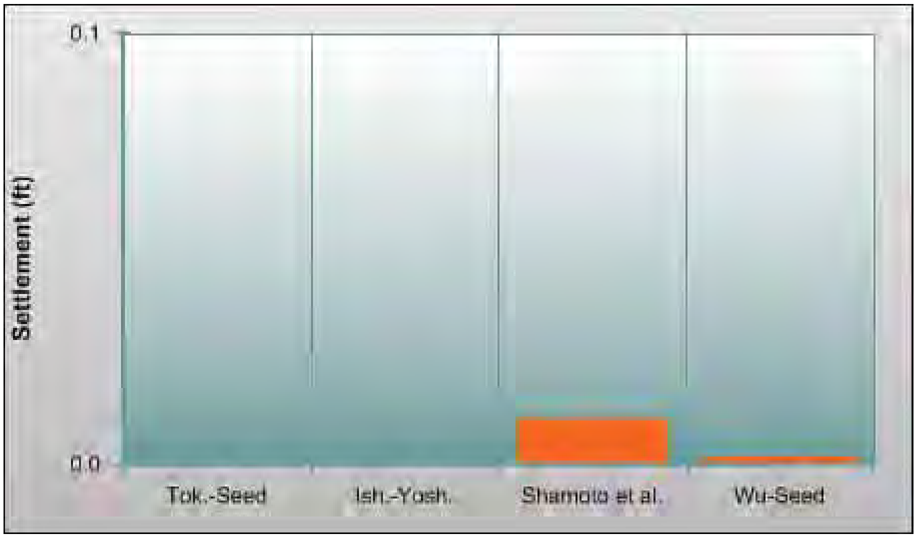
#	Depth ft	thickness ft	ev %	Weight	dh ft
1	2.50	5.0	0.001	0.16	0.00
2	10.00	10.0	0.001	0.00	0.00
3	20.00	10.0	0.001	0.00	0.00
4	30.00	10.0	0.001	0.00	0.00
5	40.00	10.0	0.001	0.00	0.00
6	50.00	10.0	0.001	0.00	0.00
7	60.00	10.0	0.001	0.00	0.00
8	70.00	10.0	0.001	0.00	0.00
9	80.00	10.0	0.001	0.00	0.00
10	90.00	10.0	0.001	0.00	0.00
11	102.50	15.0	0.001	0.00	0.00

Shamoto et al.
=================
Total ground surface settlement = 0.01 ft

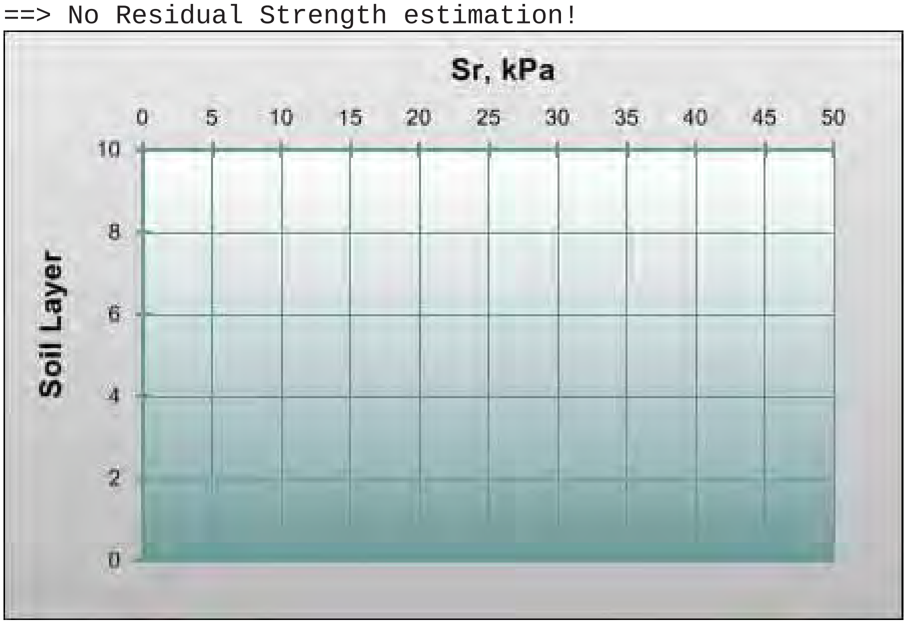
#	Depth ft	thickness ft	ev %	Weight	dh ft
1	2.50	5.0	1.011	0.22	0.01
2	10.00	10.0	0.000	0.00	0.00
3	20.00	10.0	0.000	0.00	0.00
4	30.00	10.0	0.000	0.00	0.00
5	40.00	10.0	0.000	0.00	0.00
6	50.00	10.0	0.000	0.00	0.00
7	60.00	10.0	0.000	0.00	0.00
8	70.00	10.0	0.000	0.00	0.00
9	80.00	10.0	0.000	0.00	0.00
10	90.00	10.0	0.000	0.00	0.00
11	102.50	15.0	0.000	0.00	0.00

Wu & Seed
=================
Total ground surface settlement = 0.00 ft

#	Depth ft	thickness ft	ev %	Weight	dh ft
1	2.50	5.0	0.125	0.32	0.00
2	10.00	10.0	0.000	0.00	0.00
3	20.00	10.0	0.000	0.00	0.00
4	30.00	10.0	0.000	0.00	0.00
5	40.00	10.0	0.000	0.00	0.00
6	50.00	10.0	0.000	0.00	0.00
7	60.00	10.0	0.000	0.00	0.00
8	70.00	10.0	0.000	0.00	0.00
9	80.00	10.0	0.000	0.00	0.00
10	90.00	10.0	0.000	0.00	0.00
11	102.50	15.0	0.000	0.00	0.00




```
=== Effects ===
---------------------------------------------------


** Residual Strength **
-----------------------
All soil layers that are suspcetible to liquefaction
have N1,60 > 20.
==> No Residual Strength estimation!
```



Liquefaction Hazard Evaluation Report
by WSLiq Program beta (May, 2009)

Site Name: Lockheed West Seattle
Site Location (N,W) = 47.583 , 122.367
Job No: 106-8945
Analyst: TetraTech
Date: 10/14/2011 2:58:37 PM

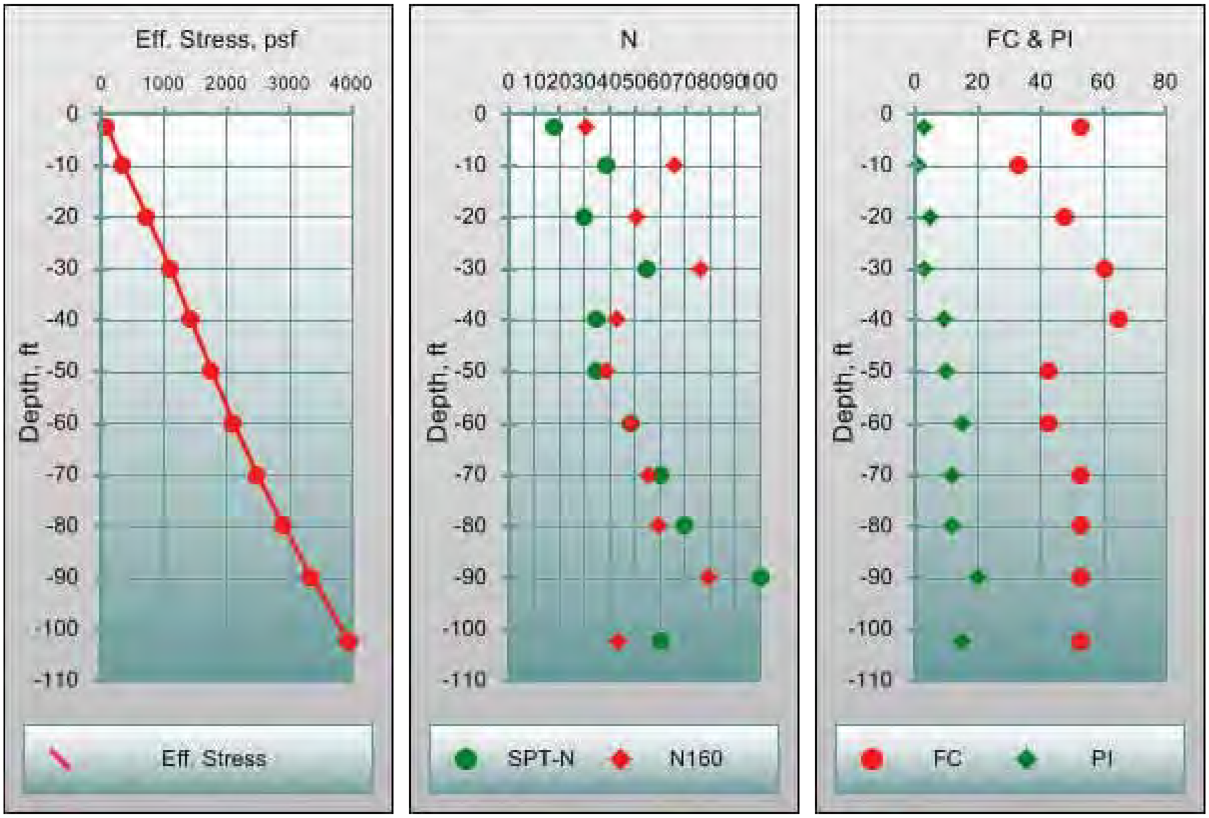
=== Soil Profile ===
Unit: ft
The number of soil layers: 11
GWT at top of layer: 1
GWT depth: 0.00
SPT Energy Ratio (%): 60.00
Amplification Factors: a= 0.1400 b= 0.0200
Elevation: 0.00
Ground Surface: Infinite Slope (%)= 0.2

Layer	Descpt.	Thickness (ft)	Unit Weight (lb/ft3)	Nm	N160	Vs ft/sec
1	Soft_sandy_silt	5	95.00	18	30.6	763.0
2	Soft_silt	10	100.00	39	66.3	954.8
3	Medium_dense_silty_sand	10	100.00	30	51.0	884.9
4	Soft_silty_sand	10	100.00	55	76.2	1054.9
5	Loose_silty_sand	10	90.00	35	42.6	925.3
6	Soft_silty_sand	10	100.00	35	38.4	925.3
7	Loose_silty_sand	10	95.00	48	48.1	1014.1
8	Medium_dense_sand	10	105.00	60	55.4	1081.9
9	Medium_dense_silty_sand	10	105.00	70	59.7	1131.3
10	Dense_sand	10	110.00	100	79.4	1254.6
11	Dense_sand	15	110.00	60	43.9	1081.9

Layer	FC (%)	PI	wc/LL	D50 (mm)	Ini. Eff. Stress (psf)	Ini. Total Stress (psf)
1	53	3	0.9	1128.0	81.5	237.50
2	33	1	1	1598.0	351.0	975.00
3	47.5	5	0.9	1786.0	727.0	1975.00
4	60.5	3	1	2068.0	1103.0	2975.00
5	65	9	0.9	2350.0	1429.0	3925.00
6	42.5	10	0.8	2726.0	1755.0	4875.00

7	42.5	15	1	3572.0	2106.0	5850.00
8	53	12	0.9	4700.0	2482.0	6850.00
9	53	12	0.9	3347.0	2908.0	7900.00
10	53	20	1	3773.0	3359.0	8975.00
11	53	15	0.9	4305.5	3954.0	10350.00

Soil Profile Plots



=== Susceptibility Evaluation ===

Threshold: 0.5

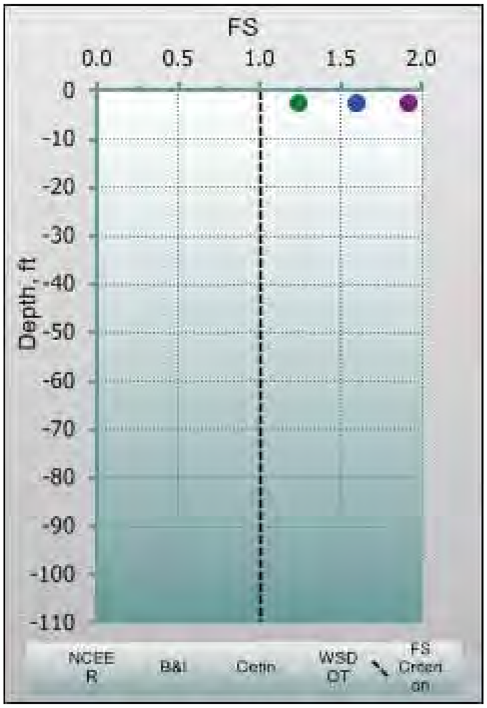
Weighting factors: B-I= 0.50 B-S= 0.50

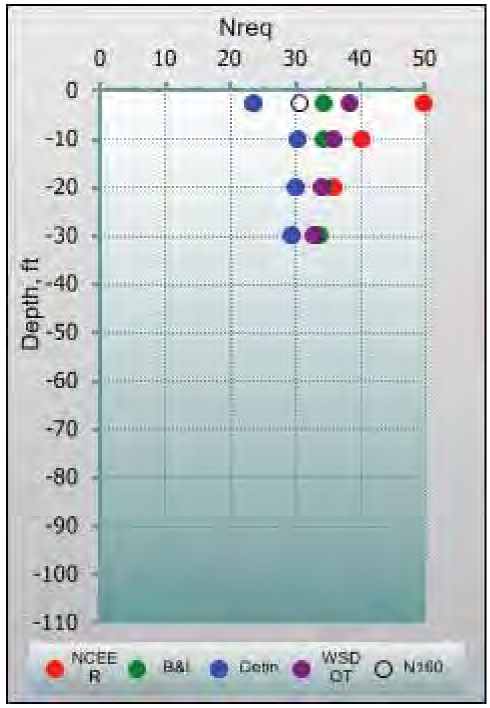
Layer	PI	wc/LL	B-I	B-S	Suscep. Index	Potential
1	3.00	0.90	0.96	0.63	0.80	YES
2	1.00	1.00	1.00	0.76	0.88	YES
3	5.00	0.90	0.62	0.63	0.62	YES
4	3.00	1.00	0.96	0.76	0.86	YES
5	9.00	0.90	0.09	0.59	0.34	NO
6	10.00	0.80	0.05	0.41	0.23	NO
7	15.00	1.00	0.01	0.37	0.19	NO
8	12.00	0.90	0.02	0.48	0.25	NO
9	12.00	0.90	0.02	0.48	0.25	NO
10	20.00	1.00	0.00	0.13	0.06	NO
11	15.00	0.90	0.01	0.31	0.16	NO

=== Initiation ===

```
Initiation - Multiple Scenario
-----------------------------------------
Retrun Period (yrs) = 2475
Models Selected :
Use All Deterministic Models.
--WSDOT Recommended--
   Use NCEER, Boulanger & Idriss, and
   Cetin's model with weighting factors
   of 0.4, 0.4, and 0.2 respectively.
-----------------------------------------


===== Mean Mw and FS ==============
---NCEER Model------------
--- PGA = 0.754  Mw = 6.71---------

Layer  (N1)60    CSR     CRR     FS     Nreq
-----  ------  ------  ------  ------  ------
    1   30.60   1.033   3.000    2.90    50.0
    2   66.30   0.952   3.000    3.15    40.3
    3   51.00   0.884   3.000    3.39    35.9
    4   76.18   0.813   3.000    3.69    33.4


===== Mean Mw and FS ==============
---Boulanger and Idriss Model------------
--- PGA = 0.754  Mw = 6.71---------

Layer  (N1)60    CSR     CRR     FS     Nreq
-----  ------  ------  ------  ------  ------
    1   30.60   1.172   1.448    1.23    34.3
    2   46.00   1.085   3.000    2.76    34.5
    3   41.00   1.008   3.000    2.98    34.3
    4   46.00   0.940   3.000    3.19    33.9


===== Mean Mw and FS ==============
---Cetin et al. Model------------
--- PGA = 0.754  Mw = 6.71---------

Layer  (N1)60    CSR     CRR     FS     Nreq
-----  ------  ------  ------  ------  ------
    1   28.80   1.427   2.282    1.60    23.6
    2   62.40   1.359   3.000    2.21    30.3
    3   48.00   1.324   3.000    2.27    30.2
    4   76.18   1.302   3.000    2.30    29.5

---WSDOT Recommended------------
--- PGA = 0.754  Mw = 6.71---------

Layer  (N1)60    CSR     CRR     FS     Nreq
-----  ------  ------  ------  ------  ------
    1   30.60   1.168   2.235    1.91    38.4
    2   66.30   1.087   3.000    2.76    36.0
    3   51.00   1.022   3.000    2.94    34.1
    4   76.18   0.962   3.000    3.12    32.9
```

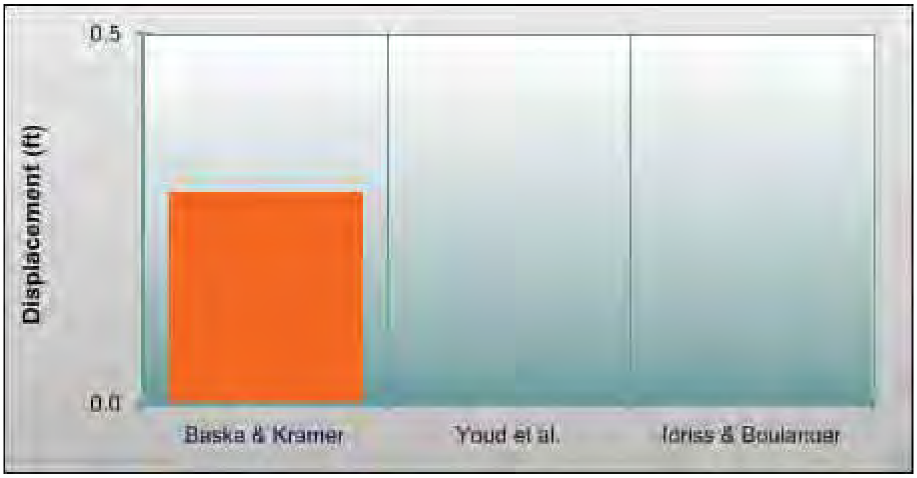
```
  Table of FS
--------------------------------------
  #      Depth   NCEER     B&I      Cetin      WSDOT
           ft                      PL=0.60    PL=0.60
  1      -2.50    2.90    1.23       1.60       1.91
  2     -10.00    3.15    2.76       2.21       2.76
  3     -20.00    3.39    2.98       2.27       2.94
  4     -30.00    3.69    3.19       2.30       3.12
```






```
=== Effects ===
---------------------------------------------------


** Lateral Spreading **
-----------------------
>>>Multiple Scenario Results
Model Selected :
   WSDOT Recommended (weighted average)
   using models of Baska & Kramer and Youd et al.
-----------------------------------------

Baska & Kramer: 0.29 ft
Youd et al.: 0.00 ft (Notice: T15 = 0)
Idriss & Boulanger: 0.00 ft

----------------------------------------
Weighting factors: Baska and Kramer = 0.65
                   Youd et al.      = 0.35
```

WSDOT Recommended: 0.19 ft



=== Effects ===

** Settlement **

>>>Multiple Scenario Results
Groud Surface Settlement MULTIPLE Scenario
Return Period (yrs) = 2475
Model Selected :
Use all deterministic models.

Tokimatsu & Seed
=================
Total ground surface settlement = 0.00 ft

#	Depth ft	thickness ft	ev %	Weight	dh ft
1	2.50	5.0	0.001	0.94	0.00
2	10.00	10.0	0.001	0.00	0.00
3	20.00	10.0	0.001	0.00	0.00
4	30.00	10.0	0.001	0.00	0.00
5	40.00	10.0	0.001	0.00	0.00
6	50.00	10.0	0.001	0.00	0.00
7	60.00	10.0	0.001	0.00	0.00
8	70.00	10.0	0.001	0.00	0.00
9	80.00	10.0	0.001	0.00	0.00
10	90.00	10.0	0.001	0.00	0.00
11	102.50	15.0	0.001	0.00	0.00

Ishihara & Yoshimine
=================
Total ground surface settlement = 0.00 ft

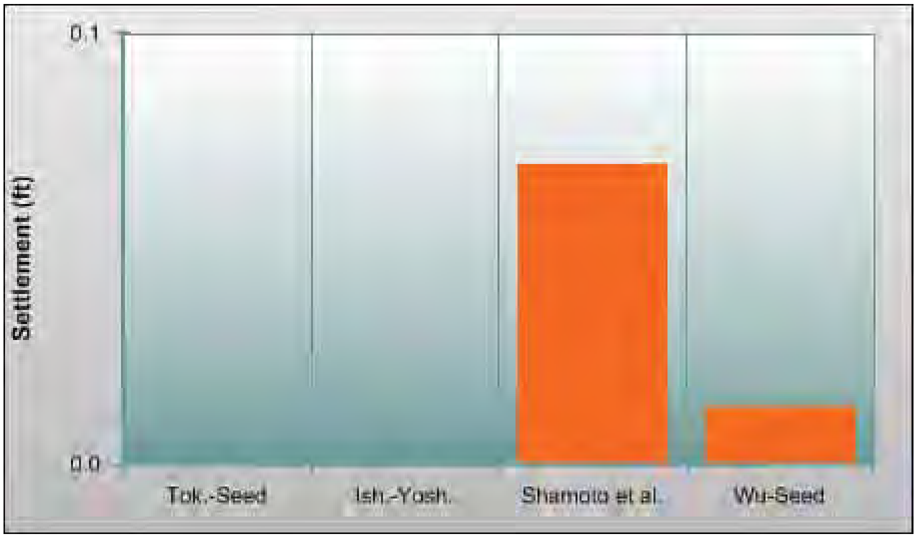
#	Depth ft	thickness ft	ev %	Weight	dh ft
1	2.50	5.0	0.005	0.99	0.00
2	10.00	10.0	0.001	0.00	0.00
3	20.00	10.0	0.001	0.00	0.00
4	30.00	10.0	0.001	0.00	0.00
5	40.00	10.0	0.001	0.00	0.00
6	50.00	10.0	0.001	0.00	0.00
7	60.00	10.0	0.001	0.00	0.00
8	70.00	10.0	0.001	0.00	0.00
9	80.00	10.0	0.001	0.00	0.00
10	90.00	10.0	0.001	0.00	0.00
11	102.50	15.0	0.001	0.00	0.00

Shamoto et al.
=================
Total ground surface settlement = 0.07 ft

#	Depth ft	thickness ft	ev %	Weight	dh ft
1	2.50	5.0	1.477	0.95	0.07
2	10.00	10.0	0.000	0.00	0.00
3	20.00	10.0	0.000	0.00	0.00
4	30.00	10.0	0.000	0.00	0.00
5	40.00	10.0	0.000	0.00	0.00
6	50.00	10.0	0.000	0.00	0.00
7	60.00	10.0	0.000	0.00	0.00
8	70.00	10.0	0.000	0.00	0.00
9	80.00	10.0	0.000	0.00	0.00
10	90.00	10.0	0.000	0.00	0.00
11	102.50	15.0	0.000	0.00	0.00

Wu & Seed
=================
Total ground surface settlement = 0.01 ft

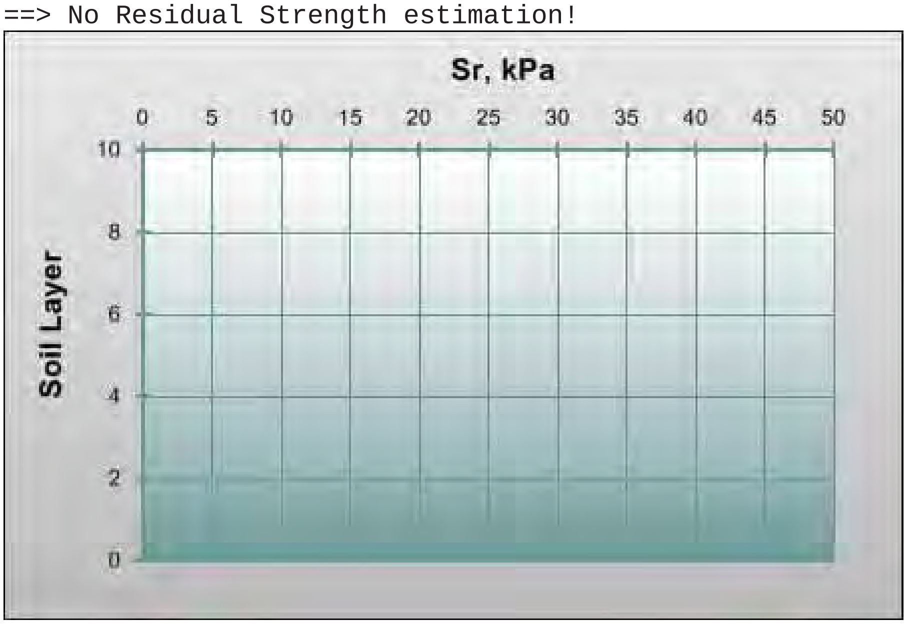
#	Depth ft	thickness ft	ev %	Weight	dh ft
1	2.50	5.0	0.289	0.95	0.01
2	10.00	10.0	0.000	0.00	0.00
3	20.00	10.0	0.000	0.00	0.00
4	30.00	10.0	0.000	0.00	0.00
5	40.00	10.0	0.000	0.00	0.00
6	50.00	10.0	0.000	0.00	0.00
7	60.00	10.0	0.000	0.00	0.00
8	70.00	10.0	0.000	0.00	0.00
9	80.00	10.0	0.000	0.00	0.00
10	90.00	10.0	0.000	0.00	0.00
11	102.50	15.0	0.000	0.00	0.00



=== Effects ===

** Residual Strength **

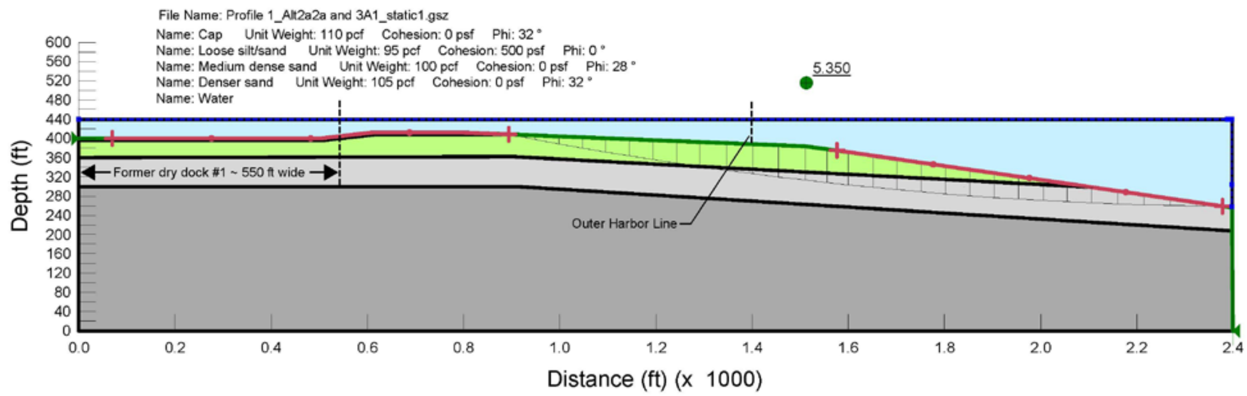
All soil layers that are suspcetible to liquefaction
have N1,60 > 20.
==> No Residual Strength estimation!

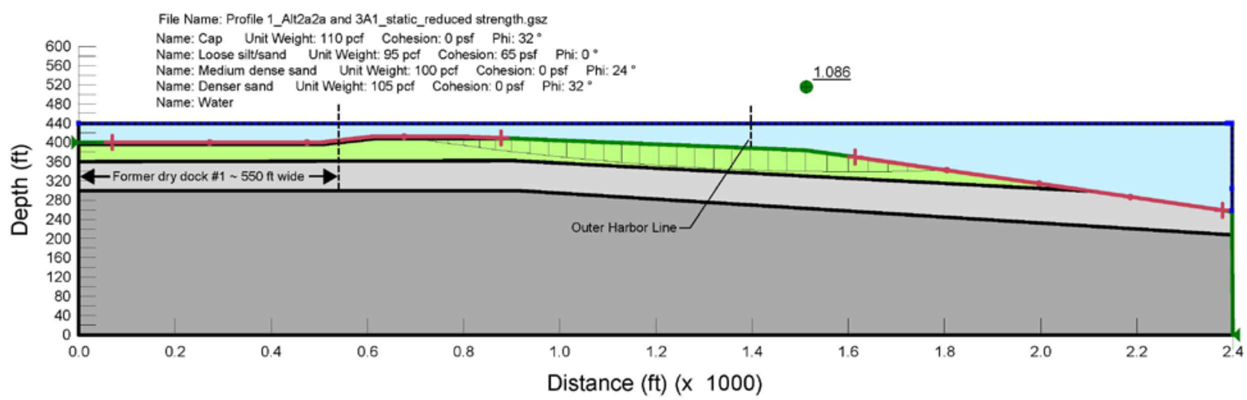


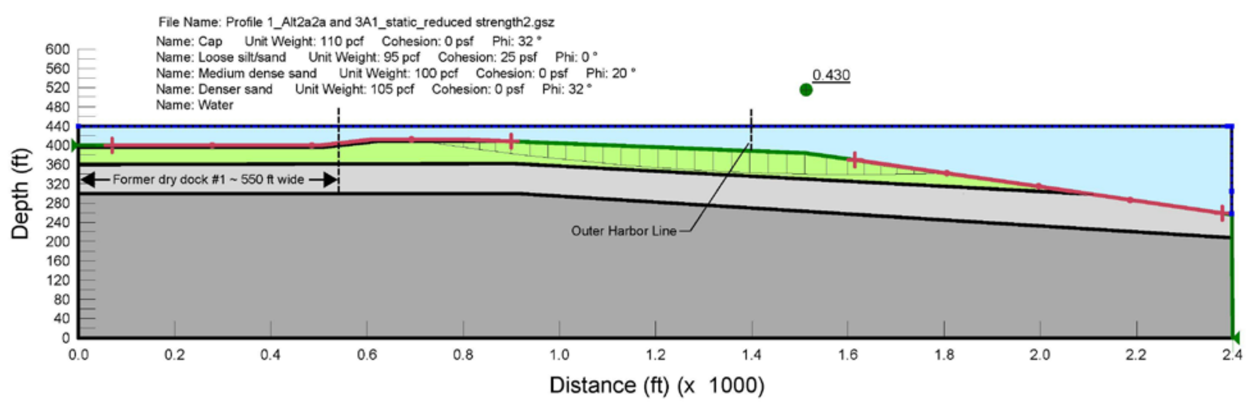
ATTACHMENT 3

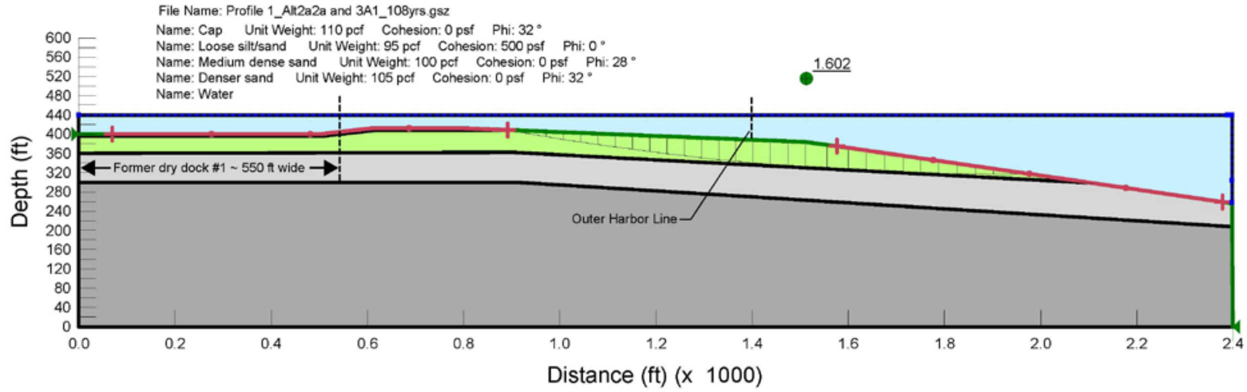
SLOPE STABILITY EVALUATION

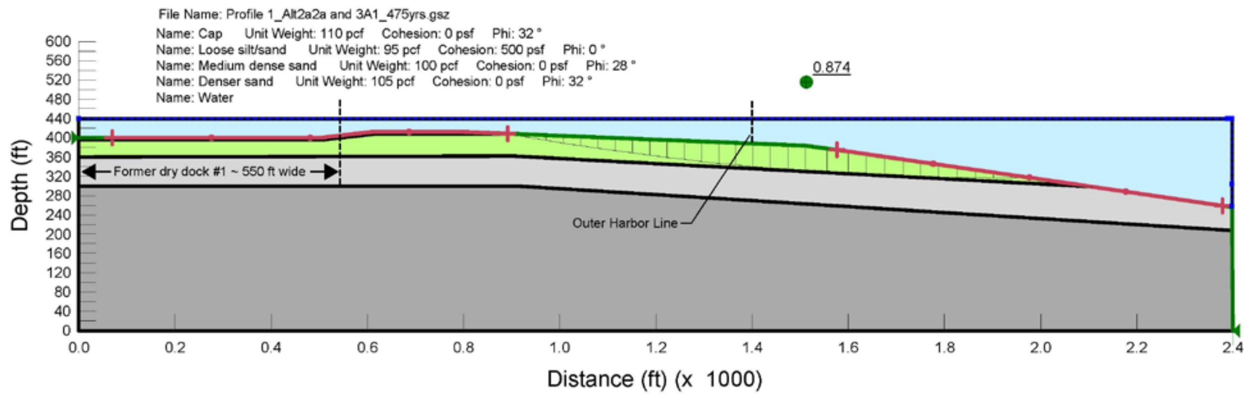
SLOPE STABILITY ANALYSIS BY SLOPE/W

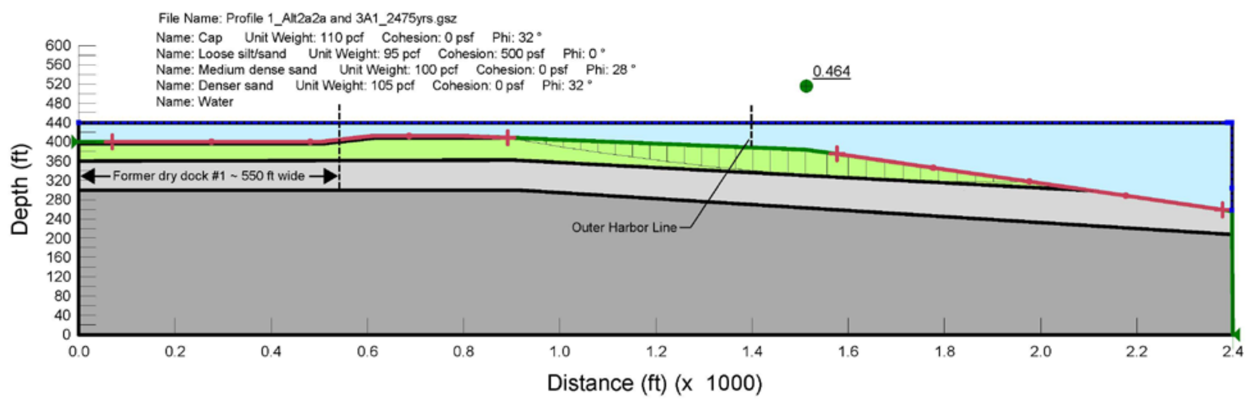

File Name: Profile 1_Alt2a2a and 3A1_static1.gsz
Name: Cap Unit Weight: 110 pcf Cohesion: 0 psf Phi: 32 °
Name: Loose silt/sand Unit Weight: 95 pcf Cohesion: 500 psf Phi: 0 °
Name: Medium dense sand Unit Weight: 100 pcf Cohesion: 0 psf Phi: 28 °
Name: Denser sand Unit Weight: 105 pcf Cohesion: 0 psf Phi: 32 °
Name: Water
5.350
Former dry dock #1 ~ 550 ft wide
Outer Harbor Line
Depth (ft)
Distance (ft) (x 1000)

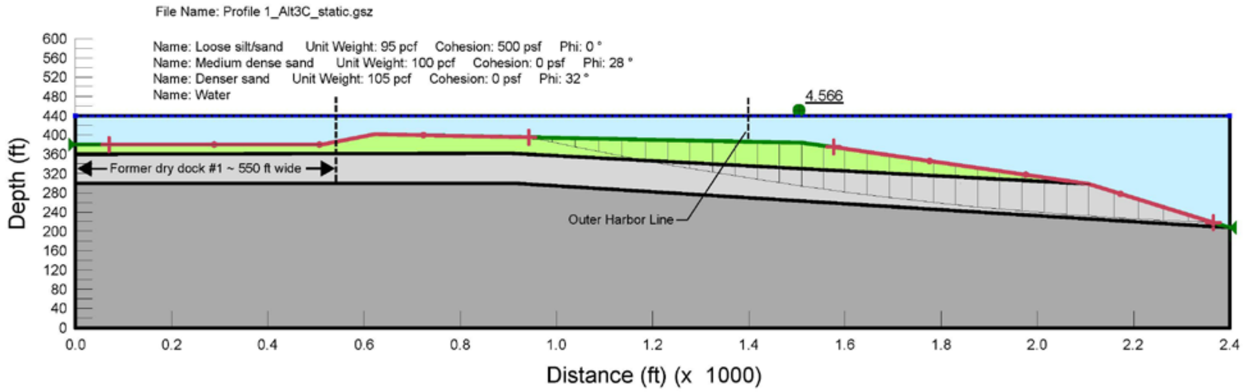

File Name: Profile 1_Alt2a2a and 3A1_static_reduced strength.gsz
Name: Cap Unit Weight: 110 pcf Cohesion: 0 psf Phi: 32 °
Name: Loose silt/sand Unit Weight: 95 pcf Cohesion: 65 psf Phi: 0 °
Name: Medium dense sand Unit Weight: 100 pcf Cohesion: 0 psf Phi: 24 °
Name: Denser sand Unit Weight: 105 pcf Cohesion: 0 psf Phi: 32 °
Name: Water
1.086
Former dry dock #1 ~ 550 ft wide
Outer Harbor Line
Depth (ft)
Distance (ft) (x 1000)

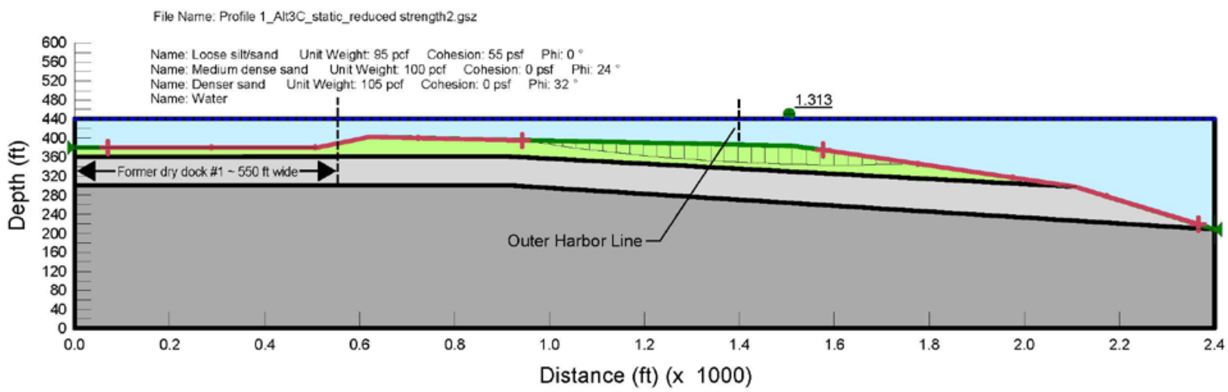

File Name: Profile 1_Alt2a2a and 3A1_static_reduced strength2.gsz
Name: Cap Unit Weight: 110 pcf Cohesion: 0 psf Phi: 32 °
Name: Loose silt/sand Unit Weight: 95 pcf Cohesion: 25 psf Phi: 0 °
Name: Medium dense sand Unit Weight: 100 pcf Cohesion: 0 psf Phi: 20 °
Name: Denser sand Unit Weight: 105 pcf Cohesion: 0 psf Phi: 32 °
Name: Water
0.430
Former dry dock #1 ~ 550 ft wide
Outer Harbor Line
Depth (ft)
Distance (ft) (x 1000)

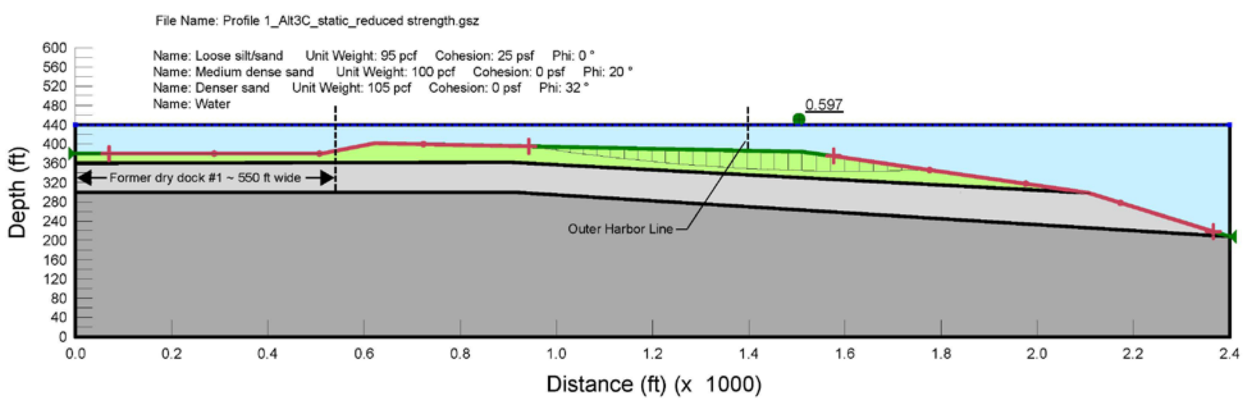

File Name: Profile 1_Alt2a2a and 3A1_108yrs.gsz
Name: Cap Unit Weight: 110 pcf Cohesion: 0 psf Phi: 32 °
Name: Loose silt/sand Unit Weight: 95 pcf Cohesion: 500 psf Phi: 0 °
Name: Medium dense sand Unit Weight: 100 pcf Cohesion: 0 psf Phi: 28 °
Name: Denser sand Unit Weight: 105 pcf Cohesion: 0 psf Phi: 32 °
Name: Water
1.602
Former dry dock #1 ~ 550 ft wide
Outer Harbor Line
Depth (ft)
Distance (ft) (x 1000)

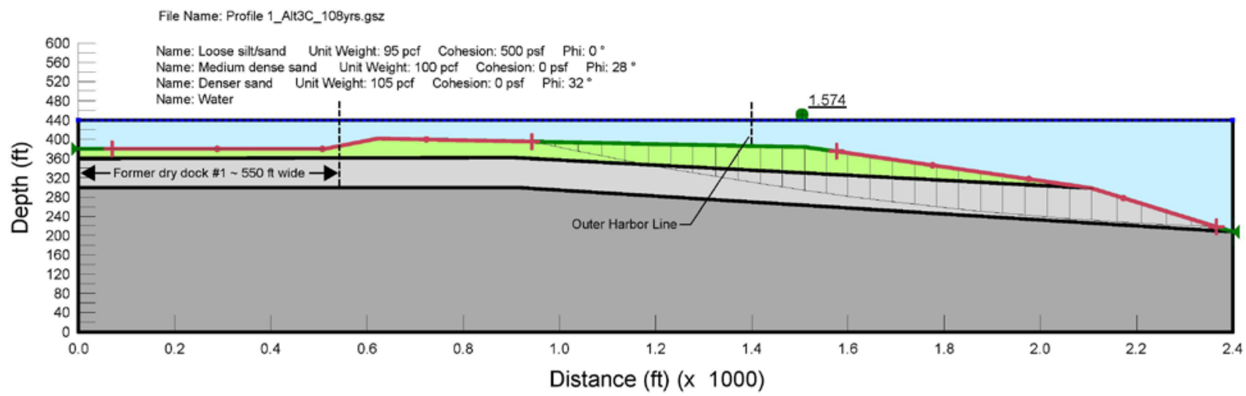

File Name: Profile 1_Alt2a2a and 3A1_475yrs.gsz
Name: Cap Unit Weight: 110 pcf Cohesion: 0 psf Phi: 32 °
Name: Loose silt/sand Unit Weight: 95 pcf Cohesion: 500 psf Phi: 0 °
Name: Medium dense sand Unit Weight: 100 pcf Cohesion: 0 psf Phi: 28 °
Name: Denser sand Unit Weight: 105 pcf Cohesion: 0 psf Phi: 32 °
Name: Water
0.874
Former dry dock #1 ~ 550 ft wide
Outer Harbor Line
Depth (ft)
Distance (ft) (x 1000)

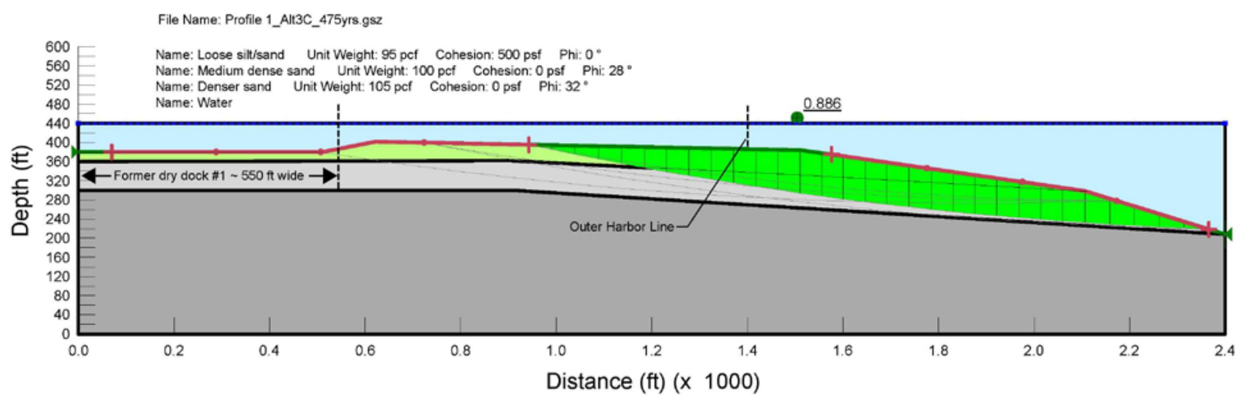

File Name: Profile 1_Alt2a2a and 3A1_2475yrs.gsz
Name: Cap Unit Weight: 110 pcf Cohesion: 0 psf Phi: 32 °
Name: Loose silt/sand Unit Weight: 95 pcf Cohesion: 500 psf Phi: 0 °
Name: Medium dense sand Unit Weight: 100 pcf Cohesion: 0 psf Phi: 28 °
Name: Denser sand Unit Weight: 105 pcf Cohesion: 0 psf Phi: 32 °
Name: Water
0.464
Former dry dock #1 ~ 550 ft wide
Outer Harbor Line
Depth (ft)
Distance (ft) (x 1000)

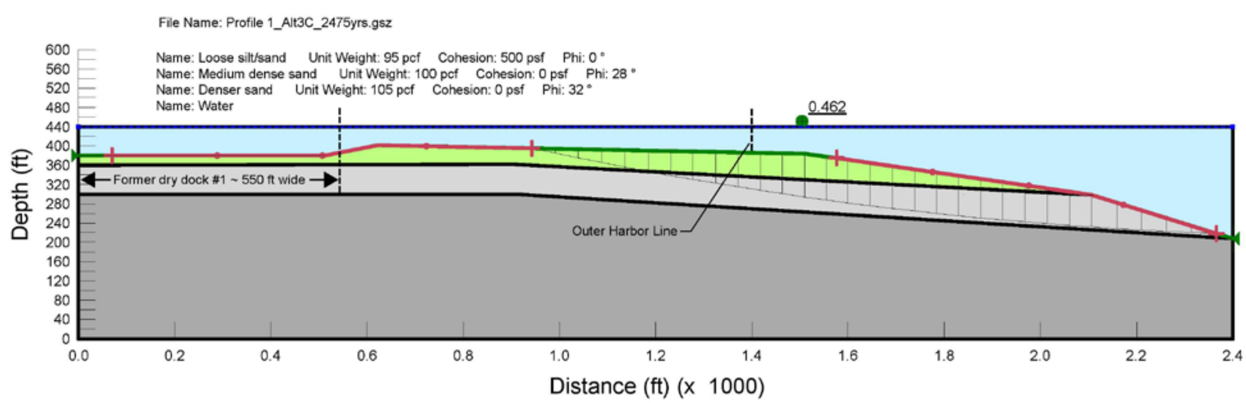

File Name: Profile 1_Alt3C_static.gsz
Name: Loose silt/sand Unit Weight: 95 pcf Cohesion: 500 psf Phi: 0 °
Name: Medium dense sand Unit Weight: 100 pcf Cohesion: 0 psf Phi: 28 °
Name: Denser sand Unit Weight: 105 pcf Cohesion: 0 psf Phi: 32 °
Name: Water
4.566
Former dry dock #1 ~ 550 ft wide
Outer Harbor Line
Depth (ft)
Distance (ft) (x 1000)

