DRAFT TECHNICAL MEMORANDUM
LOCKHEED MARTIN CORPORATION

November 5, 2009

TO: Ms. Densie Kato

FROM: Mr. Robert Johns

RE: Mass of Contaminants, Water Volume, Groundwater Velocity, and Travel Times in the Beaumont Site 1 and Site 2 Groundwater Plumes

EXECUTIVE SUMMARY

This technical memorandum (TM) summarizes Tetra Tech's recent efforts to estimate the mass of contaminants, water volume, groundwater velocity, and travel times for the groundwater plumes at Lockheed Martin Corporation (LMC) Beaumont Site 1 and Site 2, Beaumont, California.

For Site 1, the total plume area is 278 acres, water volume is 3,018 acre-feet, and mass of all contaminants of concern COCs is 5,943 pounds. The plume mass and extent is generally driven by perchlorate, although in the riparian area of Bedsprings Creek the other COCs define the plume limits since perchlorate is generally below maximum contaminant level (MCL).

For Site 2, the total plume area is 68 acres, water volume is 748 acre-feet, and mass of perchlorate – the primary Site 2 COC – is 30,468 pounds. The Test Bay Area plume has 93 percent of the Site 2 plume mass, reflecting the fact that the Test Bay Area plume is deeper, has higher concentrations, and has the second highest area relative to the other plumes. Groundwater investigations have only recently been completed and it appears some minor cross contamination took place during the installation of the vertical well pairs, particularly in Test Bay Canyon. As time passes the concentrations in the deeper wells is decreasing. Therefore, the vertical distribution and the mass of the perchlorate may decrease in Test Bay Canyon after the aquifer system comes back into equilibrium.

Groundwater velocity values are estimated to be approximately 600 feet per year for Site 1 and 110 feet per year for Site 2. Travel times across the Site 1 plume is approximately 12 years. Travel times across the two largest Site 2 plumes – the Test Bay and Liquid Discharge Area plumes – are approximately 20 to 50 years.

1.0 BACKGROUND

The objective of this TM is to estimate the current mass of contaminants, water volume, and travel times for the groundwater plumes at the Lockheed Martin Corporation (LMC) Beaumont Sites 1 and 2, Beaumont, California with the data available at this time. This information will be used to discuss preliminary remedial strategies and rough order of magnitude costs.

The water volume of the groundwater plume at Beaumont Site 1 was estimated in the 1992 Feasibility Study (FS) as 2,900 acre-feet or 950 million gallons (Radian, 1992). The mass of contaminants in the groundwater plumes at Beaumont Site 1 was estimated in the FS as 1,180 pounds of Total volatile organic compounds (VOCs) (Radian, 1992), assuming an aquifer porosity of 20 percent and a retardation factor of 1. Estimates were not given for the mass of 1,4-dioxane, perchlorate, or any other specific COCs in

groundwater in the 1992 FS. For reference, the mass of contaminants in soils at Beaumont Site 1 was estimated in the 1992 FS as 4,620 pounds of Total VOCs (Radian, 1992).

No previous estimates are given for the mass of contaminants or plume volumes in soil or groundwater at Beaumont Site 2. No previous estimates for travel times in groundwater are given for either the Beaumont Site 1 or Site 2 plumes.

Since the 1992 FS, a total of 205 pounds of Total VOCs have been removed from the Site 1 groundwater by operation of the RMPA groundwater extraction and treatment system (Table 1), which when subtracted from the 1,180 pounds of Total VOCs prior to the start of remediation yields 975 pounds of Total VOCs remaining in groundwater when the RMPA system was shut-down in 2002. Note that since 1,4-dioxane or perchlorate were not effectively treated in the RMPA prior to re-injection, it is conservatively assumed that 1,4-dioxane or perchlorate mass were not removed by the RMPA (Table 1).

2.0 CURRENT PLUME MASS AND WATER VOLUME

The mass of contaminants and water volume currently in the groundwater plumes at Site 1 and Site 2 are estimated using the current plume concentration and thickness maps, and aquifer porosity and retardation factor values.