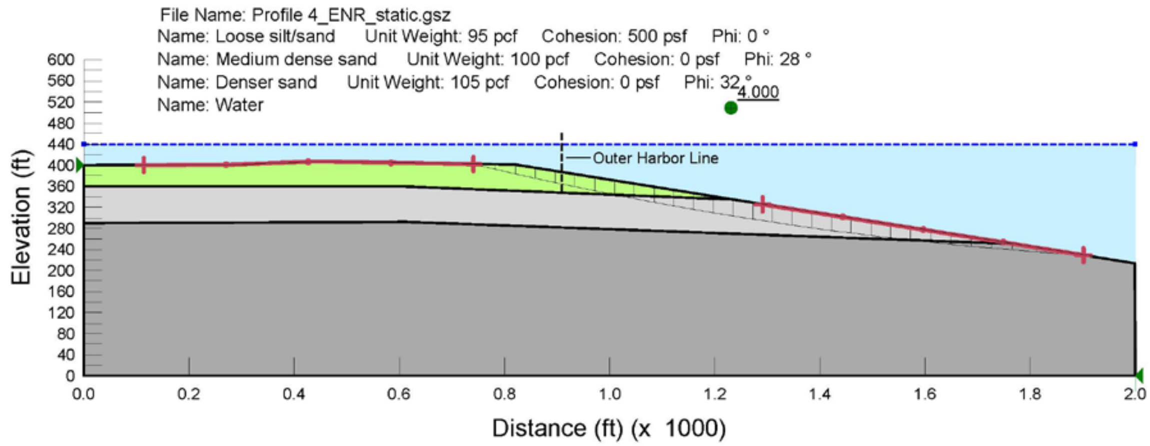

File Name: Profile 1_Alt3C_static_reduced strength2.gsz
Name: Loose silt/sand Unit Weight: 95 pcf Cohesion: 55 psf Phi: 0 °
Name: Medium dense sand Unit Weight: 100 pcf Cohesion: 0 psf Phi: 24 °
Name: Denser sand Unit Weight: 105 pcf Cohesion: 0 psf Phi: 32 °
Name: Water
1.313
Former dry dock #1 ~ 550 ft wide
Outer Harbor Line
Depth (ft)
Distance (ft) (x 1000)


File Name: Profile 1_Alt3C_static_reduced strength.gsz
Name: Loose silt/sand Unit Weight: 95 pcf Cohesion: 25 psf Phi: 0 °
Name: Medium dense sand Unit Weight: 100 pcf Cohesion: 0 psf Phi: 20 °
Name: Denser sand Unit Weight: 105 pcf Cohesion: 0 psf Phi: 32 °
Name: Water
0.597
Former dry dock #1 ~ 550 ft wide
Outer Harbor Line
Depth (ft)
Distance (ft) (x 1000)

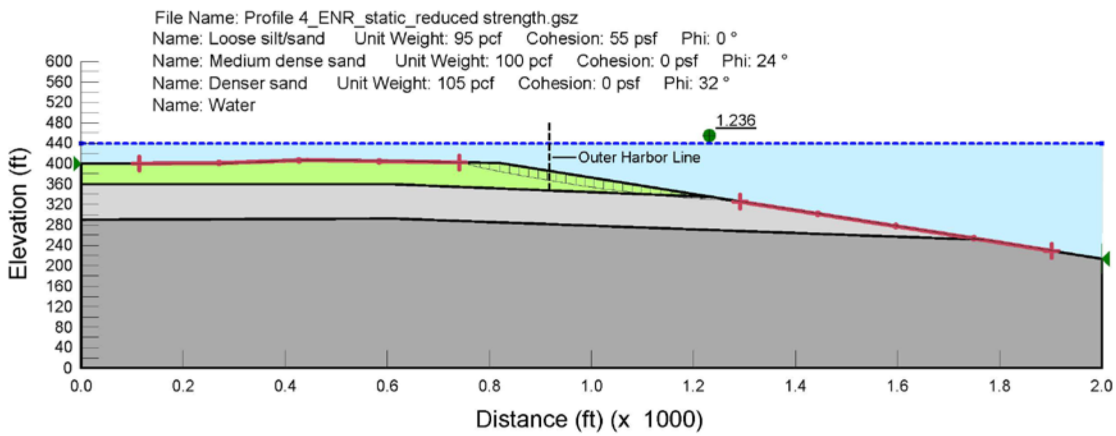

File Name: Profile 1_Alt3C_108yrs.gsz
Name: Loose silt/sand Unit Weight: 95 pcf Cohesion: 500 psf Phi: 0 °
Name: Medium dense sand Unit Weight: 100 pcf Cohesion: 0 psf Phi: 28 °
Name: Denser sand Unit Weight: 105 pcf Cohesion: 0 psf Phi: 32 °
Name: Water
1.574
Former dry dock #1 ~ 550 ft wide
Outer Harbor Line
Depth (ft)
Distance (ft) (x 1000)


File Name: Profile 1_Alt3C_475yrs.gsz
Name: Loose silt/sand Unit Weight: 95 pcf Cohesion: 500 psf Phi: 0 °
Name: Medium dense sand Unit Weight: 100 pcf Cohesion: 0 psf Phi: 28 °
Name: Denser sand Unit Weight: 105 pcf Cohesion: 0 psf Phi: 32 °
Name: Water
0.886
Former dry dock #1 ~ 550 ft wide
Outer Harbor Line
Depth (ft)
Distance (ft) (x 1000)

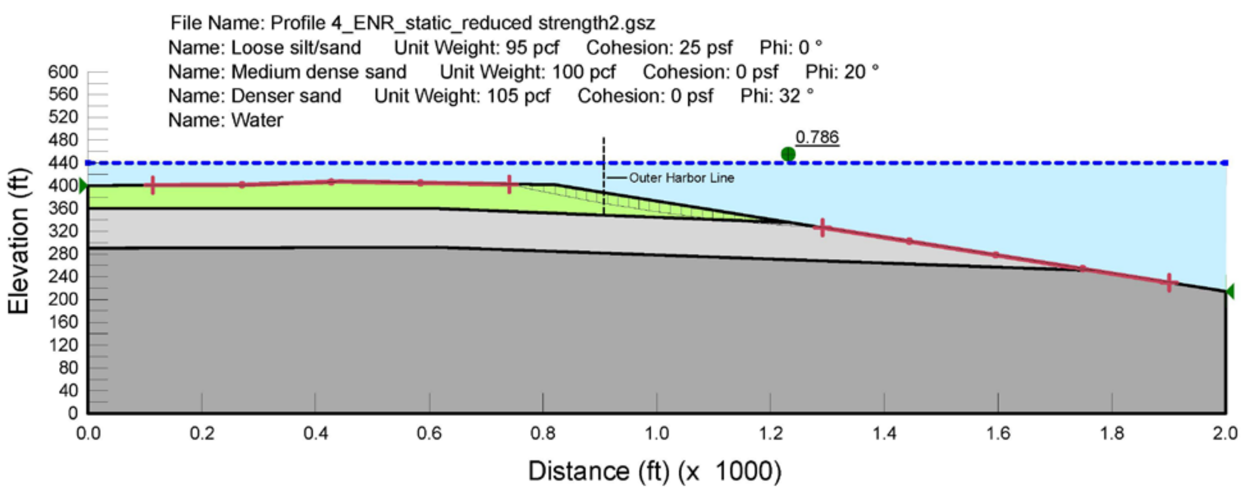

File Name: Profile 1_Alt3C_2475yrs.gsz
Name: Loose silt/sand Unit Weight: 95 pcf Cohesion: 500 psf Phi: 0 °
Name: Medium dense sand Unit Weight: 100 pcf Cohesion: 0 psf Phi: 28 °
Name: Denser sand Unit Weight: 105 pcf Cohesion: 0 psf Phi: 32 °
Name: Water
0.462
Former dry dock #1 ~ 550 ft wide
Outer Harbor Line
Depth (ft)
Distance (ft) (x 1000)



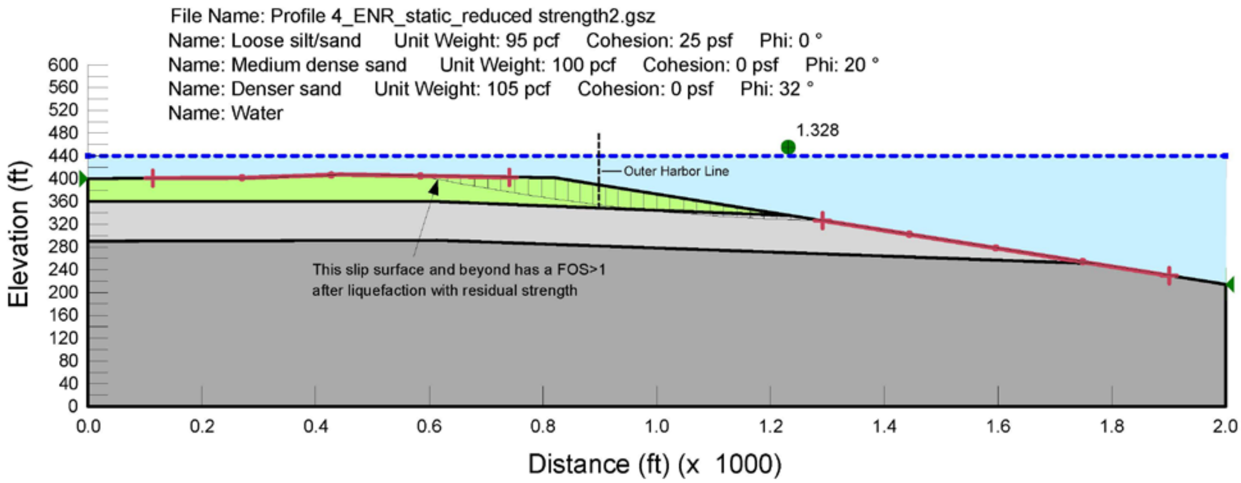
File Name: Profile 4_ENR_static.gsz
Name: Loose silt/sand Unit Weight: 95 pcf Cohesion: 500 psf Phi: 0 °
Name: Medium dense sand Unit Weight: 100 pcf Cohesion: 0 psf Phi: 28 °
Name: Denser sand Unit Weight: 105 pcf Cohesion: 0 psf Phi: 32 °
Name: Water
4.000
Outer Harbor Line
Elevation (ft)
Distance (ft) (x 1000)

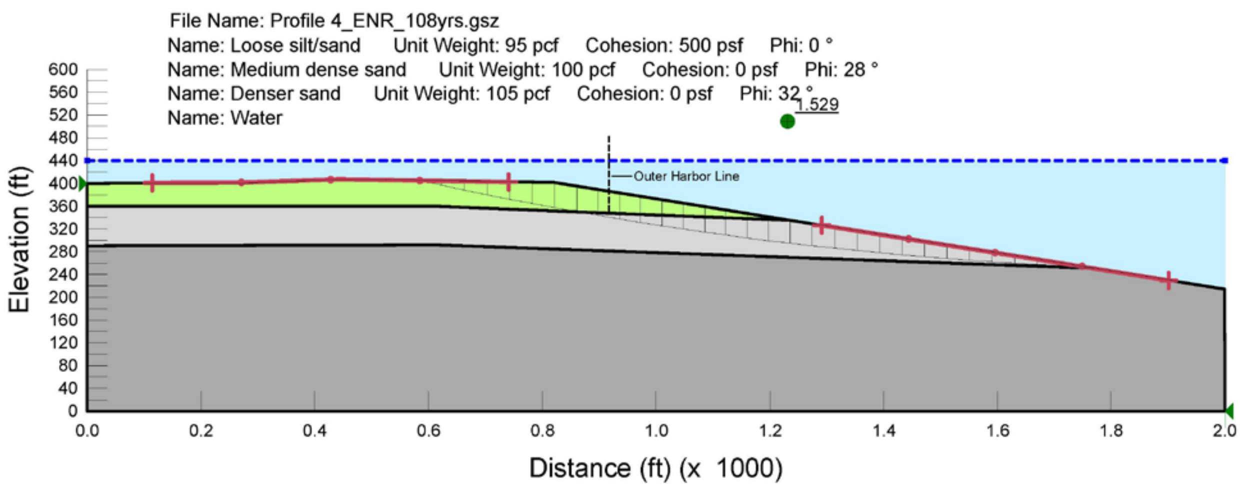


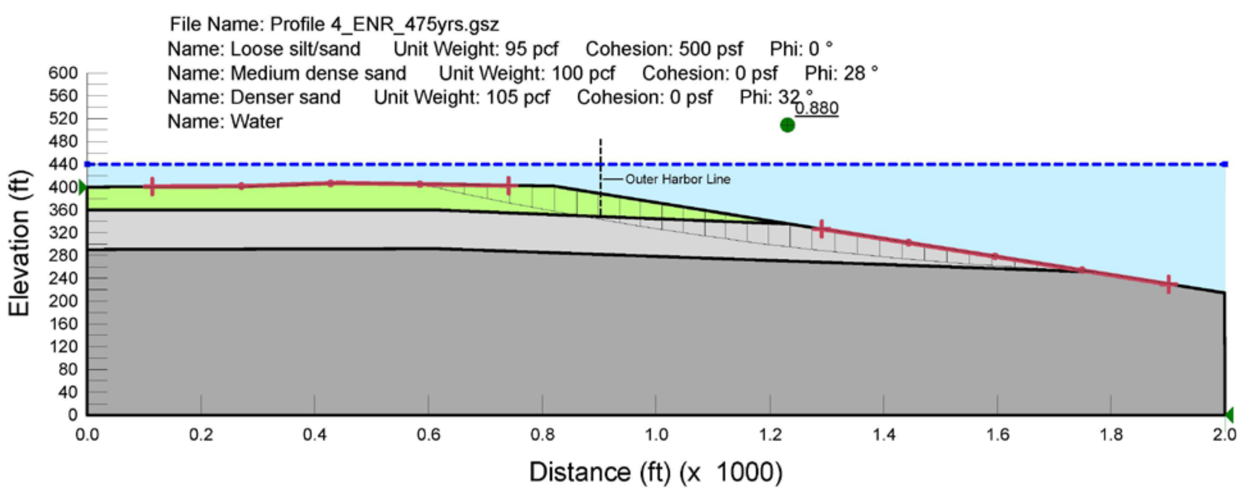
File Name: Profile 4_ENR_static_reduced strength.gsz
Name: Loose silt/sand Unit Weight: 95 pcf Cohesion: 55 psf Phi: 0 °
Name: Medium dense sand Unit Weight: 100 pcf Cohesion: 0 psf Phi: 24 °
Name: Denser sand Unit Weight: 105 pcf Cohesion: 0 psf Phi: 32 °
Name: Water
1.236
Outer Harbor Line
Elevation (ft)
Distance (ft) (x 1000)

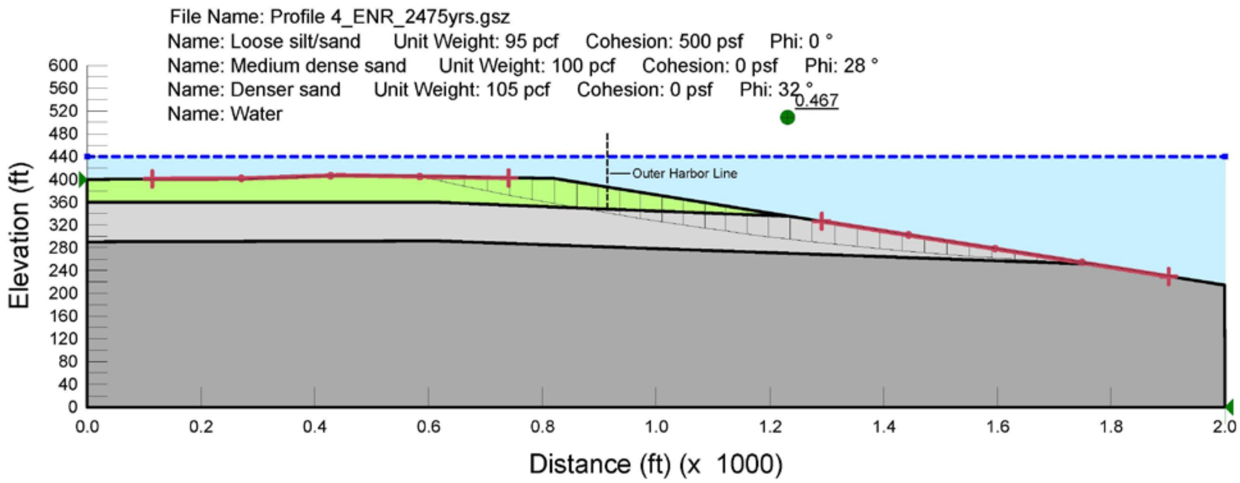


File Name: Profile 4_ENR_static_reduced strength2.gsz
Name: Loose silt/sand Unit Weight: 95 pcf Cohesion: 25 psf Phi: 0 °
Name: Medium dense sand Unit Weight: 100 pcf Cohesion: 0 psf Phi: 20 °
Name: Denser sand Unit Weight: 105 pcf Cohesion: 0 psf Phi: 32 °
Name: Water
0.786
Outer Harbor Line
Elevation (ft)
Distance (ft) (x 1000)


File Name: Profile 4_ENR_static_reduced strength2.gsz
Name: Loose silt/sand Unit Weight: 95 pcf Cohesion: 25 psf Phi: 0 °
Name: Medium dense sand Unit Weight: 100 pcf Cohesion: 0 psf Phi: 20 °
Name: Denser sand Unit Weight: 105 pcf Cohesion: 0 psf Phi: 32 °
Name: Water
1.328
Outer Harbor Line
This slip surface and beyond has a FOS>1
after liquefaction with residual strength
Elevation (ft)
Distance (ft) (x 1000)

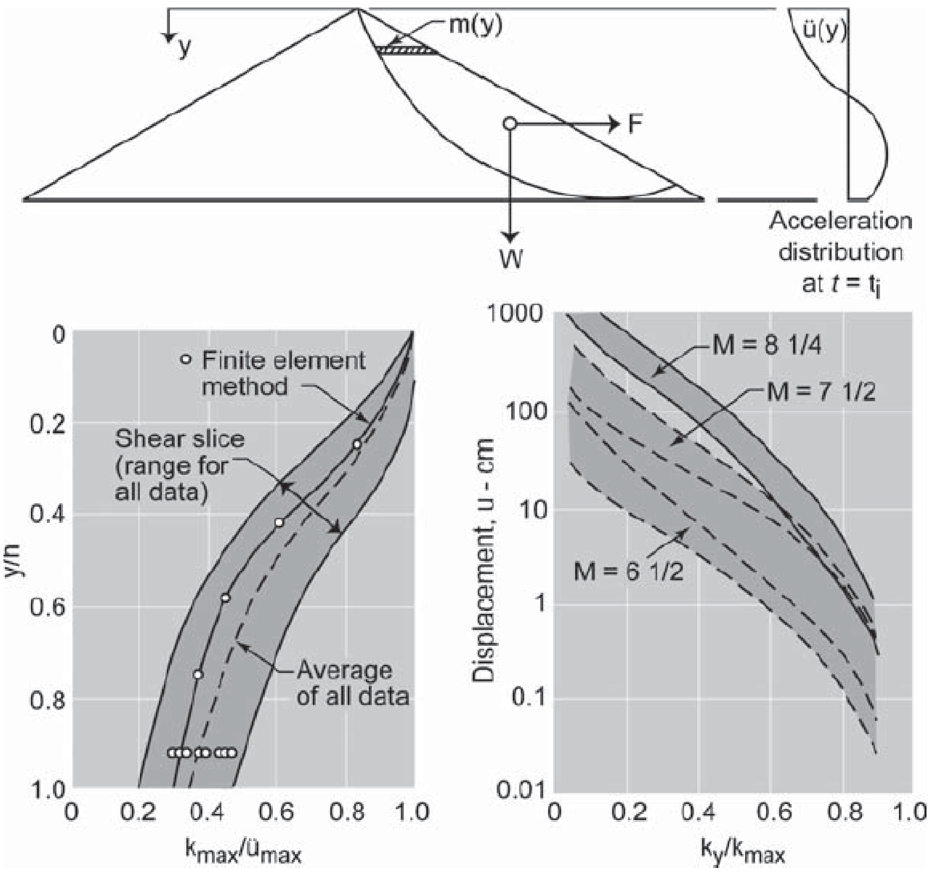

File Name: Profile 4_ENR_108yrs.gsz
Name: Loose silt/sand Unit Weight: 95 pcf Cohesion: 500 psf Phi: 0 °
Name: Medium dense sand Unit Weight: 100 pcf Cohesion: 0 psf Phi: 28 °
Name: Denser sand Unit Weight: 105 pcf Cohesion: 0 psf Phi: 32 °
Name: Water
1.529
Outer Harbor Line
Elevation (ft)
Distance (ft) (x 1000)


File Name: Profile 4_ENR_475yrs.gsz
Name: Loose silt/sand Unit Weight: 95 pcf Cohesion: 500 psf Phi: 0 °
Name: Medium dense sand Unit Weight: 100 pcf Cohesion: 0 psf Phi: 28 °
Name: Denser sand Unit Weight: 105 pcf Cohesion: 0 psf Phi: 32 °
Name: Water
0.880
Outer Harbor Line
Elevation (ft)
Distance (ft) (x 1000)

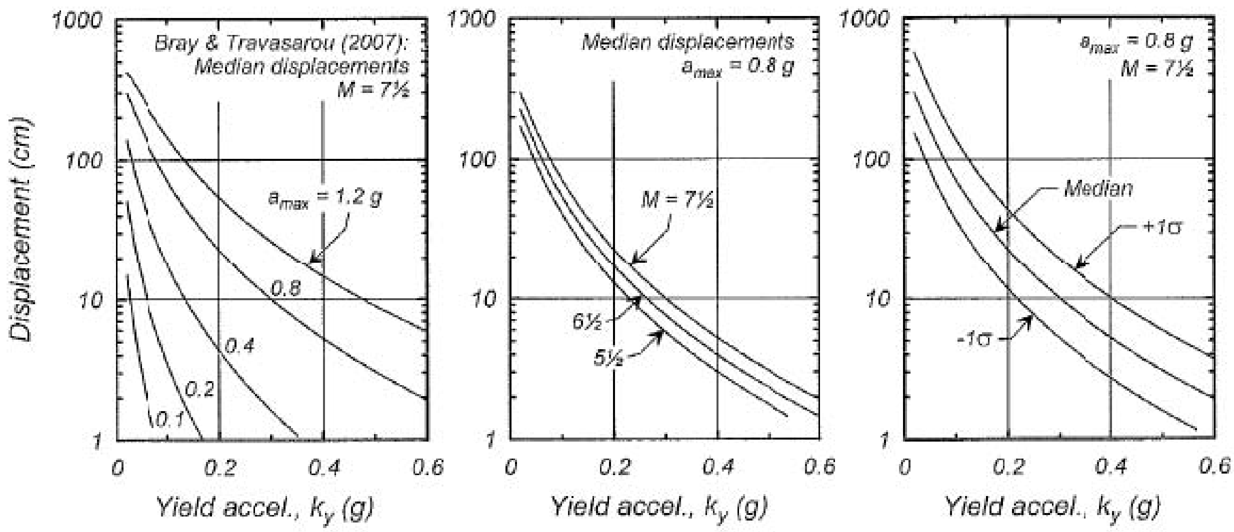

File Name: Profile 4_ENR_2475yrs.gsz
Name: Loose silt/sand Unit Weight: 95 pcf Cohesion: 500 psf Phi: 0 °
Name: Medium dense sand Unit Weight: 100 pcf Cohesion: 0 psf Phi: 28 °
Name: Denser sand Unit Weight: 105 pcf Cohesion: 0 psf Phi: 32 °
Name: Water
0.467
Outer Harbor Line
Elevation (ft)
Distance (ft) (x 1000)
600
560
520
480
440
400
360
320
280
240
200
160
120
80
40
0
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0

EARTHQUAKE-INDUCED DISPLACEMENT ANALYSIS

Newmark-based displacement charts developed by Makdisi and Seed (1978), Bray and Travasarou 2007), and Idriss and Boulanger (2008) were utilized.



Permanent seismic deformation charts (Makdisi and Seed, 1978). Source: NCHRP 2008.



Permanent Base Sliding Block Displacements as a Function of Yield Acceleration (Bray-Travasarou chart, as developed by Idriss and Boulanger (2008) based on the method developed by Bray and Travasarou (2007). Source: WSDOT 2010.

APPENDIX I— EPA REQUESTED FEASIBILITY STUDY ALTERNATIVE VARIATIONS TECHNICAL MEMORANDUM

EPA-REQUESTED FEASIBILITY STUDY ALTERNATIVE VARIATIONS
LOCKHEED WEST SEATTLE SUPERFUND SITE

Prepared for:

LOCKHEED MARTIN

Prepared by:

TETRA TECH

May 2012

Descriptions of EPA-Requested Feasibility Study Alternative Variations

This memo summarizes three Feasibility Study (FS) alternative variations for the Lockheed West Seattle Superfund Site. These three alternative variations, prepared at the request of the U.S. Environmental Protection Agency (EPA), are in addition to the alternatives presented in the Remedial Investigation/Feasibility Study (RI/FS). The sections below include the general description for each of the alternative variations, evaluation of each alternative variation using the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) criteria against the best-supported alternative 2A2a identified in Section 13, an FS cost estimate for implementation, and a summary of the residual sediment concentrations remaining at the site prior to enhanced natural recovery (ENR) or sediment cap placement, as appropriate.

Alternative Variation Descriptions

Alternative 2A2a Plus — *Estimated Cost: $35.8M*

Alternative 2A2a Plus is a variant of Alternative 2A2a in the RI/FS (i.e., conventional capping over the cleanup screening level [CSL] footprint and ENR over the remaining area to the Urban area of potential action [AOPA] footprint). Alternative 2A2a Plus adds 1) dredging sediment with concentrations above the sediment quality standard (SQS) in the navigational channel in the West Waterway and 2) the application of ENR to the study area boundary instead of the Urban AOPA footprint. In addition, Alternative 2A2a Plus includes the cost of an additional cap replacement during the operation and maintenance (O&M) period consistent with the other FS alternatives with a cap component based on the findings of the seismic analysis. Removal of contaminated sediments within the navigational channel would not restrict navigational uses or preclude potential future site uses in this part of the waterway. Capping would be applied to the rest of the site as in Alternative 2A2a. ENR would be extended to the study area boundary. Figure I-1 illustrates the removal, capping, and ENR areas, as well as the proposed remedial actions associated with the shoreline and former shipway areas. Under this alternative, about 5.4 acres of subtidal sediments in the West Waterway navigational channel would be dredged, about 7.0 acres of conventional cap would be placed, and a total of about 40 acres of subtidal sediment would be remediated. This alternative includes the removal of 76,140 cubic yards of contaminated subtidal sediments. The same elements of shoreline and former shipway remediation as Alternative 2A2a would be applied under this alternative.

Evaluation of Alternative 2A2a Plus Compared to Alternative 2A2a

Alternative 2A2a Plus meets the remedial action objectives (RAOs) of reducing ecological and human health risks: it provides incremental risk reduction for RAO 1 by making progress toward preliminary remediation goals (PRGs) and utilizing institutional controls; and it achieves PRGs associated with RAOs 2, 3, and 4. Incremental risk reduction (i.e., progress towards reaching RAO 1 PRGs from mean baseline concentrations) for Alternative 2A2a Plus would be similar or slightly higher (93–97 percent) than Alternative 2A2a (93 percent) due to removal of sediments in the navigational channel with concentrations above the SQS. Similar to Alternative 2A2a, a clean surface would be achieved at the end of construction. In the long term, contaminant of concern (COC) concentrations would reach an equilibrium between the natural background levels and the concentrations found in the Elliott Bay region. The actively remediated area under Alternative 2A2a Plus is larger and extends to the study area boundary (i.e., 40 acres) compared to Alternative 2A2a where the area remediated is to the Urban AOPA footprint (i.e., 30 acres).

Alternative 2A2a Plus includes areas of capping that would provide long-term protection of human health and the environment as long as the system remains intact. Similar to Alternative 2A2a, monitoring of the cap structure will be required to ensure containment and structural integrity. The scale of the long-term monitoring operations and maintenance (O&M) program for both alternatives would be similar. The potential for re-exposure of subsurface contaminated sediment following active remediation of Alternative 2A2a Plus is lower than Alternative 2A2a due to removal of contaminated sediments with concentrations above SQS in the navigational channel. The overall protectiveness of the alternative will further be enhanced by the institutional controls for the cap area where the similar scale of institutional controls would be applied as for Alternative 2A2a. Future site use restrictions as related to Port's future development plans within the navigational channel would be eliminated by Alternative 2A2a Plus because no capping would occur in the navigational channel while Alternative 2A2a would encumber but not preclude reasonably anticipated future land use in this area by the Port of Seattle (Port) and Washington Department of Natural Resources (DNR).

The construction of Alternative 2A2a Plus is likely to require two construction seasons compared to Alternative 2A2a, which would be constructed in one season. Due to longer construction duration and the removal component, risks to workers and the community from the general physical hazards of construction, noise, particulate emissions, and short-term elevated fish and shellfish tissue concentrations would be higher for Alternative 2A2a Plus than for Alternative 2A2a. Technical and administrative implementability of Alternative 2A2a Plus would be lower than Alternative 2A2a due to longer duration and complexity of the remedial actions involved. The estimated cost of Alternative 2A2a Plus is $35.8M compared to the Alternative 2A2a estimated cost of $18.6M.

Alternative 3A2 Plus ***Estimated Cost: $55.8M***

Alternative 3A2 Plus is a variant of Alternative 3A2 in the RI/FS (i.e., removal of up to 3 feet over the SQS footprint with conventional cap where exposed sediments are greater than 2 x SQS and ENR to Urban AOPA footprint). Alternative 3A2 Plus adds 1) dredging sediment with concentrations above the SQS in the navigational channel in West Waterway (i.e., removal not restricted to 3 feet) and 2) the extension of ENR to the study area boundary. Removal of contaminated sediments within the navigational channel would not restrict navigational uses or preclude potential future site uses in this part of the waterway. Capping and ENR would be applied to the rest of the site as in Alternative 3A2 except that ENR would extend to the study area boundary and no capping would occur within the navigational channel. Figure I-2 illustrates the removal, capping, and ENR areas, as well as the proposed remedial actions associated with the shoreline and former shipway areas. Under this alternative, about 18 acres of subtidal sediments, 5.4 of which are in the West Waterway navigational channel, would be dredged; about 4.4 acres of conventional cap would be placed; and a total of about 40 acres of subtidal sediment would be remediated. This alternative includes the removal of about 161,500 cubic yards of contaminated sediments. The same elements of shoreline and former shipway remediation as Alternative 3A2 would be applied under this alternative.

Evaluation of Alternative 3A2 Plus Compared to Alternative 2A2a

Alternative 3A2 Plus meets the RAOs of reducing ecological and human health risks: it provides incremental risk reduction for RAO 1 by making progress toward PRGs and utilizing institutional controls; and it achieves PRGs associated with RAOs 2, 3, and 4. Incremental risk reduction (i.e., progress towards reaching RAO 1 PRGs from mean baseline concentrations) for Alternative 3A2a Plus would be similar or slightly higher (93–97 percent) than the reduction under Alternative 2A2a (93 percent) due to removal of sediments in the navigational channel with concentrations above the SQS. Similar to Alternative 2A2a, a clean surface would be achieved at the end of construction. In the long term, COC concentrations would reach an equilibrium between the natural background levels and the concentrations found in the Elliott Bay region. The alternatives differ in that the actively remediated area under Alternative 3A2 Plus is to the study area boundary (i.e., 40 acres) whereas Alternative 2A2a is to the Urban AOPA footprint (i.e., 30 acres).

Alternative 3A2 Plus includes capping that will provide long-term protection of human health and the environment as long as the system remains intact. Similar to Alternative 2A2a, monitoring of the cap structure will be required to ensure containment and structural integrity. The scale of the long-term monitoring O&M program for both alternatives would be similar. The potential for re-exposure of subsurface contaminated sediment following active remediation of Alternative 3A2 Plus is lower than Alternative 2A2a due to removal of contaminated sediments with concentrations above the SQS in the navigational channel and removal of up to 3 feet of sediments over the SQS footprint outside of the navigational channel. The overall protectiveness of the alternative will further be enhanced by the institutional controls for the cap area where the similar scale of institutional controls would be applied as Alternative 2A2a. Future site use restrictions as related to Port's future development plans within the navigational channel would be eliminated by Alternative 3A2 Plus while Alternative 2A2a would encumber but not preclude reasonably anticipated future land use by the Port and DNR.

The construction of Alternative 3A2 Plus is likely to require two construction seasons while the 2A2a would be constructed in one season. Due to longer construction duration and the removal component, risks to workers and the community from the general physical hazards of construction, noise, particulate emissions, and short-term elevated fish and shellfish tissue concentrations would be higher for Alternative 3A2 Plus than Alternative 2A2a. Technical and administrative implementability of Alternative 3A2 Plus would be lower than Alternative 2A2a due to longer duration and complexity of the remedial actions involved. The estimated cost of Alternative 3A2 Plus is $55.8M compared to the Alternative 2A2a estimated cost of $18.6M.

Alternative 3C Plus ***Estimated Cost: $48.1M***

Alternative 3C Plus is a variant of Alternative 3C in the RI/FS (i.e., removal to the CSL in the former dry dock areas, capping remaining CSL areas, and ENR to the Urban AOPA footprint). Alternative 3C Plus substitutes 1.3 acres of conventional capping with dredging; adds additional dredging of sediments with concentrations above the SQS within the navigational channel in the West Waterway and former shipway remediation area with concentrations above the SQS; involves pilings removal and removal of sediments with concentrations above the SQS from the former shipway area; and extends ENR to the study area boundary. Removal of contaminated sediments within the dry dock areas and the navigational channel would not restrict navigational uses or preclude potential future site uses of the waterway. ENR would be applied to the rest of the site. Figure I-3 illustrates the removal and ENR areas, as well as the proposed remedial actions associated with the shoreline and former shipway areas. Common remedy elements of shoreline/intertidal remediation and habitat improvements (i.e., removal of about 9,300 cubic yards of sediments, backfill to the grade, habitat mix placement, and riprap shoreline stabilization as needed) would be applied. Former shipway area remediation would include removal of pilings inside the Inner Harbor Line, removal of contaminated sediments, backfill to the original grade, and habitat mix placement. Under this alternative, about 11.6 acres of subtidal sediments would be dredged and a total of about 40 acres of subtidal sediment would be remediated. This alternative includes the removal of about 151,650 cubic yards of contaminated subtidal sediments and removal of about 6,500 cubic yards of shoreline/intertidal sediments from the former shipway area.

Evaluation of Alternative 3C Plus Compared to Alternative 2A2a

Alternative 3C Plus meets the RAOs of reducing ecological and human health risks: it provides incremental risk reduction for RAO 1 by making progress toward PRGs and utilizing institutional controls; and achieves PRGs associated with RAOs 2, 3, and 4. Incremental risk reduction (i.e., progress towards reaching RAO 1 PRGs from mean baseline concentrations) for Alternative 3C Plus would be similar or slightly higher (93–97 percent) than Alternative 2A2a (93 percent) due to removal of sediments in the navigational channel with concentrations above the SQS. Similar to Alternative 2A2a, a clean surface would be achieved at the end of construction. In the long term, concentrations of COCs would reach an equilibrium between the natural background levels and the concentrations found in the Elliott Bay region. The two alternatives differ in that the actively remediated area boundary (i.e., clean surface boundary after construction) under Alternative 3C Plus is the study area boundary where the ENR boundary under Alternative 2A2a is the Urban AOPA footprint.

Alternative 3C Plus does not include any capping, and no anticipated site-specific institutional controls and limited long-term monitoring would be applied; therefore, adequacy and reliability of controls would be less than for Alternative 2A2a. The potential for re-exposure of subsurface contaminated sediment following active remediation of Alternative 3C Plus is lower than under Alternative 2A2a due to removal of contaminated sediments in the dry dock hotspot areas, and removal to the SQS levels in the navigational channel and the former shipway area. Future site use restrictions as related to Port's future development plans would be eliminated by Alternative 3C Plus, while Alternative 2A2a would encumber but not preclude reasonably anticipated future land use issues provided by the Port and DNR.

The construction of Alternative 3C Plus is likely to require two construction seasons while Alternative 2A2a could be constructed in one season. Due to longer construction duration and the removal component, risks to workers and the community from the general physical hazards of construction, noise, particulate emissions, and short-term elevated fish and shellfish tissue concentrations would be higher for Alternative 3C Plus than for Alternative 2A2a. The technical and administrative implementability of Alternative 3C Plus would be lower than Alternative 2A2a due to longer duration and complexity of the remedial actions involved. The estimated cost of Alternative 3C Plus is $48.1M compared to the Alternative 2A2a estimated cost of $18.6M.

Alternative Variation FS Cost Estimates

Cost estimates were prepared for each of the alternative variations in the same manner as used in the RI/FS. The cost estimates of all remedial alternatives included a full cap replacement cost for those alternatives that included the placement of a sediment cap (i.e., 2A2a Plus and 3A2 Plus). The inclusion of this cost addressed the replacement cost associated with potential cap failure from a seismic event. The FS cost estimates are summarized in Tables I-1 through I-3.

Post-Remedy Construction Sediment Residuals

The post-remedy construction sediment residuals for each of the alternative variations are summarized in Figures I-4 through I-6 and Tables I-4 through I-6. The figures and tables show the sediment concentrations for the risk-driver COCs that remain at the RI sampling locations and the approximate depth in the underlying sediment below the post-remedy construction mudline surface prior to ENR layer or cap placement. The tables show the elevations rather than depth below the mudline. The RI sample locations are separated in the tables for those that are in areas of capping or dredging, and for those where ENR/backfill would be placed.

Figures

Containment-Focus Alternative 2A2a Plus

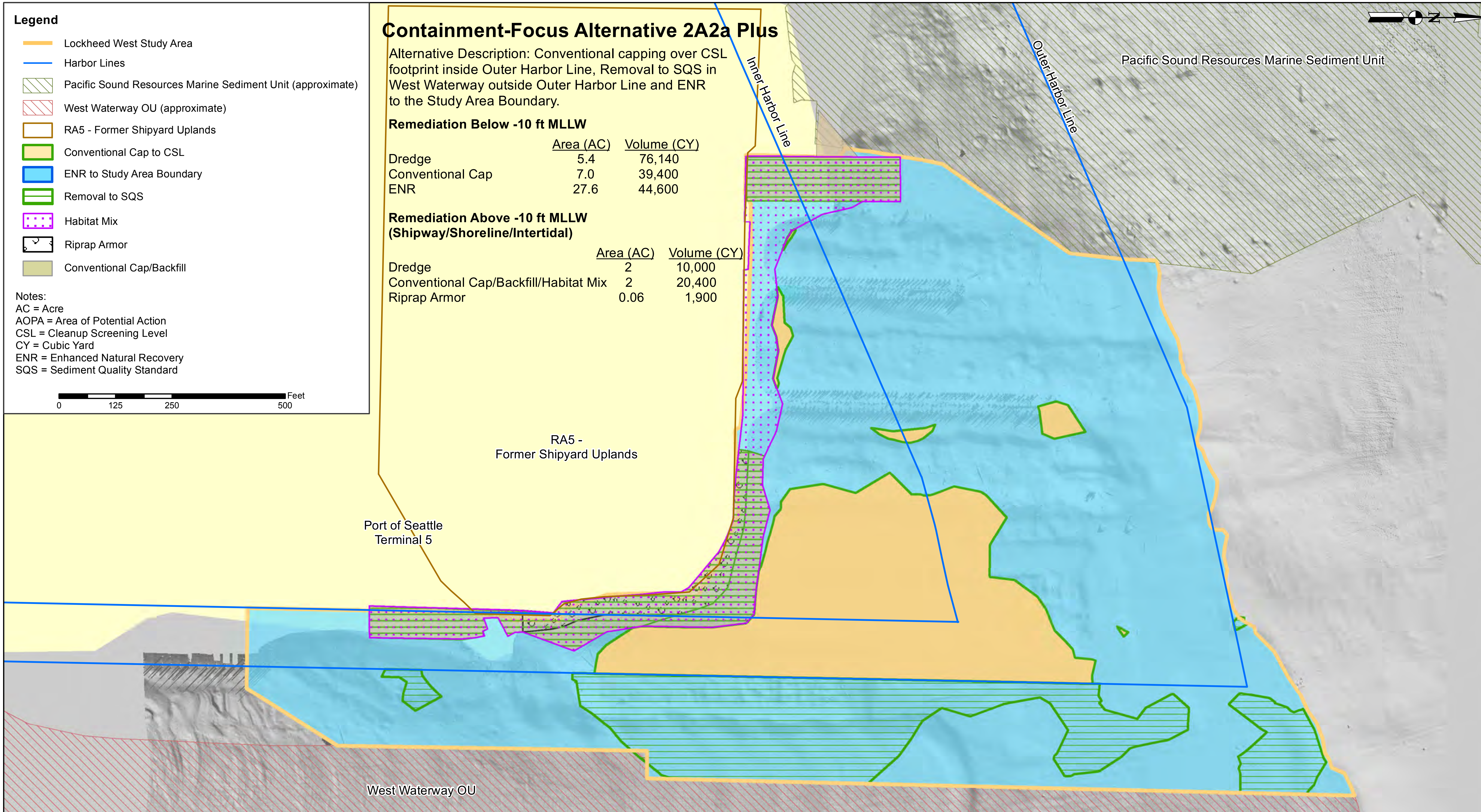
Alternative Description: Conventional capping over CSL footprint inside Outer Harbor Line, Removal to SQS in West Waterway outside Outer Harbor Line and ENR to the Study Area Boundary.

Remediation Below -10 ft MLLW

	Area (AC)	Volume (CY)
Dredge	5.4	76,140
Conventional Cap	7.0	39,400
ENR	27.6	44,600

Remediation Above -10 ft MLLW (Shipway/Shoreline/Intertidal)

	Area (AC)	Volume (CY)
Dredge	2	10,000
Conventional Cap/Backfill/Habitat Mix	2	20,400
Riprap Armor	0.06	1,900



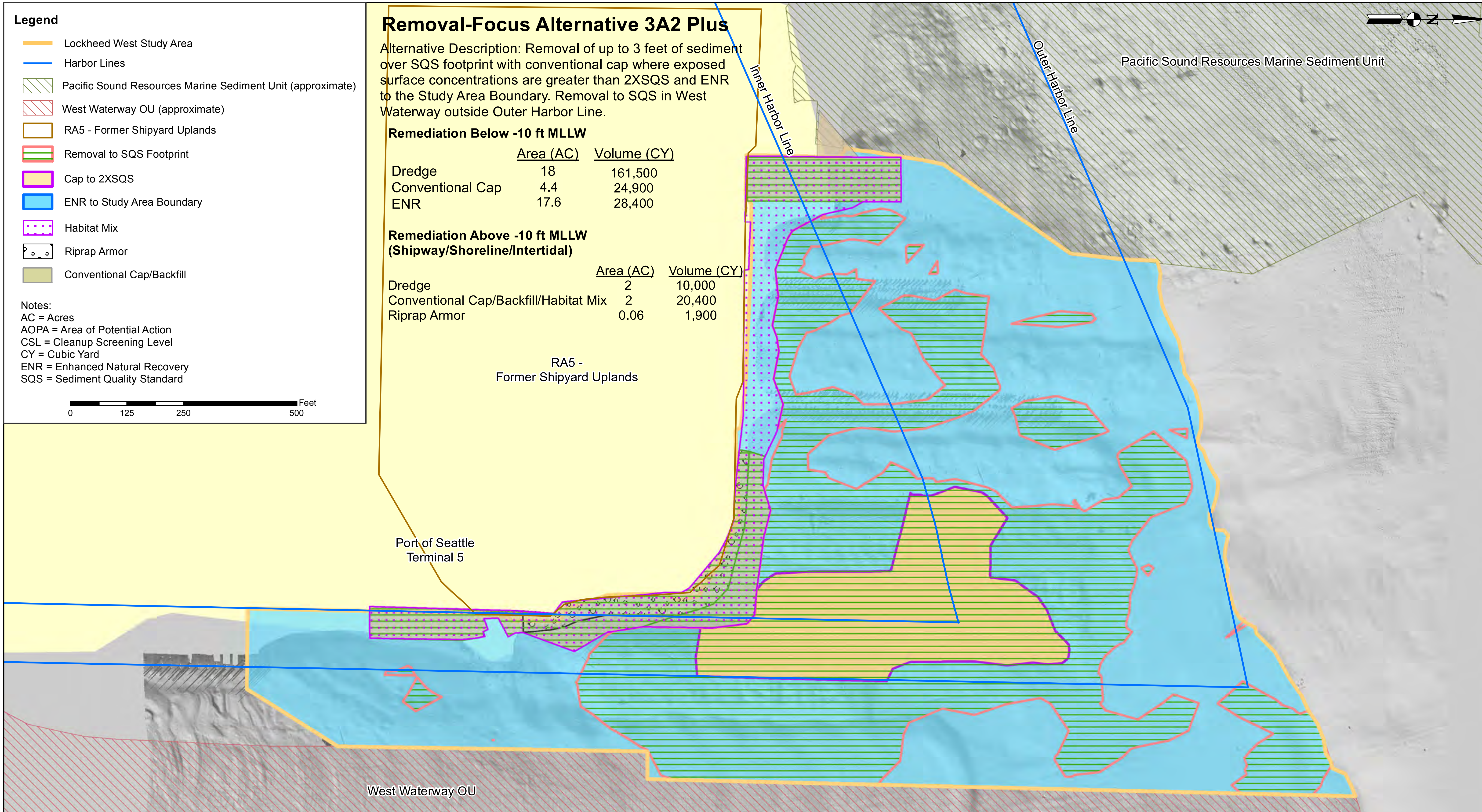
Notes:
AC = Acre
AOPA = Area of Potential Action
CSL = Cleanup Screening Level
CY = Cubic Yard
ENR = Enhanced Natural Recovery
SQS = Sediment Quality Standard

TETRA TECH

Lockheed West Seattle Superfund Site, Seattle, WA

Figure I-1
Containment-Focus Alternative 2A2a Plus

Z:\Pdrive\Projects_2006\Lockheed\maps\RIFS_Report\report_numbered\Fig1_2A2a_plus.mxd

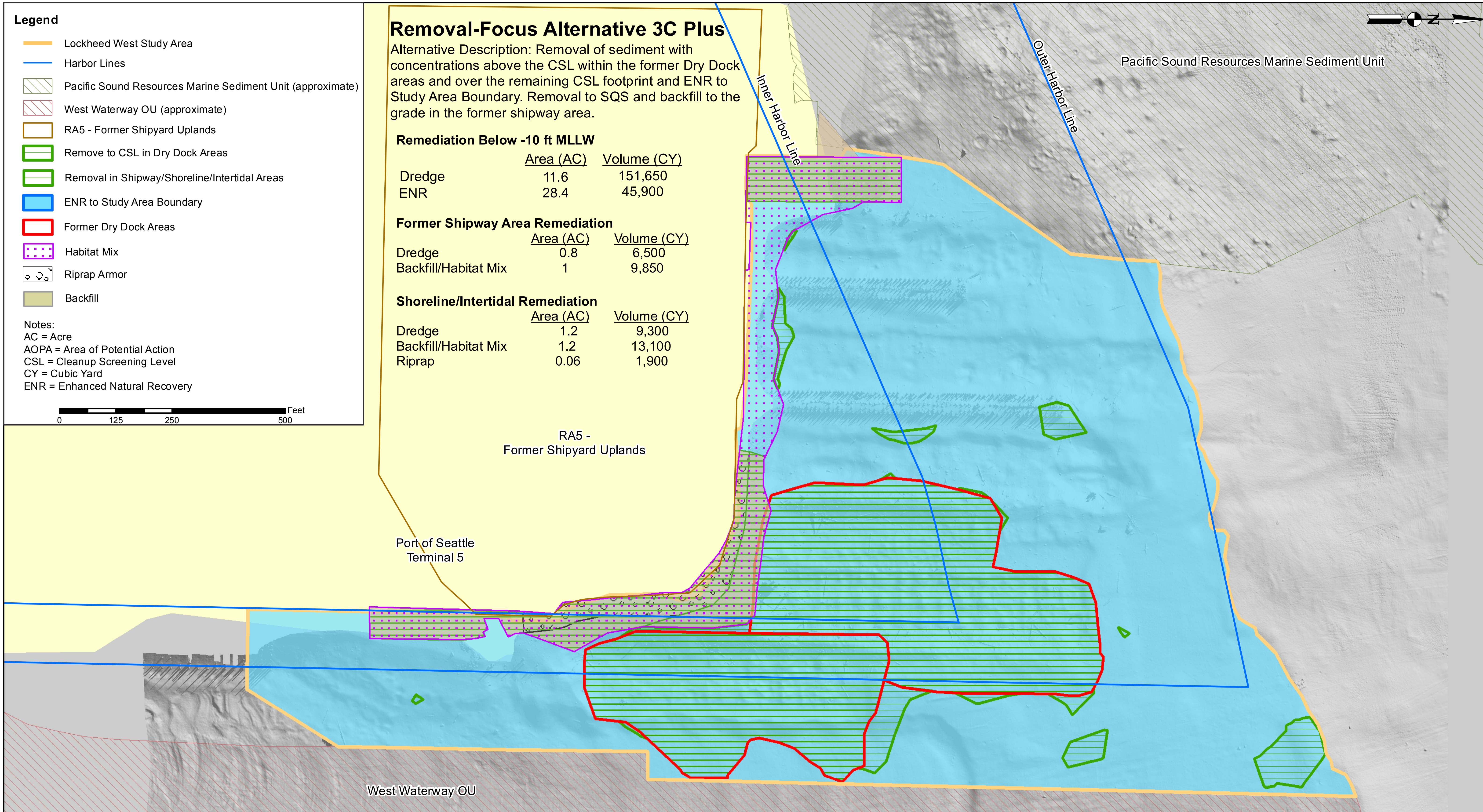


TETRA TECH

Lockheed West Seattle Superfund Site, Seattle, WA

Figure I-2
Removal-Focus Alternative 3A2 Plus

Z:\Pdrive\Projects_2006\Lockheed\maps\FS_Report\report_numbered\Fig3_3A2_plus.mxd



TETRA TECH

Lockheed West Seattle Superfund Site, Seattle, WA

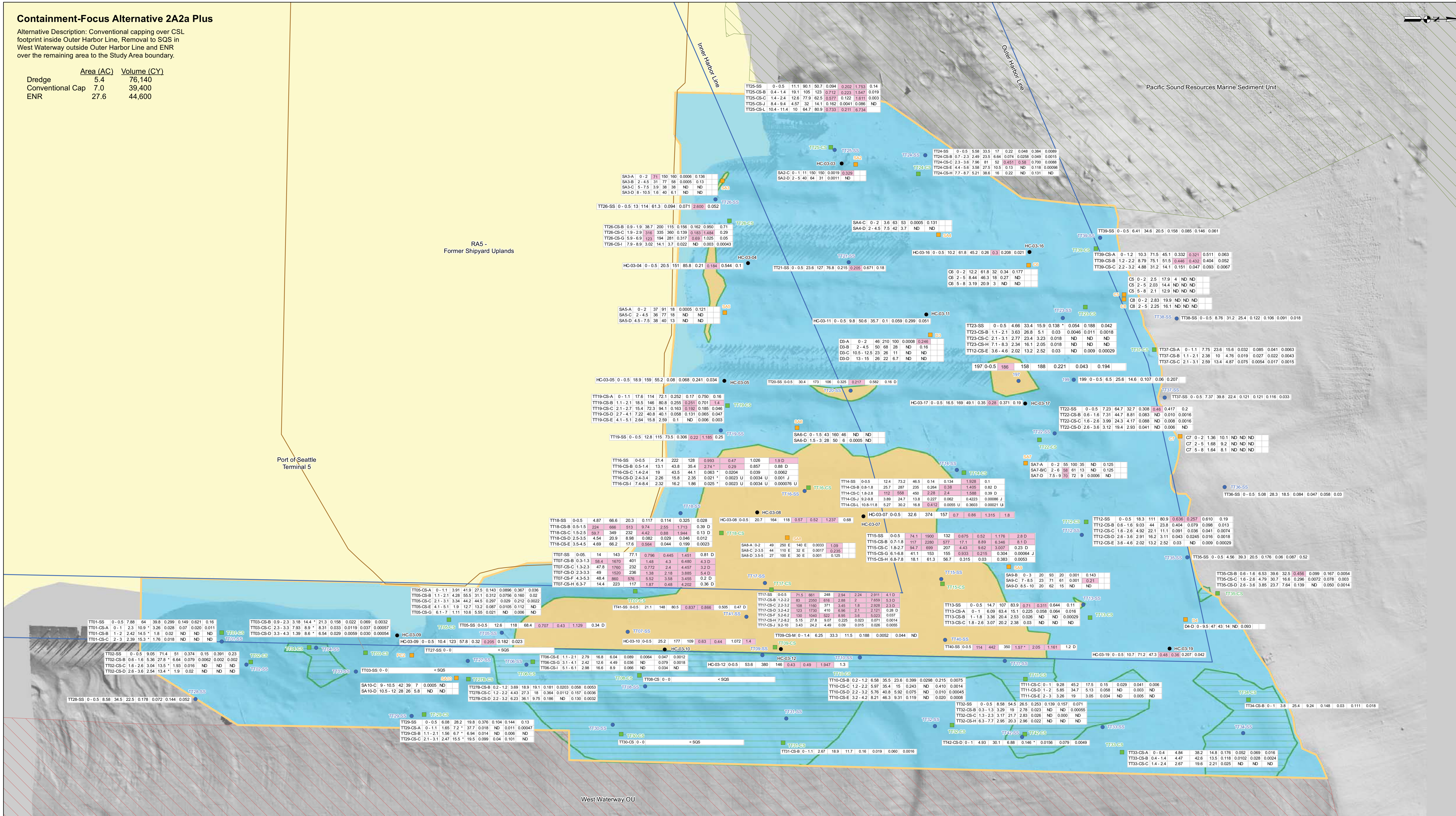
Figure I-3 Removal-Focus Alternative 3C Plus

Z:\Pdrive\Projects_2006\Lockheed\gis\RIFS_Report\report_numbered\Fig4_3C_plus.mxd

Containment-Focus Alternative 2A2a Plus

Alternative Description: Conventional capping over CSL footprint inside Outer Harbor Line, Removal to SQS in West Waterway outside Outer Harbor Line and ENR over the remaining area to the Study Area boundary.

	Area (AC)	Volume (CY)
Dredge	5.4	76,140
Conventional Cap	7.0	39,400
ENR	27.6	44,600



Legend

1998 and Earlier Sampling Locations
- Subsurface Core Sample Location

2003 Sampling Locations
- Surface Grab Sample Location

2007 Sampling Locations
- 2007 RI Subsurface Core Sample Location
- 2007 RI Surface Grab Sample Location

- Lockheed West Study Area
- Harbor Lines
- Pacific Sound Resources Marine Sediment Unit (approximate)
- West Waterway OU (approximate)
- RA5 - Former Shipyard Uplands
- Conventional Cap to CSL
- ENR to Urban
- Removal to SQS

Sample ID | Depth Interval Below Post Remedy Mudline | As | Cu | Pb | Hg | PCB | cPAH | TBT

SA5-B | 0 - 2 ft

Colored Box Indicates Result > SQS

Notes:
AC = Acre
AOPA = Area of Potential Action
CSL = Cleanup Screening Level
CY = Cubic Yard
ENR = Enhanced Natural Recovery
SQS = Sediment Quality Standard
Urban = Upper 95 UCL for Elliott Bay Urban Sediment Data (Ecology 2007)

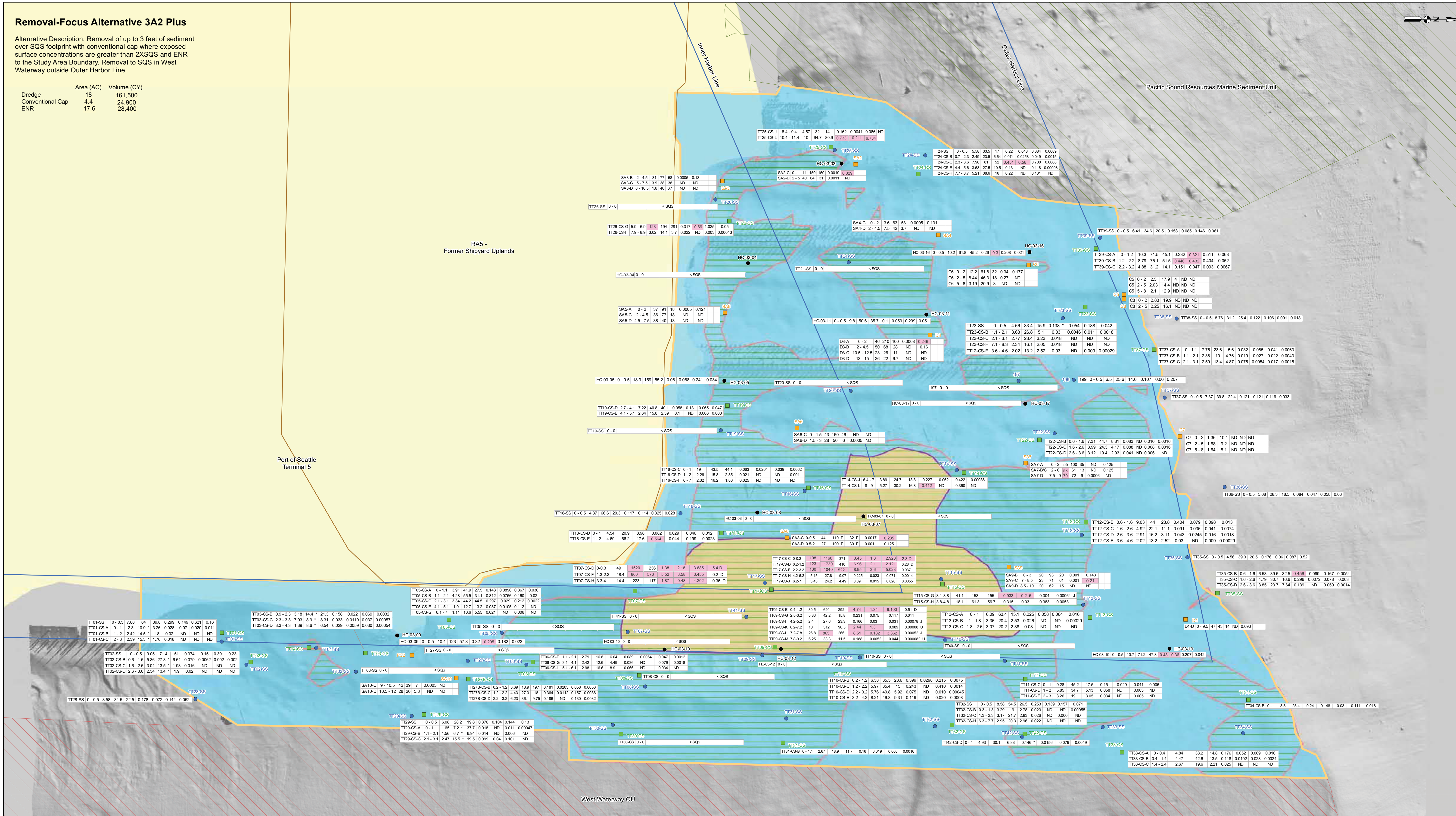
Feet: 0 50 100 200

TETRA TECH

Lockheed West Seattle Superfund Site, Seattle, WA

Figure I- 4
Residual Risk-Driver Contaminant Concentrations (Pre-ENR/Cap Placement) Alternative 2A2a Plus

Z:\Pdrive\Projects_2006\Lockheed\maps\RIFS_Report\report_numbered\Fig6_Alt_2A2aPlus_with_sampling_Data.mxd



Legend

1998 and Earlier Sampling Locations
- Subsurface Core Sample Location

2003 Sampling Locations
- Surface Grab Sample Location

2007 Sampling Locations
- 2007 RI Subsurface Core Sample Location
- 2007 RI Surface Grab Sample Location

- Lockheed West Study Area
- Harbor Lines
- Pacific Sound Resources Marine Sediment Unit (approximate)
- West Waterway OU (approximate)
- RA5 - Former Shipyard Uplands
- Remove to SQS Footprint
- Cap to 2XSQS
- ENR to Study Area Boundary

Sample ID	Depth Interval Below Post Remedy Mudline	As	Cu	Pb	Hg	PCB	cPAH	TBT
SA5-B	0 - 2 ft							

Colored Box Indicates Result > SQS

Notes:
AC = Acres
AOPA = Area of Potential Action
CSL = Cleanup Screening Level
CY = Cubic Yard
ENR = Enhanced Natural Recovery
SQS = Sediment Quality Standard

Feet 0 50 100 200

TETRA TECH

Lockheed West Seattle Superfund Site, Seattle, WA

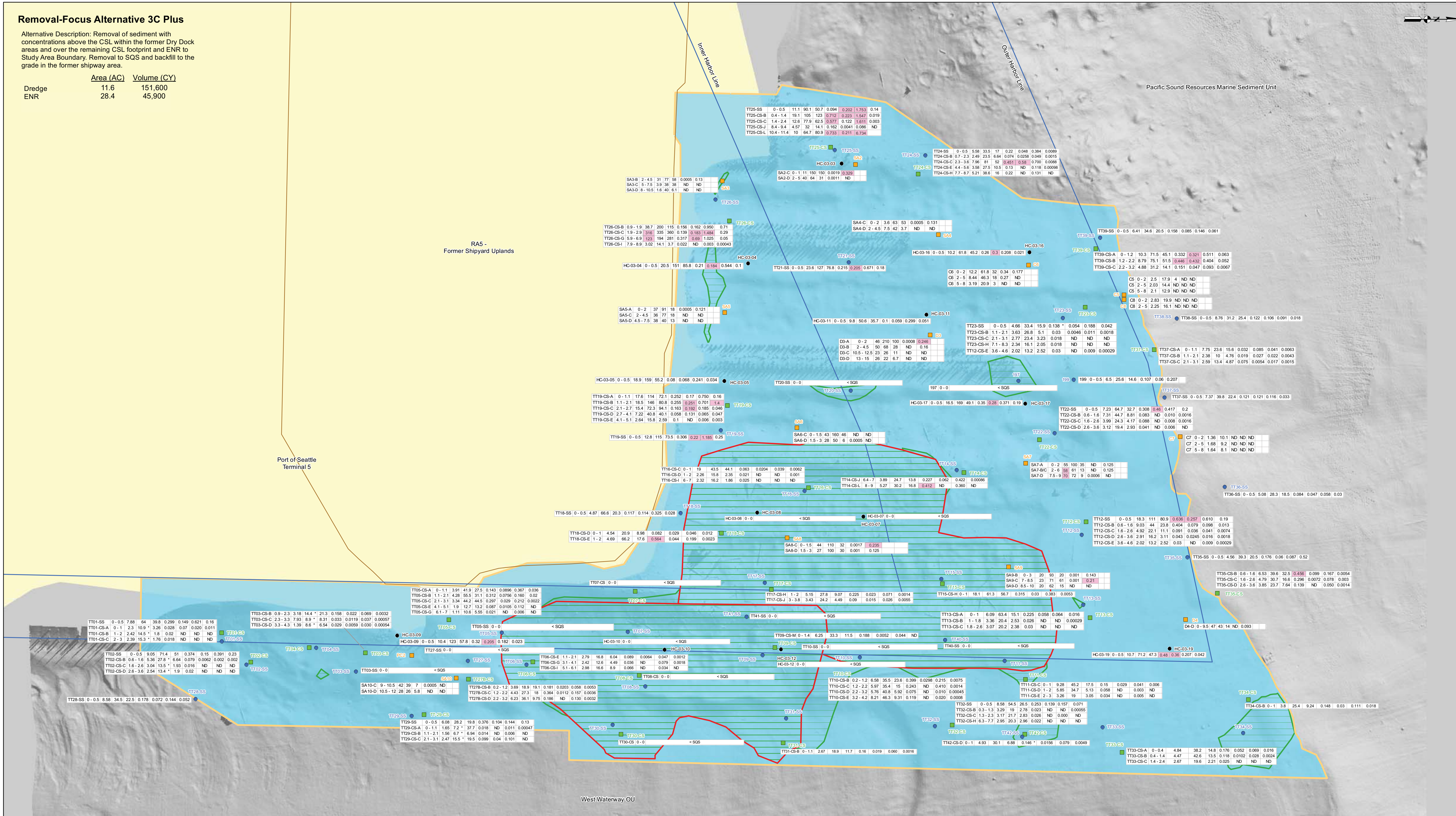
Figure I-5
Residual Risk-Driver Contaminant Concentrations (Pre-ENR/Cap Placement) Alternative 3A2 Plus

Z:\NdriveProjects_2006\Lockheed\maps\RIFS_Report\report_numbered\Fig7_Alt_3A2Plus_with_sampling_Dsize.mxd

Removal-Focus Alternative 3C Plus

Alternative Description: Removal of sediment with concentrations above the CSL within the former Dry Dock areas and over the remaining CSL footprint and ENR to Study Area Boundary. Removal to SQS and backfill to the grade in the former shipway area.

	Area (AC)	Volume (CY)
Dredge	11.6	151,600
ENR	28.4	45,900



Legend

1998 and Earlier Sampling Locations
- Subsurface Core Sample Location

2003 Sampling Locations
- Surface Grab Sample Location

2007 Sampling Locations
- 2007 RI Subsurface Core Sample Location
- 2007 RI Surface Grab Sample Location

- Lockheed West Study Area
- Harbor Lines
- Pacific Sound Resources Marine Sediment Unit (approximate)
- West Waterway OU (approximate)
- RA5 - Former Shipyard Uplands
- Remove to CSL in Dry Dock Areas
- ENR to Urban
- Former Dry Dock Areas

Sample ID	Depth Interval Below Post Remedy Mudline	As	Cu	Pb	Hg	PCB	cPAH	TBT
SA5-B	0 - 2 ft							

Colored Box Indicates Result > SQS

Notes:
AC = Acre
AOPA = Area of Potential Action
CSL = Cleanup Screening Level
CY = Cubic Yard
ENR = Enhanced Natural Recovery
Urban = Upper 95 UCL for Elliott Bay Urban Sediment Data (Ecology 2007)

0 50 100 200 Feet

TETRA TECH

Lockheed West Seattle Superfund Site, Seattle, WA

Figure I-6
Residual Risk-Driver Contaminant Concentrations (Pre-ENR/Cap Placement) Alternative 3C Plus

Z:\Pdrive\Projects_2006\Lockheed\maps\RIFS_Report\report_numbered\Fig8_Alt_3CPlus_with_sampling_Dsize.mxd

Tables

TABLE I-1. ALTERNATIVE 2A2a PLUS - CONTAINMENT FOCUS - CAP TO CSL INSIDE OUTER HARBOR LINE, REMOVE TO SQS IN WEST WATERWAY OUTSIDE OUTER HARBOR LINE, ENR TO STUDY AREA BOUNDARY

DREDGE AREA (AC) =	5.4	**DREDGE VOLUME (CY) =**	76,140
CAP AREA (AC) =	6.96	**CAP VOLUME (CY) =**	39,400
ENR AREA (AC) =	27.6	**ENR VOLUME (CY) =**	44,600

TASK	QUANTITY	UNIT	UNIT COST	TOTAL COST
PRE-CONSTRUCTION				
Contractor Submittals, Engineering, Surveying	1	LS	$150,000	$150,000
Mobilization/Demobilization	1	LS	$500,000	$500,000
Site Preparation, Environmental Controls	1	LS	$150,000	$150,000
Subtotal:				**$800,000**
PIER DEMOLITION				
Pier Demolition, Handling and Delivery to Rail				
Creosote Treated Wood	9900	TON	$110	$1,094,000
Debris and Pilings, Metal Waste	170	TON	$110	$19,000
Transport and Disposal	10070	TON	$68	$690,000
Demolition QA/QC, Waste Characterization, Monitoring	1	LS	$456,000	$456,000
Subtotal:				$2,824,000
Subtotal Cost Based on Applicability to Each Alternative:	0%		$2,824,000	**$0**
DREDGING, RESIDUAL MANAGEMENT, DISPOSAL				
Dredging	76,140	CY	$20	$1,522,800
Material Barge, Assist Tug, Transport Sediments to Transloading Facility	114,210	TON	$12	$1,370,520
Transloading Area Setup	1	LS	$1,000,000	$1,000,000
Water Management	93	Daily Rate	$8,000	$746,471
Handling, Transport and Subtitle D Landfill Disposal	114,210	TON	$60	$6,852,600
Backfill Material Procurement, Delivery, Placement	6,534	CY	$20	$130,680
Subtotal:				**$11,623,071**
SEDIMENT CAPPING & ENR				
Cap Material Procurement, Delivery, Placement	39,400	CY	$30	$1,300,200
ENR Material Procurement, Delivery, Placement	44,600	CY	$30	$1,471,800
Material Barge and Assist Tug for Capping	59,100	TON	$10	$650,100
Material Barge and Assist Tug for ENR	66,900	TON	$10	$735,900
Subtotal:				**$4,158,000**
SHIPWAY REMEDIATION				
Removal and Disposal	648	CY	$100	$64,815
Cap/Habitat Material Procurement and Placement	7,260	CY	$30	$217,800
Subtotal:				**$282,615**
SHORELINE REMEDIATION				
Removal and Disposal	9,300	CY	$100	$930,000
Backfill Placement	11,160	CY	$20	$223,200
Shoreline Stabilization (Riprap) Procurement and Placement	3,516	TON	$50	$175,817
Habitat Material (Sand & Fish Mix) Procurement and Placement	1,852	CY	$30	$55,556
Habitat Enhancement and Riparian Planting	2.00	AC	$50,000	$100,000
Subtotal:				**$1,484,572**
CONSTRUCTION QA&QC AND MONITORING				
Bathymetric Surveys/ Water Quality Monitoring	93	Daily Rate	$7,000	$653,162
Verification Sediment Sampling (Dredging)	1	LS	$0	$0
Verification Sediment Sampling (Capping)	1	LS	$64,890	$64,890
Verification Sediment Sampling (ENR)	1	LS	$124,110	$124,110
Remedial Action Completion Reporting	1	LS	$80,000	$80,000
Subtotal:				**$922,162**
			BASE CAPITAL COST	**$19,270,419**
ENGINEERING, CONSTRUCTION SUPPORT, OVERSIGHT				
Construction Contingency	35%			$6,744,647
Project Management	5%			$963,521
Remedial Design and Data Collection	8%			$1,541,634
Construction Management/QA Support	6%			$1,156,225
Agency Oversight (25% of Construction Management/QA Support)	1.5%			$289,056
WA State Sales Tax	9.5%			$1,179,693
Subtotal:				**$11,874,776**
			TOTAL CAPITAL COST	**$31,145,195**
ICs, Long-Term OM&M				
ICs Planning and Implementation	1	LS	$512,009	$512,009
Long-Term Operation and Maintenance Monitoring (Cap)	1	LS	$312,132	$312,132
Long-Term OM&M (Dredge, ENR, unremediated area)	1	LS	$915,110	$915,110
ENR Repair	1	LS	$156,100	$156,100
Cap Repair (Full cap repair at $70/CY)	1	LS	$2,758,000	$2,758,000
Subtotal:				**$4,653,351**
			TOTAL COST	**$35,800,000**

TABLE I-2. ALTERNATIVE 3A2 PLUS - REMOVAL FOCUS - REMOVE UPTO 3 FEET OVER SQS FOOTPRINT
CAP TO >2xSQS, REMOVAL TO SQS OUTSIDE OUTER HARBOR LINE, ENR TO STUDY AREA BOUNDARY

DREDGE AREA (AC) =	18	**DREDGE VOLUME (CY) =**	161,500
CAP AREA (AC) =	4.4	**CAP VOLUME (CY) =**	24,900
ENR AREA (AC) =	17.6	**ENR VOLUME (CY) =**	28,400

TASK	QUANTITY	UNIT	UNIT COST	TOTAL COST
PRE-CONSTRUCTION				
Contractor Submittals, Engineering, Surveying	1	LS	$150,000	$150,000
Mobilization/Demobilization	1	LS	$500,000	$500,000
Site Preparation, Environmental Controls	1	LS	$150,000	$150,000
Subtotal:				**$800,000**
PIER DEMOLITION				
Pier Demolition, Handling and Delivery to Rail				
Creosote Treated Wood	9900	TON	$110	$1,094,000
Debris and Pilings, Metal Waste	170	TON	$110	$19,000
Transport and Disposal	10070	TON	$68	$690,000
Demolition QA/QC, Waste Characterization, Monitoring	1	LS	$456,000	$456,000
Subtotal:				$2,824,000
Subtotal Cost Based on Applicability to Each Alternative:	75%		$2,824,000	**$2,118,000**
DREDGING, RESIDUAL MANAGEMENT, DISPOSAL				
Dredging	161,500	CY	$20	$3,230,000
Material Barge, Assist Tug, Transport Sediments to Transloading Facility	242,250	TON	$12	$2,907,000
Transloading Area Setup	1	LS	$1,000,000	$1,000,000
Water Management	198	Daily Rate	$8,000	$1,583,333
Handling, Transport and Subtitle D Landfill Disposal	242,250	TON	$60	$14,535,000
Backfill Material Procurement, Delivery, Placement	16,456	CY	$20	$329,120
Subtotal:				**$23,584,453**
SEDIMENT CAPPING & ENR				
Cap Material Procurement, Delivery, Placement	24,900	CY	$30	$821,700
ENR Material Procurement, Delivery, Placement	28,400	CY	$30	$937,200
Material Barge and Assist Tug for Capping	37,350	TON	$10	$410,850
Material Barge and Assist Tug for ENR	42,600	TON	$10	$468,600
Subtotal:				**$2,638,350**
SHIPWAY REMEDIATION				
Removal and Disposal	648	CY	$100	$64,815
Cap/Habitat Material Procurement and Placement	7,260	CY	$30	$217,800
Subtotal:				**$282,615**
SHORELINE REMEDIATION				
Removal and Disposal	9,300	CY	$100	$930,000
Backfill Placement	11,160	CY	$20	$223,200
Shoreline Stabilization (Riprap) Procurement and Placement	3,516	TON	$50	$175,817
Habitat Material (Sand & Fish Mix) Procurement and Placement	1,852	CY	$30	$55,556
Habitat Enhancement and Riparian Planting	2.00	AC	$50,000	$100,000
Subtotal:				**$1,484,572**
CONSTRUCTION QA&QC AND MONITORING				
Bathymetric Surveys/ Water Quality Monitoring	198	Daily Rate	$7,000	$1,385,417
Verification Sediment Sampling (Dredging)	1	LS	$287,280	$287,280
Verification Sediment Sampling (Capping)	1	LS	$34,020	$34,020
Verification Sediment Sampling (ENR)	1	LS	$75,600	$75,600
Remedial Action Completion Reporting	1	LS	$80,000	$80,000
Subtotal:				**$1,862,317**
			BASE CAPITAL COST	**$32,770,307**
ENGINEERING, CONSTRUCTION SUPPORT, OVERSIGHT				
Construction Contingency	35%			$11,469,607
Project Management	5%			$1,638,515
Remedial Design and Data Collection	8%			$2,621,625
Construction Management/QA Support	6%			$1,966,218
Agency Oversight (25% of Construction Management/QA Support)	1.5%			$491,555
WA State Sales Tax	9.5%			$1,732,354
Subtotal:				**$19,919,875**
			TOTAL CAPITAL COST	**$52,690,182**
ICs, Long-Term OM&M				
ICs Planning and Implementation	1	LS	$512,009	$512,009
Long-Term Operation and Maintenance Monitoring (Cap)	1	LS	$197,325	$197,325
Long-Term OM&M (Dredge, ENR, unremediated area)	1	LS	$583,548	$583,548
ENR Repair	1	LS	$99,400	$99,400
Cap Repair (Full cap repair at $70/CY)	1	LS	$1,743,000	$1,743,000
Subtotal:				**$3,135,282**
			TOTAL COST	**$55,830,000**

TABLE I-3. ALTERNATIVE 3C PLUS - REMOVAL FOCUS - REMOVE TO CSL IN DRY DOCK AREAS AND OTHER CSL FOOTPRINT, ENR TO STUDY AREA BOUNDARY

DREDGE AREA (AC) =	11.6	**DREDGE VOLUME (CY) =**	151,646
CAP AREA (AC) =	0	**CAP VOLUME (CY) =**	0
ENR AREA (AC) =	28.4	**ENR VOLUME (CY) =**	45,900

TASK	QUANTITY	UNIT	UNIT COST	TOTAL COST
PRE-CONSTRUCTION				
Contractor Submittals, Engineering, Surveying	1	LS	$150,000	$150,000
Mobilization/Demobilization	1	LS	$500,000	$500,000
Site Preparation, Environmental Controls	1	LS	$150,000	$150,000
Subtotal:				**$800,000**
PIER DEMOLITION				
Pier Demolition, Handling and Delivery to Rail				
Creosote Treated Wood	9900	TON	$110	$1,094,000
Debris and Pilings, Metal Waste	170	TON	$110	$19,000
Transport and Disposal	10070	TON	$68	$690,000
Demolition QA/QC, Waste Characterization, Monitoring	1	LS	$456,000	$456,000
Subtotal:				$2,824,000
Subtotal Cost Based on Applicability to Each Alternative:	0%		$2,824,000	**$0**
DREDGING, RESIDUAL MANAGEMENT, DISPOSAL				
Dredging	151,646	CY	$20	$3,032,920
Material Barge, Assist Tug, Transport Sediments to Transloading Facility	227,469	TON	$12	$2,729,628
Transloading Area Setup	1	LS	$1,000,000	$1,000,000
Water Management	186	Daily Rate	$8,000	$1,486,725
Handling, Transport and Subtitle D Landfill Disposal	227,469	TON	$60	$13,648,140
Backfill Material Procurement, Delivery, Placement	14,036	CY	$20	$280,720
Subtotal:				**$22,178,133**
SEDIMENT CAPPING & ENR				
Cap Material Procurement, Delivery, Placement	0	CY	$30	$0
ENR Material Procurement, Delivery, Placement	45,900	CY	$30	$1,514,700
Material Barge and Assist Tug for Capping	0	TON	$10	$0
Material Barge and Assist Tug for ENR	68,850	TON	$10	$757,350
Subtotal:				**$2,272,050**
SHIPWAY REMEDIATION				
Pilings Removal and Disposal	1	LS	$450,000	$450,000
Sediment Removal and Disposal	6,481	CY	$80	$518,519
Backfill/Habitat Material Procurement and Placement	9,853	CY	$30	$295,578
Subtotal:				**$1,264,096**
SHORELINE REMEDIATION				
Removal and Disposal	9,300	CY	$100	$930,000
Backfill Placement	11,160	CY	$20	$223,200
Shoreline Stabilization (Riprap) Procurement and Placement	3,516	TON	$50	$175,817
Habitat Material (Sand & Fish Mix) Procurement and Placement	1,852	CY	$30	$55,556
Habitat Enhancement and Riparian Planting	2.00	AC	$50,000	$100,000
Subtotal:				**$1,484,572**
CONSTRUCTION QA&QC AND MONITORING				
Bathymetric Surveys/ Water Quality Monitoring	186	Daily Rate	$7,000	$1,300,885
Verification Sediment Sampling (Dredging)	1	LS	$164,388	$164,388
Verification Sediment Sampling (Capping)	1	LS	$8,190	$8,190
Verification Sediment Sampling (ENR)	1	LS	$115,920	$115,920
Remedial Action Completion Reporting	1	LS	$80,000	$80,000
Subtotal:				**$1,669,383**
			BASE CAPITAL COST	**$29,668,235**
ENGINEERING, CONSTRUCTION SUPPORT, OVERSIGHT				
Construction Contingency	35%			$10,383,882
Project Management	5%			$1,483,412
Remedial Design and Data Collection	8%			$2,373,459
Construction Management/QA Support	6%			$1,780,094
Agency Oversight (25% of Construction Management/QA Support)	1.5%			$445,024
WA State Sales Tax	9.5%			$1,521,909
Subtotal:				**$17,987,779**
			TOTAL CAPITAL COST	**$47,656,014**
ICs, Long-Term OM&M				
ICs Planning and Implementation	1	LS	$108,002	$108,002
Long-Term Operation and Maintenance Monitoring (Cap)	0	LS	$0	$0
Long-Term OM&M (Dredge, ENR, unremediated area)	1	LS	$184,592	$184,592
ENR Repair	1	LS	$160,650	$160,650
Cap Repair (Full cap repair at $70/CY)	0	LS	$0	$0
Subtotal:				**$453,244**
			TOTAL COST	**$48,110,000**

Table I-4A
Risk Driver COC Sediment Residuals (mg/kg dry weight)
Alternative 2A2a Plus

Location	SAMPLEID	Date	Mudline Elev (FT MSL)	Approx Post Remedy Mudline (Ft MSL)	Interval Top	Interval Bottom	Arsenic	Copper	Lead	Mercury	PCBs (total)	Total cPAH	Tributyltin
						CSL	93	390	530	0.59	1	3.000	1.335
						SQS	57	390	450	0.41	0.18	1.100	1.335
						RBTC/Nat Bkgd	7	114	10.9	0.41	0.002	0.009	0.017
						Elliott Bay - Urban	8.44	48.9	47	0.438	0.119	0.757	NA
						Elliott Bay - Harbor	73.4	112	66.9	0.335	0.355	1.210	NA
						Elliot Bay - Basin	9.13	41.1	26.9	0.175	0.048	0.125	NA
SA8	SA8-A	9/1/89	-39.2	-39.2	-39.2	-41.2	49	250 E	140 E	0.0033	1.09		
SA8	SA8-C	9/1/89	-39.2	-39.2	-41.2	-42.7	44	110 E	32 E	0.0017	0.235		
SA8	SA8-D	9/1/89	-39.2	-39.2	-42.7	-44.2	27	100 E	30 E	0.001	0.125		
TT07-SS	TT07-SS	1/25/07	-40.0	-40.0	-40.0	-40.5	14	143	77.1	0.796	0.445	1.451	0.81 D
TT07-CS	TT07-CS-B	1/16/07	-5.7	-5.7	-6.0	-7.0	58.4	1670	401	1.48	4.3	6.480	4.3 D
TT07-CS	TT07-CS-C	1/16/07	-5.7	-5.7	-7.0	-8.0	47.8	1760	232	0.772	2.4	4.457	3.2 D
TT07-CS	TT07-CS-D	1/16/07	-5.7	-5.7	-8.0	-9.0	49	1520	236	1.38	2.18	3.885	5.4 D
TT07-CS	TT07-CS-F	1/16/07	-5.7	-5.7	-10.0	-11.0	48.4	860	576	5.52	3.58	3.455	0.2 D
TT07-CS	TT07-CS-H	1/16/07	-5.7	-5.7	-12.0	-12.7	14.4	223	117	1.87	0.48	4.202	0.36 D
TT10-SS	TT10-SS	1/25/07	-29.0	-30.0	-29.0	-29.5	146	894	395	0.631	1.31	1.437	4 D
TT13-SS	TT13-SS	1/26/07	-44.0	-44.0	-44.0	-44.5	14.7	107	83.9	0.71 *	0.311	0.644	0.11
TT15-SS	TT15-SS	1/25/07	-44.0	-44.0	-44.0	-44.5	74.1	1900	132	0.675	0.52	1.176	2.8 D
TT15-CS	TT15-CS-B	1/18/07	-46.2	-46.2	-46.9	-48.0	117	2280	577	17.1	8.89	6.346	8.1 D
TT15-CS	TT15-CS-C	1/18/07	-46.2	-46.2	-48.0	-48.9	94.7	699	207	4.43	9.62	3.007	0.23 D
TT15-CS	TT15-CS-G	1/18/07	-46.2	-46.2	-52.3	-53.0	41.1	153	155	0.933	0.215	0.304	0.00064 J
TT15-CS	TT15-CS-H	1/18/07	-46.2	-46.2	-53.0	-54.0	18.1	61.3	56.7	0.315	0.03	0.383	0.0053
TT16-SS	TT16-SS	1/25/07	-38.0	-38.0	-38.0	-38.5	21.4	222	128	0.993	0.47	1.026	1.9 D
TT16-CS	TT16-CS-B	1/22/07	-38.6	-38.6	-39.1	-40.0	13.1	43.8	35.4	2.74 *	0.29	0.857	0.88 D
TT16-CS	TT16-CS-C	1/22/07	-38.6	-38.6	-40.0	-41.0	19	43.5	44.1	0.063 *	0.0204	0.039	0.0062
TT16-CS	TT16-CS-D	1/22/07	-38.6	-38.6	-41.0	-42.0	2.26	15.8	2.35	0.021 *	0.0023 U	0.0034 U	0.001 J
TT16-CS	TT16-CS-I	1/22/07	-38.6	-38.6	-46.0	-47.0	2.32	16.2	1.86	0.025 *	0.0023 U	0.0034 U	0.000076 U
TT17-SS	TT17-SS	1/25/07	-44.0	-44.0	-44.0	-44.5	71.5	661	248	2.94	2.24	2.911	4.1 D
TT17-CS	TT17-CS-B	1/12/07	-41.8	-41.8	-43.0	-44.0	83	2350	616	2.88	2	7.659	5.3 D
TT17-CS	TT17-CS-C	1/12/07	-41.8	-41.8	-44.0	-45.0	108	1160	371	3.45	1.8	2.928	2.3 D
TT17-CS	TT17-CS-D	1/12/07	-41.8	-41.8	-45.0	-46.0	123	1730	410	6.96	2.1	2.121	0.28 D
TT17-CS	TT17-CS-F	1/12/07	-41.8	-41.8	-47.0	-48.0	130	1040	522	8.95	3.6	5.023	0.037
TT17-CS	TT17-CS-H	1/12/07	-41.8	-41.8	-49.0	-50.0	5.15	27.8	9.07	0.225	0.023	0.071	0.0014
TT17-CS	TT17-CS-J	1/12/07	-41.8	-41.8	-51.0	-51.8	3.43	24.2	4.49	0.09	0.015	0.026	0.0055
TT18-CS	TT18-CS-B	1/15/07	-34.5	-34.5	-35.0	-36.0	224	666	513	9.74	2.55	1.713	0.39 D
TT18-CS	TT18-CS-C	1/15/07	-34.5	-34.5	-36.0	-37.0	59.7	349	232	4.42	0.88	1.944	0.13 D
TT18-CS	TT18-CS-D	1/15/07	-34.5	-34.5	-37.0	-38.0	4.54	20.9	8.98	0.082	0.029	0.046	0.012
TT18-CS	TT18-CS-E	1/15/07	-34.5	-34.5	-38.0	-39.0	4.69	66.2	17.6	0.564	0.044	0.199	0.0023
TT20-SS	TT20-SS	1/25/07	-27.0	-27.0	-27.0	-27.5	30.4	173	106	0.325	0.217	0.582	0.16 D
TT26-SS	TT26-SS	1/25/07	-24.0	-24.0	-24.0	-24.5	13	114	61.3	0.094	0.071	2.600	0.052
TT40-SS	TT40-SS	1/26/07	-31.0	-31.0	-31.0	-31.5	114	442	350	1.57 *	2.05	1.161	1.2 D
TT41-SS	TT41-SS	1/25/07	-32.0	-32.0	-32.0	-32.5	21.1	148	80.5	0.837	0.866	0.505	0.47 D
197	197	2009	-28.9	-28.9	-28.9	-29.4	186	158	188	0.221	0.043	0.194	
HC-03-07	HC-03-07	2003	-40.8	-40.8	-40.8	-41.3	32.6	374	157	0.7	0.86	1.315	1.8
HC-03-08	HC-03-08	2003	-38.8	-38.8	-38.8	-39.3	20.7	164	118	0.57	0.52	1.237	0.68
HC-03-10	HC-03-10	2003	-40.7	-40.7	-40.7	-41.2	25.2	177	109	0.63	0.44	1.072	1.4
HC-03-12	HC-03-12	2003	-38.2	-38.2	-38.2	-38.7	53.6	380	146	0.43	0.49	1.974	1.3

Results in mg/kg dry weight
Value above the SMS (CSL) level
Value above the SMS (SQS) level

U - Result is not detected at the quantitation limit noted
J - Result is an estimated concentration
D - Result is from a diluted sample analysis
E - Result is an estimated concentration for laboratory control data outside of control limits (metals)
B - Result is an estimated concentration below the reporting limit (metals)
* - Result is an estimated concentration for laboratory duplicate results outside control limits (metals)

Table I-4B
Risk Driver COC Sediment Residuals (mg/kg dry weight)
Alternative 2A2a Plus ENR

Location	SAMPLEID	Date	Mudline Elev (FT MSL)	Approx Post Remedy Mudline (Ft MSL)	Interval Top	Interval Bottom	Arsenic	Copper	Lead	Mercury	PCBs (total)	Total cPAH	Tributyltin
						Parameter	Arsenic	Copper	Lead	Mercury	PCBs (total)	Total cPAH	Tributyltin
						CSL	93	390	530	0.59	1	3.000	1.335
						SQS	57	390	450	0.41	0.18	1.100	1.335
						RBTC/Nat Bkgd	7	114	10.9	0.41	0.002	0.009	0.017
						Elliott Bay - Urban	8.44	48.9	47	0.438	0.119	0.757	NA
						Elliott Bay - Harbor	73.4	112	66.9	0.335	0.355	1.210	NA
						Elliot Bay - Basin	9.13	41.1	26.9	0.175	0.048	0.125	NA
C5	C5 (0 - 2)	12/1/91	-39.4	-39.4	-39.4	-41.4	2.5	17.9 J	4	0.1 U	0.0785 U		
C5	C5 (2 - 5)	12/1/91	-39.4	-39.4	-41.4	-44.4	2.03	14.4 J	3 U	0.07 U	0.0798 U		
C5	C5 (5 - 8)	12/1/91	-39.4	-39.4	-44.4	-47.4	2.1	12.9 J	3 U	0.05 U	0.0781 U		
C6	C6 (0 - 2)	12/1/91	-37.2	-37.2	-37.2	-39.2	12.2	61.8 J	32	0.34	0.177		
C6	C6 (2 - 5)	12/1/91	-37.2	-37.2	-39.2	-42.2	8.44	46.3 J	18	0.27	0.0821 U		
C6	C6 (5 - 8)	12/1/91	-37.2	-37.2	-42.2	-45.2	3.19	20.9 J	3	0.06 U	0.000787 U		
C7	C7 (0 - 2)	12/1/91	-46.4	-46.4	-46.4	-48.4	1.36	10.1 J	3 U	0.06 U	0.0792 U		
C7	C7 (2 - 5)	12/1/91	-46.4	-46.4	-48.4	-51.4	1.68	9.2 J	3 U	0.05 U	0.0770 U		
C7	C7 (5 - 8)	12/1/91	-46.4	-46.4	-51.4	-54.4	1.64	8.1 J	2 U	0.05 U	0.0804 U		
D3	D3-A	9/5/89	-41.6	-41.6	-41.6	-43.6	46	210 E	100 E	0.0008	0.246		
D3	D3-B	9/5/89	-41.6	-41.6	-43.6	-46.1	50	68 E	28 E	0.0005 U	0.16		
D3	D3-C	9/5/89	-41.6	-41.6	-52.1	-54.1	23	26 E	11 E	0.0005 U	0.12 U		
D3	D3-D	9/5/89	-41.6	-41.6	-54.6	-56.6	26	22 E	6.7 E	0.0005 U	0.12 U		
D4	D4-D	9/8/89	-48.7	-48.7	-48.7	-58.2	47	43 E	14 E	0.0005 U	0.093		
SA2	SA2-C	8/29/89	-25.0	-25.0	-25.0	-26.0	11	150 E	150 E	0.0019	0.329		
SA2	SA2-D	8/29/89	-25.0	-25.0	-27.0	-30.0	40	64 E	31 E	0.0011	0.12 U		
SA3	SA3-A	8/30/89	-19.5	-19.5	-19.5	-21.5	71	150 E	160 E	0.0006	0.136		
SA3	SA3-B	8/30/89	-19.5	-19.5	-21.5	-24.0	31	77 E	58 E	0.0005	0.13		
SA3	SA3-C	8/30/89	-19.5	-19.5	-24.5	-27.0	3.9	38 E	38 E	0.0005 U	0.12 U		
SA3	SA3-D	8/30/89	-19.5	-19.5	-27.5	-30.0	1.6	40 E	6.1 E	0.0005 U	0.12 U		
SA4	SA4-C	8/30/89	-29.4	-29.4	-29.4	-31.4	3.6	63 E	53 E	0.0005	0.131		
SA4	SA4-D	8/30/89	-29.4	-29.4	-31.4	-33.9	7.5	42 E	3.7 E	0.0005 U	0.12 U		
SA5	SA5-A	8/31/89	-37.6	-37.6	-37.6	-39.6	37	91 E	18 E	0.0005	0.121		
SA5	SA5-C	8/31/89	-37.6	-37.6	-39.6	-42.1	36	77 E	18 E	0.0005 U	0.12 U		
SA5	SA5-D	8/31/89	-37.6	-37.6	-42.1	-45.1	38	40 E	13 E	0.0005 U	0.12 U		
SA6	SA6-C	8/31/89	-33.0	-33.0	-33.0	-34.5	43	160 E	46 E	0.0005 U	0.135 U		
SA6	SA6-D	8/31/89	-33.0	-33.0	-34.5	-36.0	28	50 E	6 E	0.0005	0.12 U		
SA7	SA7-A	8/31/89	-31.6	-31.6	-31.6	-33.6	55	100 E	35 E	0.0005 U	0.125		
SA7	SA7-B/C	8/31/89	-31.6	-31.6	-33.6	-37.6	58	61 E	13 E	0.0005 U	0.125		
SA7	SA7-D	8/31/89	-31.6	-31.6	-39.1	-40.6	70	72 E	9 E	0.0006	0.12 U		
SA9	SA9-A	9/1/89	-44.7	-44.7	-44.7	-46.7	36	220 E	120 E	0.0038	0.61		
SA9	SA9-B	9/1/89	-44.7	-44.7	-46.7	-49.7	20	93 E	20 E	0.001	0.143		
SA9	SA9-C	9/1/89	-44.7	-44.7	-53.7	-55.2	23	71 E	61 E	0.001	0.21		
SA9	SA9-D	9/1/89	-44.7	-44.7	-55.2	-56.7	20	62 E	15 E	0.0005 U	0.135 U		
SA10	SA10-A	9/16/1989	-28.0	-33.0	-28.0	-30.0							
SA10	SA10-B	9/16/1989	-28.0	-33.0	-30.0	-33.0							
SA10	SA10-C	9/16/1989	-28.0	-33.0	-37.0	-38.5	42	39 E	7 E	0.0005	0.12 U		
SA10	SA10-D	9/16/1989	-28.0	-33.0	-38.5	-40.0	28	26 E	5.8 E	0.0005 U	0.12 U		
TT01-SS	TT01-SS	1/24/07	-39.0	-39.0	-39.0	-39.5	7.88	64	39.8	0.299	0.149	0.621	0.16 D
TT01-CS	TT01-CS-A	1/19/07	-30.0	-30.0	-30.0	-31.0	2.3	10.9 *	3.26	0.028	0.07	0.020	0.011
TT01-CS	TT01-CS-B	1/19/07	-30.0	-30.0	-31.0	-32.0	2.42	14.5 *	1.8	0.02	0.0023 U	0.0034 U	0.000075 U
TT01-CS	TT01-CS-C	1/19/07	-30.0	-30.0	-32.0	-33.0	2.39	15.3 *	1.76	0.018 B	0.0024 U	0.0034 U	0.000074 U
TT02-SS	TT02-SS	1/24/07	-41.0	-41.0	-41.0	-41.5	9.05	71.4	51	0.374	0.15	0.391	0.23 D
TT02-CS	TT02-CS-B	1/18/07	-38.4	-38.4	-39.0	-40.0	5.36	27.8 *	6.64	0.079	0.0062	0.002	0.002
TT02-CS	TT02-CS-C	1/18/07	-38.4	-38.4	-40.0	-41.0	3.04	13.5 *	1.93	0.016 B	0.0024 U	0.0035 U	0.000077 U
TT02-CS	TT02-CS-D	1/18/07	-38.4	-38.4	-41.0	-42.0	2.54	13.4 *	1.9	0.02	0.0024 U	0.0034 U	0.000076 U
TT03-SS	TT03-SS	1/24/07	-27.0	-27.5	-27.0	-27.5							
TT03-CS	TT03-CS-B	1/18/07	-16.7	-16.7	-17.6	-19.0	3.18	14.4 *	21.3	0.158	0.022	0.069	0.0032
TT03-CS	TT03-CS-C	1/18/07	-16.7	-16.7	-19.0	-20.0	7.93	8.9 *	8.31	0.033	0.0119	0.037	0.00057 J
TT03-CS	TT03-CS-D	1/18/07	-16.7	-16.7	-20.0	-21.0	1.39	8.6 *	6.54	0.029	0.0059	0.030	0.00054 J
TT05-SS	TT05-SS	1/25/07	-31.0	-31.0	-31.0	-31.5	12.6	118	68.4	0.707	0.43	1.129	0.34 D
TT05-CS	TT05-CS-A	1/12/07	-5.9	-5.9	-5.9	-7.0	3.91	41.9	27.5	0.143	0.0896	0.367	0.036
TT05-CS	TT05-CS-B	1/12/07	-5.9	-5.9	-7.0	-8.0	4.28	55.5	31.1	0.312	0.0756	0.160	0.02
TT05-CS	TT05-CS-C	1/12/07	-5.9	-5.9	-8.0	-9.0	3.34	44.2	44.5	0.297	0.029	0.212	0.0022
TT05-CS	TT05-CS-E	1/12/07	-5.9	-5.9	-10.0	-11.0	1.9	12.7	13.2	0.087	0.0105	0.112	0.000072 U
TT05-CS	TT05-CS-G	1/12/07	-5.9	-5.9	-12.0	-12.9	1.11	10.6	5.55	0.021	0.0022 U	0.006	0.00024 Ui
TT10-CS	TT10-CS-B	1/22/07	-31.8	-31.8	-32.0	-33.0	6.58	35.5	23.6	0.399 *	0.0298	0.215	0.0075
TT10-CS	TT10-CS-C	1/22/07	-31.8	-31.8	-33.0	-34.0	5.97	35.4	15	0.243 *	0.0027 U	0.410	0.0014 J
TT10-CS	TT10-CS-D	1/22/07	-31.8	-31.8	-34.0	-35.0	5.76	40.8	5.92	0.075 *	0.003 U	0.010	0.00045 J
TT10-CS	TT10-CS-E	1/22/07	-31.8	-31.8	-35.0	-36.0	8.21	46.3	9.31	0.119	0.0032 U	0.020	0.0008 J
TT11-CS	TT11-CS-B	1/19/07	-44.5	-46.0	-45.0	-46.0							
TT11-CS	TT11-CS-C	1/19/07	-44.5	-44.5	-46.0	-47.0	9.28	45.2 *	17.5	0.15	0.029	0.041	0.006
TT11-CS	TT11-CS-D	1/19/07	-44.5	-44.5	-47.0	-48.0	5.85	34.7 *	5.13	0.058	0.0027 U	0.003	0.000087 U
TT11-CS	TT11-CS-E	1/19/07	-44.5	-44.5	-48.0	-49.0	3.26	19	3.05	0.034	0.0024 U	0.005	0.000079 U
TT12-SS	TT12-SS	1/26/07	-43.0	-43.0	-43.0	-43.5	18.3	111	80.9	0.636 *	0.257	0.610	0.19 D
TT12-CS	TT12-CS-B	1/15/07	-42.4	-42.4	-43.0	-44.0	9.03	44	23.8	0.404	0.079	0.098	0.013
TT12-CS	TT12-CS-C	1/15/07	-42.4	-42.4	-44.0	-45.0	4.92	22.1	11.1	0.091	0.036	0.041	0.0074
TT12-CS	TT12-CS-D	1/15/07	-42.4	-42.4	-45.0	-46.0	2.91	16.2	3.11	0.043	0.0245	0.016	0.0018
TT12-CS	TT12-CS-E	1/15/07	-42.4	-42.4	-46.0	-47.0	2.02	13.2	2.52	0.03	0.0024 U	0.009	0.00029 J
TT13-CS	TT13-CS-A	1/19/07	-45.2	-45.2	-45.2	-46.2	6.09	63.4	15.1	0.225	0.058	0.064	0.016
TT13-CS	TT13-CS-B	1/19/07	-45.2	-45.2	-46.2	-47.0	3.36	20.4	2.53	0.026	0.0025 U	0.0037 U	0.00029 J
TT13-CS	TT13-CS-C	1/19/07	-45.2	-45.2	-47.0	-47.8	3.07	20.2	2.38	0.03	0.0025 U	0.0037 U	0.000082 U
TT14-SS	TT14-SS	1/25/07	-25.0	-25.0	-25.0	-25.5	12.4	73.2	46.5	0.14	0.134	1.928	0.1
TT14-CS	TT14-CS-B	1/13/07	-25.2	-25.2	-26.0	-27.0	25.7	287	235	0.264	0.38	1.405	0.82 D