The primary COCs are perchlorate, 1,4-dioxane, 1,1-DCE, and TCE for Site 1, and perchlorate for Site 2. For Site 1, 1,1,1-TCA was originally considered a COC, but the concentrations of 1,1,1-TCA quickly declined to trace levels in the early 1990. Since the loss of 1,1,1-TCA from the plume also was coincident with large increases in 1,1-DCE plume concentrations, and the transformation of 1,1,1-TCA to 1,1-DCE is a documented attenuation route for 1,1,1-TCA (USEPA, 1998), the loss of 1,1,1-TCA is attributed to this fate mechanism. Since the loss of 1,1,1-TCA, Total VOC concentrations in the Site 1 plume are dominated by TCE and 1,1-DCE as other VOCs such as 1,1,1-TCA, 1,1-DCA and 1,2-DCA contribute very little to VOC mass (Table 1).

COC plume maps are given for the 2008 time period for Site 1 and Site 2 in Appendix A and C, respectively. There is generally one distinct plume at Site 1 that covers approximately 3,018 acres, although the plume area does vary by COC due the varying concentrations and MCLs of the COCs. There are also small portions of the Site 1 plume that appear as separate islands of contamination further down Potrero Creek near well MW-14, MW-18, and MW-70. However, this occurs as portions of the single Site 1 plume increase and decrease relative to the MCL, with trace levels of COCs found between the main plume and the smaller plume bodies. There are four separate plumes at Site 2 covering a total of approximately 68 acres: the 2-acre centrifuge area plume in the far north of the site; the 20-acre test bay area plume in the center of the site; the 3-acre solid waste disposal area plume in the east of the site; and the 45-acre liquid waste discharge area plume in the south of the site that extends approximately one mile offsite. Due to limited data below the site boundary at Site 2, the extent of the 100 µg/L contour is assumed to extend to the riparian zone located approximately one-quarter mile to the south, and the extent of the 10 µg/L contour is assumed to extend to monitoring well Tt-MW2-19S/D located approximately one mile to the south.

Groundwater Plume thickness maps for the 2008 time period are given for Site 1 and Site 2 in Appendix B and C, respectively. Due to limited data below the site boundary at Site 2, the plume thickness is assumed to gradually decrease from 25 feet at the site boundary to 10 feet at Tt-MW2-19S/D. The vertical distribution of contaminants and plume thickness in groundwater was estimated by comparing COC data from vertically paired wells, with the top of groundwater contamination typically occurring at the water table. The following factors were also considered in developing the plume thickness maps:

- Site 1 – Contamination typically decreases with depth except in the riparian area where concentrations are generally the same in both shallow and deep wells. The COCs are generally restricted to the alluvium and weathered Mt. Eden, except in the BPA where the Mt Eden extends above the water table and the contamination is present in the shallow Mt Eden. Estimates show the plume thickness generally ranges from 25 to 90 feet.
- Site 2 – Contamination typically decreases with depth, although in some locations such as the Test Bay area the highest concentrations are at an intermediate depth, perhaps due to the speculation of a rising groundwater level at the site. Plume thickness is up to 150 feet in the Test Bay area, but generally 25 to 50 feet elsewhere. The COCs are generally restricted to the weathering profile within the San Timoteo Formation. It should be noted that groundwater investigations have only recently been completed at Site 2 and it appears some minor cross contamination took place during the installation of the vertical well pairs, particularly in Test Bay Canyon. As time passes the concentrations in the deeper wells is decreasing. Therefore, the vertical distribution and the mass of the perchlorate may decrease in Test Bay Canyon after the aquifer system comes back into equilibrium.

Aquifer porosity is assumed to be 20 percent at both Site 1 and 2. The retardation factor for the organic TCE and 1,1-DCE is assumed to be 1, which assumes that the aquifer solids organic carbon content is very small (less than 0.0001). While the assumption that aquifer solid organic carbon content is very small may be reasonable in most areas given the arid environment and large depths to groundwater, this may not be a good assumption in the site riparian areas where larger organic carbon content is plausible and has been observed during drilling. However, site specific aquifer organic carbon content has not been measured at the site. The lack of aquifer organic carbon content is identified as a data gap that could be filled by limited sampling in areas where groundwater in very deep to confirm this assumption that aquifer solid organic carbon content is very small, and more extensive sampling in the riparian area where aquifer solid organic carbon content may be greater and more variable.