Table I-4B
Risk Driver COC Sediment Residuals (mg/kg dry weight)
Alternative 2A2a Plus ENR

Location	SAMPLEID	Date	Mudline Elev (FT MSL)	Approx Post Remedy Mudline (Ft MSL)	Interval Top	Interval Bottom	Arsenic	Copper	Lead	Mercury	PCBs (total)	Total cPAH	Tributyltin
						Parameter	Arsenic	Copper	Lead	Mercury	PCBs (total)	Total cPAH	Tributyltin
						CSL	93	390	530	0.59	1	3.000	1.335
						SQS	57	390	450	0.41	0.18	1.100	1.335
						RBTC/Nat Bkgd	7	114	10.9	0.41	0.002	0.009	0.017
						Elliott Bay - Urban	8.44	48.9	47	0.438	0.119	0.757	NA
						Elliott Bay - Harbor	73.4	112	66.9	0.335	0.355	1.210	NA
						Elliot Bay - Basin	9.13	41.1	26.9	0.175	0.048	0.125	NA
TT14-CS	TT14-CS-C	1/13/07	-25.2	-25.2	-27.0	-28.0	112	558	450	2.28	2.4	1.588	0.39 D
TT14-CS	TT14-CS-J	1/13/07	-25.2	-25.2	-34.4	-35.0	3.89	24.7	13.8	0.227	0.062	0.422	0.00086 J
TT14-CS	TT14-CS-L	1/13/07	-25.2	-25.2	-36.0	-37.0	5.27	30.2	16.8	0.412	0.0055 U	0.360	0.00021 Ui
TT18-SS	TT18-SS	1/25/07	-10.0	-10.0	-10.0	-10.5	4.87	66.6	20.3	0.117	0.114	0.325	0.028
TT19-SS	TT19-SS	1/25/07	-33.0	-33.0	-33.0	-33.5	12.8	115	73.5	0.306	0.22	1.185	0.25 D
TT19-CS	TT19-CS-A	1/15/07	-32.9	-32.9	-32.9	-34.0	17.6	114	72.1	0.252	0.17	0.750	0.16 D
TT19-CS	TT19-CS-B	1/15/07	-32.9	-32.9	-34.0	-35.0	18.5	146	80.8	0.255	0.251	0.701	1.4 D
TT19-CS	TT19-CS-C	1/15/07	-32.9	-32.9	-35.0	-35.6	15.4	72.3	94.1	0.163	0.192	0.185	0.046
TT19-CS	TT19-CS-D	1/15/07	-32.9	-32.9	-35.6	-37.0	7.22	40.8	40.1	0.058	0.131	0.065	0.047
TT19-CS	TT19-CS-E	1/15/07	-32.9	-32.9	-37.0	-38.0	2.64	15.8	2.59	0.1	0.0023 U	0.006	0.003
TT21-SS	TT21-SS	1/25/07	-32.0	-32.0	-32.0	-32.5	23.6	127	76.8	0.215	0.205	0.671	0.18 D
TT22-SS	TT22-SS	1/25/07	-47.0	-47.0	-47.0	-47.5	7.23	64.7	32.7	0.308	0.46	0.417	0.2 D
TT22-CS	TT22-CS-B	1/12/07	-43.4	-43.4	-44.0	-45.0	7.31	44.7	8.81	0.083	0.003 U	0.010	0.0016 J
TT22-CS	TT22-CS-C	1/12/07	-43.4	-43.4	-45.0	-46.0	3.99	24.3	4.17	0.088	0.0026 U	0.008	0.0016
TT22-CS	TT22-CS-D	1/12/07	-43.4	-43.4	-46.0	-47.0	3.12	19.4	2.93	0.041	0.0024 U	0.006	0.00021 Ui
TT23-SS	TT23-SS	1/26/07	-45.0	-45.0	-45.0	-45.5	4.66	33.4	15.9	0.138 *	0.054	0.188	0.042
TT23-CS	TT23-CS-B	1/10/07	-42.9	-42.9	-44.0	-45.0	3.63	26.8	5.1	0.03	0.0046	0.011	0.0018
TT23-CS	TT23-CS-C	1/10/07	-42.9	-42.9	-45.0	-46.0	2.77	23.4	3.23	0.018 B	0.0022 U	0.0033 U	0.0004 Ui
TT23-CS	TT23-CS-H	1/10/07	-42.9	-42.9	-50.0	-51.2	2.34	16.1	2.05	0.018	0.0023 U	0.0033 U	0.000074 U
TT24-SS	TT24-SS	1/25/07	-24.0	-24.0	-24.0	-24.5	5.58	33.5	17	0.22	0.048	0.384	0.0089
TT24-CS	TT24-CS-B	1/10/07	-26.3	-26.3	-27.0	-28.6	2.49	23.5	6.64	0.074	0.0258	0.049	0.0015
TT24-CS	TT24-CS-C	1/10/07	-26.3	-26.3	-28.6	-29.9	7.96	81	52	0.451	0.58	0.700	0.0088
TT24-CS	TT24-CS-E	1/10/07	-26.3	-26.3	-30.7	-31.9	3.58	27.5	10.5	0.13	0.013 U	0.118	0.00098 J
TT24-CS	TT24-CS-H	1/10/07	-26.3	-26.3	-34.0	-35.0	5.21	38.6	16	0.22	0.014 U	0.131	0.000087 U
TT25-SS	TT25-SS	1/25/07	-26.0	-26.0	-26.0	-26.5	11.1	90.1	50.7	0.094	0.202	1.753	0.14
TT25-CS	TT25-CS-B	1/12/07	-24.6	-24.6	-25.0	-26.0	19.1	105	123	0.712	0.223	1.547	0.019
TT25-CS	TT25-CS-C	1/12/07	-24.6	-24.6	-26.0	-27.0	12.6	77.9	62.5	0.577	0.122	1.611	0.003
TT25-CS	TT25-CS-J	1/12/07	-24.6	-24.6	-33.0	-34.0	4.57	32	14.1	0.162	0.0041	0.086	0.000079 U
TT25-CS	TT25-CS-L	1/12/07	-24.6	-24.6	-35.0	-36.0	10	64.7	80.9	0.733	0.211	6.734	
TT26-CS	TT26-CS-B	1/12/07	-30.1	-30.1	-31.0	-32.0	38.7	200	115	0.156	0.162	0.950	0.71 D
TT26-CS	TT26-CS-C	1/12/07	-30.1	-30.1	-32.0	-33.0	316	335	360	0.139	0.183	1.484	0.29 D
TT26-CS	TT26-CS-G	1/12/07	-30.1	-30.1	-36.0	-37.0	123	194	281	0.317	0.69	1.025	0.05
TT26-CS	TT26-CS-I	1/12/07	-30.1	-30.1	-38.0	-39.0	3.02	14.1	3.7	0.022	0.0023 U	0.003	0.00043 J
TT27-SS	TT27-SS	1/24/07	-17.0	-18.0	-17.0	-17.5							
TT27B-C	TT27B-CS-B	1/23/07	-28.8	-28.8	-29.0	-30.0	3.69	18.9	19.1	0.181 *	0.0203	0.058	0.0053
TT27B-C	TT27B-CS-C	1/23/07	-28.8	-28.8	-30.0	-31.0	4.43	27.3	18	0.364 *	0.0112	0.157	0.0036
TT27B-C	TT27B-CS-D	1/23/07	-28.8	-28.8	-31.0	-32.0	6.23	36.1	9.75	0.186 *	0.0027 U	0.130	0.0032
TT28-SS	TT28-SS	1/24/07	-52.0	-52.0	-52.0	-52.5	8.58	34.5	22.5	0.178	0.072	0.144	0.052
TT29-SS	TT29-SS	1/24/07	-44.0	-44.0	-44.0	-44.5	6.08	28.2	19.8	0.376	0.104	0.144	0.13 D
TT29-CS	TT29-CS-A	1/18/07	-41.0	-41.0	-41.0	-42.1	1.65	7.2 *	37.7	0.018 B	0.0023 U	0.011	0.00047 J
TT29-CS	TT29-CS-B	1/18/07	-41.0	-41.0	-42.1	-43.1	1.56	6.7 *	6.94	0.014 B	0.0022 U	0.006	0.00023 Ui
TT29-CS	TT29-CS-C	1/18/07	-41.0	-41.0	-43.1	-44.1	2.47	15.5 *	19.5	0.099	0.04	0.101	0.00007 U
TT30-SS	TT30-SS	1/24/07	-51.0	-54.0	-51.0	-51.5							
TT30-CS	TT30-CS-A	1/16/07	-52.2	-54.0	-52.2	-53.0							
TT30-CS	TT30-CS-B	1/16/07	-52.2	-54.0	-53.0	-54.0					< SQS		
TT31-SS	TT31-SS	1/26/07	-49.0	-52.9	-49.0	-49.5							
TT31-CS	TT31-CS-A	1/17/07	-51.8	-52.9	-51.8	-52.9							
TT31-CS	TT31-CS-B	1/17/07	-51.8	-52.9	-52.9	-54.0	2.67	18.9	11.7	0.16	0.019	0.060	0.0016
TT32-SS	TT32-SS	1/26/07	-43.0	-43.0	-43.0	-43.5	8.58	54.5	26.5	0.253 *	0.139	0.157	0.071
TT32-CS	TT32-CS-B	1/13/07	-41.7	-41.7	-42.0	-43.0	3.29	19	2.78	0.023	0.0025 U	0.0036 U	0.00055 J
TT32-CS	TT32-CS-C	1/13/07	-41.7	-41.7	-43.0	-44.0	3.17	21.7	2.83	0.026	0.0025 U	0.000	0.00008 U
TT32-CS	TT32-CS-H	1/13/07	-41.7	-41.7	-48.0	-49.4	2.95	20.3	2.96	0.022	0.0024 U	0.0035 U	0.00026 Ui
TT33-SS	TT33-SS	1/26/07	-47.0	-48.0	-47.0	-47.5							
TT33-CS	TT33-CS-A	1/23/07	-50.6	-50.6	-50.6	-51.0	4.84	38.2	14.8	0.176 *	0.052	0.069	0.016
TT33-CS	TT33-CS-B	1/23/07	-50.6	-50.6	-51.0	-52.0	4.47	42.6	13.5	0.118 *	0.0102	0.028	0.0024
TT33-CS	TT33-CS-C	1/23/07	-50.6	-50.6	-52.0	-53.0	2.67	19.6	2.21	0.025 *	0.0023 U	0.0034 U	0.000075 U
TT34-CS	TT34-CS-B	1/17/07	-51.3	-52.0	-52.0	-53.0	3.8	25.4	9.24	0.148	0.03	0.111	0.018
TT35-SS	TT35-SS	1/25/07	-44.0	-44.0	-44.0	-44.5	4.56	39.3	20.5	0.176	0.06	0.087	0.52 D
TT35-CS	TT35-CS-B	1/15/07	-49.4	-49.4	-50.0	-51.0	6.53	39.6	32.5	0.456	0.099	0.167	0.0054
TT35-CS	TT35-CS-C	1/15/07	-49.4	-49.4	-51.0	-52.0	4.79	30.7	16.6	0.296	0.0072	0.078	0.003
TT35-CS	TT35-CS-D	1/15/07	-49.4	-49.4	-52.0	-53.0	3.85	23.7	7.64	0.139	0.0025 U	0.050	0.0014 J
TT37-SS	TT37-SS	1/25/07	-49.0	-49.0	-49.0	-49.5	7.37	39.8	22.4	0.121	0.121	0.116	0.033
TT37-CS	TT37-CS-A	1/13/07	-40.9	-40.9	-40.9	-42.0	7.75	23.6	15.6	0.032	0.085	0.041	0.0063
TT37-CS	TT37-CS-B	1/13/07	-40.9	-40.9	-42.0	-43.0	2.38	10	4.76	0.019	0.027	0.022	0.0043
TT37-CS	TT37-CS-C	1/13/07	-40.9	-40.9	-43.0	-44.0	2.59	13.4	4.87	0.075	0.0054	0.017	0.0015
TT39-SS	TT39-SS	1/25/07	-44.0	-44.0	-44.0	-44.5	6.41	34.6	20.5	0.158	0.085	0.146	0.061
TT39-CS	TT39-CS-A	1/12/07	-42.8	-42.8	-42.8	-44.0	10.3	71.5	45.1	0.332	0.321	0.511	0.063
TT39-CS	TT39-CS-B	1/12/07	-42.8	-42.8	-44.0	-45.0	8.79	75.1	51.5	0.446	0.432	0.404	0.052
TT39-CS	TT39-CS-C	1/12/07	-42.8	-42.8	-45.0	-46.0	4.88	31.2	14.1	0.151	0.047	0.093	0.0067
TT42-SS	TT42-SS	1/26/07	-50.0	-52.0	-50.0	-50.5							
TT42-CS	TT42-CS-B	1/23/07	-49.7	-52.0	-50.0	-51.0							
TT42-CS	TT42-CS-C	1/23/07	-49.7	-52.0	-51.0	-52.0							
TT42-CS	TT42-CS-D	1/23/07	-49.7	-52.0	-52.0	-53.0	4.93	30.1	6.88	0.146 *	0.0156	0.079	0.0049
199	199	2009	-44.3	-44.3	-44.3	-44.8	6.5	25.6	14.6	0.107	0.06	0.207	

Table I-4B
Risk Driver COC Sediment Residuals (mg/kg dry weight)
Alternative 2A2a Plus ENR

Location	SAMPLEID	Date	Mudline Elev (FT MSL)	Approx Post Remedy Mudline (Ft MSL)	Interval Top	Interval Bottom	Arsenic	Copper	Lead	Mercury	PCBs (total)	Total cPAH	Tributyltin
						CSL	93	390	530	0.59	1	3.000	1.335
						SQS	57	390	450	0.41	0.18	1.100	1.335
						RBTC/Nat Bkgd	7	114	10.9	0.41	0.002	0.009	0.017
						Elliott Bay - Urban	8.44	48.9	47	0.438	0.119	0.757	NA
						Elliott Bay - Harbor	73.4	112	66.9	0.335	0.355	1.210	NA
						Elliot Bay - Basin	9.13	41.1	26.9	0.175	0.048	0.125	NA
HC-03-04	HC-03-04	2003	29.5	29.5	29.5	29.0	20.5	151	85.8	0.21	0.184	0.544	0.1
HC-03-05	HC-03-05	2003	-24.3	-24.3	-24.3	-24.8	18.9	159	55.2	0.08	0.068	0.241	0.034
HC-03-09	HC-03-09	2003	-7.5	-7.5	-7.5	-8.0	10.4	123	57.8	0.32	0.205	0.182	0.023
HC-03-11	HC-03-11	2003	-42.5	-42.5	-42.5	-43.0	9.8	50.6	35.7	0.1	0.059	0.299	0.051
HC-03-16	HC-03-16	2003	-37.8	-37.8	-37.8	-38.3	10.2	61.8	45.2	0.26	0.3	0.208	0.021
HC-03-17	HC-03-17	2003	-43.4	-43.4	-43.4	-43.9	16.5	169	49.1	0.35	0.28	0.371	0.19
HC-03-19	HC-03-19	2003	-50.5	-50.5	-50.5	-51.0	10.7	71.2	47.3	0.48	0.36	0.207	0.042

Results in mg/kg dry weight
Value above the SMS (CSL) level
Value above the SMS (SQS) level

U - Result is not detected at the quantitation limit noted
J - Result is an estimated concentration
D - Result is from a diluted sample analysis
E - Result is an estimated concentration for laboratory control data outside of control limits (metals)
B - Result is an estimated concentration below the reporting limit (metals)
* - Result is an estimated concentration for laboratory duplicate results outside control limits (metals)

Table I-5A
Risk Driver COC Sediment Residuals (mg/kg dry weight)
Alternative 3A2 Plus

						Parameter	Arsenic	Copper	Lead	Mercury	PCBs (total)	Total cPAH	Tributyltin
						CSL	93	390	530	0.59	1	3.000	1.335
						SQS	57	390	450	0.41	0.18	1.100	1.335
						RBTC/Nat Bkgd	7	114	10.9	0.41	0.002	0.009	0.017
						Elliott Bay - Urban	8.44	48.9	47	0.438	0.119	0.757	NA
				Approx Post Remedy Mudline (Ft MSL)		Elliott Bay - Harbor	73.4	112	66.9	0.335	0.355	1.210	NA
			Mudline Elev (FT MSL)			Elliot Bay - Basin	9.13	41.1	26.9	0.175	0.048	0.125	NA
					Interval								
Location	SAMPLEID	Date			Top	Bottom							
SA8	SA8-A	9/1/89	-39.2	-42.2	-39.2	-41.2							
SA8	SA8-C	9/1/89	-39.2	-42.2	-41.2	-42.7	44	110 E	32 E	0.0017	0.235		
SA8	SA8-D	9/1/89	-39.2	-42.2	-42.7	-44.2	27	100 E	30 E	0.001	0.125		
TT07-SS	TT07-SS	1/25/07	-40.0	-43.0	-40.0	-40.5							
TT07-CS	TT07-CS-B	1/16/07	-5.7	-8.7	-6.0	-7.0							
TT07-CS	TT07-CS-C	1/16/07	-5.7	-8.7	-7.0	-8.0							
TT07-CS	TT07-CS-D	1/16/07	-5.7	-8.7	-8.0	-9.0	49	1520	236	1.38	2.18	3.885	5.4 D
TT07-CS	TT07-CS-F	1/16/07	-5.7	-8.7	-10.0	-11.0	48.4	860	576	5.52	3.58	3.455	0.2 D
TT07-CS	TT07-CS-H	1/16/07	-5.7	-8.7	-12.0	-12.7	14.4	223	117	1.87	0.48	4.202	0.36 D
TT09-SS	TT09-SS	1/25/07	-40.0	-43.0	-40.0	-40.5							
TT09-CS	TT09-CS-B	1/16/07	-40.8	-43.8	-41.0	-42.0							
TT09-CS	TT09-CS-C	1/16/07	-40.8	-43.8	-42.0	-43.0							
TT09-CS	TT09-CS-E	1/16/07	-40.8	-43.8	-44.2	-45.0	30.5	640	292	4.74	1.34	9.100	0.51 D
TT09-CS	TT09-CS-G	1/16/07	-40.8	-43.8	-46.3	-47.0	5.36	42.2	15.8	0.231	0.075	0.117	0.011
TT09-CS	TT09-CS-I	1/16/07	-40.8	-43.8	-48.0	-49.0	2.4	27.6	23.3	0.166	0.03	0.031	0.00078 J
TT09-CS	TT09-CS-K	1/16/07	-40.8	-43.8	-50.0	-51.0	10	312	96.5	2.44	1.3	0.989	0.00008 U
TT09-CS	TT09-CS-L	1/16/07	-40.8	-43.8	-51.0	-51.6	26.8	865	266	8.51	0.182	3.362	0.00052 J
TT09-CS	TT09-CS-M	1/16/07	-40.8	-43.8	-51.6	-53.0	6.25	33.3	11.5	0.188	0.0052	0.044	0.000082 U
TT15-SS	TT15-SS	1/25/07	-44.0	-47.0	-44.0	-44.5							
TT15-CS	TT15-CS-B	1/18/07	-46.2	-49.2	-46.9	-48.0							
TT15-CS	TT15-CS-C	1/18/07	-46.2	-49.2	-48.0	-48.9							
TT15-CS	TT15-CS-G	1/18/07	-46.2	-49.2	-52.3	-53.0	41.1	153	155	0.933	0.215	0.304	0.00064 J
TT15-CS	TT15-CS-H	1/18/07	-46.2	-49.2	-53.0	-54.0	18.1	61.3	56.7	0.315	0.03	0.383	0.0053
TT17-SS	TT17-SS	1/25/07	-44.0	-47.0	-44.0	-44.5							
TT17-CS	TT17-CS-B	1/12/07	-41.8	-44.8	-43.0	-44.0							
TT17-CS	TT17-CS-C	1/12/07	-41.8	-44.8	-44.0	-45.0	108	1160	371	3.45	1.8	2.928	2.3 D
TT17-CS	TT17-CS-D	1/12/07	-41.8	-44.8	-45.0	-46.0	123	1730	410	6.96	2.1	2.121	0.28 D
TT17-CS	TT17-CS-F	1/12/07	-41.8	-44.8	-47.0	-48.0	130	1040	522	8.95	3.6	5.023	0.037
TT17-CS	TT17-CS-H	1/12/07	-41.8	-44.8	-49.0	-50.0	5.15	27.8	9.07	0.225	0.023	0.071	0.0014
TT17-CS	TT17-CS-J	1/12/07	-41.8	-44.8	-51.0	-51.8	3.43	24.2	4.49	0.09	0.015	0.026	0.0055
TT18-CS	TT18-CS-B	1/15/07	-34.5	-37.5	-35.0	-36.0							
TT18-CS	TT18-CS-C	1/15/07	-34.5	-37.5	-36.0	-37.0							
TT18-CS	TT18-CS-D	1/15/07	-34.5	-37.5	-37.0	-38.0	4.54	20.9	8.98	0.082	0.029	0.046	0.012
TT18-CS	TT18-CS-E	1/15/07	-34.5	-37.5	-38.0	-39.0	4.69	66.2	17.6	0.564	0.044	0.199	0.0023
TT40-SS	TT40-SS	1/26/07	-31.0	-34.0	-31.0	-31.5	< SQS						
TT41-SS	TT41-SS	1/25/07	-32.0	-35.0	-32.0	-32.5	< SQS						
197	197	2009	-28.9	-31.9	-28.9	-29.4	< SQS						
HC-03-07	HC-03-07	2003	-40.8	-43.8	-40.8	-41.3	< SQS						
HC-03-10	HC-03-10	2003	-40.7	-43.7	-40.7	-41.2	< SQS						
HC-03-12	HC-03-12	2003	-38.2	-41.2	-38.2	-38.7	< SQS						

Results in mg/kg dry weight
Value above the SMS (CSL) level
Value above the SMS (SQS) level

U - Result is not detected at the quantitation limit noted
J - Result is an estimated concentration
D - Result is from a diluted sample analysis
E - Result is an estimated concentration for laboratory control data outside of control limits (metals)
B - Result is an estimated concentration below the reporting limit (metals)
* - Result is an estimated concentration for laboratory duplicate results outside control limits (metals)

Table I-5B
Risk Driver COC Sediment Residuals (mg/kg dry weight)
Alternative 3A2 Plus - ENR

Location	SAMPLEID	Date	Mudline Elev (FT MSL)	Approx Post Remedy Mudline (Ft MSL)	Top	Bottom	Arsenic	Copper	Lead	Mercury	PCBs (total)	Total cPAH	Tributyltin
						Parameter	Arsenic	Copper	Lead	Mercury	PCBs (total)	Total cPAH	Tributyltin
						CSL	93	390	530	0.59	1	3.000	1.335
						SQS	57	390	450	0.41	0.18	1.100	1.335
						RBTC/Nat Bkgd	7	114	10.9	0.41	0.002	0.009	0.017
						Elliott Bay - Urban	8.44	48.9	47	0.438	0.119	0.757	NA
						Elliott Bay - Harbor	73.4	112	66.9	0.335	0.355	1.210	NA
						Elliot Bay - Basin	9.13	41.1	26.9	0.175	0.048	0.125	NA
					Interval								
Location	SAMPLEID	Date	Mudline Elev (FT MSL)	Approx Post Remedy Mudline (Ft MSL)	Top	Bottom							
C5	C5 (0 - 2)	12/1/91	-39.4	-39.4	-39.4	-41.4	2.5	17.9 J	4	0.1 U	0.0785 U		
C5	C5 (2 - 5)	12/1/91	-39.4	-39.4	-41.4	-44.4	2.03	14.4 J	3 U	0.07 U	0.0798 U		
C5	C5 (5 - 8)	12/1/91	-39.4	-39.4	-44.4	-47.4	2.1	12.9 J	3 U	0.05 U	0.0781 U		
C6	C6 (0 - 2)	12/1/91	-37.2	-37.2	-37.2	-39.2	12.2	61.8 J	32	0.34	0.177		
C6	C6 (2 - 5)	12/1/91	-37.2	-37.2	-39.2	-42.2	8.44	46.3 J	18	0.27	0.0821 U		
C6	C6 (5 - 8)	12/1/91	-37.2	-37.2	-42.2	-45.2	3.19	20.9 J	3	0.06 U	0.000787 U		
C7	C7 (0 - 2)	12/1/91	-46.4	-46.4	-46.4	-48.4	1.36	10.1 J	3 U	0.06 U	0.0792 U		
C7	C7 (2 - 5)	12/1/91	-46.4	-46.4	-48.4	-51.4	1.68	9.2 J	3 U	0.05 U	0.0770 U		
C7	C7 (5 - 8)	12/1/91	-46.4	-46.4	-51.4	-54.4	1.64	8.1 J	2 U	0.05 U	0.0804 U		
D3	D3-A	9/5/89	-41.6	-46.6	-41.6	-43.6							
D3	D3-B	9/5/89	-41.6	-46.6	-43.6	-46.1							
D3	D3-C	9/5/89	-41.6	-46.6	-52.1	-54.1	23	26 E	11 E	0.0005 U	0.12 U		
D3	D3-D	9/5/89	-41.6	-46.6	-54.6	-56.6	26	22 E	6.7 E	0.0005 U	0.12 U		
D4	D4-D	9/8/89	-48.7	-48.7	-48.7	-58.2	47	43 E	14 E	0.0005 U	0.093		
SA2	SA2-C	8/29/89	-25.0	-26.0	-25.0	-26.0							
SA2	SA2-D	8/29/89	-25.0	-26.0	-27.0	-30.0	40	64 E	31 E	0.0011	0.12 U		
SA3	SA3-A	8/30/89	-19.5	-21.5	-19.5	-21.5							
SA3	SA3-B	8/30/89	-19.5	-21.5	-21.5	-24.0	31	77 E	58 E	0.0005	0.13		
SA3	SA3-C	8/30/89	-19.5	-21.5	-24.5	-27.0	3.9	38 E	38 E	0.0005 U	0.12 U		
SA3	SA3-D	8/30/89	-19.5	-21.5	-27.5	-30.0	1.6	40 E	6.1 E	0.0005 U	0.12 U		
SA4	SA4-C	8/30/89	-29.4	-29.4	-29.4	-31.4	3.6	63 E	53 E	0.0005	0.131		
SA4	SA4-D	8/30/89	-29.4	-29.4	-31.4	-33.9	7.5	42 E	3.7 E	0.0005 U	0.12 U		
SA5	SA5-A	8/31/89	-37.6	-37.6	-37.6	-39.6	37	91 E	18 E	0.0005	0.121		
SA5	SA5-C	8/31/89	-37.6	-37.6	-39.6	-42.1	36	77 E	18 E	0.0005 U	0.12 U		
SA5	SA5-D	8/31/89	-37.6	-37.6	-42.1	-45.1	38	40 E	13 E	0.0005 U	0.12 U		
SA6	SA6-C	8/31/89	-33.0	-33.0	-33.0	-34.5	43	160 E	46 E	0.0005 U	0.135 U		
SA6	SA6-D	8/31/89	-33.0	-33.0	-34.5	-36.0	28	50 E	6 E	0.0005	0.12 U		
SA7	SA7-A	8/31/89	-31.6	-34.6	-31.6	-33.6							
SA7	SA7-B/C	8/31/89	-31.6	-34.6	-33.6	-37.6	58	61 E	13 E	0.0005 U	0.125		
SA7	SA7-D	8/31/89	-31.6	-34.6	-39.1	-40.6	70	72 E	9 E	0.0006	0.12 U		
SA9	SA9-A	9/1/89	-44.7	-47.7	-44.7	-46.7							
SA9	SA9-B	9/1/89	-44.7	-47.7	-46.7	-49.7	20	93 E	20 E	0.001	0.143		
SA9	SA9-C	9/1/89	-44.7	-47.7	-53.7	-55.2	23	71 E	61 E	0.001	0.21		
SA9	SA9-D	9/1/89	-44.7	-47.7	-55.2	-56.7	20	62 E	15 E	0.0005 U	0.135 U		
SA10	SA10-A	9/16/1989	-28.0	-31.0	-28.0	-30.0							
SA10	SA10-B	9/16/1989	-28.0	-31.0	-30.0	-33.0	36	38 E	13 E	0.0009	0.23		
SA10	SA10-C	9/16/1989	-28.0	-31.0	-37.0	-38.5	42	39 E	7 E	0.0005	0.12 U		
SA10	SA10-D	9/16/1989	-28.0	-31.0	-38.5	-40.0	28	26 E	5.8 E	0.0005 U	0.12 U		
TT01-SS	TT01-SS	1/24/07	-39.0	-39.0	-39.0	-39.5	7.88	64	39.8	0.299	0.149	0.621	0.16 D
TT01-CS	TT01-CS-A	1/19/07	-30.0	-30.0	-30.0	-31.0	2.3	10.9 *	3.26	0.028	0.07	0.020	0.011
TT01-CS	TT01-CS-B	1/19/07	-30.0	-30.0	-31.0	-32.0	2.42	14.5 *	1.8	0.02	0.0023 U	0.0034 U	0.000075 U
TT01-CS	TT01-CS-C	1/19/07	-30.0	-30.0	-32.0	-33.0	2.39	15.3 *	1.76	0.018 B	0.0024 U	0.0034 U	0.000074 U
TT02-SS	TT02-SS	1/24/07	-41.0	-41.0	-41.0	-41.5	9.05	71.4	51	0.374	0.15	0.391	0.23 D
TT02-CS	TT02-CS-B	1/18/07	-38.4	-38.4	-39.0	-40.0	5.36	27.8 *	6.64	0.079	0.0062	0.002	0.002
TT02-CS	TT02-CS-C	1/18/07	-38.4	-38.4	-40.0	-41.0	3.04	13.5 *	1.93	0.016 B	0.0024 U	0.0035 U	0.000077 U
TT02-CS	TT02-CS-D	1/18/07	-38.4	-38.4	-41.0	-42.0	2.54	13.4 *	1.9	0.02	0.0024 U	0.0034 U	0.000076 U
TT03-SS	TT03-SS	1/24/07	-27.0	-28.0	-27.0	-27.5							
TT03-CS	TT03-CS-B	1/18/07	-16.7	-16.7	-17.6	-19.0	3.18	14.4 *	21.3	0.158	0.022	0.069	0.0032
TT03-CS	TT03-CS-C	1/18/07	-16.7	-16.7	-19.0	-20.0	7.93	8.9 *	8.31	0.033	0.0119	0.037	0.00057 J
TT03-CS	TT03-CS-D	1/18/07	-16.7	-16.7	-20.0	-21.0	1.39	8.6 *	6.54	0.029	0.0059	0.030	0.00054 J
TT04-SS	TT04-SS	1/24/07	-23.0	-36.0	-23.0	-23.5							
TT04-CS	TT04-CS-B	1/22/07	-23.5	-36.0	-24.0	-25.0							
TT04-CS	TT04-CS-C	1/22/07	-23.5	-36.0	-25.0	-26.0							
TT04-CS	TT04-CS-J	1/22/07	-23.5	-36.0	-32.0	-33.0							
TT04-CS	TT04-CS-K	1/22/07	-23.5	-36.0	-33.0	-34.0							
TT04-CS	TT04-CS-M	1/22/07	-23.5	-36.0	-35.0	-36.0					< SQS		
TT05-SS	TT05-SS	1/25/07	-31.0	-32.0	-31.0	-31.5							
TT05-CS	TT05-CS-A	1/12/07	-5.9	-5.9	-5.9	-7.0	3.91	41.9	27.5	0.143	0.0896	0.367	0.036
TT05-CS	TT05-CS-B	1/12/07	-5.9	-5.9	-7.0	-8.0	4.28	55.5	31.1	0.312	0.0756	0.160	0.02
TT05-CS	TT05-CS-C	1/12/07	-5.9	-5.9	-8.0	-9.0	3.34	44.2	44.5	0.297	0.029	0.212	0.0022
TT05-CS	TT05-CS-E	1/12/07	-5.9	-5.9	-10.0	-11.0	1.9	12.7	13.2	0.087	0.0105	0.112	0.000072 U
TT05-CS	TT05-CS-G	1/12/07	-5.9	-5.9	-12.0	-12.9	1.11	10.6	5.55	0.021	0.0022 U	0.006	0.00024 Ui
TT06-SS	TT06-SS	1/24/07	-42.0	-45.9	-42.0	-42.5							
TT06-CS	TT06-CS-A	1/17/07	-43.0	-45.9	-43.0	-44.0							
TT06-CS	TT06-CS-B	1/17/07	-43.0	-45.9	-44.0	-45.0							
TT06-CS	TT06-CS-C	1/17/07	-43.0	-45.9	-45.0	-45.9							
TT06-CS	TT06-CS-E	1/17/07	-43.0	-45.9	-47.0	-48.0	2.79	16.8	6.04	0.089	0.0064	0.047	0.0012 J
TT06-CS	TT06-CS-G	1/17/07	-43.0	-45.9	-49.0	-50.0	2.42	12.6	4.49	0.036	0.0023 U	0.079	0.0018
TT06-CS	TT06-CS-I	1/17/07	-43.0	-45.9	-51.0	-52.0	2.98	16.6	8.9	0.066	0.0023 U	0.034	0.000073 U
TT10-SS	TT10-SS	1/25/07	-29.0	-30.0	-29.0	-29.5							
TT10-CS	TT10-CS-B	1/22/07	-31.8	-30.0	-32.0	-33.0	6.58	35.5	23.6	0.399 *	0.0298	0.215	0.0075
TT10-CS	TT10-CS-C	1/22/07	-31.8	-30.0	-33.0	-34.0	5.97	35.4	15	0.243 *	0.0027 U	0.410	0.0014 J
TT10-CS	TT10-CS-D	1/22/07	-31.8	-30.0	-34.0	-35.0	5.76	40.8	5.92	0.075 *	0.003 U	0.010	0.00045 J
TT10-CS	TT10-CS-E	1/22/07	-31.8	-30.0	-35.0	-36.0	8.21	46.3	9.31	0.119	0.0032 U	0.020	0.0008 J

Table I-5B
Risk Driver COC Sediment Residuals (mg/kg dry weight)
Alternative 3A2 Plus - ENR

Location	SAMPLEID	Date	Mudline Elev (FT MSL)	Approx Post Remedy Mudline (Ft MSL)	Interval Top	Interval Bottom	Arsenic	Copper	Lead	Mercury	PCBs (total)	Total cPAH	Tributyltin
						Parameter	Arsenic	Copper	Lead	Mercury	PCBs (total)	Total cPAH	Tributyltin
						CSL	93	390	530	0.59	1	3.000	1.335
						SQS	57	390	450	0.41	0.18	1.100	1.335
						RBTC/Nat Bkgd	7	114	10.9	0.41	0.002	0.009	0.017
						Elliott Bay - Urban	8.44	48.9	47	0.438	0.119	0.757	NA
						Elliott Bay - Harbor	73.4	112	66.9	0.335	0.355	1.210	NA
						Elliot Bay - Basin	9.13	41.1	26.9	0.175	0.048	0.125	NA
TT11-SS	TT11-SS	1/26/07	-38.0	-39.0	-38.0	-38.5							
TT11-CS	TT11-CS-B	1/19/07	-44.5	-46.0	-45.0	-46.0							
TT11-CS	TT11-CS-C	1/19/07	-44.5	-46.0	-46.0	-47.0	9.28	45.2 *	17.5	0.15	0.029	0.041	0.006
TT11-CS	TT11-CS-D	1/19/07	-44.5	-46.0	-47.0	-48.0	5.85	34.7 *	5.13	0.058	0.0027 U	0.003	0.000087 U
TT11-CS	TT11-CS-E	1/19/07	-44.5	-46.0	-48.0	-49.0	3.26	19	3.05	0.034	0.0024 U	0.005	0.000079 U
TT12-SS	TT12-SS	1/26/07	-43.0	-44.0	-43.0	-43.5							
TT12-CS	TT12-CS-B	1/15/07	-42.4	-44.0	-43.0	-44.0	9.03	44	23.8	0.404	0.079	0.098	0.013
TT12-CS	TT12-CS-C	1/15/07	-42.4	-44.0	-44.0	-45.0	4.92	22.1	11.1	0.091	0.036	0.041	0.0074
TT12-CS	TT12-CS-D	1/15/07	-42.4	-44.0	-45.0	-46.0	2.91	16.2	3.11	0.043	0.0245	0.016	0.0018
TT12-CS	TT12-CS-E	1/15/07	-42.4	-44.0	-46.0	-47.0	2.02	13.2	2.52	0.03	0.0024 U	0.009	0.00029 J
TT13-SS	TT13-SS	1/26/07	-44.0	-45.0	-44.0	-44.5							
TT13-CS	TT13-CS-A	1/19/07	-45.2	-45.0	-45.2	-46.2	6.09	63.4	15.1	0.225	0.058	0.064	0.016
TT13-CS	TT13-CS-B	1/19/07	-45.2	-45.0	-46.2	-47.0	3.36	20.4	2.53	0.026	0.0025 U	0.0037 U	0.00029 J
TT13-CS	TT13-CS-C	1/19/07	-45.2	-45.0	-47.0	-47.8	3.07	20.2	2.38	0.03	0.0025 U	0.0037 U	0.000082 U
TT14-SS	TT14-SS	1/25/07	-25.0	-28.0	-25.0	-25.5							
TT14-CS	TT14-CS-B	1/13/07	-25.2	-28.0	-26.0	-27.0							
TT14-CS	TT14-CS-C	1/13/07	-25.2	-28.0	-27.0	-28.0							
TT14-CS	TT14-CS-J	1/13/07	-25.2	-28.0	-34.4	-35.0	3.89	24.7	13.8	0.227	0.062	0.422	0.00086 J
TT14-CS	TT14-CS-L	1/13/07	-25.2	-28.0	-36.0	-37.0	5.27	30.2	16.8	0.412	0.0055 U	0.360	0.00021 Ui
TT18-SS	TT18-SS	1/25/07	-10.0	-10.0	-10.0	-10.5	4.87	66.6	20.3	0.117	0.114	0.325	0.028
TT18-CS	TT18-CS-B	1/15/07	-34.5	-37.0	-35.0	-36.0							
TT18-CS	TT18-CS-C	1/15/07	-34.5	-37.0	-36.0	-37.0							
TT18-CS	TT18-CS-D	1/15/07	-34.5	-37.0	-37.0	-38.0	4.54	20.9	8.98	0.082	0.029	0.046	0.012
TT18-CS	TT18-CS-E	1/15/07	-34.5	-37.0	-38.0	-39.0	4.69	66.2	17.6	0.564	0.044	0.199	0.0023
TT19-SS	TT19-SS	1/25/07	-33.0	-35.0	-33.0	-33.5							
TT19-CS	TT19-CS-A	1/15/07	-32.9	-35.9	-32.9	-34.0							
TT19-CS	TT19-CS-B	1/15/07	-32.9	-35.9	-34.0	-35.0							
TT19-CS	TT19-CS-C	1/15/07	-32.9	-35.9	-35.0	-35.6							
TT19-CS	TT19-CS-D	1/15/07	-32.9	-35.9	-35.6	-37.0	7.22	40.8	40.1	0.058	0.131	0.065	0.047
TT19-CS	TT19-CS-E	1/15/07	-32.9	-35.9	-37.0	-38.0	2.64	15.8	2.59	0.1	0.0023 U	0.006	0.003
TT20-SS	TT20-SS	1/25/07	-27.0	-28.0	-27.0	-27.5					< SQS		
TT21-SS	TT21-SS	1/25/07	-32.0	-33.0	-32.0	-32.5					< SQS		
TT22-SS	TT22-SS	1/25/07	-47.0	-48.0	-47.0	-47.5							
TT22-CS	TT22-CS-B	1/12/07	-43.4	-43.4	-44.0	-45.0	7.31	44.7	8.81	0.083	0.003 U	0.010	0.0016 J
TT22-CS	TT22-CS-C	1/12/07	-43.4	-43.4	-45.0	-46.0	3.99	24.3	4.17	0.088	0.0026 U	0.008	0.0016
TT22-CS	TT22-CS-D	1/12/07	-43.4	-43.4	-46.0	-47.0	3.12	19.4	2.93	0.041	0.0024 U	0.006	0.00021 Ui
TT23-SS	TT23-SS	1/26/07	-45.0	-45.0	-45.0	-45.5	4.66	33.4	15.9	0.138 *	0.054	0.188	0.042
TT23-CS	TT23-CS-B	1/10/07	-42.9	-42.9	-44.0	-45.0	3.63	26.8	5.1	0.03	0.0046	0.011	0.0018
TT23-CS	TT23-CS-C	1/10/07	-42.9	-42.9	-45.0	-46.0	2.77	23.4	3.23	0.018 B	0.0022 U	0.0033 U	0.0004 Ui
TT23-CS	TT23-CS-H	1/10/07	-42.9	-42.9	-50.0	-51.2	2.34	16.1	2.05	0.018	0.0023 U	0.0033 U	0.000074 U
TT24-SS	TT24-SS	1/25/07	-24.0	-24.0	-24.0	-24.5	5.58	33.5	17	0.22	0.048	0.384	0.0089
TT24-CS	TT24-CS-B	1/10/07	-26.3	-26.3	-27.0	-28.6	2.49	23.5	6.64	0.074	0.0258	0.049	0.0015
TT24-CS	TT24-CS-C	1/10/07	-26.3	-26.3	-28.6	-29.9	7.96	81	52	0.451	0.58	0.700	0.0088
TT24-CS	TT24-CS-E	1/10/07	-26.3	-26.3	-30.7	-31.9	3.58	27.5	10.5	0.13	0.013 U	0.118	0.00098 J
TT24-CS	TT24-CS-H	1/10/07	-26.3	-26.3	-34.0	-35.0	5.21	38.6	16	0.22	0.014 U	0.131	0.000087 U
TT25-SS	TT25-SS	1/25/07	-26.0	-27.6	-26.0	-26.5							
TT25-CS	TT25-CS-B	1/12/07	-24.6	-27.6	-25.0	-26.0							
TT25-CS	TT25-CS-C	1/12/07	-24.6	-27.6	-26.0	-27.0							
TT25-CS	TT25-CS-J	1/12/07	-24.6	-27.6	-33.0	-34.0	4.57	32	14.1	0.162	0.0041	0.086	0.000079 U
TT25-CS	TT25-CS-L	1/12/07	-24.6	-27.6	-35.0	-36.0	10	64.7	80.9	0.733	0.211	6.734	
TT26-SS	TT26-SS	1/25/07	-24.0	-25.0	-24.0	-24.5							
TT26-CS	TT26-CS-B	1/12/07	-30.1	-33.0	-31.0	-32.0							
TT26-CS	TT26-CS-C	1/12/07	-30.1	-33.0	-32.0	-33.0							
TT26-CS	TT26-CS-G	1/12/07	-30.1	-33.0	-36.0	-37.0	123	194	281	0.317	0.69	1.025	0.05
TT26-CS	TT26-CS-I	1/12/07	-30.1	-33.0	-38.0	-39.0	3.02	14.1	3.7	0.022	0.0023 U	0.003	0.00043 J
TT27-SS	TT27-SS	1/24/07	-17.0	-20.0	-17.0	-17.5							
TT27B-C	TT27B-CS-B	1/23/07	-28.8	-28.8	-29.0	-30.0	3.69	18.9	19.1	0.181 *	0.0203	0.058	0.0053
TT27B-C	TT27B-CS-C	1/23/07	-28.8	-28.8	-30.0	-31.0	4.43	27.3	18	0.364 *	0.0112	0.157	0.0036
TT27B-C	TT27B-CS-D	1/23/07	-28.8	-28.8	-31.0	-32.0	6.23	36.1	9.75	0.186 *	0.0027 U	0.130	0.0032
TT28-SS	TT28-SS	1/24/07	-52.0	-52.0	-52.0	-52.5	8.58	34.5	22.5	0.178	0.072	0.144	0.052
TT29-SS	TT29-SS	1/24/07	-44.0	-44.0	-44.0	-44.5	6.08	28.2	19.8	0.376	0.104	0.144	0.13 D
TT29-CS	TT29-CS-A	1/18/07	-41.0	-41.0	-41.0	-42.1	1.65	7.2 *	37.7	0.018 B	0.0023 U	0.011	0.00047 J
TT29-CS	TT29-CS-B	1/18/07	-41.0	-41.0	-42.1	-43.1	1.56	6.7 *	6.94	0.014 B	0.0022 U	0.006	0.00023 Ui
TT29-CS	TT29-CS-C	1/18/07	-41.0	-41.0	-43.1	-44.1	2.47	15.5 *	19.5	0.099	0.04	0.101	0.00007 U
TT30-SS	TT30-SS	1/24/07	-51.0	-54.0	-51.0	-51.5							
TT30-CS	TT30-CS-A	1/16/07	-52.2	-54.0	-52.2	-53.0							
TT30-CS	TT30-CS-B	1/16/07	-52.2	-54.0	-53.0	-54.0					< SQS		
TT31-SS	TT31-SS	1/26/07	-49.0	-52.9	-49.0	-49.5							
TT31-CS	TT31-CS-A	1/17/07	-51.8	-52.9	-51.8	-52.9							
TT31-CS	TT31-CS-B	1/17/07	-51.8	-52.9	-52.9	-54.0	2.67	18.9	11.7	0.16	0.019	0.060	0.0016
TT32-SS	TT32-SS	1/26/07	-43.0	-43.0	-43.0	-43.5	8.58	54.5	26.5	0.253 *	0.139	0.157	0.071
TT32-CS	TT32-CS-B	1/13/07	-41.7	-41.7	-42.0	-43.0	3.29	19	2.78	0.023	0.0025 U	0.0036 U	0.00055 J
TT32-CS	TT32-CS-C	1/13/07	-41.7	-41.7	-43.0	-44.0	3.17	21.7	2.83	0.026	0.0025 U	0.000	0.00008 U
TT32-CS	TT32-CS-H	1/13/07	-41.7	-41.7	-48.0	-49.4	2.95	20.3	2.96	0.022	0.0024 U	0.0035 U	0.00026 Ui