The groundwater plume water volume and COCs mass values estimated using the aforementioned plume concentration maps, plume thickness maps, aquifer porosity, and retardation factor values are given in Table 2. For Site 1, the total plume area is 278 acres, water volume is 3,018 acre-feet, and mass of all COCs is 5,943 pounds. The Site 1 plume mass and extent is generally driven by perchlorate, although in the riparian area of Bedsprings Creek the other COCs define the plume limits since perchlorate is generally below the MCL. Total mass of VOCs is estimated to be 861 pounds from the sum of TCE and 1,1-DCE, and this value of 861 pounds generally agrees with the 1,180 pounds estimated in the 1992 FS when adjusted for the RMPA system removal of 205 pounds. For Site 2, the total plume area is 68 acres, water volume is 748 acre-feet, and mass of perchlorate is 30,468 pounds. The Test Bay Area plume has 93 percent of the Site 2 plume mass, reflecting the fact that the Test Bay Area plume is deeper, has higher concentrations, and has the second highest area relative to the other plumes. Therefore, the Site 2 plume mass is generally driven by the Test Bay plume.

Uncertainties

The plume volume is fairly well constrained by the tight network of monitoring wells. The lateral extent of the plume is especially well constrained by both the monitoring well locations and the natural boundaries of the alluvium/weathered Mt Eden.

The most significant uncertainties in the plume mass include the following:

- Concentration Trends – Although the lateral concentration trends are fairly well defined by the monitoring network and system boundaries, the vertical concentration trends are less well known, especially at areas where there are no vertically paired wells. Generally, at Site 1 there is a strong decline in concentration versus depth in vertically paired wells within the BPA and RMPA, but in the riparian areas the shallow and deep concentrations are essentially equal. Maps of the plume concentration are not currently available for each depth zone in the Qal/weathered Mt Eden aquifer, but these maps will be developed in the proposed transport modeling study to be conducted later this year. Thus, the plume maps given in Appendix A and C are two-dimensional and reflect the highest concentration observed at any depth – or a depth maximum value. While the Site 1 plume concentration maps (Appendix A) are good depictions of the concentration for the entire saturated plume thickness in the riparian areas and for the shallow areas in the BPA and RMPA, they are somewhat higher than the concentration observed at depth in the BPA and RMPA. As a conservative assumption, these plume maps were used for the entire plume thickness, which is likely to somewhat overstate the plume mass in the RMPA and BPA. To test this assumption, the concentration versus depth trend in vertically paired wells was reviewed and used to modify the depth-maximum plume maps to reflect depth average values, with the resulting figures given in Appendix A and B. The plume mass estimates based upon the depth-average concentration values are also given in Table 2. Using the depth average values, the COCs mass estimates are 30 to 40 percent lower than the values defined using the depth-maximum concentrations at both Site 1 and Site 2.
- COC Retardation Factor – The Retardation Factor is assumed to be equal to one for all COCs. While this is a good assumption for perchlorate and 1,4-dioxane, it may be too low for the chlorinated organics (TCE and 1,1-DCE), which can adsorb onto organic carbon in the aquifer solids. This is likely to be most important in the riparian areas where aquifer organic carbon content may not be negligible. However, since most of the high concentration areas of the Site 1 plume that drive the total mass estimates are in the BPA and RMPA above the riparian areas, the assumption of a retardation factor equal to one may not have that large of an influence on the plume mass estimates. However, a TCE and 1,1-DCE retardation factor greater than one in the riparian area could have a significant impact on the fate of TCE and 1,1-DCE as they migrate through the riparian areas into Potrero Creek. Estimates of the aquifer organic carbon content are not currently available, but these will be developed in the proposed transport modeling study to be conducted later this year in order to estimate TCE and 1,1-DCE retardation factors in the riparian area.
- Soil and NAPL Source Areas – The COC mass estimates given in this TM are based upon dissolved phase concentrations in groundwater samples, and they do not reflect any mass that may be present in the soil zone above the water table or as non-aqueous phase liquids (NAPLs) that may be trapped in pore spaces below the water table. The presence of contaminants in soils or NAPLs that may impact groundwater could significantly increase the mass estimates presented in Table 2. This will be addressed further in the mass flux budget being prepared in the upcoming Transport Model work assignment.

3.0 TRAVEL TIMES IN GROUNDWATER PLUMES

This section presents estimates of travel times in the Site 1 and Site 2 groundwater plumes. Travel times are calculated as the product of the aquifer hydraulic gradient and aquifer hydraulic conductivity, divided by the product of the aquifer effective porosity and the COC retardation factor. As a cross-check on the

travel time calculations, the calculated travel times are also contrasted with the observed extent of the plume and the elapsed time since contaminant release.

The aquifer effective porosity is estimated to be 10 percent for Site 1, or approximately equal to the aquifer specific yield value estimated in the recent Site 1 transient groundwater model calibration (Tetra Tech, Inc., 2009). This Site 1 aquifer effective porosity of 10 percent is one-half of the total aquifer porosity of 20 percent used in the plume volume and mass estimates presented in Section 2. The hydraulic gradient for Site 1 varies from values of 0.002 to 0.015, with smaller values in the upper portion of the plume in Bedsprings Creek and larger values in Potrero Creek. The hydraulic conductivity for Site 1 varies from values of 1 to 30 feet per day, with larger values in the upper portion of the plume in Bedsprings Creek and smaller values in the riparian area. These hydraulic gradient and hydraulic conductivity values for Site 1 are documented in the recent groundwater model report (Tetra Tech, Inc, 2009). The travel times are then calculated using the Site 1 groundwater model, with the results given in Figure 1. Groundwater velocity values vary from 400 to 2,000 feet per year, but are typically 600 feet per year within the main plume area. Therefore, transport times across the 7,200 foot long plume are approximately 12 years.

The aquifer effective porosity is estimated to be 10 percent for Site 2, which is one-half of the total aquifer porosity of 20 percent used in the above plume volume and mass estimates. The hydraulic gradient for Site 2 is 0.03, with uniform values across the site. The hydraulic conductivity for Site 2 is not well known since there are limited aquifer tests in the area, but data from slug and specific capacity tests suggests an average site value of approximately 1 feet per day. The groundwater velocity values are then calculated to be 110 feet per year. Therefore, transport times are approximately 21 years across the 2,300 foot long Test Bay Area plume and 78 years across the 8,600 foot long Liquid Discharge Area plume. Since the elapsed time since Site 2 operations is only 50 years, the 78 year Travel Time across the 8,600 foot long Liquid Discharge Area plume suggests that the groundwater velocity may be locally higher in that area, or that dispersion and storm water run off is locally accelerating the plume movement.

Comparison with Plume Extent and Elapsed Time

The Site 1 plume is approximately 7,200 feet long. From 1960 to 1974, Site 1 was used for solid rocket motor and ballistics testing, and therefore the elapsed time to 2009 is 35 to 49 years. Using the plume length and elapsed time, the net plume velocity is estimated at 147 to 206 feet per year, which is much smaller than the average plume velocity of 600 feet given in Figure 1. This difference is attributed to the attenuation of the plume within the riparian area and the dilution of the plume in Potrero Creek. This attenuation of the plume is further supported by the site monitoring data that shows very little change in the areal extent of the plume during the last twenty years (the 1990 to 2009 time period). If not for the proposed plume attenuation, the Site 1 plume extent may be expected to be 21,000 to 29,400 feet given the 600 feet per year velocity and the 35 to 49 years elapsed since the site was operating. Note also that the first site investigations in the late 1980 detected a plume that is much the same as that observed today – 7,200 feet in length. Given that these first investigations occurred approximately 15 to 30 years after the site operating period, this would imply a plume velocity of 240 to 480 feet per year, which is not inconsistent with the average plume velocity of 600 feet given in Figure 1, especially if attenuation of the plume in the riparian area is considered.

The major Site 2 plumes are approximately 2,300 feet long (Test Bay Area plume) and 8,600 feet long (Liquid Discharge Area plume). From 1958 to 1974, Site 2 was used for rocket motor testing, and therefore the elapsed time to 2009 is 35 to 51 years. Using the plume length and elapsed time, the net plume velocity values are estimated to be 45 to 66 feet per year for the Test Bay Area plume and 169 to

246 feet per year for the Liquid Discharge Area plume. These values average approximately 134 feet per year, which is comparable to the average plume velocity of 110 feet per year given above.