Table I-5B
Risk Driver COC Sediment Residuals (mg/kg dry weight)
Alternative 3A2 Plus - ENR

Location	SAMPLEID	Date	Mudline Elev (FT MSL)	Approx Post Remedy Mudline (Ft MSL)	Interval Top	Interval Bottom	Arsenic	Copper	Lead	Mercury	PCBs (total)	Total cPAH	Tributyltin
						CSL	93	390	530	0.59	1	3.000	1.335
						SQS	57	390	450	0.41	0.18	1.100	1.335
						RBTC/Nat Bkgd	7	114	10.9	0.41	0.002	0.009	0.017
						Elliott Bay - Urban	8.44	48.9	47	0.438	0.119	0.757	NA
						Elliott Bay - Harbor	73.4	112	66.9	0.335	0.355	1.210	NA
						Elliot Bay - Basin	9.13	41.1	26.9	0.175	0.048	0.125	NA
TT33-SS	TT33-SS	1/26/07	-47.0	-48.0	-47.0	-47.5							
TT33-CS	TT33-CS-A	1/23/07	-50.6	-50.6	-50.6	-51.0	4.84	38.2	14.8	0.176 *	0.052	0.069	0.016
TT33-CS	TT33-CS-B	1/23/07	-50.6	-50.6	-51.0	-52.0	4.47	42.6	13.5	0.118 *	0.0102	0.028	0.0024
TT33-CS	TT33-CS-C	1/23/07	-50.6	-50.6	-52.0	-53.0	2.67	19.6	2.21	0.025 *	0.0023 U	0.0034 U	0.000075 U
TT34-SS	TT34-SS	1/26/07	-51.0	-52.0	-51.0	-51.5							
TT34-CS	TT34-CS-A	1/17/07	-51.3	-52.0	-51.3	-52.0							
TT34-CS	TT34-CS-B	1/17/07	-51.3	-52.0	-52.0	-53.0	3.8	25.4	9.24	0.148	0.03	0.111	0.018
TT35-SS	TT35-SS	1/25/07	-44.0	-44.0	-44.0	-44.5	4.56	39.3	20.5	0.176	0.06	0.087	0.52 D
TT35-CS	TT35-CS-B	1/15/07	-49.4	-51.0	-50.0	-51.0							
TT35-CS	TT35-CS-C	1/15/07	-49.4	-49.4	-51.0	-52.0	4.79	30.7	16.6	0.296	0.0072	0.078	0.003
TT35-CS	TT35-CS-D	1/15/07	-49.4	-49.4	-52.0	-53.0	3.85	23.7	7.64	0.139	0.0025 U	0.050	0.0014 J
TT37-SS	TT37-SS	1/25/07	-49.0	-49.0	-49.0	-49.5	7.37	39.8	22.4	0.121	0.121	0.116	0.033
TT37-CS	TT37-CS-A	1/13/07	-40.9	-40.9	-40.9	-42.0	7.75	23.6	15.6	0.032	0.085	0.041	0.0063
TT37-CS	TT37-CS-B	1/13/07	-40.9	-40.9	-42.0	-43.0	2.38	10	4.76	0.019	0.027	0.022	0.0043
TT37-CS	TT37-CS-C	1/13/07	-40.9	-40.9	-43.0	-44.0	2.59	13.4	4.87	0.075	0.0054	0.017	0.0015
TT39-SS	TT39-SS	1/25/07	-44.0	-44.0	-44.0	-44.5	6.41	34.6	20.5	0.158	0.085	0.146	0.061
TT39-CS	TT39-CS-A	1/12/07	-42.8	-42.8	-42.8	-44.0	10.3	71.5	45.1	0.332	0.321	0.511	0.063
TT39-CS	TT39-CS-B	1/12/07	-42.8	-42.8	-44.0	-45.0	8.79	75.1	51.5	0.446	0.432	0.404	0.052
TT39-CS	TT39-CS-C	1/12/07	-42.8	-45.0	-45.0	-46.0	4.88	31.2	14.1	0.151	0.047	0.093	0.0067
TT41-SS	TT41-SS	1/25/07	-32.0	-33.0	-32.0	-32.5	< SQS						
TT42-SS	TT42-SS	1/26/07	-50.0	-52.0	-50.0	-50.5							
TT42-CS	TT42-CS-B	1/23/07	-49.7	-52.0	-50.0	-51.0							
TT42-CS	TT42-CS-C	1/23/07	-49.7	-52.0	-51.0	-52.0							
TT42-CS	TT42-CS-D	1/23/07	-49.7	-52.0	-52.0	-53.0	4.93	30.1	6.88	0.146 *	0.0156	0.079	0.0049
199	199	2009	-44.3	-44.3	-44.3	-44.8	6.5	25.6	14.6	0.107	0.06	0.207	
HC-03-04	HC-03-04	2003	-29.5	-30.5	-29.5	-30.0	< SQS						
HC-03-05	HC-03-05	2003	-24.3	-25.3	-24.3	-24.8	< SQS						
HC-03-08	HC-03-08	2003	-38.8	-39.8	-38.8	-39.3	< SQS						
HC-03-09	HC-03-09	2003	-7.5	-8.0	-7.5	-8.0	< SQS						
HC-03-11	HC-03-11	2003	-42.5	-43.5	-42.5	-43.0	< SQS						
HC-03-16	HC-03-16	2003	-37.8	-38.8	-37.8	-38.3	< SQS						
HC-03-17	HC-03-17	2003	-43.4	-44.4	-43.4	-43.9	< SQS						
HC-03-19	HC-03-19	2003	-50.5	-51.5	-50.5	-51.0	< SQS						

Results in mg/kg dry weight
Value above the SMS (CSL) level
Value above the SMS (SQS) level

U - Result is not detected at the quantitation limit noted
J - Result is an estimated concentration
D - Result is from a diluted sample analysis
E - Result is an estimated concentration for laboratory control data outside of control limits (metals)
B - Result is an estimated concentration below the reporting limit (metals)
* - Result is an estimated concentration for laboratory duplicate results outside control limits (metals)

Table I-6A
Risk Driver COC Sediment Residuals (mg/kg dry weight)
Alternative 3C Plus

Location	Sample ID	Collection	Mudline Elev (FT MSL)	Approx Post Remedy Mudline (Ft MSL)	Interval Top	Interval Bottom	Arsenic	Copper	Lead	Mercury	PCBs (total)	Total cPAH	Tributyltin
						Parameter	Arsenic	Copper	Lead	Mercury	PCBs (total)	Total cPAH	Tributyltin
						CSL	93	390	530	0.59	1	3.000	1.335
						SQS	57	390	450	0.41	0.18	1.100	1.335
						RBTC/Nat Bkgd	7	114	10.9	0.41	0.002	0.009	0.017
						Elliott Bay - Urban	8.44	48.9	47	0.438	0.119	0.757	NA
						Elliott Bay - Harbor	73.4	112	66.9	0.335	0.355	1.210	NA
						Elliot Bay - Basin	9.13	41.1	26.9	0.175	0.048	0.125	NA
SA8	SA8-A	9/1/89	-39.2	-41.2	-39.2	-41.2							
SA8	SA8-C	9/1/89	-39.2	-41.2	-41.2	-42.7	44	110 E	32 E	0.0017	0.235		
SA8	SA8-D	9/1/89	-39.2	-41.2	-42.7	-44.2	27	100 E	30 E	0.001	0.125		
SA9	SA9-A	9/1/89	-44.7	-46.7	-44.7	-46.7							
SA9	SA9-B	9/1/89	-44.7	-46.7	-46.7	-49.7	20	93 E	20 E	0.001	0.143		
SA9	SA9-C	9/1/89	-44.7	-46.7	-53.7	-55.2	23	71 E	61 E	0.001	0.21		
SA9	SA9-D	9/1/89	-44.7	-46.7	-55.2	-56.7	20	62 E	15 E	0.0005 U	0.135 U		
TT04-SS	TT04-SS	1/24/07	-23.0	-36.0	-23	-23.5							
TT04-CS	TT04-CS-B	1/22/07	-23.5	-36.0	-24	-25							
TT04-CS	TT04-CS-C	1/22/07	-23.5	-36.0	-25	-26							
TT04-CS	TT04-CS-J	1/22/07	-23.5	-36.0	-32	-33							
TT04-CS	TT04-CS-K	1/22/07	-23.5	-36.0	-33	-34							
TT04-CS	TT04-CS-M	1/22/07	-23.5	-36.0	-35	-36					< SQS		
TT05-SS	TT05-SS	1/25/07	-31.0	-32.0	-31.0	-31.5					< SQS		
TT06-SS	TT06-SS	1/24/07	-42.0	-45.9	-42.0	-42.5							
TT06-CS	TT06-CS-A	1/17/07	-43.0	-45.9	-43.0	-44.0							
TT06-CS	TT06-CS-B	1/17/07	-43.0	-45.9	-44.0	-45.0							
TT06-CS	TT06-CS-C	1/17/07	-43.0	-45.9	-45.0	-45.9							
TT06-CS	TT06-CS-E	1/17/07	-43.0	-45.9	-47.0	-48.0	2.79	16.8	6.04	0.089	0.0064	0.047	0.0012 J
TT06-CS	TT06-CS-G	1/17/07	-43.0	-45.9	-49.0	-50.0	2.42	12.6	4.49	0.036	0.0023 U	0.079	0.0018
TT06-CS	TT06-CS-I	1/17/07	-43.0	-45.9	-51.0	-52.0	2.98	16.6	8.9	0.066	0.0023 U	0.034	0.000073 U
TT07-SS	TT07-SS	1/25/07	-40.0	-41.0	-40.0	-40.5							
TT07-CS	TT07-CS-B	1/16/07	-5.7	-12.7	-6.0	-7.0							
TT07-CS	TT07-CS-C	1/16/07	-5.7	-12.7	-7.0	-8.0							
TT07-CS	TT07-CS-D	1/16/07	-5.7	-12.7	-8.0	-9.0							
TT07-CS	TT07-CS-F	1/16/07	-5.7	-12.7	-10.0	-11.0							
TT07-CS	TT07-CS-H	1/16/07	-5.7	-12.7	-12.0	-12.7					< SQS		
TT08-SS	TT08-SS	1/24/07	-40.0	-41.0	-40.0	-40.5							
TT08-CS	TT08-CS-B	1/16/07	-40.4	-53.1	-41.1	-42.1							
TT08-CS	TT08-CS-C	1/16/07	-40.4	-53.1	-42.1	-43.1							
TT08-CS	TT08-CS-I	1/16/07	-40.4	-53.1	-48.1	-49.1							
TT08-CS	TT08-CS-K	1/16/07	-40.4	-53.1	-50.1	-51.1							
TT08-CS	TT08-CS-M	1/16/07	-40.4	-53.1	-51.9	-53.1					< SQS		
TT09-SS	TT09-SS	1/25/07	-40.0	-51.6	-40.0	-40.5							
TT09-CS	TT09-CS-B	1/16/07	-40.8	-51.6	-41.0	-42.0							
TT09-CS	TT09-CS-C	1/16/07	-40.8	-51.6	-42.0	-43.0							
TT09-CS	TT09-CS-E	1/16/07	-40.8	-51.6	-44.2	-45.0							
TT09-CS	TT09-CS-G	1/16/07	-40.8	-51.6	-46.3	-47.0							
TT09-CS	TT09-CS-I	1/16/07	-40.8	-51.6	-48.0	-49.0							
TT09-CS	TT09-CS-K	1/16/07	-40.8	-51.6	-50.0	-51.0							
TT09-CS	TT09-CS-L	1/16/07	-40.8	-51.6	-51.0	-51.6							
TT09-CS	TT09-CS-M	1/16/07	-40.8	-51.6	-51.6	-53.0	6.25	33.3	11.5	0.188	0.0052	0.044	0.000082 U
TT10-SS	TT10-SS	1/25/07	-29.0	-30.0	-29.0	-29.5					< SQS		
TT11-SS	TT11-SS	1/26/07	-38.0	-46.0	-38.0	-38.5							
TT11-CS	TT11-CS-B	1/19/07	-44.5	-46.0	-45.0	-46.0							
TT11-CS	TT11-CS-C	1/19/07	-44.5	-46.0	-46.0	-47.0	9.28	45.2 *	17.5	0.15	0.029	0.041	0.006
TT11-CS	TT11-CS-D	1/19/07	-44.5	-46.0	-47.0	-48.0	5.85	34.7 *	5.13	0.058	0.0027 U	0.003	0.000087 U
TT11-CS	TT11-CS-E	1/19/07	-44.5	-46.0	-48.0	-49.0	3.26	19	3.05	0.034	0.0024 U	0.005	0.000079 U
TT14-SS	TT14-SS	1/25/07	-25.0	-28.0	-25.0	-25.5							
TT14-CS	TT14-CS-B	1/13/07	-25.2	-28.0	-26.0	-27.0							
TT14-CS	TT14-CS-C	1/13/07	-25.2	-28.0	-27.0	-28.0							
TT14-CS	TT14-CS-J	1/13/07	-25.2	-28.0	-34.4	-35.0	3.89	24.7	13.8	0.227	0.062	0.422	0.00086 J
TT14-CS	TT14-CS-L	1/13/07	-25.2	-28.0	-36.0	-37.0	5.27	30.2	16.8	0.412	0.0055 U	0.360	0.00021 Ui
TT15-SS	TT15-SS	1/25/07	-44.0	-53.0	-44.0	-44.5							
TT15-CS	TT15-CS-B	1/18/07	-46.2	-53.0	-46.9	-48.0							
TT15-CS	TT15-CS-C	1/18/07	-46.2	-53.0	-48.0	-48.9							
TT15-CS	TT15-CS-G	1/18/07	-46.2	-53.0	-52.3	-53.0							
TT15-CS	TT15-CS-H	1/18/07	-46.2	-53.0	-53.0	-54.0	18.1	61.3	56.7	0.315	0.03	0.383	0.0053
TT16-SS	TT16-SS	1/25/07	-38.0	-40.0	-38.0	-38.5							
TT16-CS	TT16-CS-B	1/22/07	-38.6	-40.0	-39.1	-40.0							
TT16-CS	TT16-CS-C	1/22/07	-38.6	-40.0	-40.0	-41.0	19	43.5	44.1	0.063 *	0.0204	0.039	0.0062
TT16-CS	TT16-CS-D	1/22/07	-38.6	-40.0	-41.0	-42.0	2.26	15.8	2.35	0.021 *	0.0023 U	0.0034 U	0.001 J
TT16-CS	TT16-CS-I	1/22/07	-38.6	-40.0	-46.0	-47.0	2.32	16.2	1.86	0.025 *	0.0023 U	0.0034 U	0.000076 U
TT17-SS	TT17-SS	1/25/07	-44.0	-48.0	-44.0	-44.5							
TT17-CS	TT17-CS-B	1/12/07	-41.8	-48.0	-43.0	-44.0							
TT17-CS	TT17-CS-C	1/12/07	-41.8	-48.0	-44.0	-45.0							
TT17-CS	TT17-CS-D	1/12/07	-41.8	-48.0	-45.0	-46.0							
TT17-CS	TT17-CS-F	1/12/07	-41.8	-48.0	-47.0	-48.0							
TT17-CS	TT17-CS-H	1/12/07	-41.8	-48.0	-49.0	-50.0	5.15	27.8	9.07	0.225	0.023	0.071	0.0014
TT17-CS	TT17-CS-J	1/12/07	-41.8	-48.0	-51.0	-51.8	3.43	24.2	4.49	0.09	0.015	0.026	0.0055
TT18-CS	TT18-CS-B	1/15/07	-34.5	-37.0	-35.0	-36.0							
TT18-CS	TT18-CS-C	1/15/07	-34.5	-37.0	-36.0	-37.0							
TT18-CS	TT18-CS-D	1/15/07	-34.5	-37.0	-37.0	-38.0	4.54	20.9	8.98	0.082	0.029	0.046	0.012
TT18-CS	TT18-CS-E	1/15/07	-34.5	-37.0	-38.0	-39.0	4.69	66.2	17.6	0.564	0.044	0.199	0.0023

Table I-6A
Risk Driver COC Sediment Residuals (mg/kg dry weight)
Alternative 3C Plus

						Parameter	Arsenic	Copper	Lead	Mercury	PCBs (total)	Total cPAH	Tributyltin
						CSL	93	390	530	0.59	1	3.000	1.335
						SQS	57	390	450	0.41	0.18	1.100	1.335
						RBTC/Nat Bkgd	7	114	10.9	0.41	0.002	0.009	0.017
						Elliott Bay - Urban	8.44	48.9	47	0.438	0.119	0.757	NA
						Elliott Bay - Harbor	73.4	112	66.9	0.335	0.355	1.210	NA
						Elliot Bay - Basin	9.13	41.1	26.9	0.175	0.048	0.125	NA
Location	Sample ID	Collection	Mudline Elev (FT MSL)	Approx Post Remedy Mudline (Ft MSL)	Interval Top	Interval Bottom							
TT20-SS	TT20-SS	1/25/07	-27.0	-28.0	-27.0	-27.5	< SQS						
TT30-SS	TT30-SS	1/24/07	-51.0	-54.0	-51.0	-51.5							
TT30-CS	TT30-CS-A	1/16/07	-52.2	-54.0	-52.2	-53.0							
TT30-CS	TT30-CS-B	1/16/07	-52.2	-54.0	-53.0	-54.0	< SQS						
TT31-SS	TT31-SS	1/26/07	-49.0	-52.9	-49.0	-49.5							
TT31-CS	TT31-CS-A	1/17/07	-51.8	-52.9	-51.8	-52.9							
TT31-CS	TT31-CS-B	1/17/07	-51.8	-52.9	-52.9	-54.0	2.67	18.9	11.7	0.16	0.019	0.060	0.0016
TT34-SS	TT34-SS	1/26/07	-51.0	-52.0	-51.0	-51.5							
TT34-CS	TT34-CS-A	1/17/07	-51.3	-52.0	-51.3	-52.0							
TT34-CS	TT34-CS-B	1/17/07	-51.3	-52.0	-52.0	-53.0	3.8	25.4	9.24	0.148	0.03	0.111	0.018
TT40-SS	TT40-SS	1/26/07	-31.0	-32.0	-31.0	-31.5	< SQS						
TT41-SS	TT41-SS	1/25/07	-32.0	-33.0	-32.0	-32.5	< SQS						
TT42-SS	TT42-SS	1/26/07	-50.0	-52.0	-50.0	-50.5							
TT42-CS	TT42-CS-B	1/23/07	-49.7	-52.0	-50.0	-51.0							
TT42-CS	TT42-CS-C	1/23/07	-49.7	-52.0	-51.0	-52.0							
TT42-CS	TT42-CS-D	1/23/07	-49.7	-52.0	-52.0	-53.0	4.93	30.1	6.88	0.146 *	0.0156	0.079	0.0049
197	197	2009	-28.9	-29.9	-28.9	-29.4	< SQS						
HC-03-07	HC-03-07	2003	-40.8	-41.8	-40.8	-41.3	< SQS						
HC-03-08	HC-03-08	2003	-38.8	-39.8	-38.8	-39.3	< SQS						
HC-03-10	HC-03-10	2003	-40.7	-41.7	-40.7	-41.2	< SQS						
HC-03-12	HC-03-12	2003	-38.2	-39.2	-38.2	-38.7	< SQS						

Results in mg/kg dry weight
Value above the SMS (CSL) level
Value above the SMS (SQS) level

U - Result is not detected at the quantitation limit noted
J - Result is an estimated concentration
D - Result is from a diluted sample analysis
E - Result is an estimated concentration for laboratory control data outside of control limits (metals)
B - Result is an estimated concentration below the reporting limit (metals)
* - Result is an estimated concentration for laboratory duplicate results outside control limits (metals)

Table I-6B
Risk Driver COC Sediment Residuals (mg/kg dry weight)
Alternative 3C Plus - ENR

Location	Sample ID	Date	Mudline Elev (FT MSL)	Approx Post Remedy Mudline (Ft MSL)	Interval Top	Interval Bottom	Arsenic	Copper	Lead	Mercury	PCBs (total)	Total cPAH	Tributyltin
						Parameter	Arsenic	Copper	Lead	Mercury	PCBs (total)	Total cPAH	Tributyltin
						CSL	93	390	530	0.59	1	3.000	1.335
						SQS	57	390	450	0.41	0.18	1.100	1.335
						RBTC/Nat Bkgd	7	114	10.9	0.41	0.002	0.009	0.017
						Elliott Bay - Urban	8.44	48.9	47	0.438	0.119	0.757	NA
						Elliott Bay - Harbor	73.4	112	66.9	0.335	0.355	1.210	NA
						Elliot Bay - Basin	9.13	41.1	26.9	0.175	0.048	0.125	NA
C5	C5 (0 - 2)	12/1/91	-39.4	-39.4	-39.4	-41.4	2.5	17.9 J	4	0.1 U	0.0785 U		
C5	C5 (2 - 5)	12/1/91	-39.4	-39.4	-41.4	-44.4	2.03	14.4 J	3 U	0.07 U	0.0798 U		
C5	C5 (5 - 8)	12/1/91	-39.4	-39.4	-44.4	-47.4	2.1	12.9 J	3 U	0.05 U	0.0781 U		
C6	C6 (0 - 2)	12/1/91	-37.2	-37.2	-37.2	-39.2	12.2	61.8 J	32	0.34	0.177		
C6	C6 (2 - 5)	12/1/91	-37.2	-37.2	-39.2	-42.2	8.44	46.3 J	18	0.27	0.0821 U		
C6	C6 (5 - 8)	12/1/91	-37.2	-37.2	-42.2	-45.2	3.19	20.9 J	3	0.06 U	0.000787 U		
C7	C7 (0 - 2)	12/1/91	-46.4	-46.4	-46.4	-48.4	1.36	10.1 J	3 U	0.06 U	0.0792 U		
C7	C7 (2 - 5)	12/1/91	-46.4	-46.4	-48.4	-51.4	1.68	9.2 J	3 U	0.05 U	0.0770 U		
C7	C7 (5 - 8)	12/1/91	-46.4	-46.4	-51.4	-54.4	1.64	8.1 J	2 U	0.05 U	0.0804 U		
C8	C8 (0 - 2)	12/1/91	-39.4	-39.4	-39.4	-41.4	2.83	19.9 J	3 U	0.06 U	0.0816 U		
C8	C8 (2 - 5)	12/1/91	-39.4	-39.4	-41.4	-44.4	2.25	16.1 J	3 U	0.06 U	0.0778 U		
D3	D3-A	9/5/89	-41.6	-41.6	-41.6	-43.6	46	210 E	100 E	0.0008	0.246		
D3	D3-B	9/5/89	-41.6	-41.6	-43.6	-46.1	50	68 E	28 E	0.0005 U	0.16		
D3	D3-C	9/5/89	-41.6	-41.6	-52.1	-54.1	23	26 E	11 E	0.0005 U	0.12 U		
D3	D3-D	9/5/89	-41.6	-41.6	-54.6	-56.6	26	22 E	6.7 E	0.0005 U	0.12 U		
D4	D4-D	9/8/89	-48.7	-48.7	-48.7	-58.2	47	43 E	14 E	0.0005 U	0.093		
SA2	SA2-C	8/29/89	-25.0	-25.0	-25.0	-26.0	11	150 E	150 E	0.0019	0.329		
SA2	SA2-D	8/29/89	-25.0	-25.0	-27.0	-30.0	40	64 E	31 E	0.0011	0.12 U		
SA3	SA3-A	8/30/89	-19.5	-21.5	-19.5	-21.5							
SA3	SA3-B	8/30/89	-19.5	-21.5	-21.5	-24.0	31	77 E	58 E	0.0005	0.13		
SA3	SA3-C	8/30/89	-19.5	-21.5	-24.5	-27.0	3.9	38 E	38 E	0.0005 U	0.12 U		
SA3	SA3-D	8/30/89	-19.5	-21.5	-27.5	-30.0	1.6	40 E	6.1 E	0.0005 U	0.12 U		
SA4	SA4-C	8/30/89	-29.4	-29.4	-29.4	-31.4	3.6	63 E	53 E	0.0005	0.131		
SA4	SA4-D	8/30/89	-29.4	-29.4	-31.4	-33.9	7.5	42 E	3.7 E	0.0005 U	0.12 U		
SA5	SA5-A	8/31/89	-37.6	-37.6	-37.6	-39.6	37	91 E	18 E	0.0005	0.121		
SA5	SA5-C	8/31/89	-37.6	-37.6	-39.6	-42.1	36	77 E	18 E	0.0005 U	0.12 U		
SA5	SA5-D	8/31/89	-37.6	-37.6	-42.1	-45.1	38	40 E	13 E	0.0005 U	0.12 U		
SA6	SA6-C	8/31/89	-33.0	-33.0	-33.0	-34.5	43	160 E	46 E	0.0005 U	0.135 U		
SA6	SA6-D	8/31/89	-33.0	-33.0	-34.5	-36.0	28	50 E	6 E	0.0005	0.12 U		
SA7	SA7-A	8/31/89	-31.6	-31.6	-31.6	-33.6	55	100 E	35 E	0.0005 U	0.125		
SA7	SA7-B/C	8/31/89	-31.6	-31.6	-33.6	-37.6	58	61 E	13 E	0.0005 U	0.125		
SA7	SA7-D	8/31/89	-31.6	-31.6	-39.1	-40.6	70	72 E	9 E	0.0006	0.12 U		
SA10	SA10-A	9/16/1989	-28.0	-33.0	-28.0	-30.0							
SA10	SA10-B	9/16/1989	-28.0	-33.0	-30.0	-33.0							
SA10	SA10-C	9/16/1989	-28.0	-33.0	-37.0	-38.5	42	39 E	7 E	0.0005	0.12 U		
SA10	SA10-D	9/16/1989	-28.0	-33.0	-38.5	-40.0	28	26 E	5.8 E	0.0005 U	0.12 U		
TT01-SS	TT01-SS	1/24/07	-39.0	-39.0	-39.0	-39.5	7.88	64	39.8	0.299	0.149	0.621	0.16 D
TT01-CS	TT01-CS-A	1/19/07	-30.0	-30.0	-30.0	-31.0	2.3	10.9 *	3.26	0.028	0.07	0.020	0.011
TT01-CS	TT01-CS-B	1/19/07	-30.0	-30.0	-31.0	-32.0	2.42	14.5 *	1.8	0.02	0.0023 U	0.0034 U	0.000075 U
TT01-CS	TT01-CS-C	1/19/07	-30.0	-30.0	-32.0	-33.0	2.39	15.3 *	1.76	0.018 B	0.0024 U	0.0034 U	0.000074 U
TT02-SS	TT02-SS	1/24/07	-41.0	-41.0	-41.0	-41.5	9.05	71.4	51	0.374	0.15	0.391	0.23 D
TT02-CS	TT02-CS-B	1/18/07	-38.4	-38.4	-39.0	-40.0	5.36	27.8 *	6.64	0.079	0.0062	0.002	0.002
TT02-CS	TT02-CS-C	1/18/07	-38.4	-38.4	-40.0	-41.0	3.04	13.5 *	1.93	0.016 B	0.0024 U	0.0035 U	0.000077 U
TT02-CS	TT02-CS-D	1/18/07	-38.4	-38.4	-41.0	-42.0	2.54	13.4 *	1.9	0.02	0.0024 U	0.0034 U	0.000076 U
TT03-SS	TT03-SS	1/24/07	-27.0	-27.5	-27.0	-27.5							
TT03-CS	TT03-CS-B	1/18/07	-16.7	-16.7	-17.6	-19.0	3.18	14.4 *	21.3	0.158	0.022	0.069	0.0032
TT03-CS	TT03-CS-C	1/18/07	-16.7	-16.7	-19.0	-20.0	7.93	8.9 *	8.31	0.033	0.0119	0.037	0.00057 J
TT03-CS	TT03-CS-D	1/18/07	-16.7	-16.7	-20.0	-21.0	1.39	8.6 *	6.54	0.029	0.0059	0.030	0.00054 J
TT05-CS	TT05-CS-A	1/12/07	-5.9	-5.9	-5.9	-7.0	3.91	41.9	27.5	0.143	0.0896	0.367	0.036
TT05-CS	TT05-CS-B	1/12/07	-5.9	-5.9	-7.0	-8.0	4.28	55.5	31.1	0.312	0.0756	0.160	0.02
TT05-CS	TT05-CS-C	1/12/07	-5.9	-5.9	-8.0	-9.0	3.34	44.2	44.5	0.297	0.029	0.212	0.0022
TT05-CS	TT05-CS-E	1/12/07	-5.9	-5.9	-10.0	-11.0	1.9	12.7	13.2	0.087	0.0105	0.112	0.000072 U
TT05-CS	TT05-CS-G	1/12/07	-5.9	-5.9	-12.0	-12.9	1.11	10.6	5.55	0.021	0.0022 U	0.006	0.00024 Ui
TT10-CS	TT10-CS-B	1/22/07	-31.8	-31.80	-32.0	-33.0	6.58	35.5	23.6	0.399 *	0.0298	0.215	0.0075
TT10-CS	TT10-CS-C	1/22/07	-31.8	-31.80	-33.0	-34.0	5.97	35.4	15	0.243 *	0.0027 U	0.410	0.0014 J
TT10-CS	TT10-CS-D	1/22/07	-31.8	-31.80	-34.0	-35.0	5.76	40.8	5.92	0.075 *	0.003 U	0.010	0.00045 J
TT10-CS	TT10-CS-E	1/22/07	-31.8	-31.80	-35.0	-36.0	8.21	46.3	9.31	0.119	0.0032 U	0.020	0.0008 J
TT12-SS	TT12-SS	1/26/07	-43.0	-43.0	-43.0	-43.5	18.3	111	80.9	0.636 *	0.257	0.610	0.19 D
TT12-CS	TT12-CS-B	1/15/07	-42.4	-42.4	-43.0	-44.0	9.03	44	23.8	0.404	0.079	0.098	0.013
TT12-CS	TT12-CS-C	1/15/07	-42.4	-42.4	-44.0	-45.0	4.92	22.1	11.1	0.091	0.036	0.041	0.0074
TT12-CS	TT12-CS-D	1/15/07	-42.4	-42.4	-45.0	-46.0	2.91	16.2	3.11	0.043	0.0245	0.016	0.0018
TT12-CS	TT12-CS-E	1/15/07	-42.4	-42.4	-46.0	-47.0	2.02	13.2	2.52	0.03	0.0024 U	0.009	0.00029 J
TT13-SS	TT13-SS	1/26/07	-44.0	-45.0	-44.0	-44.5							
TT13-CS	TT13-CS-A	1/19/07	-45.2	-45.2	-45.2	-46.2	6.09	63.4	15.1	0.225	0.058	0.064	0.016
TT13-CS	TT13-CS-B	1/19/07	-45.2	-45.2	-46.2	-47.0	3.36	20.4	2.53	0.026	0.0025 U	0.0037 U	0.00029 J
TT13-CS	TT13-CS-C	1/19/07	-45.2	-45.2	-47.0	-47.8	3.07	20.2	2.38	0.03	0.0025 U	0.0037 U	0.000082 U
TT18-SS	TT18-SS	1/25/07	-10.0	-10.0	-10.0	-10.5	4.87	66.6	20.3	0.117	0.114	0.325	0.028
TT19-SS	TT19-SS	1/25/07	-33.0	-33.0	-33.0	-33.5	12.8	115	73.5	0.306	0.22	1.185	0.25 D
TT19-CS	TT19-CS-A	1/15/07	-32.9	-32.9	-32.9	-34.0	17.6	114	72.1	0.252	0.17	0.750	0.16 D
TT19-CS	TT19-CS-B	1/15/07	-32.9	-32.9	-34.0	-35.0	18.5	146	80.8	0.255	0.251	0.701	1.4 D
TT19-CS	TT19-CS-C	1/15/07	-32.9	-32.9	-35.0	-35.6	15.4	72.3	94.1	0.163	0.192	0.185	0.046
TT19-CS	TT19-CS-D	1/15/07	-32.9	-32.9	-35.6	-37.0	7.22	40.8	40.1	0.058	0.131	0.065	0.047
TT19-CS	TT19-CS-E	1/15/07	-32.9	-32.9	-37.0	-38.0	2.64	15.8	2.59	0.1	0.0023 U	0.006	0.003
TT21-SS	TT21-SS	1/25/07	-32.0	-32.0	-32.0	-32.5	23.6	127	76.8	0.215	0.205	0.671	0.18 D

Table I-6B
Risk Driver COC Sediment Residuals (mg/kg dry weight)
Alternative 3C Plus - ENR

Location	Sample ID	Date	Mudline Elev (FT MSL)	Approx Post Remedy Mudline (Ft MSL)	Interval Top	Interval Bottom	Arsenic	Copper	Lead	Mercury	PCBs (total)	Total cPAH	Tributyltin
						Parameter	Arsenic	Copper	Lead	Mercury	PCBs (total)	Total cPAH	Tributyltin
						CSL	93	390	530	0.59	1	3.000	1.335
						SQS	57	390	450	0.41	0.18	1.100	1.335
						RBTC/Nat Bkgd	7	114	10.9	0.41	0.002	0.009	0.017
						Elliott Bay - Urban	8.44	48.9	47	0.438	0.119	0.757	NA
						Elliott Bay - Harbor	73.4	112	66.9	0.335	0.355	1.210	NA
						Elliot Bay - Basin	9.13	41.1	26.9	0.175	0.048	0.125	NA
TT22-SS	TT22-SS	1/25/07	-47.0	-47.0	-47.0	-47.5	7.23	64.7	32.7	0.308	0.46	0.417	0.2 D
TT22-CS	TT22-CS-B	1/12/07	-43.4	-43.4	-44.0	-45.0	7.31	44.7	8.81	0.083	0.003 U	0.010	0.0016 J
TT22-CS	TT22-CS-C	1/12/07	-43.4	-43.4	-45.0	-46.0	3.99	24.3	4.17	0.088	0.0026 U	0.008	0.0016
TT22-CS	TT22-CS-D	1/12/07	-43.4	-43.4	-46.0	-47.0	3.12	19.4	2.93	0.041	0.0024 U	0.006	0.00021 Ui
TT23-SS	TT23-SS	1/26/07	-45.0	-45.0	-45.0	-45.5	4.66	33.4	15.9	0.138 *	0.054	0.188	0.042
TT23-CS	TT23-CS-B	1/10/07	-42.9	-42.9	-44.0	-45.0	3.63	26.8	5.1	0.03	0.0046	0.011	0.0018
TT23-CS	TT23-CS-C	1/10/07	-42.9	-42.9	-45.0	-46.0	2.77	23.4	3.23	0.018 B	0.0022 U	0.0033 U	0.0004 Ui
TT23-CS	TT23-CS-H	1/10/07	-42.9	-42.9	-50.0	-51.2	2.34	16.1	2.05	0.018	0.0023 U	0.0033 U	0.000074 U
TT24-SS	TT24-SS	1/25/07	-24.0	-24.0	-24.0	-24.5	5.58	33.5	17	0.22	0.048	0.384	0.0089
TT24-CS	TT24-CS-B	1/10/07	-26.3	-26.3	-27.0	-28.6	2.49	23.5	6.64	0.074	0.0258	0.049	0.0015
TT24-CS	TT24-CS-C	1/10/07	-26.3	-26.3	-28.6	-29.9	7.96	81	52	0.451	0.58	0.700	0.0088
TT24-CS	TT24-CS-E	1/10/07	-26.3	-26.3	-30.7	-31.9	3.58	27.5	10.5	0.13	0.013 U	0.118	0.00098 J
TT24-CS	TT24-CS-H	1/10/07	-26.3	-26.3	-34.0	-35.0	5.21	38.6	16	0.22	0.014 U	0.131	0.000087 U
TT25-SS	TT25-SS	1/25/07	-26.0	-26.0	-26.0	-26.5	11.1	90.1	50.7	0.094	0.202	1.753	0.14
TT25-CS	TT25-CS-B	1/12/07	-24.6	-24.6	-25.0	-26.0	19.1	105	123	0.712	0.223	1.547	0.019
TT25-CS	TT25-CS-C	1/12/07	-24.6	-24.6	-26.0	-27.0	12.6	77.9	62.5	0.577	0.122	1.611	0.003
TT25-CS	TT25-CS-J	1/12/07	-24.6	-24.6	-33.0	-34.0	4.57	32	14.1	0.162	0.0041	0.086	0.000079 U
TT25-CS	TT25-CS-L	1/12/07	-24.6	-24.6	-35.0	-36.0	10	64.7	80.9	0.733	0.211	6.734	
TT26-SS	TT26-SS	1/25/07	-24.0	-25.0	-24.0	-24.5							
TT26-CS	TT26-CS-B	1/12/07	-30.1	-30.1	-31.0	-32.0	38.7	200	115	0.156	0.162	0.950	0.71 D
TT26-CS	TT26-CS-C	1/12/07	-30.1	-30.1	-32.0	-33.0	316	335	360	0.139	0.183	1.484	0.29 D
TT26-CS	TT26-CS-G	1/12/07	-30.1	-30.1	-36.0	-37.0	123	194	281	0.317	0.69	1.025	0.05
TT26-CS	TT26-CS-I	1/12/07	-30.1	-30.1	-38.0	-39.0	3.02	14.1	3.7	0.022	0.0023 U	0.003	0.00043 J
TT27-SS	TT27-SS	1/24/07	-17.0	-18.0	-17.0	-17.5							
TT27B-C	TT27B-CS-B	1/23/07	-28.8	-28.8	-29.0	-30.0	3.69	18.9	19.1	0.181 *	0.0203	0.058	0.0053
TT27B-C	TT27B-CS-C	1/23/07	-28.8	-28.8	-30.0	-31.0	4.43	27.3	18	0.364 *	0.0112	0.157	0.0036
TT27B-C	TT27B-CS-D	1/23/07	-28.8	-28.8	-31.0	-32.0	6.23	36.1	9.75	0.186 *	0.0027 U	0.130	0.0032
TT28-SS	TT28-SS	1/24/07	-52.0	-52.0	-52.0	-52.5	8.58	34.5	22.5	0.178	0.072	0.144	0.052
TT29-SS	TT29-SS	1/24/07	-44.0	-44.0	-44.0	-44.5	6.08	28.2	19.8	0.376	0.104	0.144	0.13 D
TT29-CS	TT29-CS-A	1/18/07	-41.0	-41.0	-41.0	-42.1	1.65	7.2 *	37.7	0.018 B	0.0023 U	0.011	0.00047 J
TT29-CS	TT29-CS-B	1/18/07	-41.0	-41.0	-42.1	-43.1	1.56	6.7 *	6.94	0.014 B	0.0022 U	0.006	0.00023 Ui
TT29-CS	TT29-CS-C	1/18/07	-41.0	-41.0	-43.1	-44.1	2.47	15.5 *	19.5	0.099	0.04	0.101	0.00007 U
TT32-SS	TT32-SS	1/26/07	-43.0	-43.0	-43.0	-43.5	8.58	54.5	26.5	0.253 *	0.139	0.157	0.071
TT32-CS	TT32-CS-B	1/13/07	-41.7	-41.7	-42.0	-43.0	3.29	19	2.78	0.023	0.0025 U	0.0036 U	0.00055 J
TT32-CS	TT32-CS-C	1/13/07	-41.7	-41.7	-43.0	-44.0	3.17	21.7	2.83	0.026	0.0025 U	0.000	0.00008 U
TT32-CS	TT32-CS-H	1/13/07	-41.7	-41.7	-48.0	-49.4	2.95	20.3	2.96	0.022	0.0024 U	0.0035 U	0.00026 Ui
TT33-SS	TT33-SS	1/26/07	-47.0	-48.0	-47.0	-47.5							
TT33-CS	TT33-CS-A	1/23/07	-50.6	-50.6	-50.6	-51.0	4.84	38.2	14.8	0.176 *	0.052	0.069	0.016
TT33-CS	TT33-CS-B	1/23/07	-50.6	-50.6	-51.0	-52.0	4.47	42.6	13.5	0.118 *	0.0102	0.028	0.0024
TT33-CS	TT33-CS-C	1/23/07	-50.6	-50.6	-52.0	-53.0	2.67	19.6	2.21	0.025 *	0.0023 U	0.0034 U	0.000075 U
TT35-SS	TT35-SS	1/25/07	-44.0	-44.0	-44.0	-44.5	4.56	39.3	20.5	0.176	0.06	0.087	0.52 D
TT35-CS	TT35-CS-B	1/15/07	-49.4	-49.4	-50.0	-51.0	6.53	39.6	32.5	0.456	0.099	0.167	0.0054
TT35-CS	TT35-CS-C	1/15/07	-49.4	-49.4	-51.0	-52.0	4.79	30.7	16.6	0.296	0.0072	0.078	0.003
TT35-CS	TT35-CS-D	1/15/07	-49.4	-49.4	-52.0	-53.0	3.85	23.7	7.64	0.139	0.0025 U	0.050	0.0014 J
TT36-SS	TT36-SS	1/25/07	-53.9	-53.9	-53.9	-54.4	5.08	28.3	18.5	0.084	0.047	0.058	0.03
TT37-SS	TT37-SS	1/25/07	-49.0	-49.0	-49.0	-49.5	7.37	39.8	22.4	0.121	0.121	0.116	0.033
TT37-CS	TT37-CS-A	1/13/07	-40.9	-40.9	-40.9	-42.0	7.75	23.6	15.6	0.032	0.085	0.041	0.0063
TT37-CS	TT37-CS-B	1/13/07	-40.9	-40.9	-42.0	-43.0	2.38	10	4.76	0.019	0.027	0.022	0.0043
TT37-CS	TT37-CS-C	1/13/07	-40.9	-40.9	-43.0	-44.0	2.59	13.4	4.87	0.075	0.0054	0.017	0.0015
TT38-SS	TT38-SS	1/25/07	-63.0	-63.0	-63.0	-63.5	8.76	31.2	25.4	0.122	0.106	0.091	0.018
TT39-SS	TT39-SS	1/25/07	-44.0	-44.0	-44.0	-44.5	6.41	34.6	20.5	0.158	0.085	0.146	0.061
TT39-CS	TT39-CS-A	1/12/07	-42.8	-42.8	-42.8	-44.0	10.3	71.5	45.1	0.332	0.321	0.511	0.063
TT39-CS	TT39-CS-B	1/12/07	-42.8	-42.8	-44.0	-45.0	8.79	75.1	51.5	0.446	0.432	0.404	0.052
TT39-CS	TT39-CS-C	1/12/07	-42.8	-42.8	-45.0	-46.0	4.88	31.2	14.1	0.151	0.047	0.093	0.0067
199	199	2009	-44.3	-44.3	-44.3	-44.8	6.5	25.6	14.6	0.107	0.06	0.207	
HC-03-04	HC-03-04	2003	29.5	29.5	29.5	29.0	20.5	151	85.8	0.21	0.184	0.544	0.1
HC-03-05	HC-03-05	2003	-24.3	-24.3	-24.3	-24.8	18.9	159	55.2	0.08	0.068	0.241	0.034
HC-03-09	HC-03-09	2003	-7.5	-7.5	-7.5	-8.0	10.4	123	57.8	0.32	0.205	0.182	0.023
HC-03-11	HC-03-11	2003	-42.5	-42.5	-42.5	-43.0	9.8	50.6	35.7	0.1	0.059	0.299	0.051
HC-03-16	HC-03-16	2003	-37.8	-37.8	-37.8	-38.3	10.2	61.8	45.2	0.26	0.3	0.208	0.021
HC-03-17	HC-03-17	2003	-43.4	-43.4	-43.4	-43.9	16.5	169	49.1	0.35	0.28	0.371	0.19
HC-03-19	HC-03-19	2003	-50.5	-50.5	-50.5	-51.0	10.7	71.2	47.3	0.48	0.36	0.207	0.042

Results in mg/kg dry weight
Value above the SMS (CSL) level
Value above the SMS (SQS) level

U - Result is not detected at the quantitation limit noted
J - Result is an estimated concentration
D - Result is from a diluted sample analysis
E - Result is an estimated concentration for laboratory control data outside of control limits (metals)
B - Result is an estimated concentration below the reporting limit (metals)
* - Result is an estimated concentration for laboratory duplicate results outside control limits (metals)

APPENDIX J— RESPONSE TO EPA COMMENTS

Comment Number	Page	Comment	Response
General Comments			
Site Dioxins/Furans			
1		Dioxin/furans. Clearly state the assumptions used to determine why site specific data were not collected for dioxin/furans. Also note that during Remedial Design, baseline sampling for dioxin/furans will be necessary. Provide a summary of the 4 d/f sediment samples collected with the Clam Survey.	During the development of the RI/FS Work Plan and SOW, the approach to not collecting and compiling data on the dioxins and furans was agreed to by EPA. This was generally based on the fact that EPA's cleanup of the PSR Marine Sediment Unit, where dioxins/furans were a known site COC, had addressed those contaminants that were above levels of concern. In addition, there was no reason to believe that dioxins/furans were related to shipyard site activities. As part of the RI data collection effort, several samples were collected and archived for possible analyses of dioxins/furans but these samples were never analyzed and were disposed of after the holding times had been exceeded. A summary of the dioxin/furan data collected as part of the Clam Survey has been added to the text.
COPCs and COCs			
2		COPCs were screened using RBTCs adjusted for Tulalip exposure parameters. Identify what, if any, additional COPCs would have been identified if the RBTCs had been adjusted for Suquamish parameters (e.g., consumption rates). Discuss the potential impact on risk estimates if additional contaminants were identified d.	Text on the uncertainty regarding the use of the Suquamish survey seafood ingestion rates in developing sediment screening criteria for selecting COPCs has been added to Section 7 of the RI/FS, which was summarized from the Uncertainty Analysis (Section 6) of the 2009 EPA-approved human health risk assessment (HHRA). The text indicates that if additional COPCs were identified by using the Suquamish survey ingestion rates to develop screening criteria, they would potentially contribute less than 0.02 percent of total cancer risk for the Suquamish seafood ingestion scenario. Recently, the draft final HHRA for the East Waterway site evaluated the use of Suquamish seafood ingestion rates in developing sediment screening criteria and selecting COPCs, and quantified the resultant impact on risks for the Suquamish seafood ingestion scenario. The East Waterway HHRA found that the use of Suquamish seafood ingestion rates identified two additional chemicals as COPCs (two undetected chemicals would also be selected based on reporting limits exceeding the criteria); the sum of the contributions of the detected chemicals to total cancer risk estimates for the Suquamish seafood ingestion scenario was 0.04 percent, and no additional COCs would have been identified for the East Waterway site using screening criteria based on the Suquamish ingestion rates. Those results are consistent with the estimated contribution of potential COPCs to human health risks at the Lockheed West site.

Comment Number	Page	Comment	Response
3		In the risk assessment uncertainty discussion, it is stated that the use of alternative BSAF for chromium and mercury would result in HQ > 1 for tribal children. For this reason, it is stated that chromium and mercury will be retained as COCs (see Appendix C, page 6-13). Clarify the risk assessment discussion and tables to include chromium and mercury as human health COCs. (Note that chromium and mercury also had HQs > 1 for Suquamish scenarios.)	Text and tables in Section 7 of the RI/FS have been edited to include chromium and mercury as COCs. Text has been clarified that the use of alternative BSAFs in modeling tissue concentrations from sediment, and their evaluation in the RME tribal seafood ingestion scenarios (as described in the Uncertainty Analysis, Section 6 of the HHRA), is the basis for their inclusion.
Use of the Term “Chemicals”			
4		Globally change "chemicals" to "contaminants" or "COCs," or at times to "hazardous substances, " consistent with LDW and Portland Harbor FSs, among other sites. CERCLA does not give EPA jurisdiction over "chemicals."	Revised text as suggested throughout text.
Background Concentrations			
5		Throughout the FS clarify that Elliott Bay background data, or other potential background data different from the Bold Survey are not PRGs. There can't be multiple grades or levels of PRGs. The less stringent of RBTCs or Bold data for PCBs, dioxins/furans, cPAHs, mercury, etc., must be defined as PRGs for any final remedial action. The necessity of risk-based cleanup levels defaulting to natural background rather than area or anthropogenic background is defined in WAC173-340-700 (6)(d), among other places. Therefore, values are misidentified as a PRG could be considered an Removal Action Level (RAL), and used as an active cleanup level that IC’s will then be added to in order for the site to be protective to the PRG. If the use of ENR achieves the Site PRGs, further explanation and descriptions of how this is accomplished must be added .	Text has been modified to reflect that the Bold Study data are defined as natural background and noted as the PRGs for those contaminants with RBTCs below background.
6		The FS must further clarify that the Bold Survey data as natural background defines PRGs for applicable risk driver COCs for RAO 1 HH seafood consumption and RAO 2 direct contact. The FS must consistently clarify throughout that use of natural background over more stringent RBTCs for defining PRGs addresses and complies with MTCA as an ARAR (as described in Section 9.4.1). This clarification applies if the remedy is deemed final. Anthropogenic background would only apply to interim remedies, absent a waiver of MTCA	Comment noted. Text has been modified to reflect that the Bold Study data are defined as natural background and noted as the PRGs for those contaminants with RBTCs below background.
RAOs, PRGs and RALs			
7		Most of the alternatives do not achieve the narrative intent of RAO 1. Only alternatives 2A4c and 4C arguably achieve the PRGs for RAO 1 in the short-term.	All alternatives meet the narrative intent of RAO1 through active remediation and institutional controls. Revised text to make it clear that RAO 1 will be met by a combination of the implementation of the engineered remedy and the application of ICs. At the end of construction and in the short-term, the remediated areas associated with each alternative will result in a clean surface. In the long term, with sediment mixing and new sediment deposition at the Site, the surface sediment concentrations are likely to increase, especially for PCBs and cPAHs where the sediment concentrations in Elliott Bay are above the natural background concentrations.