4.0 REFERENCES

Radian Corporation
1992 Lockheed Propulsion Company, Beaumont Test Facilities, Beaumont 1 treatment design feasibility study. March 1992

Tetra Tech, Inc.
2009 Transient Groundwater Model Report, Numerical Flow Model Development, Beaumont Site 1, Lockheed Martin Corporation, Beaumont, California, May 2009.

US Environmental Protection Agency (EPA)
1998 Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Ground Water, Office of Research and Development, EPA/600/R-98/128, September 1998.

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Table 1
Site 1 RMPA Groundwater Extraction Volumes and Mass Removals

Quarterly Period	Start Date	End Date	End Cumulative Volume (gallons)	Period Volume (gals)	EW-1 Volume (gals)	EW-1 1,1-DCE Concentration (ug/L)	EW-1 1,1-DCE Mass Removal (Kg)	EW-1 TCE Concentration (ug/L)	EW-1 TCE Mass Removal (Kg)	EW-1 1,1,1 TCA Concentration (ug/L)	EW-1 1,1,1 TCA Mass Removal (Kg)	EW-1 DCAs Concentration (ug/L)	EW-1 DCAs Mass Removal (Kg)	EW-2 Volume (gals)	EW-2 1,1-DCE Concentration (ug/L)	EW-2 1,1-DCE Mass Removal (Kg)	EW-2 TCE Concentration (ug/L)	EW-2 TCE Mass Removal (Kg)	EW-2 1,1,1 TCA Concentration (ug/L)	EW-2 1,1,1 TCA Mass Removal (Kg)	EW-2 DCAs Concentration (ug/L)	EW-2 DCAs Mass Removal (Kg)
1	10/1/92	12/31/92	0	0	0	1,150.0		360.0		75.0		48.0		0	955.0		110.0		314.7		150.0	
2	12/31/92	4/1/93	0	0	0	646.0		101.6		68.0		42.0		0	595.8		87.0		39.9		131.9	
3	4/1/93	7/1/93	0	0	0	566.0		102.8		60.3		36.4		0	547.8		110.3		38.3		113.9	
4	7/1/93	10/1/93	0	0	0	486.0		104.0		52.6		30.9		0	499.9		133.6		36.8		95.8	
5	10/1/93	12/31/93	0	0	0	406.0		105.2		44.9		25.3		0	451.9		156.9		35.2		77.8	
6	12/31/93	4/1/94	0	0	0	326.0		106.4		37.1		19.8		0	403.9		180.1		33.7		59.7	
7	4/1/94	7/2/94	414,900	414,900	362,208	246.0	0.34	107.6	0.15	29.4	0.04	14.2	0.02	52,692	355.9	0.07	203.4	0.04	32.1	0.01	41.7	0.01
8	7/2/94	10/1/94	7,280,293	6,865,393	5,993,488	166.0	3.77	108.8	2.47	21.7	0.49	8.7	0.20	871,905	308.0	1.02	226.7	0.75	30.6	0.10	23.6	0.08
9	10/1/94	12/31/94	14,368,100	7,087,807	6,187,656	86.0	2.01	110.0	2.58	14.0	0.33	3.1	0.07	900,151	260.0	0.89	250.0	0.85	29.0	0.10	5.6	0.02
10	12/31/94	4/2/95	20,955,274	6,587,174	5,750,603	79.5	1.73	97.5	2.12	14.0	0.30	4.5	0.10	836,571	195.0	0.62	190.0	0.60	22.0	0.07	5.4	0.02
11	4/2/95	7/2/95	27,260,665	6,305,391	5,504,606	73.0	1.52	85.0	1.77	14.0	0.29	5.9	0.12	800,785	130.0	0.39	130.0	0.39	15.0	0.05	5.3	0.02
12	7/2/95	10/1/95	34,662,335	7,401,670	6,461,658	73.3	1.79	81.0	1.98	12.3	0.30	5.2	0.13	940,012	132.5	0.47	130.0	0.46	13.8	0.05	4.9	0.02