Comment Number	Page	Comment	Response
8		It is not sufficient to state that alternatives will meet RAO 1 simply because sediment concentrations will be closer to the PRGs. RAO 1 includes reducing risks by reducing contaminant concentrations to protective levels. SWAC predictions following implementation of each remedial alternative should be used to estimate residual risk levels for RAO 1. Provide the calculations to demonstrate the range of protection afforded by each alternative.	Comment noted. Revised text to make it clear that RAO 1 will be met by a combination of the implementation of the engineered remedy and the application of ICs. The residual risk for each alternative was not calculated since the risk calculation using the LDW food web model is driven by the assumed surface water PCB concentration which results in a risk level of 2×10^{-4}. For the range of sitewide average surface PCB concentrations calculated for the alternatives, the residual risk for PCBs ranges from 2×10^{-4} to 2.8×10^{-4}. This information was added to Section 12.1.2.1.
9		Text should clarify that PRGs are developed to address CERCLA threshold criteria for 1) overall protectiveness of human health and the environment, and 2) compliance with ARARs. For example, current text on Page 9-2 says PRGs were developed to comply with ARARs and [merely] consider RBTCs.	Comment noted; text was revised to address the comment.
Recontamination			
10		Other background concentrations less stringent than the Bold study should be more clearly defined as RALs. Alternative selection based on RALs would constitute an interim remedy.	Text has been revised in appropriate places throughout the document to address the comment.
11		Conclusions regarding the potential for re-contamination are presented as a function of clean up levels (i.e. the site has a greater potential to be re-contaminated the lower or more conservative the clean-up levels). This is misleading and does not clearly address the overall potential for recontamination from off-site sources. The conditions and dynamics that contribute to the potential for recontamination remain the same, regardless of clean up levels. Lockheed's ability to achieve or maintain compliance, however, may vary with clean up level stringency.	Comment noted. Edits have been made to the text to clarify that "the conditions and dynamics that contribute to the potential for recontamination remains the same, regardless of cleanup levels" in Section 5. Edits have been made throughout the text to address these comments (e.g., see Sections 6, 8.3, 8.6).
12		Based on statements throughout the report, the potential for recontamination from in water sources seems relatively low, with the Elliott Bay sources having a lesser potential impact than the upstream Duwamish sources. Clarify the source control discussion to indicate the relative potential for off-site sources, particularly in water sources, to re-contaminate the Lockheed West site. Provide an assessment of what the most "likely" sources of recontamination are for this site—adjacent areas, Elliott Bay at large or contamination moving through the LDW system and settling out at this Site. Currently the text in the RI/FS identifies the LDW sources as more likely to impact the Site, however, the Elliott Bay Urban Background data have been selected as a data set that most likely will approximate what the Lockheed West Seattle site "looks like" over time as concentrations on the clean surface of the site reach "equilibrium." Provide further explanation about why the "likely" off-site sources of contamination cannot be easily identified despite the high likelihood of COC re-equilibration to urban levels.	Disagree with the comment that "the potential for recontamination from in water sources seems relatively low." The source control evaluation report concludes that in-water contaminated sediment transport and deposition represents a relatively high likelihood of remedy recontamination at low level concentrations above likely cleanup levels. The Source Control Evaluation Report (Tetra Tech 2009b) includes summary and evaluation of nearby sediment cleanup sites including ongoing sediment cap monitoring data. These data show that contaminants are currently being deposited over a broad area at low –level concentrations above Lockheed West RBTC's and natural background. Sediment transport conditions and dynamics for the West Waterway/LDW and from Elliott Bay are also summarized in the Source Control Evaluation Report. It was not possible to distinguish the potential relative contribution of in-water sediment sources.

Comment Number	Page	Comment	Response
ENR Technology			
13		The FS does not present a clear rationale supporting the use of ENR as appropriate and/or effective in reducing human health and environmental impacts at the subject site. The evaluation of ENR as a remedial technology should include some estimate of the sedimentation rate, as well as estimated time to achieve recovery and/or RAOs. Simply assuming a 50% reduction in contaminant concentrations immediately after remediation does not address effectiveness or permanence. As currently presented, ENR is the most prominent component of the remedial alternatives. More of the total remediated area is proposed for ENR than any other active remediation approach -- alternatives 2A2a, 2A3, 2B, 3A1, 3B, and 3C. ENR proposed for at least 50% of the total remediated area in remedial alternatives 2A1, 2A2b, and 3A2. Overall—In Section 10, separate out MNR and ENR. As the RI/FS does not rely on MNR occurring at this site, the text needs to more explicitly define what ENR is. Therefore, define "ENR" more akin to thin capping, but not for isolation/containment. In addition provide the rationale for applying ENR that it will occur in areas with 2xSQS **after** sediments with CSL exceedances have been dredged or capped, for example. In Chapters 11 or12 include the histograms identifying the "final" sediment concentrations after ENR. ENR is the largest component of most of the FS alternatives and needs further discussion. Need to project when the site will reach compliance (i.e., PRGs). Also, if this area is slightly depositional, then the RI/FS has to emphasize that recontamination will occur. If the area is not depositional, then using ENR which is effectively a technique to "jump start" monitored natural recovery may not be appropriate and ENR would need to be evaluated as a thin-layer cap, with some intent to "contain" the contaminated sediments. Regardless of how it is referred to, the standard the site is striving to meet are the PRGs which will be identified as RGs in a Record of Decision. When Lockheed looked at ENR, there are no studies regarding the sedimentation rate, nor studies done on the estimated rate of recovery re: sediment deposition or rate of bioturbation/mixing. The issue is that ENR needs to used as a cleanup approach to "tidy up the edges" of a site , not be the bulk of the remedy.	See response to comments 142 and 143 on the separating of MNR and ENR in the revised text. The discussion of MNR and ENR has been clarified in the text by dividing them into separate sections and describing individually. It is noted in the text that MNR is not carried forward in any of the FS alternatives, though it is retained as a potential component for the design phase if future data indicates a value to the project. It is not possible to determine when "long-term steady state" will be reached after the completion of construction. The application of ENR based on 2 x SQS is based on the relatively low concentrations present in the surface sediments over much of the site, and the ability of ENR to contribute to the reduction of the concentrations for the risk-driver COCs on a sitewide basis towards or to the PRGs for RAOs 1,2 and 4 and the achieving of the PRGs for RAO 3. In addition, outside of the dry docks and some isolated locations, much of the Site only has contamination present in the surface sediments with the underlying sediment having significantly lower concentrations.
FS Alternatives, Monitoring, Institutional Controls, and Costing			
14		In "Common Elements" add language identifying monitoring, performance standards (benchmarks) and contingency actions, if necessary, under "Long-term monitoring."	Requested discussion was added to Section 11.3.2.4 under Common Remedy Elements stating that an OMMP will be prepared during design outlining the sampling requirements, performance standards and contingency actions.

Comment Number	Page	Comment	Response
15		The "cost" of implementing ICs that limit or negate tribal treaty rights should reflect that loss to tribal members in perpetuity. A fish advisory isn't regulatory or enforceable. Lockheed Martin has to be able to be responsible for an IC that is proposed in the FS –Lockheed Martin is not/cannot be responsible for a fish advisory, therefore, the IC proposed needs to take the tack of "Education and Outreach" that is developed in consultation with the community and the Tribes to be culturally appropriate. In addition, an Education and Outreach program should not be forever (as the goal is for improvement in fish tissue concentrations throughout the whole Bay over time). As the reason for a fish advisory is not solely because of contamination at this site, note that for the most effectiveness, multiple parties/agencies will have to participate in the development of such a program. Note: The state (DOH)/Tribe co-manage the resource (i.e., determine the appropriate amount/type of fish and shellfish that can be consumed). The Tribe then manages, regulates and enforces the harvest for the Tribe on a ceremonial, subsistence, and commercial basis.	More discussion was added to incorporate the comment in Sections 10, 11, 12, and 13. IC costs associated with management of future use restriction ICs of capped areas were incorporated but third-party settlement costs or loss to tribal members were not. It was stated in Sections 11, 12, and 13 that "a remedy should reduce or minimize conflicts with tribal treaty rights, so future use restrictions will be minimized during design." For the FS analysis, these limitations are assumed to be part of cap areas and were discussed and incorporated during evaluation of NCP criteria.
16		Caps cannot conflict with or restrict Tribal treaty fishing rights or other treaty protected rights in any way, which means : 1.Tribal fishing vessels have to be able to anchor, or tie up, and fish; 2. Use the PSR language with respect to ICs with the Coast Guard; and 3. Cannot prohibit access to the resources.	The comment was incorporated into Sections 10, 11, 12, and 13. The PSR language was used in Section 10.4.2.2, Implementability of ICs.
17		Applicable institutional controls are listed for capping alternatives throughout the RI/FS. These institutional controls include restrictive covenants, deed or use restrictions, and potential waterway use restrictions for activities that could disturb a cap. Lockheed Martin is considering a thicker capping section to eliminate the need for anchoring restrictions, among other potential benefits. Accordingly, the discussion of institutional controls should be revised to clarify that institutional controls apply to potential cap disturbing activities exclusive of vessel anchoring.	Specific ICs for capping alternatives were clearly listed in Section 12. For the FS evaluation, restrictions on anchorage and grounding were not eliminated from the list and incorporated into Sections 12 and 13. In Sections 10, 11, 12, and 13, it was clearly stated that these restrictions will be minimized or eliminated during design.

Comment Number	Page	Comment	Response
Extent of Contamination and Remedial Alternatives Depiction			
18		It is not easy for reviewers to compare the extent of contamination with the extent of the various remedial alternatives. The former is mapped in Section 4 and the latter in Section 11; it would be helpful to have these in the same format and size so that they can be overlaid on each other. For example, it appears that part of the footprint of PCB SQS exceedances (Figure 4-42) is not included in the SQS remedial area (e.g. Figures 11-3 and 11-15). However, it's difficult to tell whether this is the case, since the figures are different sizes. Two presentation options are: Resize the figures so that Section 4 and Section 11 can be readily compared. Include the footprints from figures 4-41 (all chemicals except PCBs and dioxin) and 4-42 (PCBs) on the Section 11 figures to allow for direct comparison. To avoid creating extremely cluttered figures, a single color for all the contaminants to show a combined SQS footprint might provide the best presentation.	A narrative has been added at the beginning of Section 1.4, RI/FS Organization, to clarify the transition between the RI and FS within the document. Figures in Section 4 and 11 depict different things. For example, Figure 4-42 depicts the extent of contamination based on both surface and subsurface characterization, while the figures in Section 11 depict footprints developed to address the risks associated with project-specific remedial action objectives. Note: clarification has been provided on Figures 4-18 through 4-24, and 4-41 through 4-44 to indicate extent of contamination based on both surface and subsurface characterization. Also, Figure 4-44 in Section 4 has been revised to incorporate the study area boundary as subsequently used in the FS portion of the document. A note has also been added to Figure 4-44 indicating that the study area boundary encompasses the extent of sediment SQS exceedances for PCBs and PAHs.
19		Related to the above comment, it is not easy to tell where contamination at depth will be left behind after remediation. Appendix G to the LDW draft FS provides an example of how this could be presented. Change the title of the Table on page 4-44 to "Study Area" and add a notation to the legend regarding the extent of the PCBs and PAHs.	See response to Comment # 18 above. Also, additional information has been incorporated under long-term effectiveness and permanence throughout Chapter 12 to better address the magnitude of residual risks, including residual contamination remaining after remediation.
Environmental Justice			
20		There is no discussion of environmental justice issues. This evaluation does not identify or consider the disproportionate risks and lost opportunity costs borne by tribal members. An assessment of the disproportionate risk to Tribal populations resulting from contaminants left behind must be included. A Disproportionate Impact Assessment is being conducted by EPA's Environmental Justice office for the LDW Superfund site. Although this analysis will not be finished until Spring 2012, it would be familiar with this report.	Comment noted. Text has been revised throughout the document to recognize that the Site is a tribal U&A area, and therefore the future use restrictions related to cap areas will be minimized or eliminated during design to reduce conflicts or restrictions on tribal treaty fishing rights or other treaty protected rights. In addition, text has been added to Section 2 addressing environmental justice issues.
Reference to Lower Duwamish (LDW) RI/FS			
21		We commend the efforts to align the work for Lockheed West with the work on the LDW. However, some aspects of the work on LDW are still under discussion, and thus in those cases it is not appropriate to cite LDW draft documents in this RI/FS. For example, this document cites the AECOM 2010 2nd draft feasibility study numerous times, but that document is under heavy revision (EPA is currently working with the LDWG to resolve the issues identified in their comment letter on that draft). We recognize the difficulty involved in trying to follow LDW's lead on some remedial decisions when their process is not yet complete. In this comment letter we have attempted to identify specific topics where the LDW draft FS model should not be followed. For the most up-to-date information on FS-related discussions between EPA and LDWG, Allison Hiltner should be consulted and a meeting can be arranged.	Comment noted.

Specific Comments – Sorted by Page Number

Comment Number	Section	Page	Comment	Response
22	Section E-2		Section E.3.2. First sentence is misleading, as dredge lines were designed to smooth topographic transitions through the cuts, rather than "minimizing changes in existing water depth" as stated. Clarify. Intention of leaving the "front of the Terminal 5 area utilizable for future use" may also be misconstrued. Rephrase to say dredging to –46 feet MLLW to maintain or slightly increase water depth. This dredge depth may or may not be sufficient to make T5 utilizable in the future.	More discussion was added to Appendix E, Section E.3.2 to clarify that this exercise was done for Alternative 2B which has the intention of minimizing existing water depths. The sentence cited in the comment was also rephrased as requested.
23		Table ES-3	Update TBT RBTCs and provide text explanation here and elsewhere in the RI/FS.	Table ES-3 and Table 9-5 have been updated as appropriate. Explanation has been added in Section 9.
24		Figure ES-3	Need consistent site boundary abutting WW OU on all figures. The "evolution" of the site boundary location could be discussed briefly in Section 2.0, but having multiple versions of the boundary is confusing for the purposes of the document. Section 4 figures in particular are a good example of where clarification needed and check other figures throughout the document. Change the title to "LW Vicinity" and remove the legend for the approximate site boundary (i.e., yellow dashed line)	See response to comment #18. Figure ES-3 has been revised by deleting approximate site boundary (yellow dash line) from the figure and the legend; and by revising the title to "Lockheed West Site Vicinity."
25		ES-11	Quantitative risk estimates should be provided for the different chemicals and exposure scenarios. In particular, chemicals exceeding a risk of 1 in 10,000 should be identified, as exceedance of this risk level requires action on the part of EPA.	A summary table of risks for COCs for human health scenarios and for ecological receptors has been added to the Executive Summary.
26		ES-16	It is unclear why PRGs could not be computed for many of the chemical/RAO combinations as estimates of risk and background are available. The table should provide greater detail (e.g. net fishing and beach play PRGs). And the background values for RAO 1 should include the Bold data used as natural background for this project. (Table 9-3 that is referred to in the footnote does not accurately identify the Bold data set as the one that EPA and Ecology consider "natural background", although it should.) On Table ES-3, there is not a PRG identified for direct human contact. Provide the explanation for this and why there are so many "NAs" on the table and what they mean. – Clarify that the "n/a" for these COCs were determined not to be risk pathway concerns.	Tables ES-3 and 9-5 were revised to identify the Bold Study data for those COCs where the RBTC is less than natural background. Clarified that the "n/a" in the tables were for COCs that were determined not to be risk pathway concerns.
27		ES-19	Line 13 – The AOPA concept needs clarification here, Section 11, and elsewhere. AOPAs should be based on areas of unacceptable human and ecological risks – in this case inclusive of site areas to the study area boundary shown on Figure ES-5. The AOPA discussion should then be further clarified to better explain why the Urban Background criteria have also been included in defining site AOPAs, i.e. because PRGs based on RBTCs and natural background cannot be met in perpetuity. The LWD FS (page 6-8) provides a good discussion of this in the context of RALs and areas, which if remediated, would yield SWACs achieving expected long-term "equilibration." A flowchart approach might be best used to demonstrate this.	Text has been revised to clarify the AOPAs and how they meet the RAOs.

Specific Comments – Sorted by Page Number

Comment Number	Section	Page	Comment	Response
28		2-13	Line 26 and 27 - States that LM will consider POS plans for future uses to the extent possible in the evaluation of potential remedial options at the Site. Section 11 should explain what specific future use scenarios were considered in the context of alternatives development, ICs, and future use restrictions.	Added reference to Section 11. A statement was added to Section 11.4.2.2- description of Alternative 2B where LMC considered Port's request on not changing the existing water depths at the Site.
29		3-3	Lines 1 and 2 - Explain rationale for selection of "Urban Background" data set for consideration in LW FS, rather than "Basin" or "Harbor" data sets. Further explain inclusion of the Green River anthropogenic background as is being used in the Lower Duwamish Waterway Superfund site, and limitation on applicability to Lockheed West.	This section of the report is outlining the specific site-related data used in the RI evaluation. Rationale for use of the Ecology data sets is further described in Sections 4 and 9. Similarly, the Green River data and their applicability to Lockheed West are discussed in Section 9. In general, the Green River anthropogenic data is not as relevant to Lockheed West based on distance from site and type of system (fresh water vs marine)
30		3-5	Line 19-22 - Note that EPA is further evaluating chemical monitoring results for the PSR cap in comparison to Urban Background, Natural Background, and RBTCs. Add another brief subsection noting same for West Waterway, and Harbor Island LSSOU and TSSOU sites re: EPA's evaluation of available data for recontamination/long-term equilibration levels. Note that results of this evaluation will be used to determine long-term performance and OMMP criteria.	Added text to section recognizing that EPA is further evaluating chemical monitoring results for the PSR cap in comparison to Urban Background, Natural Background, and RBTCs. Section already notes that current environmental status of the PSR site is included in the Source Control Information and Data Gap Report. Added similar text to West Waterway OU section.
31	Section 4.2.3	4-4	Line 30 - Provide further description of contaminant mobility testing and state where the results are reported.	Text was revised to provide additional detail on the contaminant mobility testing and to note the table for the results.
32		4-9	Compute total cPAHs.	The description of the calculation for the cPAH concentrations was added to the text.
33		4-13	Section 4.5 – Add a table listing the different SQS, CSL, LAET, 2LAET values – and consider moving Table 4-14 earlier in this section.	A table was added in the introduction of section 4.5 to introduce SQS, CSL, LAET and 2LAET. Since Table 4-14 includes the reference area data sets this table needs to be kept with the summary of those data in section 4.9.
34		4-13	Line 2 - The definition of CSL should be "will result in" rather than "may occur."	Text edited to replace "may occur" with "are likely to occur" since exceedance of a CSL does not always result in adverse effects.
35		4-14, line 19	Note in this section that exceedance factors have no regulatory or toxicological significance, and could be misleading to a lay reader as they may believe that something with an exceedance factor of "5" may be five times more harmful, which is not necessarily the case .	Text is clarified to note that exceedance factors are only to provide a means to relatively compare data using the regulatory standards.
36		4-15	Summarize cPAHs.	Text has been added for the cPAHs.
37		4-18	Computation of cPAHs is needed for consideration of clamming and beach play risks.	Text has been added for the cPAHs in core samples.

Specific Comments – Sorted by Page Number

Comment Number	Section	Page	Comment	Response
38	4.7:	4-20,	Clam Tissue, 4th paragraph of section. Most of the fish BSAFs employed by this project are a several fold greater than those computed from LDW data. However, Lockheed West fish BSAFs for arsenic, chromium and mercury are less than LDW fish BSAFs. There were two significant changes in seafood consumption HQs and risks evaluated for tribal adults using Tulalip data. Arsenic risk increased from the 10 -3 range to the 10-2 range. The chromium HQ using LDW BSAFs was great than 1.0. There were three significant changes in seafood consumption HQs and risks evaluated for tribal children assuming Tulalip child seafood consumption rates were 40% of adult rates. Arsenic risk increased from the 10-4 range to the 10-3 range. The chromium and mercury HQs based on LDW BSAFs exceeded 1.0. Identify that Chapter 4 is a summary of this information and in Chapter 7, the information will apply these concerns.	Text added to clarify that this section is a summary of the data and that Section 7 applies the data for the risk assessment evaluation.
39		4-21	Lines 1-3 - State whether CST results were used in conceptual dredging design and to assess short-term effects.	Text is clarified to note that CST results will be used during design to assess dredging and short-term effects.
40	Section 4.9.1	4-21	Line 18 - State why this section uses the UCL on the mean of the background data, rather than just the mean. Generally the UCL is used when we want to be 95% confident that the average is below a compliance level. Explain the rationale for using the UCL to set the compliance level.	The use of the 95% UCL to determine concentration values for comparison purposes is consistent with the methods used by EPA for the Bold Study data and other reference data sets.
41		4-21	Reference Data Summaries A table listing the Bold and Elliott Bay study values for the risk drivers should be added and consider moving Table 4-14 earlier in this section.	The requested information is included in Table 4-14. This section introduces the evaluation of the extent of contamination and the comparisons used in the next sections.
42		4-22	Lines 21-22 - Since Table 4-14 does not include detection limits for arsenic, cPAHs or PCBs it is difficult to evaluation whether this assertion is correct. Add detection limits.	Detection limits have been added to Table 4-14.
43		4-28	Lines 1-3 and Lines 13-16 - These statements are not accurate for the for Dry Dock 1 area for many risk driver COCs.	Text has been revised by adding additional detail and qualifications to the statements.
44		4-30	Lines 21-22 and Figures 4-41 through 4-44 - Figure 4-41 only shows COC extent with respect to SQS exceedances and excludes impact areas based on other PRGs. Therefore this figure does not show all “impacts due to shipyard-related activities” as stated in the text.	Text revised to address the comment.
45		4-30	Lines 27-29 - The actual study area boundary should be shown on this figure as indicated in the text. The figure caption is different – “horizontal extent…” and there is no depiction of the actual study area boundary established along the top of the slope near the Outer Harbor Line. On figure 4-44 draw the final Study Area boundary.	See response to Comment #18.This section is to define the nature and extent of the contamination at the site. The “site area boundary” was added to Figure 4-44.

Specific Comments – Sorted by Page Number

Comment Number	Section	Page	Comment	Response
46		4-31	Lines 12-14 - For alternatives involving partial dredging, the vertical extent of contamination should be defined by residual COC concentrations exceeding any PRG or Urban Background, not just SQS. Such conditions represent exposure risks requiring further management, such as back-capping or ENR.	This section describes the nature and extent of contamination. Later sections describe potential remedies including partial dredging and residual exposure risks. As noted in the text, for the purposes of defining the extent of site-related contamination, the SQS level comparison can be used. For exposure risks based on lower threshold levels, a point-based comparison is not appropriate.
47		4-58	Compute BaP equivalents for clam tissue.	The total cPAH concentrations have been added to Table 4-11 for the clam tissue and to Table 4-12 for the sediment.
48		5-2 and 5-3	Include the tribes in identifying the parties that need to participate in the coordination of long term monitoring.	The text has been revised.
49	Section 5	5-3	The Department of Natural Resources is not the State's natural resources trustee. The Governor assigned Ecology to act as the State's lead trustee. DNR manages state owned aquatic lands under Title 79 RCW, and must balance numerous factors, including resource protection, in managing those lands.	The text has been revised to reflect Washington DNR's role as indicated in the comment.
50		5-8	Clarify that the parameters of the permits, and whether they include sampling for the Lockheed West contaminants or not. The discussion of permits should make it clear that they do not generally monitor for the COCs at the site and are therefore of limited value in assessing source control.	The wastewater discharge permits and monitoring parameters are discussed in detail in the Source Control Evaluation Report (Tetra Tech 2009b). The text has been modified to clarify where this detailed information can be found and to indicate monitoring parameters in common with site COPCs. These sites all monitor for chemicals in their waste discharges and are therefore relevant from a source control perspective. There is also overlap with site COPCs, so they are relevant from that perspective.
51		5-11	Lines 21-28 - Include August 11, 2011 Field Monitoring Report Update, June 2011 Sampling Event, Pacific Sound Resources Superfund Site (Letter from Seattle District USACE to EPA reference (and forthcoming complete report). Summarize results re: NAPL presence in well MW-15IR (NAPL-impacted), and absence in other wells closest to the west boundary of the Lockheed West site. If these data are not yet available, indicate that they are expected to be available next year.	A detailed discussion of the PSR groundwater data as it pertains to the Lockheed West site is presented in the Source Control Evaluation Report (Tetra Tech, 2009b). The text has been revised to more clearly reference this report and to specifically reference well IMW-15IR results. The text was also modified to indicate that the most recent August 2011 data will become available during 2012.
52		5-12	Lines 1-4 - Summarize history and trends of available NAPL and groundwater monitoring results for well MW-15IR (NAPL-impacted) and other wells closest to the west boundary of the Lockheed West site. State that EPA is continuing to monitor NAPL conditions and groundwater quality in accordance with the PSR SOW, and related USACE QAPP and revisions.	See response to Comment 51. The text was revised to state that EPA is performing ongoing groundwater monitoring at the PSR site.

Specific Comments – Sorted by Page Number

Comment Number	Section	Page	Comment	Response
53		5-12	Lines 3 and 4 - Further explain the last sentence clause re: current chemical data from for the former shipyard uplands (RA-5) do not show a groundwater contamination problem. Cite reference source(s).	Further clarification and referenced citation(s) were added.
54		5-12, line 24	This is a draft document and is the work product of LDWG not the agencies. It should be made clear that these data are highly uncertain and apply to Green River inputs rather than inputs into the WW.	This study has been summarized in more detail in the Source Control Evaluation Report (Tetra Tech 2009b). The text was revised to more fully reference this LDWG document and acknowledge uncertainties associated with the conclusions.
55		5-13	Lines 8-13 - Add a table listing these data.	A table summarizing recent sediment remedial action monitoring data was included in the Source Control Evaluation Report (Table 3-7, Tetra Tech 2009b). This table will be included in the text of the RI/FS report.
56		5-15	Lines 7-9 - Considering adding "but not the SQS", since that is the statement made on page 5-14, lines 28 through 30.	The text was revised to incorporate the suggested revision.
57	Section 6	6-1	Core idea in this sentence at beginning of Section 6, summarizing Section5 on recontamination sources, is troubling, especially italics: "The source control evaluation (Section 5.0) concluded that off-site in-water sources are a potential source for recontamination to the Site sediments if selected cleanup goals are set at concentrations near the Site RBTCs." Instead, reword to indicate that the site would be expected to re-equilibrate to concentrations above RBTCs. Reference discussion of PRGs and cleanup goals to other sections of the FS.	Text has been revised to indicate the expectation that sediment concentrations would re-equilibrate to concentrations above RBTCs
58		6-3	State the date of the last dredging event.	This page has no reference to dredging. Page 6-6 includes dates for the last dredging permit found for the site (1954).
59		6-3	Lines 17-19 - State whether the sediment transport analysis cited has been accepted. Suggest adding "which is located in Elliott Bay" after Marine Sediment Unit.	Added note in text that this was the Final Design Submittal to EPA. Added text indicating that PSR is located in Elliott Bay to the west of the Site.
60		6-4	Section 6.1.2.1 - State whether landslides or seismic displacement events were considered in the surface sediment dynamics evaluation.	Text was revised by adding a new section 6.1.2.4 that summarizes the results of the seismic evaluation completed. Reference to Appendix H for the complete study was added.
61		6-15, line 8	TBT is subject to oxidation. Should be mentioned here that at least in surface sediments this is a significant degradation mechanism.	The text notes that TBT can undergo photolysis where UV light can penetrate. However for sediments it is documented that biodegradation is the primary mechanism for degrading TBT and oxidation does not occur or is very limited.
62		7-15	Present the cancer risks for the 183 day per year clamming scenario too.	Table 7-1 shows the risk estimates only for the RME scenarios, so the risks for the 183-day clamming scenario are not shown since that is not an RME scenario. Text has been clarified that only RME scenarios are shown in Table 7-1.

Specific Comments – Sorted by Page Number

Comment Number	Section	Page	Comment	Response
63		7-4	The discussion of the application of EPA's tribal seafood consumption risk assessment framework needs to be edited. The framework is an internal EPA document that is used in site and tribe specific consultations. The RI/FS should state that EPA proposed the use of Tulalip consumption rates as specified in its tribal seafood consumption framework. In the process with consulting with the Muckleshoot and Suquamish Tribes, the tribes reluctantly agreed to use of the Tulalip rates, realizing that risk based cleanup levels were not attainable because of background considerations. Be clear that the Tulalip consumption rates were used for RME, but the Suquamish consumption rates were used as the "high end" rates.	Text describing use of the EPA tribal framework and identification of tribal seafood ingestion rates in Section 7 has been edited to address the comment.
64		7-5	Focus the discussion of not including contaminant exposure from salmon consumption on PCB body burdens in juvenile and adult salmon.	Text in Section 7 has been edited to include more discussion on the exclusion of salmon from the ingestion rates.
65		7-5	Add that low clam abundance may also be due to chemical concentrations as well.	It is not appropriate to speculate on any specific reasons for the low clam abundance other than the poor habitat quality.
66		7-6	Discuss the use of the hazard index to screen for non-cancer concerns and the use of endpoint specific HIs.	Text was added to Section 7 on the use of the hazard index to screen for non-cancer concerns; text is consistent with the LDW HHRA.
67		Table 7-1:	Include chromium and mercury as COCs for human health.	Table 7-1 has been revised to include chromium and mercury as COCs for human health, based on alternative BSAFs developed from site data for clams and LDW site-wide data for crabs and fish.
68		8-6	Lines 2-4 - Clarify here and/or elsewhere that further delineation of N&E is accounted for in the design line item for App F remedial cost estimates. Or add if necessary.	This section is a summary of the RI; no discussion of the FS, alternatives or the design process has been discussed yet, therefore the suggested text addition is not appropriate here. The fourth bullet in Section 8.6 discusses the potential for additional nature and extent sampling as part of the design process. Costs for design related sampling are included in the remedial cost estimates in Appendix F.
69		8-6, line 11 (also 9-8, RAO 3):	Provide a short discussion about gastropods here since they are one of the most sensitive types of organism to TBT and they are not discussed here.	Page 8-6 Line 11 identifies TBT as a risk driver for human health scenarios and ecological receptors, which did not include gastropods; and RAO 3 on Page 9-8 is to reduce risks to benthic invertebrates. Since the risk to gastropods for imposex related to TBT tissue levels was determined in the ecological risk assessment to be low (NOAEL HQ < 1 based on tissue residue approach), TBT was not identified as a COC or a risk driver for gastropods, and hence gastropods are not discussed in these sections.

Specific Comments – Sorted by Page Number

Comment Number	Section	Page	Comment	Response
70	Section9		This section is unnecessarily long and repetitive, the same concepts and approaches are described multiple times within the chapter. Edit.	Comment acknowledged; however, this section was already approved by EPA as part of the final RAO memo so major reorganization was not performed.
71	Section 9	9-1	Overall section organization and text should further deemphasize ARARs and maintain focus on PRGs.	Comment noted. Text has been modified throughout the section to deemphasize ARARs to the extent possible.
72		9-2	Numeric PRG values also require information as to how they are to be spatially applied (e.g. a point by point basis, over particular sediment areas for example subtidal or tidal).	Revised text to clarify spatial application of PRGs.
73		9-6 and 9-7	This discussion isn't as complete as the LDW section as it doesn't discuss the Bold Study concentrations in the narrative. There should be some discussion that spatially weighted approach is used and that even though a clean cap can be done, it will not eliminate , but only reduce risk and ICs will still be necessary to further control consumption of seafood for additional protectiveness.	The RAO narratives are a description of the remedial objectives and how they can be achieved. Discussion of natural background is included with the selection of PRGs.
74		9-8	RAO 3. Add a discussion about toxicity test out option in this section and that the determination that the sediment concentrations are acceptable will be determined on a point by point basis.	Text revised to include the use of toxicity testing and that achievement of the RAO is on a point basis.
75		9-8	RAO 4. Add that the determination that sediment concentration will be acceptable will be done on a spatially weighted basis.	Text revised to note the application on a site-wide basis.
76		9-9	Lines 29-31 - Migration of deeper contaminated sediments via groundwater flux, reworking, bioturbation etc. is not discussed in the F&T section. Clarify why this pathway was not further evaluated.	Text revised to make consistent with the mechanisms noted in the fate and transport section.
77		9-13, line 19	ARARs need to specify MTCA, too, rather than SMS alone.	Text revised to specify MTCA.
78		9-13	Lines 7-8 and 22-23 - Clarify that PQLs were not selected as PRGs for any RAOs, describe why.	PQLs were selected as PRGs for DDT and chlordane, so no changes to the text were made.
79	Section 9.4.1.1	9-15	Delete lines 9-10 that "Anthropogenic background may be more pertinent than natural background for developing sediment PRGs for the Lockheed West Site." EPA is required to meet the most stringent ARARs, and MTCA is the ARAR that defaults to natural background which is more stringent than CERCLA's acceptance of anthropogenic background.	Text revised to note the use of natural background.
80	9.4.1.1.	9-16,	On line 3 - change "EPA" to "LDWG" and on line 6, change "potential" to "potentially provisional."	Text revised per comment.
81	Section 9.4.1.2	9-16	Clarify what is meant by the opening sentence to this section –"Natural background values for sediment sites in the Duwamish Basin have not been identified by EPA or Ecology" when the rest of this paragraph discusses the Bold Study and that this "data set was identified by EPA and Ecology as the primary data set for defining natural background…"	Text has been revised to note the EPA's direction to use the Bold Study data as natural background.
82		9-18	Include maps of Elliott Bay sample locations along with applicable concentrations. Maps should identify which stations fall into deep, mid bay, and inner bay areas. Maps should also identify potential sources. Such maps would be useful in determining the spatial representativeness of the data.	Map from the Ecology report has been added to the section.

Specific Comments – Sorted by Page Number

Comment Number	Section	Page	Comment	Response
83		9-18	The presence and impact of non-detects in the Elliott Bay sample set should be discussed as it applies to computing statistics on the data. The 95% UCL values should be included in the text, as was done for the provisional LDW background values	95% UCLs were calculated using ProUCL and the handling of non-detect data was per EPA guidance as applied by ProUCL. The ProUCL results were added to Appendix Table A-15. The results are presented in Tables 9-3 and 9-4.
84		9-18	Lines 22-23 - The number of samples associated with each group is very small considering the importance of anthropogenic background in development of PRGs. Further clarify data use or other statistical analysis from Bold study.	EPA has determined that natural background is to be used in the selection of PRGs. The anthropogenic data sets are included for reference purposes to be used in delineating the site, determining the potential for recontamination and for long term monitoring Considerations.
85		9-19	Lines 9-10 - This is not a valid conclusion given that there were only 2 samples in the deep basin data set.	Text was revised to clarify.
86		9-19	Line 12 - Why is the harbor/inner bay values excluded in this sentence? Table 9-3 does list these values.	Text was revised to clarify.
87		9-20	Note that the narrative approach in this case is the risk assessment approach and that risk based standards may be applied on different scales.	Text was revised to clarify.
88		9-22, line 14	Delete line 14 - Background could only be at issue after the adoption of the EPA Region 10 tribal framework, and there have been a limited number of opportunities to apply it. It is disingenuous to argue that the State has been inconsistent. If Lockheed Martin feels that It has been, then it needs to provide additional evidence. Suggested comment rewording: Lines 9 -12 (retain last two sentences). Reword to indicate that natural background or RBTCs are the basis for determining PRGs based on MTCA, and that alternate background levels or other Tribal Framework considerations are outside of the current MTCA regulatory criteria for establishing permanent cleanup levels.	Text revised per the suggested change.
89		9-23	Please note that the spatial considerations in applying ARARs also need to be considered. A seeming lax standard applied on a point specific basis could ultimately be more stringent than a standard applied on an area basis.	The spatial application of RBTCs is noted in Tables 9-3 through 9-6.
90		9-28 & 9-29	Lines 28-16 - Clarify that PQLs were not selected as PRGs for any RAOs, describe why.	Revised text to note that PQLs were used for some COCs (DDT, chlordanes).
91		9-29 to 9-33	Suggest changing title of this subsection to " PRG Selection and Use", delete the repetitive summary information and focus on which sets of values prevail as PRGs for each RAO and describe how the PRG will be used to identify where remedies will applied and to gauge the effectiveness of the remedies.	Title of the section has been revised per suggested change.
92		9-31	Delete the paragraph that begins on Line 6. If this is relevant information, present it in the evaluation sections.	Paragraph has been deleted.
93		9-39	Clarify whether this has been verified by a credentialed professional archaeologist. Otherwise state this as an opinion they are not qualified to make this statement. Regardless, they must consult with the Tribes under Section 106. Suggested replacement language is “The sediment is in the U&A for two Tribes. Lockheed Martin needs to conduct a Section 106 consultation with the Tribes.”	Text in table has been revised to note the need for consultation under Section 106.

Specific Comments – Sorted by Page Number

Comment Number	Section	Page	Comment	Response
94	Tables 9-5 and 9-6.	9-53	Identify the rationale behind NA entries (e.g. the contaminant had an HQ of less than 1.0 or a risk less than 10-6).	Table updated to include note on NA.
95		9-57-58:	Expand the scale of Figures 9-1 and 9-2 with maximum values identified numerically above bars.	Figure revised per comment.
96		Table 9-1	Add/specify more stringent of CWA Sections 303 and 304. Note that 304 includes federal criteria that are only advisory for CWA purposes, but nevertheless represent a cleanup standard/ARAR per last sentence of Section 121(d)(2)(A)(ii) of CERCLA.	Table has been revised to include reference to CWA section 303 and 304 along with the application of section 304 for CERCLA.
97		Table 9-1	Add RCW statute citation for MTCA.	RCW citation added.
98		Table 9-1	Confirm that the following are not ARARs (Table 9-1) but should be retained in Table 9-2 as other requirements (and not TBCs): • State aquatic lands statutes. • ESA. • Historical Preservation Act or Archeological or Indian artifact laws or regulations. • OSHA and related state-level regulations for worker safety.	Confirmed that Table 9-2 is consistent with EPA comments on LDW FS and that these are treated as "Other Requirements" and not TBCs.
99		Table 9-3 and 9-4	Include chromium and mercury as COCs for human health.	Chromium and mercury added as COCs for human health.
100		Table 9-4	Clearly distinguish here and elsewhere between PRGs and RALs (e.g., background criteria such as Elliott Bay Urban, etc). More clearly identify most stringent PRGs.	Tables 9-5 and 9-6 outline the most stringent PRGs according to the RAOs. Tables 9-3 and 9-4 show all of the relevant data for the selection of the PRGs.
101		Table 9-5	PRGs need to be set to natural background, at least until the MTCA rules are revised or ARARs waived, and the values need to be consistent with the LDW calculations for natural background.	The natural background values are listed for those PRGs set to natural background.
102		Table 9-5	Clarify that PRGs were established using natural background for RAO 1 and RAO 2 where natural background concentrations exceed RBTCs. Same for Table 9-6.	The table has been revised to note that PRGs, where the RBTC is lower than natural background, are set to natural background.
103	Figure 9-1		Clarify that the Elliott Bay urban background concentrations are an area background.	The Elliott Bay urban background concentrations are included as one of several reference data sets and no determination has been made regarding the designation of any as representing "Area Background" as defined under MTCA.
104	Figure 9-1 & 9-2		Graphs do not use the same nomenclature to describe the background studies as presented in text (e.g. Elliott Bay Industrial - is this Harbor/Inner Bay?). Would be good to include the number of results included in each study on the graphs.	Figures revised per comment.
105	Figure 9-2		Verify whether there is supposed to be TBT data here.	TBT removed from figure legend.
106		10-3	Lines 4-8 - GRA description does not match EPA (1988) guidance wording, which states "general response actions describe those actions that will satisfy the remedial action objective".	Revised as requested.

Specific Comments – Sorted by Page Number

Comment Number	Section	Page	Comment	Response
107		10-4	Lines 10-18 - Implementability description does not match EPA (1988) wording and focuses on technical, rather than institutional aspects of implementability (e.g., ability to obtain permits for offsite actions, the availability of TSDs, equipment and skilled workers).	Revised as requested
108		10-6	Line 12 – Add the following reference: EPA ARCS Guidance for In-Situ Subaqueous Capping of Contaminated Sediments (Palermo and others 1998) Shown in Reference Section 14 as EPA 1998.	This is the list of guidance documents for the identification and screening of applicable technologies and assembly of preliminary alternatives. Suggested reference is a capping design guidance document and does not belong to this list. As noted in the comment, this document is already cited in the document in the appropriate section.
109		10-7	Lines 12-13 – Add that related actions such as long-term monitoring for remedy performance assessment are associated components of applicable alternatives.	This is the list of GRAs. LTM is not a GRA per EPA 1998. GRAs are the actions that will satisfy the remedial action objectives. LTM is a technology to measure and verify the performance of the remedy.
110		10-7	Lines 25-26 - Give examples of engineering measures.	Added examples, as requested.
111		10-8	Line 19 - Add "and institutional controls" after program.	Edit made.
112		10-8	Line 24 - It appears that this is the 1998 EPA ARCS reference per citation in Section 14 and noted in comment above on pg 10-6. Clarify.	Confirmed that EPA 1998 is the correct reference. Revised text.
113		10-9	Line 3 - Include need for long term monitoring and institutional controls in the description for capping.	Revised text as requested.
114		10-11	Lines 17-29 - This description of implementability evaluation is more consistent with guidance than the one on Page 10-4. Use this description when “implementabilty” is discussed.	Comment noted.
115		10-12	Line 3 - Add that comparative costing excludes assignment of actual dollar values at the technology/process option screening level.	Revised text as requested.
116		10-12	Line 5 - Insert: "...providing similar or greater effectiveness and implementability...."	Following sentence was added to paragraph to address the comment: Technologies providing similar or greater effectiveness and implementability were retained.
117		10-12	Line 9 - Clarify that subsequent subsections describe why such technologies and process options were not included as components for the current FS alternatives.	The paragraph above explains the requested info.
118		10-12	Line 22 –Add an explanation in Section 1 about the intent of the RI in order to “manage expectations” as this is a “joint” RI/FS and it is easy to get the “cart before the horse” with this type of a format. Note that the extent of contamination on Figure 4-44 is different than the implied (but unlabeled) study area boundary on this figure. For example, the extent of contamination shown on Figure 4-44 does not include the entire extent of PCBs exceeding the Bold study natural background. Figure 4-44 and other Section 4 figures should cite or clarify the basis of the area of "contamination" shown. Identify the study area boundary on this figure.	See response to Comment #18. Text has been revised to clarify what is shown on Figure 4-44 and to clarify the extent of PCB and cPAH contamination.
119		10-12	Line 25 - Abbreviate sediment quality standards as SQS.	Abbreviated.

Specific Comments – Sorted by Page Number

Comment Number	Section	Page	Comment	Response
120		10-12	Line 28 - Reference the area in question as extending to the study area boundary shown on FS figures. Clarify that the site boundary will be finalized in the ROD, as noted on several FS figures.	The text has been revised.
121		10-12	Line 29 - EPA believes the range is closer to 15 feet, taking into account extreme low tide.	Revised to 15 feet.
122	Section 10.3.2	10-13	The United States and the State of Washington have concurrent jurisdiction over the management of West Waterway. This waterway is not only a federal waterway, but a State waterway designated under RCW 79.120.010. That statute precludes DNR from selling or leasing the waterway. However, other statutes authorize DNR to issue permits, licenses or easements for uses that do not conflict with the navigational purposes of the waterway. Prior to the issuance of any authorization, DNR will have to obtain Corps of Engineers concurrence that the use will not conflict with navigation. Though the Congressionally authorized project depth for the waterway is -34 feet MLLW, the operational depth is -50 feet MLL W or greater. The Port of Seattle is authorized to develop all waterways within its boundaries under Title 53 R CW.	These statements were incorporated into Section 10.3.2.

Specific Comments – Sorted by Page Number

Comment Number	Section	Page	Comment	Response
123	Section 10.4	10-13	Screening of Institutional Control Technologies. Delete the phrase “Technologies” as it is misleading. Overall, this section states several times that land use and resources will be restricted by institutional controls (ICs). While this can be true at cleanup sites, EPA does not believe it is necessarily the “rule.” For example, the engineered remediation options (caps and/or dredging) can be designed to take future land use into consideration (i.e., Port of Seattle (POS), Washington Department of Natural Resources (DNR), Muckelshoot and Suquamish Tribes have all expressed future land use and/or tribal treaty rights for considerations). After this these actions have been designed and implemented, it then may be necessary to “layer” ICs onto the remedy to ensure protectiveness of the engineered control, but still allow for fishing and clamming, fishing boat ties offs, commerce and navigation, etc. This section should be more explicit about this approach, otherwise it appears that ICs are very limiting and restrict future land uses. Also, consideration of this area being a “high security” (aka TWIC site) designation by the Port of Seattle may also obviate the need to consider “restrictive grounding of small vessels on the shoreline and or restrictions of vessel draft, horse power, speed and time in area” as discussed in Section 10.4.1.1 under Government Controls. State that it is the intention of the project to minimize the need for ICs. In addition, since the POS, DNR and the Tribes have expressed future land use issues and concerns, specific ICs should be identified in Section 11—Development of Remedial Alternatives, rather than defaulting to the design process to determine this. There should be enough information provided to date to allow Lockheed to identify specific ICs rather than stating under the Common Remedy Elements (Section 11.3) “Institutional Controls” or in Section 12. Sections 11.4.2 and 11.4.3 Common Elements currently state “Employing institutional controls (public outreach, education and seafood consumption advisories sitewide; proprietary controls, monitoring and notification of waterway users, enforcement tools, site registry to apply conventional capping areas). Additionally, but being more specific regarding which ICs are most likely to be effective, then costs can be appropriately identified in Appendix F so the costs between the remedies can be evaluated.	A paragraph was added to Section 10.4.1 incorporating these statements. ICs that may be required are common to the alternatives but just vary in intensity/size of area. ICs were specifically discussed in Sections 11 and 12. The associated costs were appropriately identified in Appendix F and the costs between the remedies were evaluated.
124	Section 10.4.1	10-13	In the first sentence of Section 10.4.1, delete “rather than reducing risk through cleanup actions.” As per EPA’s Institutional Controls (IC) guidance (December 2002), EPA defines IC’s as non-engineered instruments, such as administrative and/or legal controls, that help to minimize the potential for human exposure to contamination and/or protect the integrity of a remedy. IC’s are not meant to be in lieu of cleanup actions, rather they limit “land or resource use and/or by providing information that helps modify or guide human behavior at the site.” Additionally, the guidance states, “ICs play an important role in remedies to help minimize the potential for exposure and protect engineered remedies.”	Part of the first sentence was deleted. Suggested text was added to the section.
125		10-13	Line 7 - Include expected depth of deep draft moorage.	Expected depth of deep draft moorage (up to -50 ft MLLW) was added.
126		10-13	Line 7 - Add reference to POS 2011 FS comment letter.	Reference was added as requested.