13	10/1/95	1/1/96	40,969,880	6,307,545	5,506,487	73.5	1.53	77.0	1.60	10.7	0.22	4.5	0.09	801,058	135.0	0.41	130.0	0.39	12.5	0.04	4.5	0.01
14	1/1/96	4/1/96	47,292,135	6,322,255	5,519,329	73.8	1.54	73.0	1.53	9.0	0.19	3.7	0.08	802,926	137.5	0.42	130.0	0.40	11.3	0.03	4.1	0.01
15	4/1/96	7/1/96	51,757,459	4,465,324	3,898,228	74.0	1.09	69.0	1.02	7.3	0.11	3.0	0.04	567,096	140.0	0.30	130.0	0.28	10.0	0.02	3.7	0.01
16	7/1/96	10/1/96	55,814,639	4,057,180	3,541,918	78.5	1.05	92.5	1.24	7.2	0.10	2.0	0.03	515,262	133.5	0.26	143.0	0.28	11.0	0.02	2.9	0.01
17	10/1/96	12/31/96	60,324,400	4,509,761	3,937,021	83.0	1.24	116.0	1.73	7.0	0.10	1.0	0.01	572,740	127.0	0.28	156.0	0.34	12.0	0.03	2.0	0.00
18	12/31/96	4/1/97	62,803,174	2,478,774	2,163,970	77.5	0.63	101.4	0.83	6.6	0.05	2.4	0.02	314,804	102.5	0.12	155.0	0.18	9.8	0.01	3.0	0.00
19	4/1/97	7/1/97	64,811,557	2,008,383	1,753,318	72.0	0.48	86.7	0.58	6.2	0.04	3.7	0.02	255,065	78.0	0.08	154.0	0.15	7.5	0.01	3.9	0.00
20	7/1/97	10/1/97	66,642,257	1,830,700	1,598,201	80.5	0.49	86.5	0.52	4.9	0.03	2.7	0.02	232,499	114.5	0.10	154.0	0.14	6.6	0.01	3.4	0.00
21	10/1/97	12/31/97	69,318,507	2,676,250	2,336,366	88.9	0.79	86.3	0.76	3.6	0.03	1.6	0.01	339,884	151.0	0.19	154.0	0.20	5.6	0.01	2.9	0.00
22	12/31/97	4/1/98	72,276,092	2,957,585	2,581,972	92.8	0.91	89.2	0.87	5.4	0.05	5.7	0.06	375,613	158.5	0.23	171.5	0.24	7.2	0.01	7.6	0.01
23	4/1/98	7/2/98	77,164,382	4,888,290	4,267,477	96.7	1.56	92.0	1.49	7.2	0.12	9.8	0.16	620,813	166.0	0.39	189.0	0.44	8.7	0.02	12.2	0.03
24	7/2/98	10/1/98	79,458,682	2,294,300	2,002,924	95.2	0.72	84.5	0.64	6.0	0.05	6.4	0.05	291,376	174.5	0.19	177.5	0.20	7.4	0.01	8.1	0.01
25	10/1/98	12/31/98	84,404,382	4,945,700	4,317,596	93.6	1.53	77.0	1.26	4.8	0.08	3.0	0.05	628,104	183.0	0.44	166.0	0.39	6.0	0.01	4.0	0.01
26	12/31/98	4/2/99	89,064,282	4,659,900	4,068,093	76.3	1.17	77.0	1.19	5.0	0.08	1.5	0.02	591,807	146.5	0.33	166.0	0.37	5.0	0.01	1.5	0.00
27	4/2/99	7/2/99	92,684,984	3,620,702	3,160,873	59.0	0.71	77.0	0.92	4.8	0.06	0.5	0.01	459,829	110.0	0.19	166.0	0.29	6.0	0.01	3.2	0.01
28	7/2/99	10/1/99	95,470,784	2,785,800	2,432,003	59.0	0.54	77.0	0.71	5.0	0.05	1.0	0.01	353,797	115.0	0.15	166.0	0.22	5.5	0.01	3.3	0.00
29	10/1/99	1/1/00	96,917,385	1,446,601	1,262,883	59.0	0.28	77.0	0.37	5.0	0.02	1.0	0.00	183,718	120.0	0.08	166.0	0.12	5.0	0.00	3.4	0.00
30	1/1/00	4/1/00	100,996,385	4,079,000	3,560,967	59.0	0.80	77.0	1.04	5.0	0.07	1.0	0.01	518,033	125.0	0.25	166.0	0.33	4.5	0.01	3.5	0.01