Specific Comments – Sorted by Page Number

Comment Number	Section	Page	Comment	Response
127		10-13	Line 15 - Revise the sentence to read "The range of detected surface and subsurface ...." to be consistent with information presented in table.	Revised as suggested.
128	Section 10.4.1	10-13	In line 21 - after “activities”, add “or protect engineered remedies”, and after “occurring” in this same sentence, delete the remaining sentence and add, “and to ensure both the short-and long-term protection of human health and the environment.” Also, in line 23, after “that” add, “supplement engineered remedies and may….”	Revised as suggested.
129	Section 10.4.1.1:	10-14	The ability of State and local governments to adopt institutional controls is not only a function of their willingness, but of the statutes that authorize and limit agency actions. Clarify. Lines 8-11. Reword to indicate the effectiveness depends on governmental “authority and ability to adopt…”	Revised as suggested.
130	Section 10.4.1.1	10-14	Change “willingness” to “ability” in fourth sentence.	Revised as suggested.
131		10-14	First sentence. Revise sentence to state “enforcement and permit tools” as it is stated in guidance and in Section 10.4.1.3.	Revised as suggested.
132		10-14	Line 1 - Clarify that this applies to engineered capping rather than thin-layer capping.	This sentence is listing the general types of ICs. Some of these ICs such as fish advisories will be applied regardless of the remedy. Suggested comment is not applicable here.
133		10-14	Line 3 - Clarify that the degree of IC implementation is typically related to the remedy application area and method. i.e. fewer ICs are needed for dredging (possible temporary fish advisories) than for alternatives involving extensive capping.	Suggested clarification was added.
134		10-14	Line 25 - Add "...or special maintenance requirements..."	Added as suggested.
135		10-16	Line 8 - Also mention/include long-term monitoring pursuant to typical SOW requirements from AOC, CD, etc.	Included as suggested.
136	Section 10.4.2.2	10-17	Delete the first sentence “Institutional Controls are generally relatively easy to implement” or clearly define which elements Lockheed believes would be easy. Since the following paragraph adequately describes challenges that can be encountered -- EPA’s experience with implementing UECA’s and Coast Guard navigation or no anchor restrictions – there is also no information provide regarding how the Muckelshoot and/or Suquamish Tribes feel specifically about fish advisories for the Lockheed West site, or how the Port of Seattle or Department of Natural Resources feel about specific ICs or if they would be willing to implement them.	The first sentence was deleted as suggested. Additional text was added to address the rest of the comment.
137	Section 10.4.2.2	10-17	Delete line 15 – “Institutional controls are generally relatively easy to implement.” Later the section offers contrary examples to this and the sentence doesn’t add any value to the overall discussion.	Line 15 was deleted as suggested.
138		10-17	Line 25 - Further expand implementability discussion to include future aquatic land use considerations.	Discussion was added as suggested.
139		10-17 and 10-18	Clarify how the alternatives address compliance with the SMS narrative standard for protection of human health.	The comment was addressed in Section 12. This section focuses on screening of remedial technologies. A discussion of compliance with SMS fits into the detailed evaluation of alternatives section.

Specific Comments – Sorted by Page Number

Comment Number	Section	Page	Comment	Response
140	Section 10.4.2.3	10-18	Include the statement that the intent of the design will be to minimize IC's and not impact (restrict) the U&A areas.	The statement was included in Section 10.4.3.
141		10-19	Line 18 - Table 10-4 should include governmental controls and enforcement/permit tools as separate categories. Enforcement tools are not administratively the same as information devices.	Revised as suggested.
142		10-20	Line 9 - Viability of this mechanism to reduce contaminant concentrations is marginal given the extent of near surface contamination and apparent limited net sediment accumulation. Bioturbation within the upper foot or so of the sediment profile would mix contaminated sediments with contaminated sediments. Deeper bioturbation would be expected to be incomplete and spotty at best. Additional rationale/evidence should be presented, or this section reworked. MNR should be 1) clearly and consistently discounted throughout the document based on lack of more substantive evidence, or 2) acknowledged as potentially occurring but with major data gaps as to actual data. Either way, FS should clearly convey that ENR is not "taking credit" for MNR via sediment accumulation or other contaminant reduction mechanisms.	The discussion of MNR and ENR has been clarified in the text by dividing them into separate sections and describing individually. It is noted in the text that MNR is not carried forward in any of the FS alternatives, though it is retained as a potential component for the design phase if future data indicate a value to the project.
143	Section 10.5.1	10-20	Lines 24-25 - Further clarify how ENR "may reduce contaminant concentrations in the bioactive zone by up to 50 percent through dilution alone, i.e. mixing via bioturbation, but without assumed added degradation mechanisms such as natural sedimentation. Line 24 mentions the "long-term steady state equilibrium condition", state when this is expected to occur. Also, provide further explanation as to why meeting the SQS through placement of ENR at 2xSQS on approximately three-quarters of the Site meets the PRGs set for this project.	See response to comment 142 on the separating of MNR and ENR in the revised text. It is not possible to determine when "long-term steady state" will be reached after the completion of construction. The application of ENR based on 2 x SQS is based on the relatively low concentrations present in the surface sediments over much of the site, and the ability of ENR to contribute to the reduction of the concentrations for the risk-driver COCs on a site wide basis towards or to the PRGs for RAOs 1,2 and 4 and the achieving of the PRGs for RAO 3. In addition, outside of the drydocks and some isolated locations, much of the Site only has contamination present in the surface sediments with the underlying sediment having significantly lower concentrations.

Specific Comments – Sorted by Page Number

Comment Number	Section	Page	Comment	Response
144	Section 10.5.1	10-20	Overall, the ENR discussion throughout the document needs to be more consistent in identifying for this specific site what ENR is. Sometimes, ENR is discussed in conjunction with MNR, as a "boosting" influence to enhance the natural depositional environment and give the surface sediments an additional 4-6+ inches (or 6-9 inches is referenced in line 26) of clean material to mix with. At this site, because it is a low depositional/erosional environment, ENR is not being used to jumpstart the MNR processes and as discussed later in the report, MNR is not considered a viable alternative here. Therefore explain specifically what is meant by "ongoing recovery processes" that are expected to be taking place in order to reduce the bioavailability or toxicity of contaminants in sediments and why in the areas later identified for ENR the contaminant levels are amenable to this thin-layer cap versus a 3 foot engineered cap. These may be the same process discussed by Merritt et. al. in their 2009 paper, or different ones that are specific to this cleanup area.	See responses to comments 142 and 143.
145	Section 10.5.2.1	10-21	EPA does not believe that Monitored Natural Recovery (MNR) is a remediation option at the Lockheed West site. Page 10-1, bullet one states that Section 10 will "Identify and screen appropriate remedial technologies and process options for cleanup of the Lockheed West Site sediments." As is stated on Page 10-20, "MNR as a remedy is evaluated through a multiple lines of evidence approach used to qualitatively assess the combined action of site-specific physical, biological and chemical mechanisms to reduce the availability of contaminants." This project has not actively evaluated these lines of evidence at this site and EPA in not satisfied that this should be evaluated as a remediation option at this late stage of the cleanup evaluation process. Also, the text on page 10-21 states that "Observations of recent bathymetric data and knowledge of Site use and dredging history indicate the bottom surface has not changed significantly since the era of historic operations" which further supports EPA's position. The second paragraph of Section 10.5.2.1 concludes by stating, "However, MNR may be effective as a component of a combined remedial alternative." This is unlikely based on the facts that very little sediment deposition occurs in this area. Therefore, the top of the cap and/or dredged surface following an engineered remedy will need to be considered the "final" surface of those locations.	Comment noted. See response to comment 142.
146	Section 10.5.2.1	10-21	It is presumed in paragraph 3 that in areas where hazards presented by contaminated sediment are relatively low (COC concentrations equal or less than two times the RAL) which in many parts of this document means " 2 times the SQS". If it is the case that ENR would not be protective in these areas, it would only meet RAO 3 –protective of benthic invertebrates, and may not be protective of RAOs 1, 2 and 4 which are developed to be protective of human health (e.g., clams burrow up to 45 cm. and would be exposed to sediments greater than SQS).	See responses to comments 142 and 143.
147		10-21	Line 18 - EPA agrees that there is less likelihood that bioturbation is viable mechanism for MNR as described above. Clarify these sections for consistency.	See responses to comments 142 and 143

Specific Comments – Sorted by Page Number

Comment Number	Section	Page	Comment	Response
148	Section 10.5.2.1	10-21	RI Delete line 24 "MNR may be effective as a component of a combined remedial alternative" as this may be true in the larger sense for "any site" to consider, but specifically for the Lockheed West Seattle site this is not true for the reasons identified in the previous sentence.	See response to comment 142.
149		10-21	Line 24 - Not supported nor included with current alternatives. Clarify or discard per comment above.	See response to comment 142.
150		10-21	Line 27 - Remedial action levels are not defined for LW until Section 11, suggest using some other term.	Text revised to refer to SMS criteria and not remedial action levels.
151		10-22	Line 9 - Delete that MNR is technically feasible and delete from screening process.	See response to comment 142.
152		10-22	Line 13 - Clarify this applies only to the monitoring component of for MNR.	See response to comment 142.
153		10-22	Line 20 - Include an example of "reactive material."	Text revised to include examples of "reactive material."
154		10-22	Line 28 - Per comments above, MNR has limited applicability based on known extent of near-surface contamination and current understanding of deposition rates. MNR is also not used in current alternatives and unlikely to be applicable in the future. Should be rejected based on lack of expected effectiveness, or provide further evidence to support retaining it.	See response to comment 142.
155	Section 10.6	10-23	Overall, a seismic analysis will need to be completed, preferably prior to the Proposed Plan, to ascertain the relative surety that in a reasonably anticipated seismic event for this region, that engineered caps, and ENR capped areas, will stay in place in all of the areas they are proposed if this seismic event occurs. Now that this has been completed, Appendix H submitted in November 2011, modify this section to reflect these findings.	A discussion was added in Section 10.7.1.1 to incorporate the comment. This is a general description section. The findings of the seismic analysis were incorporated into detailed and comparative evaluations of alternatives.
156	Section 10.6.1.1	10-23	Cautionary note, while the statement that "riprap can be used to stabilize a cap and underlying sediments, and cobbles can be used to minimize bioturbation from burrowing organisms" be cognizant that this is a tribal treaty U&A area and caps will need to be designed to support clamming and fishing activities. Therefore, if it is believed that this is an erosional environment, then more capping material will need to be placed vs. adding a layer of riprap and cobbles on top, in order to support the benthic infauna necessary for fish foraging. Caps need to be designed to meet site specific uses, and this is a significant one. Add language to this section clarifying this point.	Requested language was added to the section.
157		10-24	Line 3 - Include stability during seismic events in remedial design considerations.	A new sentence was added to address the comment.
158		10-25	Line 16 - Overwater pneumatic placement should also be mentioned/included.	Requested cap placement method, surface discharge using conventional equipment, was added as the first bullet.
159	Section 10.6.1.1	10-27	Lines 1-3 - clarify this point. In order to decide if a cap is appropriate at a site, long-term monitoring data / confirmational monitoring data will not be available yet, so clarify how this information will be used pre-decision).	The text was revised for clarification.
160		10-27	Provide more recent data regarding reactive caps if there is something available since 2005 and summarize the latest discussions at LDW.	More discussion was added to Sections 10.7.1.3 and 10.7.2.2 by incorporating recent research to address the comment.

Specific Comments – Sorted by Page Number

Comment Number	Section	Page	Comment	Response
161	Section 10.6.2.1	10-27	Provide further elaboration as to what is meant by "A significant decision factor (emphasis added) for the use of a sediment cap is the requirement for long-term monitoring of cap integrity and maintenance…." The following list of decision factors in the NRC report, does not identify this factor.	The sentence was revised and moved to the end of the Section 10.7.2.1.
162	Section 10.6.2.1	10-27	An additional decision factor that also shall be considered is seismic stability of the region and specifically of the site to ensure that a cap would be stable in the event of most likely seismic events and/or that the material the cap is containing will stay in place.	Seismic stability issue as one of the decision factors was added to the end of Section 10.7.2.1.
163	Section 10.6.2.4	10-28	The cost discussion is for capping technologies, but also state that costs for the requisite ICs will need to be included as well.	Added as requested.
164		10-28	Line 20 - This sentence does not make sense (clarify/smooth). Suggest deleting "at this time." Given the type and concentrations of site contaminants, EPA is evaluating whether reactive or composite capping would provide additional benefit relative to conventional capping.	Revised as suggested.
165		10-36	Line 12 - State potential piling, bulkhead, and debris removal methods.	Piling and debris removal is discussed under cap and removal technologies and in Section 11 under common remedy elements. Such removal methods are not considered typical ancillary technologies, therefore not added to this section.
166		10-38	Line 18 - State whether Mechanical conveyor transport/transfer is also considered.	Mechanical conveyor systems were added as recommended.
167		10-39	Line 14 - State that no PTWs have been identified at LW site.	Revised per the comment.
168		10-42	Line 1 - Section should emphasize that treatment methods in general are expected to provide limited incremental benefit re: toxicity reduction/destruction and immobilization relative to off-site landfill disposal. (Unless necessary to physically solidify dredged materials containing free water, prior to off-site landfill disposal).	A sentence was added to the end of the first paragraph to emphasize the incremental benefits of treatment per the comment.
169		10-46	Line 5 - Or on adjacent land areas. Indicate that off-site disposal will require consideration of appropriate permitted facilities away from the site and vicinity.	Off-site disposal options were discussed in Section 10.10.1.2. This section (10.10.1.1) covers on-site disposal.
170		10-52	Include tribal treaty rights and treaty-protected resources in the CDF discussion.	Included per the comment.
171		Table 10-1	Thin-Layer Replacement should be Thin-Layer Cap.	ENR is thin-layer placement. Thin-layer caps are meant to be isolation caps.
172		Table 10-2	Conveyor between barge and upland?	In Table 10-2, conveyor between barge and upland is not listed as a transport option.
173		Table 10-4	Governmental Controls and Enforcement/Permit Tools? Process options should include monitoring.	Table 10-4 was revised to address comment.
174		Table 10-5	See text notes on concerns re: retention of MNR based on effectiveness.	Table 10-5 entries are consistent with the text. Revisions were made in terms of technology type and process options.
175		Table 10-6	Retain composite and reactive for FS evaluation.	Composite and reactive caps were retained for design. Both types of caps require design level evaluation in order to implement. At FS level evaluation, all caps were treated as conventional caps.

Specific Comments – Sorted by Page Number

Comment Number	Section	Page	Comment	Response
176		Table 10-8	Include piling/bulkhead/debris removal technologies as retained technology in Table 8.	This table is not meant to be comprehensive of all ancillary technologies. Therefore, not all of them are listed in this table.
177		Table 10-10	Bottom right cell, Add “or TCLP failure.”	Added per the comment.
178		Table 10-11	Upper right cell – On-site disposal of dredged material. Should be rejected if not further considered for FS evaluation and based on background provided in text.	During RAA approval process, it was EPA’s direction to keep CDF and CAD for design but not incorporate into the FS.
179		Table 10-12	See previous Section 10 text and table notes re: retention of MNR, composite/reactive capping, CAD/CDF.	Screening decisions identified in Table 10-12 are consistent with previous text in Section 10. MNR decision was revised to “Retained for design but not carried forward for detailed analysis in the FS.”
180		Table 10-12	Upper left cell. Clarify” retained in conjunction with other technologies/process options”, rather than stand-alone.	Refer to Comment #179 response.
181		Figure 10-1	Indicate the U.S. Army Corps of Engineers navigational dredge channel on this Figure.	Figure revised as requested.
182	Section 11 Introducti on	11-1	Overall, Section 10 acknowledges that ENR (and MNR) are ”supplemental” measures that would be done in conjunction with site capping and/or dredging. However, the second paragraph in Section 11, states “For this FS, active remediation refers to capping, dredging, ENR (emphasis added), or some combination of the three.) EPA believes that ENR should be supplemental; however, many of the FS alternatives rely on ENR for over 50% of the Site. Additional rationale should be included about ENR as a significant component of the alternatives considered and how ENR will achieve the PRGs for this Site.	ENR (and MNR) are supplemental to dredging and capping as these technologies cannot meet the RAOs for areas with concentrations above a certain threshold. It does not necessarily mean that ENR (and MNR) are spatially limited. A flowchart depicting the process for selection of each remedial technology was added to Section 11.2. Additional discussion regarding ENR was added to Section 10.
183	Section 11.1	11-2	In the discussion of the AOPAs, it is stated “For the purposes of the FS, three AOPAs are defined. They represent potential remedial footprints that would achieve the remedial goals if the PRGs are set to 1) the SQS, 2) an anthropogenic background level (e.g., Urban), or 3) the RBTC/natural background.” In Section 9.4.5, all of the PRGs for RAOs 1-4 cleanup are explained and identified on Tables 9-5 and 9-6. The approach for selecting PRGs in Section 11 appears to disregard the process developed in Section 9. The PRGs identified in Section 9 needs to be used.	The text has been revised to clarify that the PRGs are based on the RAOs as noted in Section 9.
184	Section 11	11-2?	The language in the RAOs call for a “reduction” in human health and ecological risks (not a complete elimination), so in principal any contaminant cleaned up to a lower concentration than those found at the site now would result in a “reduction” of risk to human health and ecological benthos. For example, If SQS or the anthropogenic background is selected as a an RAL, then RAO 3 will be met, and RAOs 1, 2 and 4 will be met but to a lesser extent (i.e., these chemical concentrations will be protective of benthic invertebrates, and the human health risks for RAOs 1, 2 and 4 will reduced, but these concentrations will not be as protective for humans as they are for benthic invertebrates). If RBTC/natural background is selected, then again, all of the RAOs will be met since the criterion is to “reduce” the risk to human health and benthos.	Comment noted. Text has been revised to address the RAO language on “reduction” in risks.

Specific Comments – Sorted by Page Number

Comment Number	Section	Page	Comment	Response
185	Section 11.1	11-2	Add a discussion that gets to the idea presented above – RAOs call for a reduction in risk, not total elimination. A capping/dredging to clean background alternative would, albeit temporarily, completely eliminate risk. Any cleanup resulting in lower contaminant concentrations than are at the site today, would result in "reduced risk", and based on the overall environment which this site is located (Elliott Bay and adjacent to Superfund sites that were only cleaned up to the SMS SQS), this site will not maintain the post-remedy levels of protectiveness for human health or the environment.	The text has been revised to discuss the reduction in risk from the remedy, and how at the completion of construction the PRGs based on RBTCs or natural background are achieved and what the long term expectations are.
186		11-2	Line 15 - See ES section comments on AOPAs above. Same comment for Section 11.1.1.	Text has been revised to clarify the AOPAs and how they meet the RAOs.
187		11-2	Line 25 - Clarify text: AOPAs should address the most stringent PRG for each RAO – ultimately driven by the site boundary as representative of natural background. See comment for page ES-19, above.	The text has been revised to clarify how remediation within the AOPAs addresses the PRGs for the RAOs.
188		11-2	Line 27 - RALs, not PRGs. Here and elsewhere in Section 11 - PRGs must address natural background concentrations, not anthropogenic (unless waiver considered).	Text has been revised to indicate the numerical PRGs for the RAOs and how applying the RALs meets the PRGs.
189	Section 11.1.1.	11-3	In the SQS bullet, change "may" to "will" in the fourth sentence.	Text has been revised.
190	Section 11.1.1	11-3	In the Urban bullet, it is stated that "implementation of remedial actions within this area will likely address RAOs 2, 3, 4 and address RAO 1 to some extent." See comment above regarding "framing" that the RAOs call for risk reduction, not complete elimination of risk. Delete the word "likely" and provide further discussion about the phrase "to some extent" in this context (or frame this all before this discussion as recommended above).	Text has been revised to discuss how remediation within the Urban footprint achieves the RAO PRGs at the completion of construction and in the long term.
191		11-4	Line 4 - Modify to indicate the same as study area boundary in this case.	See response to comment 190 with text revised per the study area boundary.
192		11-4	Lines 3-6 - However, indicate that remedy application would temporarily achieve concentrations below natural background.	Text has been revised to discuss how remedies achieve natural background PRGs at the end of construction.
193		11-4	Line 10 - Include a site map showing the areas associated with each of the RALs listed. This RAL map differs from the Figure 11-1 AOPA map, and needs to set up discussion of where the various remedial alternatives would be applied.	The RALs are applied over a spatial area but also vertically for removal options. A flowchart depicting the process for selection of each remedial technology was added to Section 11.2.
194	Section 11.1.3	11-5	RAO 2 states that "the application of the remedial actions based on the RALs defined above is expected to achieve RAO 2." This appears to assert that whether the RAL is the SQS or Natural Background, the RAO will be achieved regardless. Confirm and explain how this is the case.	RAO 2 is not based on SQS. The COCs and PRGs for RAO 2 are noted in the text.
195		11-5	Line 8 - Clarify that this is also applicable to capping and ENR options on a temporary basis.	Text has been revised to indicate that the RBTC/natural background RAL can be applied to the Study Area boundary.
196		11-5	Line 18 – Clarify that the natural background concentration is achievable as a PRG for RAO 1 on a short term basis, prior to re-equilibration with the surrounding environment.	Text has been revised to discuss that by applying a RAL at the end of construction the PRGs for RAO 1 can be achieved.
197		11-5	Line 21 - Clarify that the need for ICs is based on other factors (need for fish advisories, cap protection, etc.).	Text has been revised to clarify why ICs are required for some remedies.

Specific Comments – Sorted by Page Number

Comment Number	Section	Page	Comment	Response
198		11-5	Line 25 - Change to "RBTC levels."	Text revised per comment.
199	Section 11.1.3	11-6	Regarding RAO 3, if a CSL RAL is selected (e.g., concentrations greater than the CSL were capped/dredged, and surface concentrations of a dredged surface were CSL) this would not meet the RAO and be protective of the benthos. Selecting SQS as the RAL would be. Also, this paragraph states, "This is a conservative approach because long-term natural recovery, which potentially reduces the surface sediment concentrations is not included in the evaluation." However, as noted above in comments regarding Section 10.5.2.1, natural recovery processes are not dynamic at this site through multiple lines of evidence used.	The situation described in the comment (i.e., concentrations greater than the CSL were capped/dredged, and surface concentrations of a dredged surface were CSL) is addressed by the stepwise process used to evaluate appropriate remedial technologies. A flowchart depicting the process for selection of each remedial technology was added to Section 11.2. This is a conservative approach since any long term natural recovery that is occurring, even if minimal, is not considered to provide any benefit to the ENR evaluation.
200		11-8	Line 4 - Except for "no action " and Alternative 4, include site-wide monitoring.	Text revised per comment.
201		11-8	Line 7 - Clarify off-site upland disposal.	Text revised per comment.
202		11-9	Line 20 - Should be PRG exceedances.	The application of a technology to an area is based on its ability to achieve the RAL not necessarily the PRG.
203		11-9	Explain the basis of the upper confidence limit for ENR of two times the RAL. If it is also assumed that ENR will result in a 50% decrease in contaminant concentrations, and that no additional natural recovery will occur, it seems likely that contaminant concentrations will remain at or above the SQS RAL for ENR areas and will not achieve the site PRGs. Clarify.	See response to comment 143 on application of ENR at the Site.
204	Section 11.3.1.2	11-10	There is a Termination Agreement between the Port and DNR which requires that all pilings in this area be removed. EPA expects that these piling will be removed by the time the Superfund remedy is implemented.	Text has been revised to indicate EPA's expectations.
205		11-11	Reactive and composite capping are included as technology retained for design, but were not carried forward for detailed evaluation or considered in the cost appendix of the FS. Deferring inclusion of these technologies to the design phase without further FS evaluation is confusing and may also bias cost comparisons. Provide relevant FS screening analysis and conclusions if this technology is to be further considered during design.	Text revised per comment.
206		11-11	Lines 21-23 - Clarify how composite/reactive caps provide further benefit over conventional caps based on effectiveness, implementability, or cost. Either retain for FS evaluation if further consideration is contemplated during design (and provide rational for doing so).	See response to comment 205.
207		11-12	Descriptions of ENR implementation assumes that sand will be placed as the capping material. Potential impacts to the nature of the substrate and to the benthic community must be considered. At the least, design should include a cover of material that is the appropriate grain size, etc. for the benthos in this area. It is preferable to place material with physical characteristics similar to existing sediments.	Text revised to indicate that the nature of the substrate will be evaluated in the design phase to determine the appropriate material to be placed.

Specific Comments – Sorted by Page Number

Comment Number	Section	Page	Comment	Response
208		11-12	State the fish window (June 15-February 15) for this cleanup area and verify that the duration for remedial activities will fit within this work window. Avoidance of tribal fishery activities will need to be coordinated with the Muckleshoot and Suquamish tribal finfish program managers. State that Consultation with tribal fisheries will need to be done to identify issues about working in the tribal U&As.	Stated the official fish work window and acknowledged that this window may be limited due to site-specific factors and that additional consultation with the tribes and other resource agencies will need to be conducted during design to confirm the assumptions.
209	Section 11.3.1.3	11-12	Line 1 - Confirm whether the August start time is correct. For LDW, a later timeframe (October/November) has been discussed, but EPA is not aware whether this applies to Lockheed West. If this Site also requires a later start date due to fish window or other considerations, this will affect the duration of the remedial alternatives and the duration to complete each alternative should be reevaluated.	See response to Comment # 208
210		11-12	Line 6 - This sentence should state that "ENR is included in areas where COCs are greater than PRGs after active remediation.	ENR is applied as described in response to comment 143.
211	Section 11.3.1.4	11-15	Slope Stability. Any habitat improvement or restoration options on SOAL will need authorization from DNR and the Port of Seattle.	Text revised per comment.
212		11-15	Line 5 – Clarify whether alternatives costing assume establishing a facility at T5, or somewhere else.	It was clarified that the cost estimates include setting up a transloading facility.
213		11-15	Line 21 - Clarify if additional coastal engineering work is planned during design to address these details.	Clarified as requested.
214		11-16	Treatment of shoreline areas will need to be coordinated during remedial design with EPA, the stakeholders and the tribes. Make it clearer that in the middle of the north face of Terminal 5 the large rip rap that is currently there serves as shoreline protection and will remain in place. However, state that fish mix will be placed in the interstices of this riprap to provide a more favorable environment for aquatic species.	Revised the text as suggested.
215		11-17	Line 25 - Needs clarification re: governmental controls per comments in Section 10. CERCLA administrative requirements as governmental controls will remain through long-term O&M monitoring and should be included.	The section was revised per this comment and similar comments given in Section 10.
216	Section 11.3.2.3	11-17	Add a paragraph that discusses site cleanup realities; that fish advisories would be needed regardless of the Site cleanup alternative even if complete dredging occurs because the Site PRG (2 ppb) is a 2x10-4 risk.	Text was added to incorporate the comment.
217		11-17	Line 26 - Short term fish advisories may still apply.	A sentence was added to incorporate the comment.
218	Section 11.3.2.3	11-18	Describe why proprietary controls (or ICs in general) would be necessary with an engineered cap, but not with ENR which typically is used in the various alternatives as a 1 foot layer over 2 times the SQS concentrations. Unless designed to not need them, an engineered cap would require navigation ICs which include no anchor and no scour zones.	Additional discussion was added to address the comment.
219	Section 11.3.2.3	11-18	Although institutional controls are not required for ENR, add a clarifying sentence(s) that EPA will require ongoing monitoring to ensure ENR's long-term effectiveness and protectiveness. Move the last sentence of 11.3.2.3 after this explanation.	Clarifying sentence was added to the section as requested.

Specific Comments – Sorted by Page Number

Comment Number	Section	Page	Comment	Response
220		11-18	Cost estimates based on a 30-year period for ICs and O&M may underestimate long term costs and may bias cost comparisons between alternative. The costs determined for ICs will likely be based on a calculation that some use of this area will be limited forever. In addition, though EPA guidance suggests a 30 year period for cost purposes, as long as a cap is in place to contain contaminants, long-term monitoring will be required in perpetuity; and at a minimum before each Five Year Review is conducted. Lockheed Martin shall state that although EPA requires cost estimating for 30 years, the cap will be in place forever, and costs and responsibility will be associated with it forever.	Clarifying sentence was added to recognize the indefinite requirement of long-term O&M associated with the cap.
221	Section 11.3.2.4	11-18	Lines 23-24 - Monitoring, at least in the short term, may also be needed in the case of complete removal to assess recontamination.	A sentence was added per the comment.
222		11-18	Line 26 – Add, “and Alternative 4”, and although cost projections are only required for 30 years as per EPA guidance, any site with a capping remedy will be monitored and maintained in perpetuity.	Revised per the comment.
223	Section 11.4	11-19	Line 11- Revise to read plus or minus as opposed to greater than and less than.	Revised as suggested.
224		11-19	Line 22 - Clarify - ENR is not targeted as a containment methodology even though it may provide some containment benefit.	Clarifying sentence was added per the comment.
225		11-20	Line 9 – Clarify that POS is responsible for piling removal per previous agreement with DNR.	This clarification was made in Section 11.3.1.2.
226	Section 11.4.3.2	11-24	Here and for all dredging alternatives, describe how the depth of dredging will be determined. Even if the decision criteria are very simple (e.g. dredge down to the depth of the RAL exceedance, as modeled), it would be helpful to have it laid out explicitly, since some of the other alternatives include limited dredging down to 3 feet. This description could be included in the description of each alternative, or could be placed up front if it will be identical throughout the dredging alternatives.	Requested discussion was added to Section 11.3.1.4 where common elements of removal activities were discussed.
227		Figures 11-3 through 11-17	The areas of various dredging, capping, and ENR application are confusing and don’t seem to follow the pattern of available surface or subsurface sampling data and testing results. For example, figures most of the alternatives show odd shaped blips for active remediation in the southernmost “panhandle” area of the site in the WW. However, there appears to be no sampling data (RI, 2003, or earlier) in this area? Per Appendix D, it is understood that the area estimation approach using krieging can create odd shapes (at the FS level), but some of the area shapes look like computational artifacts rather than based on actual sampling data. This requires further clarification.	There was data collected in the area of the south between the Terminal 5 uplands and the West Waterway. Within this area are some isolated locations with exceedances of SQS and Urban levels (TT-04). These exceedances result in small localized areas being identified as within a remedial footprint.
228		Figure 11-8 and Figure 11-9	Change the legend on Figure 11-9 to be consistent with the map.	Legend was corrected to be consistent with the map.
229		Figure 11-12	The legend should state “cap to > 2xSQS” instead of “cap to 2xSQS.”	Revised per the comment.

Specific Comments – Sorted by Page Number

Comment Number	Section	Page	Comment	Response
230		Figure 11-13 and 11-14	Both of the legends identify "Remove to CSL in Dry Dock 1", but the area indicated on Figure 11-14 is almost double in size compared to Figure 11-13. Clarify.	The legend in Fig. 11-14 states "Remove to CSL in Dry Dock Areas" as compared to Fig, 11-13 states "Remove to CSL in Dry Dock 1".
231		Figure 11-14	Clarify how much of the area capped by ENR to Urban exceeds SQS.	Additional information on post-construction residual risk driver contaminant concentrations by depth were included in Section 12 as new figures that visually display the answer to this comment.
232	Section 12	12	Lockheed Martin shall provide further explanation regarding how meeting RAO1 will be evaluated using a Site Wide Averaging Concentration (SWAC), or how RAO 3 will be evaluated using a point by point basis in addition to the site-wide averaging approach described on pages 12-3 and 12-4. This should be provided for the 3 different remedy "types" and include the calculations and assumptions that are used, and the "remaining" residual concentrations left on the site after the remedy is implemented.	The commented section was revised for clarification. Refer to Section 12.1.2.1 for the methodology for residual concentration calculations and assumptions used. Refer to Table 12-3 for the summary of the calculated residual concentrations.
233	Section 12	12	Additional consideration of future seismic risks is needed for alternatives with capping and ENR components. This should include O&M for potential repair and replacement of capping components, and additional remediation if needed if released contaminants redistribute and spread to other areas of the site or off-site.	The results of seismic evaluation were incorporated into long-term effectiveness and permanence evaluation of all alternatives.
234		12-2	Lines 18-25 - This description includes slight enhancements to description of overall protection of human health and ecological receptors in the NCP. These enhancements should either be explained, or the description be changed to match the wording as presented in the NCP.	The description was revised to match with the NCP.
235		12-2	Lines 27 through and page 2-13 lines 1-17 – The description of Compliance with ARARs do not match language in NCP "(B) Compliance with ARARs. The alternatives shall be assessed to determine whether they attain applicable or relevant and appropriate requirements under federal environmental laws and state environmental or facility siting laws or provide grounds for invoking one of the waivers under paragraph (f)(1)(ii)(C) of this section."	The description was revised to match with the NCP.
236	Section 12.1.1.2.	12-3	The description starting on line 10 of the alternatives meeting all of the other ARARs (i.e., the ones other than specifically specified in this section) needs more detail. A description of how the alternatives meet the substantive portions of the other ARARs must be provided.	More detail was added to the section stating that the decision on compliance will be made based on the details provided in the remedial design and remedial action work plan to be prepared during design.
237		12-3, line 4	Only 3 of the ARARs are applied without sufficient rationale for why other relevant ARARs were not evaluated. Add language requested in previous comment regarding ARARs.	Details provided per the Comment #236 also address this comment.
238		12-4, line 3	This discussion is confusing because of introducing the concept of site-wide averaging for SMS-related data rather than point by point, and conflicting metrics. Is the purpose of the discussion to point out that scattered exceedances of SQS still comply because they are isolated? If so, state more plainly or otherwise clarify. Why is the 98% number chosen as a metric? For each alternative identify what stations and COCs remain in excess of SQS criteria following remediation.	The section was revised per this comment and the Comment #232.

Specific Comments – Sorted by Page Number

Comment Number	Section	Page	Comment	Response
239		12-3	Lines 8–18 - description does not match the NCP. The NCP language should be referenced directly: "Alternatives shall be assessed for the long-term effectiveness and permanence they afford, along with the degree of certainty that the alternative will prove successful."	The description was revised to match with the NCP.
240		12-5, line 23	MTCA natural background has been defined using the Bold study using a 95UCL on the mean, not the 90th percentile. Edit.	Edited per the comment.
241	Section 12.1.2.1	12-7	Lines 14 and 25 - State whether the average or the 95% UCL on the average used for this ratio.	Clarified that the mean was used for this ratio.
242		12-8	Magnitude of Subsurface Residual Risks Discuss the results of the seismic evaluation.	Discussion was added to the section summarizing the findings of the seismic evaluation.
243		12-8	Magnitude of Subsurface Residual Risks. On line 12, it is stated potential impacts from a seismic event would be reduced "as natural recovery progresses." However, there is little to no supporting information that there is natural recovery occurring on this site. Delete this sentence.	The sentence was deleted per the comment.
244		12-8	Lines 10-11 - This states that determining the seismic stability of caps is deferred to design stage. Update based on the seismic evaluation that has now been completed.	The write-up was updated based on the results of the seismic evaluation.
245		12-9	Adequacy and Reliability of Controls, line19. Add a sentence about the likelihood of sediment recontamination above the Urban background concentrations and that although not known for certain, but that recontamination above these concentrations is unlikely based on concentrations seen at adjacent Superfund sites that have been remediated in the past 5-7 years.	A sentence was added and a reference to Table 5-1 was included, which is a summary of data from adjacent Superfund sites.
246		12-9	Maintaining the condition of the remedy is a main component of long term protectiveness. If repairs are needed, then they will be made consistent with the type of cap needing repair in order to maintain its protectiveness—a three foot cap or a thin-layer cap.	The sentence was revised to state that the repairs will be consistent with the original remedial design intent such as maintaining 3-feet conventional cap.
247	Section 12.1.2.1	12-9	Line 2 - Monitoring and maintenance is also required for "no action" areas outside of the capping and ENR boundaries, i.e. it is not correct to assume that monitoring and maintenance requirements increase in proportion to the area with caps & ENR, because that proportion would make large-cleanup-footprint alternatives look unduly expensive. Additionally, duration will not always increase in proportion to the cap/ENR area. Duration might be the same for all alternatives, or might be specified to continue until recovery is complete, so smaller cleanup footprints that leave more exceedances behind might require monitoring for a longer period of time. Beyond maintaining the remedy, Lockheed Martin will be required to also make sure the overall objectives of the site cleanup are being achieved too.	Monitoring requirement in no action areas to the study area boundary was added. The "duration" was deleted from the sentence for consistency.

Specific Comments – Sorted by Page Number

Comment Number	Section	Page	Comment	Response
248		12-10	Adequacy and Reliability of Controls. More specific ICs need to be identified so that reviewing parties (EPA, stakeholders, public and owners of the property) can evaluate the effectiveness and implementability (therefore, long-term protectiveness) of each of these measures. For convenience, a list of ICs that will be necessary for capping, ENR, and dredging should be identified specifically. Break out the IC's from 2 categories into approximately 7 discrete bullets, or whatever is applicable, then evaluate them against the 9 criteria like you would evaluate capping/dredging/ENR. Specifically, implementability and long-term effectiveness are key. Also, this discussion states that proprietary controls would prevent "…the owners of the property subject to the covenant from conducting any activity that could result in the release or exposure to the environment of residual contamination." This is not strictly the case with proprietary controls. Regardless of the cleanup remedy, in the future, EPA will closely with the property owners as new developments occur to make sure that development can happen while implementing short-term controls to minimize potential residual risks.	Specific ICs applicable to cap, ENR and dredge areas were outlined. Suggested narrative regarding the proprietary controls was added to the section.
249		12-10	Lines 17-22 - Description for Reduction of Treatment, Mobility and Volume does not match NCP description. The NCP language should be referenced directly: "The degree to which alternatives employ recycling or treatment that reduces toxicity, mobility, or volume shall be assessed, including how treatment is used to address the principal threats posed by the site." Also note that no Principal Threat waste is present at site.	The description was revised to match with the NCP. It was noted that there is no principal threat waste at the Site.
250		12-11	Line 3 - Add citation for "EPA guidance."	Citation was added.
251		12-12	Lines 5 and 6 - NCP states first consideration a bit differently-- "Short-term risks that might be posed to the community during implementation of an alternative." Modify to reflect the language presented in the NCP.	The description was revised to match with the NCP.

Specific Comments – Sorted by Page Number

Comment Number	Section	Page	Comment	Response
252	Section 12.1.2.3	12-13	Tissue concentrations are not expected to remain elevated for the entire construction period; only for the portion of the time when the highest sediment contaminant concentrations are being actively dredged. This topic is being discussed between LDWG and the agencies in relation to the Duwamish FS, and the draft version should not be cited at this time. Instead, provide data from other completed remediation sites where monitoring was done and state whether it supports the assumption that concentrations will remain elevated throughout and after construction. Our experience with the Hudson and Fox Rivers indicates that the increase would be of short duration (<1-2 years). LDW text states -- Draft Final FS, page 9-10. Fish and shellfish tissue concentrations are also assumed to increase and remain elevated during the course of the multi-year construction periods and for some time thereafter, based on documented experience at other sites (City of Tacoma and Floyd│Snider 2007b, BBL 1995a and 1995b, Bauman and Harshbarger 1998). Bauman, P.C. and J.C. Harshbarger 1998. Long-term trends in liver neoplasm epizootics of brown bullhead in the Black River, Ohio. Environmental Monitoring and Assessment. October 53(1): 213-223. 1998. BBL 1995a. Non-time Critical Removal Action Documentation Report, Volume 1, Grasse River Study Area, Massena, New York. Blasland, Bouck, and Lee, Inc. Syracuse, New York. December 1995. City of Tacoma and Floyd|Snider 2007. Thea Foss and Wheeler -Osgood Waterways Remediation Project. Year 0 Baseline Monitoring, Annual Operations, Maintenance, and Monitoring Report. Prepared for the U.S. Environmental Protection Agency, Region10, Seattle WA. February 28, 2007.	Comment noted. The section was revised based on recent data of Fox River OU1 post-remediation monitoring results which also refers to other large dredging projects including Hudson River.
253	Section 12.1.2.5:	12-14	Cost. The remedial alternatives at this site have differing life cycle cost estimates. Some of these alternatives (such as capping) will have life cycles much longer than 30 years, some (such as complete dredging) much less. By placement of restrictive covenants and issuance of easements, costs that account for altered fish and wildlife habitat, DNR and Port of Seattle rents, response costs for changing land uses, and restrictions on public access, will be forever and not just the 30 years identified. Note this in this section.	A discussion was added to the section per the comment. It was acknowledged that life cycle of cap and ENR remedies may be longer than 30 years. However the cost estimates were based on 30-year analysis for consistent comparison. The longer life cycle of these remedies were incorporated during the other NCP criteria analyses.
254	Section 12.1.2.5	12-14	Line 2 - On the Duwamish FS, an early draft used this same methodology of zero discount factor for construction costs, but agencies required a change to a 3% discount factor. Please justify using zero or else make this consistent with the 3% discount factor used for the other costs. The CERCLA cost estimation guidance recommends a discount factor of 7% for PRP-led cleanups. (Section 4.3 of http://www.epa.gov/superfund/policy/remedy/pdfs/finaldoc.pdf).	The statement was corrected. The present value of 30-year duration ICs and long-term OM&M costs were calculated based on 3% discount factor.
255		12-16	Section 12.3 and elsewhere re: Alternative 2A2a. The engineered capping area should be extended to the 2 x SQS boundary to capture potential SQS exceedances not be expected to be addressed by ENR.	The application of a cap and ENR is explained in the flow chart added to Section 11.2.

Specific Comments – Sorted by Page Number

Comment Number	Section	Page	Comment	Response
256	Section 12.3.1	12-17	Containment Focus: Overall protection of human health and the environment. The administrative feasibility of institutional controls such as restricted anchorage and navigation zones within federal an d state waterways needs to be evaluated and discussed with the Tribes as this area is their U&A area. Since the scale of institutional controls (to include more than notification of waterway users) will increase with proposed cap area for each alternative, the variable costs of these controls should be evaluated.	A sentence was added to address the comment. Requested evaluations were done in Section 12.3.3.2. The incremental effect of cap areas regarding ICs was incorporated into the cost estimates.
257		12-19	Magnitude of Subsurface Residual Risks. This paragraph states that, "The magnitude of subsurface residual risks was qualitatively gauged by evaluating the re-exposure potential from the sediment cores with concentrations above SMS criteria (emphasis added) and located within the remediated areas." Instead, this should be evaluated against the PRGs.	Consistent with RAOs established for this Site, surface sediment residual risks were evaluated against PRGs and the performance of alternatives meeting the Site RAOs were assessed accordingly. Subsurface residual risks were qualitatively gauged by evaluating the re-exposure potential from the sediment cores with concentrations above SMS criteria and located within the remediated areas. An evaluation of subsurface residual risks against the PRGs is not applicable to meet the Site RAOs. For additional information, post-construction residual risk driver contaminant concentrations by depth were also included in Section 12 as new figures.
258		12-20	Magnitude of Contaminant Mass Removal. State whether surface and subsurface areas that are >SQS and >CSL are co-located or if there are areas where deeper sediments are covered by clean or cleaner sediments. Also discuss mass removal of other dredge alternatives.	The first part of the comment was addressed in Section 12.1.2.1 under Magnitude of Residual Risk. It is correct that some cores with >CSL and >SQS may be co-located and deeper cores may be covered by a cleaner layer. Contaminant mass removal of other dredge alternatives was discussed in Sections 12.4.3.1 and 12.5.3.1 under Magnitude of Contaminant Mass Removal.
259	Section 12.3.3.2	12-21	Containment Focus: Adequacy and Reliability of Controls. Future use impacts resulting from the imposition of institutional controls should not only be identified but evaluated for their administrative feasibility.	Additional discussion was added to evaluate administrative implementability of these ICs.
260		12-21	Lines 14 and 15 – Clarify whether restrictions to future use are accounted for in cost estimates.	It was clarified that IC costs associated with future site use restrictions were accounted for but a third-party settlement cost was not included.
261	Section 12.3.5	12-22	Lines 25-29 - The evaluation of environmental impacts to habitat should also include residual contamination in habitat areas.	This paragraph lists short-term environmental impact metrics due to remedial construction. Residual contamination was discussed under long-term effectiveness and permanence criterion.
262	Section 12.3.5	12-22	The text refers to the benefits of natural recovery at this site which hasn't been established actually happens. Delete this sentence. Also, cite the studies that despite there being spikes in elevated fish tissue concentrations after dredging activities, that these concentrations decrease shortly after remediation is completed (e.g., within 1 year or less).	The commented sentence was deleted. Requested discussion and reference to previous studies were added to short-term effectiveness discussion of Alternative 3 and 4.

Specific Comments – Sorted by Page Number

Comment Number	Section	Page	Comment	Response
263	Section 12.3.5	12-22	Explain more clearly how site wide monitoring being “minimally intrusive” relates to “negligible potential risks to site workers.” Presumably the workers would still be on a boat regardless of the nature of the activities which has its own inherent risks.	The sentence was revised to state that “Sitewide monitoring and sampling activities will be relatively infrequent and less intrusive than remedial construction activities.”
264	Section 12.3.6.1	12-24	At some point a discussion about the type of cap (coarse and medium grained sand material) needs and the future use of the site (tribal and development) needs to be added if there are any limitations this type of cap may have on future use.	Discussion was added per the comment.
265	Section 12.3.6.1	12-24	Define the term “serviceability” in line 10. Also add to the discussion about verifying the success of a cap is to also verify benthic recolonization, abundance and diversity.	The word was revised to “remedial design intent” for clarification. A sentence was added about the use of SPIs to verify benthic community dynamics.
266	Section 12.3.7	12-25	Dredging/Capping Focus: Cost. EPA does not agree that costs associated with future use restrictions for capped areas should not be taken into account during the evaluation process. To acknowledge that institutional controls are a part of the remedial alternatives that assures the site remedy remains protective over time "consistent with the Site's future use" but to not evaluate the costs to those future uses is inappropriate. Make same note to Chapter 11.	IC costs associated with future use restrictions of capped areas were incorporated into the cost estimates but third-party settlement costs were not incorporated. Future use limitations were discussed and incorporated during evaluation of NCP criteria. Additional discussion and clarification was added to the section to address the comment.
267	Section 12.4	12-26	At the beginning of each of these “9 Criteria” sections, in bulleted format, re-identify the cleanup alternatives. There are enough alternatives, and “variations on the theme” it is hard to keep the nuances of the alternatives straight when reading though the comparative analyses.	The suggestion would cause unnecessary repetition. It would be easier to read the text while cross-referencing with the alternative figures and Tables 12-2 to 12-4.
268	Section 12.4.1	12-26	Identify how many fish meals/month are recommended by the Health Department for Elliott Bay currently.	Requested information was added to Section 11.3.2.3 Institutional Controls under Common Remedy Elements.
269	Section 12.4.1.	12-27	Overall, the potential for contaminant re-exposure mechanisms (e.g., scour, anchor drag, seismic) in ENR areas has to be further discussed by specifically identifying them and discussing what the result to the environment might be if any, or all of them, occurred.	Additional discussion was added on potential for re-exposure mechanisms in ENR areas in Section 12.1.2.1 under Magnitude of Subsurface Residual Risks. More discussion was also added to the commented section.
270	Section 12.4.1.	12-27,	Identify the types of ICs that would be “required to protect consumers of resident seafood during construction.”	A statement of the requirement for a short-term fish advisory during dredging activities was added to Section 11.3.2.3-Institutional Controls under Common Remedy Elements, 12.1.2.1- Adequacy and Reliability of Controls, Section 12.1.2.3, 12.4.1, and 12.5.1.
271	Section 12.4.1.	12-27	Line 13 - specifically identify the ICs anticipated for removal-focus alternatives.	All the applicable ICs were listed per the comment.

Specific Comments – Sorted by Page Number

Comment Number	Section	Page	Comment	Response
272	Section 12.4.3.1.	12-28	In Section 11.4.3 – Alternative 3 –Removal-Focus, the section only includes "removal of contaminated sediments with risk-driver COCs elevated above specific RALs and capping/ENR of the residuals…" However, in Section 12.4.3.1, Magnitude of Surface Sediment Residual Risks discusses whether the removal focus alternatives meet the RAOs. Clarify how dredging decisions are made for these alternatives. For example, dredging to the PCB and/or cPAH PRG was not anticipated because of depth and surface area considerations for these contaminants. Identify the driver contaminants for making these determinations. In addition, identify the concentrations and depths of PCB, lead, cPAHs and TBT after removal.	A decision making flow chart was included in Section 11.2 to illustrate the approach on application of technologies for each alternative. Additional figures were included in Section 12 presenting post-construction residual risk driver contaminant concentrations.
273	Section 12.4.3.1	12-29	Lines 1-4 - "Meeting" RAOs means that some reduction has to occur as the terminology used for the RAOs is to reduce and not to eliminate the different risk pathways. The way this is stated, it appears that all risk for RAOs 2-4 is eliminated. Clarify.	It was clarified by stating that "… meeting RAO 2, 3, 4 PRGs…"
274		12-29	Magnitude of Subsurface Residual Risks. Again, the magnitude of risk shall be compared to the PRG, not the SMS criteria for the best assessment of residual risk. Comparing this to the Urban Background numbers could also be done for an assessment of whether the subsurface residual risk might be greater than what is already found in the Elliott Bay area.	See response to Comment #257. Additional figures were also included in Section 12 presenting post-construction residual risk driver contaminant concentrations.
275		12-29	Magnitude of Subsurface Residual Risks, line 14. Section 11.1.2 doesn't discuss disturbance mechanisms. Either provide the correct citation or identify these mechanisms in this section. When discussing the disturbance mechanism, discuss the potential sediment concentrations that would be re-exposed based on the specific re-exposure disturbance mechanism (e.g., different disturbances may be more prevalent that others in different areas of the cap). Bottom line is that it is likely OK for ENR sediments to be exposed because the concentrations are very low (e.g., likely lower than SQS and likely lower than Urban background concentrations. State this more clearly.	Citation was corrected. Additional figures were included presenting residual risk driver contaminant concentrations after remedy.
276	Section 12.4.3.1	12-29	Lines 22-27 - Although in general the document is written fairly clearly, the discussion of re-exposure potential would benefit from the edits suggested below. Text currently reads: "Alternatives 3A1 and 3B would leave a similar level of subsurface contamination with CSL and SQS exceedances within the top 3 feet of sediments over the footprint of dredged and ENR areas (detected in two cores and nine cores, respectively)." It's difficult to determine what the "respectively" applies to –should the reader interpret this as saying that there are 2 exceedances in Alt 3A1 and 9 in 3B, or that both the alternatives have 2 CSL and 9 SQS exceedances, or that both the alternatives have 11 exceedances with 2 of them in the dredge footprint and 9 others in the ENR footprint. Looking at Table 12-4, it seems that the 3rd interpretation is right. If so, it would help to leave CSL out of the sentence completely, since it's included in SQS exceedances, and explicitly say "detected in 2 cores in dredged areas and 9 cores in ENR areas" rather than the parenthetical "respectively" clause. Similar comment each time this type of description of residual contamination appears.	Revised as suggested. "CSL exceedance" part of the statement was kept because it is consistently repeated at each time this type of description was given.

Specific Comments – Sorted by Page Number

Comment Number	Section	Page	Comment	Response
277		12-30	Adequacy and Reliability of Controls. The first sentence is redundant as all of the RAOs are based on human health and ecological protectiveness. State clearly that all of the PRGs are met or not.	Revised as suggested.
278	Section 12.5.2	12-34	Line 18 - Clarify the statement that “Although Alt 4C could theoretically achieve RAO 1 PRGs… it is generally not practicable to achieve natural background conditions at the Lockheed West Site.” Reconcile this statement with page 12-33, line 19 which states that “Alternative 4C can achieve the RAO 1 PRGs for the seafood consumption scenario” and page 12-35; line 15 “4C meets the RAO 2 PRGs.” Clarify whether 4C achieve RAO 1 or not.	The statement was revised for clarification.
279		12-34	Overall Protection of Human Health and the Environment. It is stated that alternatives 4B and 4C ”would not leave any subsurface contaminated sediment with concentrations above SMS criteria, therefore, no re-exposure potential following active remediation is expected (emphasis added).” However, both Alternatives 4A and 4B would result in re-exposure potential since residual risk is based on any sediment re-exposure greater than the PRG, which only Alternative 4C dredges to this horizon. This potential recontamination discussion is based on 2 cores with SQS exceedance in the top 3 feet. However, it should be based on cores with PRG exceedances in the top 45 cm.	See response to Comment #257. Evaluation of levels other than SQS to subsurface cores is not appropriate. The top 45 cm criterion is only for clamming scenarios in intertidal areas. Revised text to recognize negligible re—exposure risk for Alternatives 4A and 4B.
280		12-34	Overall Protection of Human Health and the Environment. Long-term monitoring will be required if concentrations greater than PRGs are left in the environment, therefore, Alternatives 4A and 4B would need to be monitored.	Long-term monitoring was added to Alternatives 4A and 4B, and the revisions were made accordingly.
281		12-36	Magnitude of Subsurface Residual Risks. Modify this section as Alternative 4B would result in re-exposure potential as concentrations greater than the PRG will be left in place.	Current discussion is correct and consistent. See responses to Comments #257, 274, 279.
282	Section 12.5.5	12-37	Also discuss the short-term impacts to elevated fish tissue concentrations as a result of dredge residuals.	Discussed as requested.
283		Table 12-3	Explain what the two green boxes in the lower left hand corner refer to. It is unclear if the upper one is related to PRGs and the lower one is related to SMS.	These boxes represent PRGs for RAO 3 and RAO 4. Revision was made for clarification.
284	Section 12	Figure 12-3a, 12-3b, 12-5a, 12-5b	The vertical scale for mass removal on all these figures should be adjusted so that the highest value coincides with (or is at least close to) the top of the figure. E.g. in 12-3a, all the values are less than 100 tons, so the scale should go from 0 to about 100 tons, rather than up to 1000 tons. This change would make it easier to compare success across different alternatives (as presented, all the values appear about the same). Same comment for figures 13-3a and 13-3b: the maximum values on the y axis should be 200 tons and 1 ton, respectively, rather than 1000 and 10.	Figures 12-3a, 3b, 5a, and 5b were revised as suggested. Figures 13-3a and 3b were not revised because such revision conflicts with the scale of relative contaminant mass/cy sediment line.
285	Section 12	Table 12-2	For RAO 2 - clarify whether 2A1 achieves cumulative risk ≤ 10 e-5. The other alternatives all have the word “cumulative” in this row, and I’m not sure if it’s missing here just because the column is too narrow, or because this value is intended to apply to each of the chemicals except for arsenic individually. Also, for Alternative 1, n/a should be defined as “not achieved” rather than “not applicable”.	Requested clarification was made in the footnote. Revision was made in definition of n/a per the comment.

Specific Comments – Sorted by Page Number

Comment Number	Section	Page	Comment	Response
286	Section 12	Table 12-2, 12-3, and 12-4	These tables would be easier to read if they were transposed, as it is easier to compare columns of numbers than long rows.	Comment noted.
287		Table 12-2	The term, “Total Managed Area” needs clarification. The entire 40-acre study area is the Study Area and will become the remediation area. Footnote 2 should be clarified to note that this includes areas of active remediation. Some alternatives show total managed area of 42 acres. Clarify whether this is an artifact of rounding or is something else. Construction time is 6 years for Alt 4B (802,500 cy) and 9 years for Alt 4C (1,214,000 cy). This works out to an annual production rate of 134,000 cy for each alternative. This annual rate is very low, and additional explanation is needed in the text. Provide some basic assumptions about numbers of dredge sets and productivity. If these are years per dredge set, then indicate in the text that overall construction time can be reduced using multiple dredge sets. Also, annual production rate for Alt 4A, is only 114,000 cy. State why this is lower than the already low 134,000cy for the other alternatives.	Terminology was revised to “total remediated area.” Total 40-acre study area was reported consistently to applicable alternatives. Annual production rate is same for all dredge alternatives (816 cy/day; 147,000 cy/year with 180 days per year). The number of years was revised to a range of years instead of one rounded year.
288		Table 12-3	Provide an additional table or text explanation for how residual concentrations were calculated. Complete capping Alt 2A4c to study area boundary shows residual detected TBT. This appears to be in error – please correct or otherwise explain. Same for Alt 4 complete dredging to study area boundary.	Calculation of residuals is described in Section 12.1.2.1.
289		New Section 12 Table	Provide a table similar to upper portion of Table 12-3 that shows achievement of urban background concentrations (or the higher RBTCs for copper and TBT) for residual conditions for each alternative.	The objective in Table 12-3 is to compare the alternatives to the PRGs. The calculation using the Urban reference values is not appropriate for the purposes of the FS.
290	Section 13	13-1	Overall, Sections 12 and 13 could have been combined. It is awkward to have to refer to Chapter 12 for the more extensive 9 criteria analysis and then read the evaluative sections in Section 12 as to how the types of remedies (e.g. containment, dredging, etc) compare. Section 13 doesn’t provide that much more information or comparison between alternatives.	Comment noted. The document follows the CERCLA guidance for organization.
291	Section 13	13-1	Incorporate considerations for future exposure from seismic risk for the alternatives.	This section explains the methodology for comparative analysis and rankings. Individual FS analysis factors were not discussed in this section. Seismic risk was incorporated into Sections 13.2, 13.3, and 13.5.
292	Section 13.2.1	13-3	Chapter 12 (e.g., page 12-28) - discusses several alternatives that will not meet the risk drivers for a variety of the COCs. Explain why only PCBs are discussed here. Later in this paragraph, it is stated that alternatives other than 2A4c and 4C would need institutional controls.	The statement was revised to “…risk-driver COCs….” instead of only noting PCBs.

Specific Comments – Sorted by Page Number

Comment Number	Section	Page	Comment	Response
293	Section 13.2.1	13-3	Protection of Human Health and the Environment is a threshold criterion. It is either met, or not. Figure 13-1 provides percentages of this criteria being met which is between 17-100% with most of the alternatives in the 87% to 95% range. Clarify whether these percentages are based on "engineered remedy + IC" or just "engineered remedy." Overall, this discussion needs to be clearer that even with an engineered remedy and ICs (specifically fish advisories), that none of the other cleanup alternatives (other than 2A4c and 4C) will be protective of human health and the environment. The reason for this is there will be restrictions on the number of fish that can be consumed even if the cleanup meets the PRGs as they (natural background in most cases) are higher than the risk-based threshold concentrations (RBTC). Although EPA believes that even a cleanup that doesn't meet this criteria is preferable to doing nothing, it is still incumbent upon the agency to be transparent about the protectiveness of the remedy selected.	It was clarified that Figure 13-2 shows the performance towards reaching RAO1 PRGs without ICs. Edits were also done to clarify that only 2A4c and 4C meet RAOs; other alternatives meet RAOs through implementation of the engineered remedy and application of ICs.
294	Section 13.2.1	13-4	Lines 1-2. It would be more accurate to say "Other alternatives would … average 87 percent to 98 percent progress…	Revised per the comment.
295	Section 13.2.1	13-5	Lines 11-12. It cannot be stated that Alternatives 2, 3 and 4 "achieve" the threshold criterion of overall protection of human health, although they may provide improved protection of the environment (e.g., ecological protectiveness is achieved).	Clarified that the achievement of RAOs is through implementing the engineered remedy and ICs.
296	Section 13.2.2	13-5	The alternatives must meet all of the ARARs, not just 3 significant ones. Provide additional text in this section that discusses all the alternatives and how they meet all of the ARARs.	Additional text was added to address the comment. Reference was made to Table 9-1 and Section 12.1.1.2 for more information. Section 13.2.2.4 also discusses compliance with other ARARs.
297	Section 13.2.2.2	13-6,	Clarify why only PCBs are identified and the other COCs are not discussed.	The statement was edited to "…dissolved COCs…".
298	Section 13.3.1	13-8,	Discuss the seismic evaluation in Long-Term Effectiveness and Permanence.	Discussion of seismic evaluation was added to the Section.
299	Section 13.2.2.5	13-8	Line 7 - This sentence should be modified to acknowledge that institutional controls will be required to meet ARARs. The remainder of the section clarifies this, but it should be included up front.	The sentence was revised to: "Alternatives 2, 3, and 4 comply with ARARs with application of institutional controls."
300	Section 13.3.1.1	13-9	Line 13 - Why does this say "CSL or SQS"- it should state SQS since CSL is always ≥ SQS? Similar language appears multiple times in this document. Explain or else remove references to CSL.	A sentence was added for clarification that the intent is to show the different levels of residual contaminants left in place after the remedy.
301	Section 13.3.1	13-9	Magnitude of Subsurface Residual Risks. Discuss the methodology for potential re-exposure and the likelihood of this occurring. Discuss whether this likelihood is the same for all the remedies, or whether it is greater for areas that are capped with a thin-layer vs. a dredged area. Discuss the potential risk of re-exposure. For example, discuss the potential for re-exposure In an area of the site likely to have a thin-layer cap that also might be subject to scour in the future if the remedy fails (e.g., how would this affect the SWAC or ecological exposure). Bottom line is that it is likely OK for ENR sediments to be exposed because the concentrations are very low (e.g., likely lower than SQS and likely lower than Urban background concentrations. State this more clearly.	More discussion was added to Section 13.3.1. Further discussion was included in Section 12 to address the comment.

Specific Comments – Sorted by Page Number

Comment Number	Section	Page	Comment	Response
302	Section 13.3.1	13-10	Magnitude of Subsurface Residual Risks. Explain why SQS was selected and not the PRGs.	See responses to Comments #257, 274, 279, 281.
303	Section 13.3.1	13-10	Magnitude of Subsurface Residual Risks, line 21 - This states, "….dynamic burial and mixing mechanisms" but previously this site has not identified as such. Explain.	The statement was deleted to avoid confusion.
304	Section 13.3.1.1	13-10	Line 5 - State the score that was given to cores with remaining contamination in dredging areas (if such cores existed. State whether these are considered ENR areas for this purpose since the management of dredge residuals would include a thin layer of sand.	The sentence was revised to "….remaining under dredge, cap, ENR, and unremediated areas listed in Table 12-4 …" for clarification. The SQS exceedances are based on remaining concentrations buried under the remedy without incorporating dredge residual management.
305	Section 13.3.1.2	13-12	Line 25 - Capped areas would likely require less monitoring than ENR areas. Unremediated areas should be monitored along with the ENR areas.	The capped areas would require monitoring at the same scale as ENR areas to verify the structural integrity of cap under seismic events. This section discusses scoring of technology reliability. Revisions were made considering seismic events. Scoring related to unremediated areas has been incorporated into "areas actively remediated" category.
306		13-12 and 13-13	It is clear "Monitoring is a key assessment technology…"	The sentence was revised to avoid repetition.
307	Section 13.3.1.2	13-13	The section on institutional controls is difficult to relate to Table 13-2. It would be helpful to organize this into subsections each corresponding to a line in the table so readers can easily tell where the numbers come from. See comments below on the table.	Reference to each line in Table 13-2 was given to assist the readers in finding the scores.
308		13-13	Institutional Controls. 2A4c and 4C are discussed as meeting all the RAOs upon completion of the remedy. However, a discussion needs to be added that in the event of a cap (2A4c) a Five-Year Review will be required to evaluate the effectiveness of the remedy. And, although it is likely that the cap will be found to effectively contain the underlying contamination, the cap surface will probably have chemical concentrations that are higher than the "clean".	A discussion was added to acknowledge that recontamination at a level above PRGs is likely regardless of the selected remedy but the risk is same for all alternatives and not a differentiating factor for comparative analysis of alternatives.
309	Section 13.3.1.2	13-14	This score for acreage of ENR is generally intended to represent the area of the site where recovery is less certain, so it should include the unremediated area as well, or at least the unremediated area above a certain chemistry threshold that is the same for all alternatives so as to allow for a fair comparison. For example, if an alternative has a small cap and no ENR, while another alternative has the same small cap surrounded by ENR, the latter alternative should not be penalized (e.g., the area with more remediation should result in a "higher score". Note that alternatives 2A1, 2A2a, and 2A3 all have the same cap footprint but have increasing ENR footprints, and thus 2A3 scores only 2.2 on this criterion, compared to 4.8 for 2A2a and 8.0 for 2A1. Modify.	The scoring for this metric has been updated to include the unremediated area.

Specific Comments – Sorted by Page Number

Comment Number	Section	Page	Comment	Response
310	Section 13.3.1.3	13-14	The issue of long-term effectiveness is not adequately discussed in this section. Specific ICs for the alternatives must be identified and then a complete description regarding how they will be effective over the long-term must be discussed.	Requested discussion was provided in Section 12. In this section (13.3.1.3), we compare the alternatives based on the scale of required ICs for each alternative. Some revision was made and reference to specific sections in Section 12 was provided to address the comment.
311	Section 13.3.3.3	13-18	Line 20 - states that "All alternatives are predicted to achieve the RAOs at completion of the construction, however, see comment on page 11-3, Section 11.1.1 where it is stated that RAO 1 is "met to some extent". The language in Section 11 is more reasonable for the reasons explained in several comments pertaining to Section 11. All of the text throughout the FS must be consistent.	The sentence was deleted from this section where only short-term effectiveness of alternatives is summarized.
312	Section 13.3.4	13-19	Implementability of ICs is not discussed in this section and needs to be. Add this discussion.	Section was revised to include implementability of the ICs. A new metric and corresponding scoring for administrative implementability of ICs was added to Table 13-2.
313	Section 13.3.5	13-20	Add a discussion that a specific cost for implementing ICs is not included in the appendix, but that a general sum was included. State the reasons for taking this approach. Also include the costs of future land use restrictions.	Table F-2 in Appendix F presents cost estimates of ICs. In this section, it was clarified that IC costs were included in the cost estimates. More discussion was added about the cost of future use restrictions and how those potential restrictions were incorporated into the evaluation of alternatives.
314	Section 13.3.5	13-20	The text states, "The weighted criteria rating scores for the alternatives have a narrow range of 6.3 to 8.2, which indicates that the higher cost alternatives do not necessarily show proportional increases in overall benefit." It is difficult to support this claim because proportional differences among the alternatives weren't measured by the scores, only relative differences (i.e. relative to the range of alternatives considered). These alternatives would score differently if the range of cleanups considered was broader or narrower (for example, if there was a larger footprint alternative that took 15 years to complete). In addition, the total scores would change if certain criteria (for instance, achievement of RAO 1 PRGs or need for institutional controls) were scored on a more sensitive scale (so that, for instance, alternatives that needed fewer or less severe institutional controls scored higher than those with more ICs or more restrictive ICs). Make same note to Chapter 11.	The methodology for comparative analysis and rankings and the approach behind each score has been explained in the text. The methodology was then followed consistently and the results presented.
315	Section 13.5.1.1	13-21	This section needs to be rewritten to be consistent with previous comments regarding protectiveness of any of the remedy alternatives.	The section was revised consistent with the previous comments.
316		13-21	Line 27 - SMS and natural background are ARARs too. Revise this statement by adding "…by including institutional controls to reduce human exposure to fish and shellfish".	Revised as suggested.

Specific Comments – Sorted by Page Number

Comment Number	Section	Page	Comment	Response
317		13-22	Line 14 - Need to re-examine these conclusions in light of seismic disturbance and future land use issues.	Seismic disturbance risk and hazard, and future use restrictions were incorporated into Tables 13-1 and 13-2, and the results were presented here. It was clarified that these two criteria were evaluated.
318	Section 13.5.1.6	13-23	The statement "Containment-focus alternatives have higher technical and administrative implementability than the removal-focus and complete removal alternatives." However, this statement, based on the description provided in Section 12 and previously in Section 13 does not account for institutional controls. Therefore, it is not convincing at this time that this statement is true. Include additional discussion.	The section was revised by incorporating evaluation of administrative implementability of ICs.
319	Section 13.5.2.1:	13-24	Rationale for Recommendation. The total benefits are calculated based on the goal of protecting human health and the environment and does not include a discussion regarding the benefits associated with alternatives that would encourage future uses including marine Terminal 5 expansion, habitat restoration, public access, tribal fishing and navigation.	Benefits associated with future land use, Port's future development, tribal fishing and navigation (i.e., ICs required long-term) were incorporated into the comparative evaluation. Each of these issues has its own metric and associated scoring in Table 13-2. Habitat restoration is a common element and not a differentiator between alternatives.
320	Section 13.5.2.2	13-25	This section does not provide an adequate description of why it is the Best-Supportive Alternative. ICs are not sufficiently identified nor explained how they are implementable and provide permanence for the remedy, reasonably anticipated future land use issues provided by the Port and DNR are not discussed, and other than general statements, specifics necessary to select this as a preferred remedy are not included in the FS (e.g., that ENR areas will also withstand natural and vessel-related erosion forces, that vessel-erosion forces will be minimized through ICs, that ENR is sufficiently protective to allow tribal fishing and clamming in this area.)	Sections 13.5.2.1 and 13.5.2.2 were revised to address the comment.
321		13-25	Line 2-3 - Need to consider seismic evaluation.	The bullet was revised and it was noted that there is moderate hazard predicted due to seismic events.
322		13-25	Line 4 - Clarify what is meant by "The capped area and associated restrictions on potential future uses are limited." State how Alternative 2A2a best supports future land use, or creates the fewest impediments to future land use if this is the intent of this statement.	The statement was clarified that the capped area footprint and associated restrictions on potential future uses are limited to the former dry dock area. Another bullet was also added related to how these future land use limitations will be coordinated and minimized during design.
323	Section 13	Table 13-1	Here and in Table 12-2, clarify how alternative 1 achieves RAO 1 PRGs for copper. State whether this is through natural attenuation, or some other process, and how long is that expected to take. Provide a response to comment that the Table 12-2 presentation of Alternative 1 achieving PRGs for copper is correct and state why. No change to the RI/FS is necessary.	Current mean sitewide concentration for copper is 270 ppm while RAO1 PRG is 400 ppm and RAO4 PRG is 420 ppm. Therefore No Action and all other alternatives meet PRGs for RAOs 1 and 4 for copper.

Specific Comments – Sorted by Page Number

Comment Number	Section	Page	Comment	Response
324	Section 13	Table 13-1	In Table 13-1, the row for "Site-wide ICs" states "ICs are required for all remedial alternatives to manage residual seafood consumption risks except Alternative 4C." Clarify how this relates to page 13-3, lines 24-27, which states: "2A4c … would achieve RAO 1 PRGs at the completion of construction and therefore would not require institutional controls such as seafood consumption advisories." 2A4c does require ICs for cap protection, but this is reflected in the row below.	The row was revised to "ICs are required for all remedial alternatives to manage residual seafood consumption risks except Alternative 2A4c and 4C."
325		Table 13-2	The top 4 rows (on Overall Protection of Human Health and Environment) represent a threshold criterion (i.e., yes/no) for acceptability of the alternative, and should not be factored into the overall numeric scores. By the same rationale as the "Compliance with ARARs" criterion, these should simply receive yes/no checkmarks but should not count toward the total score. The other elements should be reweighted—for example, 60% for long-term effectiveness and permanence, and 20% each for short-term effectiveness and implementability. The row on "Institutional Controls required long-term" would be more informative if it gave a more sensitive ranking than just "yes/no". For example, alternatives with multiple types of institutional controls (use restrictions AND fish consumption advisories) could score lower than alternatives with just one, and alternatives that make greater progress toward unrestricted fish consumption should score higher (because the ICs may be less stringent, e.g. 1 meal/month rather than no consumption). The row on future use restrictions should not only be based on the area of capping, since nonremediated areas where contamination is left in place should also be considered limitations on future use. This is reflected in the row on "Port future development limitations" but not in "future use limitations." Clarify why these two rows are scored separately. It seems more logical to have a single score that would reflect all future use limitations, scored on the basis of acres of contaminated sediment left in place (i.e. that would inhibit maintenance dredging due to disposal limitations). Short-term effectiveness should not only be based on lack of negative cleanup-related impacts, but also on short term achievement of RAOs, so for example, cleanup alternatives that meet RAOs in 1 year should score higher than cleanup alternatives that take longer. But see comment below on how to count the time until RAOs are achieved. Page 2 of this table includes a row for "Time until RAOs are achieved." For the alternatives that do not achieve RAO 1, that should be reflected here. Perhaps consider a scaling factor- if we are at a concentration of 2x the RAO 1 PRGs at the end of 1 year, then perhaps count it as 2 years? It seems problematic to use timescale alone to compare partial completion in 1 year with 100% completion in 9 years.	The Threshold criteria have been removed from the average calculations in the table. The individual scores are still noted for the criteria. The weightings for the primary balancing criteria have been revised to 50% for long-term effectiveness and 25% each for short-term effectiveness and implementability. The scoring on Institutional controls has been updated to reflect the difference for alternatives that include capping and those that do not to reflect the higher requirements for maintaining caps. Capping is a potentially significant encumbrance on future development and it is appropriate to use as a score for this item. The Port future use looks at a specific issue related to the existing operations in the upland of the site. The time to reach RAOs as based on time to complete remedy construction is taken into account in the scorings. Those with shorter construction times and which therefore achieve RAOs sooner are scored better. The description noted for "Time until RAOs are achieved" has been updated to better reflect the intent of the row.
326	APP F, Section F.2.2		The text states, "estimates for cap volumes in shoreline/intertidal area are increased by 20% to account for steep slopes." Explain this further; a figure may help. Natural resource trustee agencies may prefer less steep slopes in intertidal habitat area.	Explained as suggested.

Specific Comments – Sorted by Page Number

Comment Number	Section	Page	Comment	Response
327	APP F	Table F-3 and F-4.	It is not clear what is meant by these estimates for monitoring in the cap and ENR areas. If this is explained elsewhere in the text, identify where. State how these tables are used to generate cost estimates for the individual alternatives, which may include combinations of capping and ENR in different proportions(i.e. clarify whether these numbers are on a per acre basis or some other basis). It is confusing given that each alternative has a different combination of acreages of cap and ENR. Clarify how the number of samples determined. (These tables seem to indicate that 2A4c, which caps the entire study area, would have 40 surface samples in the cap area, and 2A2a would have 60 surface samples, 40 in the cap area and 20 in the ENR area- is this the intended interpretation?) Explain why a capped area merits 2x as many surface sediment samples as an ENR area. (e.g., 40 vs. 20) As caps are likely more reliable than ENR at preventing migration of buried contaminants to the surface, more surface sediment monitoring would be needed for ENR than for caps. Explain why there is subsurface sampling in the cap areas but not in the ENR areas. What is meant by including tissue monitoring in these 2 tables? Would tissue from capped and ENR areas be analyzed separately? As above for the sediment sampling, state whether 2A2a has twice as much tissue sampling as 2A4c, because 2A4c is cap-only but 2A2a includes ENR. Why is the bathymetry survey and SPI camera survey 2x as expensive for the cap areas as for the ENR areas (and clarify whether this is, on a per acre basis or total for the site.)	Basis for cost estimates were given in Table F-1. In this table, it was noted that a present value for 30-year LTM was calculated and the cost was included for each alternative based on correlation to the cap, ENR, unremediated areas. So, the number of samples and each cost line item is also interpolated per the area. The number of surface sediments samples for ENR areas was revised to match with the cap areas (1 sample/acre). More explanation was added into Section 11.3.2.4 to address these questions. Subsurface sampling is required at cap areas to make sure the isolation cap performs as designed. ENR was applied to areas where the concentrations are at acceptable level through mixing, and buried subsurface contamination is not a concern. Tissue monitoring was included into the cost estimates to monitor protectiveness of remedy for clamming. The cost of bathymetry and SPI survey was revised to be equal for all cap, ENR and unremediated areas.
328	APP H General		Tetra Tech has done a good job in evaluating the liquefaction potential and seismic stability issues associated with the Lockheed Martine West Seattle Superfund Site. Appendix H is very well written, easy to follow, and the methodologies are for the most part consistent with current state-of-the-practice for evaluating seismic hazards at a site. Methodologies discussed are also consistent with the approaches discussed in meetings with Tetra Tech. However, several clarifications and explanations are needed to address questions that readers may ask about the methodologies that were used or conclusions that are made from the analyses. Areas requiring further discussion are summarized in the following comments.	Comment noted.
329	APP H General		Remedy repair/replacement costs related to damage from seismic events are not in the seismic study report. The FS alternatives should be modified to anticipate the cost for conventional capping and ENR in the event of a seismic event that would damage the site. Lockheed Martin has discussed that it would be agreeable to provide financial assurance that a cap/ENR portion of the site would be replaced up to two times in these circumstances. Provide the replacement costs and costs for a financial assurance instrument.	The implications of the study were incorporated into the FS. The FS cost estimates were also revised by incorporating one time full cap repair cost where capping is part of the remedy (Appendix F).

Specific Comments – Sorted by Page Number

Comment Number	Section	Page	Comment	Response
330	APP H Summary	H-1	The three example alternatives are discussed in H.2.1 but a brief description is needed. The alternatives should be briefly introduced and summarized in the H.1 Introduction. Additional details for each alternative should be referred to in the main R/FS text (e.g., provide a summary of each of the 3 alternatives).	Requested information was added to Summary and Section H.1.
331	APP H Summary	H-1	Lines 7 – “Soil Penetration Test” should be “Standard Penetration Test.”	Corrected.
332	APP H Summary	H-1	Line 7 - Recommend that summary conclusions be presented as a brief, separate subsection of the Summary, or an Executive Summary.	Brief conclusions were presented in bullets.
333	APP H Summary	H-1	Line 8 – On line 8 reference is made to “failures.” Since the meaning of “failures” is not specific, please provide a more explicit explanation of what failure means. For example, is this excessive deformation, ground movement that intersects contaminated soils, or some other mechanism? The same comment applies to the next line.	The word “failure” was revised to “excessive deformation, ground movement that intersects contaminated soils.”
334	APP H Summary	H-1	Line 11 – Please provide more discussion on the meaning of cap repair.	A paragraph was added to the Summary to address the comment.
335	APP H Summary	H-1	Last Line – Define what is meant by "catastrophic," and how are catastrophic effects defined for the 2,500 year event? Agree that 2,500 years is beyond the nominal remedy design life, but this needs clarification.	The sentence was revised to: “Based on the methods and assumptions used for this analysis, no contaminant releases are predicted based on the 100-year and 500-year events evaluated.”
336	APP H Section H.1	H-1	Line 6 – Reference the August 18, 2011 meeting with EPA, and comments transmitted to Tetra Tech on August 25, 2011 on the July 21 Seismic Evaluation Approach Memo.	The reference was made in the Summary.
337	APP H Section H.2.1	H-3	Line 3 – Please include the boring logs in an appendix to support the discussion of site soil conditions. Also include a brief summary of the sufficiency and quality of the existing information to conduct the seismic hazard evaluation.	The boring logs were added as Attachment 1. Section H.8 was added to discuss data sufficiency for the analysis.
338	APP H Section H.2.1	H-3	Second Paragraph, Line 3 – Cite the date and source of bathymetry data.	Cited as requested.
339	APP H Section H.2.1	H-3	Second Paragraph, Line 5 – Indicate that steeper slopes are associated with shoreline and remnant underdock areas. Clarify that this is a focus of the current study. Describe more localized slope heights and angles (in addition to the discussion of the more general bathymetric conditions at and near the site). Also describe the potential extent of localized slope failures during a seismic event, and the potential for exposing underlying contaminated soil need discussion.	The section describes general site bathymetric conditions. Requested discussion was added to Section H.6.1, slope stability analysis section.
340	APP H Section H.2.1	H-3	Site locations described in this section should be identified on Figure H-1.	The location of former dry docks was identified in Figure H-1. The shorelines are self-explanatory. The berms under former piers are also shown through the gray shades of the bathymetry. One should follow the profile vs. plan view to identify the locations of the berms under former piers.
341	APP H Section H-3	H-5	First Bullet – It appears that the Palmer (1999) work references the wrong Hart Crowser work. The 1995 reference applies to the Port of Seattle T-5 project. The confined aquatic disposal facility is described in the Hart Crowser (1990) reference. Clarify.	Clarification was added to the first bullet. Both the Enviros (1990) and Hart Crowser (1995) studies were conducted for the Port of Seattle T-5 project.

Specific Comments – Sorted by Page Number

Comment Number	Section	Page	Comment	Response
342	APP H Section H-3	H-6	First Bullet – Add a sentence describing the slope angles that were being considered by Hart Crowser, if this information is available. Later conclusions in the document are supported if the slopes considered were flat.	Added. Hart Crowser performed the slope stability analysis for the proposed berms with side slopes of 2H:1V.
343	APP H Figure H-10	H-8	Figure placement seems odd. Recommend placing this figure with figures at the end of the text.	The figure was placed immediately after it was referred for clarity and to provide insight to the discussion.
344	APP H Section H.3.2	H-9	First Bullet, Line 2 – Delete “will” and make “reanalyze” plural.	Edited as requested.
345	APP H Section H.3.2	H-9	First Bullet – Qualify the potential for liquefaction. Most of the liquefaction is in the upper 20 feet. As noted later, liquefaction below this depth is not as prevalent but occurs in more localized zones. This becomes an issue relative to the risk that exists. The concern about the consequences of ground shaking increases if the depth of liquefaction extends to 50 to 70 feet. Later in the discussions deeper liquefaction seems to be implied as an issue. There is inconsistency in the wording of this section; clarify.	More qualifying information was added to the first bullet.
346	APP H Section H.3.2	H-10	First Bullet, Line 6 – Round slope angles to the nearest degree here and throughout the document.	Revised as commented.
347	APP H Figure H-11	H-11	Figure placement seems odd. Recommend placing this figure with figures at the end of the text.	The figure was placed immediately after it was referred for clarity and to provide insight to the discussion.
348	APP H Section H.4.1	H-11	First Partial Paragraph – Tie in the March 2011 Japanese earthquake and the recent earthquake in Chile to the subduction zone EQ. The magnitude of the Japanese EQ was very similar to what could be expected from the Cascadia Interface event. Reference is made to the Seattle fault in the same paragraph. Where does the fault trace occur relative to the site? Provide some discussion of the location of this fault, as well as the risk to the project area. If the return interval is too long to be a consideration, then state. If there is a risk, then the nature of the risk should be defined. Significant ground movements could cause severe disruption of surface sediments. Even if the likelihood of this event is low, the consequences of movement on the Seattle Fault should be discussed.	Information on 2011 Chile and Japan subduction zone earthquakes was added. More discussion and a figure showing the location of the Seattle Fault were added to the section as requested.
349	APP H Section H.4.1	H-11	Second Paragraph, Line 2 – Delete the word “extensive.”	Deleted.
350	APP H Section H.4.1	H-12	First Partial Paragraph – The discussion of historic slides is very relevant. Clarify that the Lockheed site setting is different than these areas where failures have occurred.	Requested clarification was added.
351	APP H Section H.4.2	H-12	Line 4 – EPA Comment No. 10 from the August 25, 2011 comment set indicates that WSLiq used the 2002 USGS Seismic Hazard Maps. That comment requested checking differences in results obtained from the 2002 versus newer maps from 2008. Indicate and reference which maps were used for the current analysis.	Requested information and the plots generated by 2008 USGS seismic hazard maps were added to Section H.4.2.

Specific Comments – Sorted by Page Number

Comment Number	Section	Page	Comment	Response
352	APP H Section H.4.2	H-13	End of First Partial Paragraph – Clarify how the plots define the PGAs noted and provide an example.	Clarified by additional information on how the PSHAs developed and by providing an example.
353	APP H Section H.4.2	H-13	First Complete Paragraph – Additional explanation and some references are needed. Following IBC, you would first apply the site factors (Fa) to estimate ground surface PGA and then check to see if you have liquefaction. • For most levels of firm ground shaking, the values of Fa result in amplification of the firm-ground PGA (up to 0.4g). If liquefaction is predicted, then IBC requires you to perform a site-specific ground response analyses – though no guidance is provided on whether to use effective stress or total stress methods. Results from a site-specific analysis would usually show that short-period motions decrease and long-period motions increase, as noted. • AASHTO does it a bit differently. It uses the Fa regardless of liquefaction and allows a site-specific analysis. Since IBC is commonly used as a reference document (or ASCE 7) for seismic design, the IBC approach should be discussed, with an explanation for the conclusions regarding conservative use of the firm-ground PGA. Youd and Carter (2005) in the JGGE, Vol. 131, No. 7 provide a relevant reference, and demonstrate change in short- and long-period motions. Also check Kramer (2008). Although another alternative is to conduct a site-specific ground response study, this approach is not likely warranted.	The paragraph was revised by additional explanation on IBC's approach.
354	APP H Section H.5	H-17	First Paragraph, Line 2 – Delete "rapidly." The loss in strength can be gradual.	Deleted.
355	APP H Section H.5.1	H-17	First Paragraph – Clarify whether WSLiq determined the PGA, or was PGA otherwise assigned. If the PGA determination is "built in," then it probably uses the 2002 USGS maps to be consistent with what AASHTO does. Multiple scenario analyses would seem to require the hazards values to be built in – and the same for the performance-based approach. Clarify if the WSliq methodology is using the 2002 maps and identify if there is any difference with the newer USGS maps. This comparison should be limited to the firm-ground condition.	Clarification was added as requested. WSliq computes PGAs using 2002 USGS database.
356	APP H Section H.5.2	H-18	First Paragraph – Clarify how the upper and lower bound SPT blow counts were established. Were all the data plotted, and an envelope of the results used to determine the upper and lower bounds? Or were only specific explorations used? Whichever way, the blow count plot should be shown (in an appendix). If other blow count data from the shelf area are available, these data should be "screened back" or identified separately on the blow count plot.	Clarified as requested. The boring logs were also included as Attachment 1. The SPT results at each boring log were tabulated by depth, minimum and maximum measurements observed at each 10 feet interval were identified and two sets of SPT results were identified for the analysis.
357	APP H Section H.5.2	H-19	First paragraph – State what happens to the overall mass if the "the zones of liquefactions are sporadic…..embedded within denser, less liquefiable materials within the dry dock hot spot area." State how the overall mass (hot spot area) might perform in a seismic event. Generally, in the hot spot area, based on the limited core samples, what percentage of this area would be categorized as a zone of liquefactions vs. areas with less liquefaction?	A discussion on predicted behavior of overall mass and the percentage of liquefiable zone was added as recommended.

Specific Comments – Sorted by Page Number

Comment Number	Section	Page	Comment	Response
358	APP H Section H.5.2	H-19	Second paragraph – Delete "potentially" and replace with "likely" so that the sentence states, "Liquefaction is likely initiated with all three return periods evaluated." Above, the text states that values below 1.0 indicate that liquefaction is likely, and Table H-2 for all three Return Periods at both depths have values less than 1.0.	Replaced "likely" as requested.
359	APPH Section H.5.2	H-19	Third Paragraph, Line 1 – Does the analysis for 3A1 take into account insetting of the cap within the 3-foot deep excavated area? Are potential stability benefits of inset and berming negligible? Clarify.	Clarification was added as requested. The stability benefits are negligible.
360	APPH Section H.5.2	H-19	Fourth Paragraph, Line 4 – Include the predicted depth of liquefaction. What does "localized" mean? Does it include steep slopes associated with the historical pier structures and dredging areas?	Table H-2 was revised to add the FS values to the depth where the sediment are susceptible to liquefaction. The work "localized" was revised to "sporadic" to be consistent with discussions in the same section. The berms under former piers will also be dredged under this alternative. The alternative intends to remove concerned contamination so even if liquefaction occurs there is no concern of exposure of contaminants.
361	APP H Section H.5.2	H-19	Fifth Paragraph, Line 5 – This paragraph refers to a site cap for alternatives 2A2a and 3A1, as a "3-foot-non-liquefiable sand cap layer…" Explain how a 3-foot layer of essentially non-cohesive sand, anticipated for all three alternatives considered (including 3C), placed as a cap wouldn't liquefy during shaking. This does not seem possible if it is a sand deposited under water (without compaction). If you have gravel or quarry stone, you might be able to achieve this.	Additional information was added to the paragraph. The design measures include adjustment of plasticity index, water content to liquid limit ratio, and application of quarry spall layer over the sand cap layer which will be exercised during design.
362	APP H Section H.5.3	H-20	Second Paragraph – Clarify if Kramer limits the definition of lateral spreading to flat (less than 6%) slopes. Often lateral spreading is used to refer to slope movement that is not a flow failure – so it could be flat slopes or steep slopes. In this context spreading refers to movement with liquefaction that occurs during shaking. But if Kramer limits spreading to 6% or less, than leave as is.	The reference of the statement is Bartlett and Youd (1992). To be consistent with Kramer's work, the statement was revised by deleting "(slopes less than 6 percent grade)".
363	APP H Section H.5.3	H-20	Fifth Paragraph, Last Line – Round off the deformation estimates. The empirical approaches developed by Kramer and by Youd and Perkins/Bartlett have a lot of scatter. So the accuracy is probably in the neighborhood of feet – and often is used to see if deformations are large or small.	Rounded off as recommended.
364	APP H Section H.5.3	H-21	First Partial Paragraph – The settlement estimate should be rounded off. Provide a best estimate of settlement as well (not the upper bound).	Rounded of as recommended. Post liquefaction settlements for 108- and 475-year events were also added.
365	APP H Section H.5.3	H-21	First Partial Paragraph, Line 3 – The description of "soft layers to 80 feet" seems excessive relative to previous descriptions of the soil profile (see page H-3).	The description of soft layers was revised to 50 feet.
366	APP H Section H.6.1	H-23	Line 8 – Explain how the presence of locally steeper slopes affects this analysis.	Explained as requested.

Specific Comments – Sorted by Page Number

Comment Number	Section	Page	Comment	Response
367	APP H Section H.6.2	H-24	Second Paragraph – The discussion is confusing and should be clarified: a typical approach would be to check for post-EQ flow. This is with liquefied strength and no seismic coefficient. If the factor of safety is greater than 1.0, then lateral spreading is checked. The lateral spreading analysis involves assigning the liquefied strength, determining the yield acceleration (factor of safety equal to 1), and then estimating slope movement using charts or other source(s) of information. This is discussed in Section H.6.4, so please clarify what the analyses using 87% to 95% reduction in strength refers to.	The section was revised by adding additional guidance notes from WSDOT design manual for clarification. The last sentence of the section was also revised to clarify that the discussion and the reduced shear strength values are applicable to pseudo-static slope stability analysis.
368	APP H Figures H-16, H-17, H-18, and H-19	H-26	Color coding for units is missing on the SLOPE/W section plots legend. Please include.	The program doesn't support a legend displaying the components of the model. It only has option of listing the material properties. If the comment is about Safety Map, it has such option but then it doesn't display FS values corresponding to each shade of color. So, only shaded slide mass and failure surfaces were displayed.
369	APP H Section H.5.3	H-28	Second paragraph. Discuss the potential impact of "aftershocks" following the large design event or state either why this is or may not be relevant.	The analyses were conducted per the latest design manuals and methodologies which did not include specific guidance for the analysis of aftershocks. A discussion of aftershock effects without additional analysis will be speculative and confusing. The current analysis has conservatisms built in a number of steps to accommodate uncertainties and risk. The level of analysis is comprehensive and conservative enough for the purpose of this FS.
370	APP H Section H.7	H-30	Per EPA Comment No. 10 from the August 25, 2011 comment set, conclusions should be expanded beyond the three candidate alternatives. Provide general findings as applicable to other site capping and dredging alternatives in general	Section H.7 was revised to expand the conclusions for all FS alternatives.
371	APP H Section H.7	H-30	Second Bullet – Clarify in the first sentence that the lateral spreading estimate is based on an empirically-based, lateral spreading equation that is applicable for gently sloping ground. If WSLiq was used to estimate the 9 feet of movement, it would be best to note as such. For Alternatives 2A2a, 3A1, and 3C, also include conclusions regarding potential upwelling, exposure, and spreading of contaminated sediments beneath the capped areas.	Clarified that the results were obtained through WSliq analysis. A new bullet was added discussing the potential upwelling, exposure, and spreading of contaminated sediments.
372	APP H Section H.7	H-30	Second Bullet – Modify this last sentence based on modifications in the text in previous Comment No. 34. Remove the second "period" at the end of this sentence.	The previous Comment No. 34 (Comment #361 – about liquefaction potential of 3-ft cap layer) was addressed in Section H.5.2.
373	APP H Section H.7	H-30	Third Bullet – Clarify the conclusions with respect to locally steep slopes associated with the historical pier structures and dredge cuts.	A new bullet was added discussing the stability of locally steep slopes.

Specific Comments – Sorted by Page Number

Comment Number	Section	Page	Comment	Response
374	APP H Section H.7	H-30	Third Bullet – The summary states that the “slope stability analysis for the analyzed post-remediation profiles shows stable slopes for static conditions and for a 108-year event….” However, Table H-3 shows large lateral spreading and post-liquefaction settlement for the 108-year return period. Usually, the magnitude of these movements is more than what would normally be associated with a “stable.” Revise or clarify the wording.	The conclusion refers to slope stability analysis results (Table H-5). The wording was clarified by adding reference to Table H-5.
375	APP H Section H.7	H-30	Fourth Bullet, Line 1 – The discussion of slope movement indicates that large slope movements are not likely. Clarify whether the same can be said about local failures. For example, some of the slopes shown on Figure H-9 appear to be potentially vulnerable to movement. Clarify if this is the case. Discuss the risk of potentially exposing contaminated sediments if these slopes were to fail during the large EQ. A discussion of this more localized liquefaction issue needs to be added.	Additional info was added to address the comment. A new bullet was added to discuss the risk of potentially exposing contaminated sediments per Comment #371.
376	APP H Section H.7	H-30	Fourth Bullet – Define “Earthquake-induced displacement.” This could be a hole, a crack, or lateral spreading. And, the range of 1 to 20 feet is provided, however, Table H-3 only shows 1-19.15 feet. Either add “approximately” or change the value. Clarify that the method used to estimate the 1-20 feet of movement is based on a Newmark-type analysis where liquefaction has been accounted for in the evaluation. This estimate of displacement is not for a separate geologic mechanism. It does the same thing as WSLiq but uses slope stability methods of analysis rather than the empirically based procedure in WSLiq. Some rewording is needed to explain how this estimate compares to the estimate in the second bullet. See specific discussion of the two methods in the WSDOT GDM.	The conclusion was revised per the comment. Additional text was added to displacement analysis sections, Sections H.5.3 and H.6.4 to clarify and compare the methodologies.
377	APP H Section H.7	H-31	First Partial Paragraph – The impacts for a large-scale flow slide seem understated with regard to large-scale lateral displacement and exposure of contaminated sediments beyond the current site boundary. Repair would need to anticipate a potentially larger area of impact, and therefore greater expense. This issue needs further explanation in the document conclusions.	Additional sentence was added noting that the extent of the repair will be determined. The cap repair cost and contingencies were incorporated to the FS cost estimates.
378	APP H Section H.7	H-31	Fifth Bullet, Line 5 – Edit—add “an” before “occurrence.” Also clarify that the last sentence refers to short-term disruption of the benthic community from physical disruption/displacement rather than exposure/contact with underlying contaminated sediments.	Edited and clarified as commented. Short-term disruption includes both physical disruption/displacement and exposure/contact with underlying contaminated sediments.
379	APP H Section H.7	H-31	Seventh Bullet – Define “large-scale failure.” However, also state that there will be impacts in a 100–year event and more impact with a 500-year event.	The bullet was revised per the comment.
380	APP H Table H-1	H-9	Should the PGA for Hart Crowser 1995/Lockheed Shipyard No. 2 be 0.15 rather than 0.17 to be consistent with previous discussions? Some of the information in the summary (e.g., PGA values in Hart Crowser (2003) was not discussed in previous pages and should be added to the earlier discussion.	Corrected and the additional information was added per the comment.
381	APP H Table H-2	H-18	Although the upper 20 feet may be where the contamination is, the slope stability analyses consider deeper depths. Factor of safety information should be shown to 50 feet at least, similar to the upper 20 feet. The PGA values in the table are a bit different than shown in Figure H-13. Please provide an explanation for the difference or revise. Also add the magnitude used in the liquefaction analyses for each return period.	Table H-2 was revised to add factor of safety values up to 50 feet depth. Explanation was added to clarify the reason for the differences in seismic parameters.

Specific Comments – Sorted by Page Number

Comment Number	Section	Page	Comment	Response
382	APP H Table H-3	H-21	Note 1 – Check if something is missing for the WSDOT reference or if more explanation is needed. Also round off all the values for lateral spreading and settlement to the nearest foot.	Note 1 was corrected. Agree with the suggestion of rounding to the nearest foot however the values were rounded to one digit to show any difference between the alternatives under seismic events.
383	APP H Table H-4	H-23	Clarify that the settlement estimates noted previously are consistent with the “medium dense sand” description in the table. Confirm the consistency or provide an explanation of differences.	The clarification was added to Section H.5.2 while discussing the results in Table H-2. It was noted that below 50 feet, the sediments are medium dense sand and not considered susceptible to liquefaction.
384	APP H Table H-5	H-24	Round off factor of safety values in this table and elsewhere in the document to the nearest 0.1 unit. Note 3 – Clarify whether a strength of 25 to 65 psf (not pcf) was used. Table H-4 gives a residual strength of liquefied soil of 500 psf. Correct if 65 pcf is a typo. Also clarify if the residual strengths were used only for the flow analysis in Column 3 of the table, and whether reduced strengths were used in Columns 4, 5, and 6 as well. Some further explanation is needed here. The factor of safety values less than 1.0 in Column 3 imply flow failures with very large displacements. This requires discussion. If factor of safety is less than 1.0 for the flow failure, a Newmark type displacement analysis is not applicable. The discussion on top of Page H-25 needs to be coordinated with this later section.	Factor of safety values were rounded off as commented. The typo was corrected. The residual strengths were used only for the flow analysis in Column 3 of the table. Clarification was added to Note 3.
385	APP H Figure H-1		The legend should identify “Profiles” rather than “Cross Sections.” This figure should reference Figures H-2 and H-3 for the depiction of the profiles.	The legend identifies the site profiles. Clarification was added to Section H.2 referring Fig. H-1 for the locations of the site profiles and the site profiles shown in Figures H-2 and H-3.
386	APP H Figures H-2 and H-3		These figures should reference Figures H-1 for the location of the Profiles depicted.	The explanation was given in Section H.2 where additional clarification was added per Comment #385.
387	APP H Figures H-4 and H-5		The figure legends should identify “Profiles” rather than “Cross Sections.” These figures should reference Figures H-7, H-8, and H-9 for the depiction of the profiles.	“Profiles” added to the titles of the Figs. H-4, 5, 6. Figures H-7, H-8, and H-9 are referred in Section H.2.
388	APP H Figure H-6		The legend should identify “Profiles” rather than “Cross Sections.” This figure is not currently referenced in the document, but should be kept for reference in the description of Alternative 3C, to be added to be added to the text per comment above.	“Profiles” added to the titles of the Figs. H-4, 5, 6 and referred in Section H.2.
389	APP H Figures H-7, H-8, and H-9		These figures should reference Figures H-4 and H-5 for the location of the Profiles depicted.	Figures H-7, H-8, and H-9 are referred in Section H.2.