31	4/1/00	7/1/00	103,626,414	2,630,029	2,296,015	59.0	0.51	77.0	0.67	5.0	0.04	1.0	0.01	334,014	130.0	0.16	166.0	0.21	4.0	0.01	3.6	0.00
32	7/1/00	10/1/00	105,974,414	2,348,000	2,049,804	59.0	0.46	77.0	0.60	5.0	0.04	1.0	0.01	298,196	130.0	0.15	166.0	0.19	4.0	0.00	3.6	0.00
33	10/1/00	12/31/00	106,286,414	312,000	272,376	59.0	0.06	77.0	0.08	5.0	0.01	1.0	0.00	39,624	130.0	0.02	166.0	0.02	4.0	0.00	3.6	0.00
34	12/31/00	4/1/01	106,574,414	288,000	251,424	59.0	0.06	77.0	0.07	5.0	0.00	1.0	0.00	36,576	130.0	0.02	166.0	0.02	4.0	0.00	3.6	0.00
35	4/1/01	7/1/01	110,128,414	3,554,000	3,102,642	59.0	0.69	77.0	0.90	5.0	0.06	1.0	0.01	451,358	130.0	0.22	166.0	0.28	4.0	0.01	3.6	0.01
36	7/1/01	10/1/01	113,252,414	3,124,000	2,727,252	59.0	0.61	77.0	0.79	5.0	0.05	1.0	0.01	396,748	130.0	0.20	166.0	0.25	4.0	0.01	3.6	0.01
37	10/1/01	12/31/01	113,433,354	180,940	157,961	59.0	0.04	77.0	0.05	5.0	0.00	1.0	0.00	22,979	130.0	0.01	166.0	0.01	4.0	0.00	3.6	0.00
38	12/31/01	4/1/02	116,438,259	3,004,905	2,623,282	59.0	0.59	77.0	0.76	5.0	0.05	1.0	0.01	381,623	130.0	0.19	166.0	0.24	4.0	0.01	3.6	0.01
39	4/1/02	7/2/02	119,066,423	2,628,164	2,294,387	59.0	0.51	77.0	0.67	5.0	0.04	1.0	0.01	333,777	130.0	0.16	166.0	0.21	4.0	0.01	3.6	0.00
40	7/2/02	10/1/02	121,796,594	2,730,171	2,383,439	59.0	0.53	77.0	0.69	5.0	0.05	1.0	0.01	346,732	130.0	0.17	166.0	0.22	4.0	0.01	3.6	0.00
41	10/1/02	12/31/02	123,789,093	1,992,499	1,739,452	59.0	0.39	77.0	0.51	5.0	0.03	1.0	0.01	253,047	130.0	0.12	166.0	0.16	4.0	0.00	3.6	0.00
42	12/31/02	4/2/03	0	0	0									0								
43	4/2/03	7/2/03	0	0	0									0								
44	7/2/03	10/1/03	0	0	0									0								
45	10/1/03	1/1/04	0	0	0									0								
46	1/1/04	4/1/04	0	0	0									0								
47	4/1/04	7/1/04	0	0	0									0								
48	7/1/04	10/1/04	0	0	0									0								
49	10/1/04	12/31/04	0	0	0									0								
50	12/31/04	4/1/05	0	0	0									0								
51	4/1/05	7/1/05	0	0	0									0								
52	7/1/05	10/1/05	0	0	0									0								
53	10/1/05	12/31/05	0	0	0									0								
54	12/31/05	4/1/06	0	0	0									0								
55	4/1/06	7/2/06	0	0	0									0								
56	7/2/06	10/1/06	0	0	0									0								
57	10/1/06	12/31/06	0	0	0									0								
58	12/31/06	4/2/07	0	0	0									0								
59	4/2/07	7/2/07	0	0	0									0								
60	7/2/07	10/1/07	0	0	0									0								
61	10/1/07	1/1/08	0	0	0									0								
62	1/1/08	4/1/08	0	0	0									0								
63	4/1/08	7/1/08	0	0	0									0								
64	7/1/08	10/1/08	0	0	0									0								
Sum All VOCs = 93 KG			Totals	123,789,093	108,067,878		32.66		35.15		3.57		1.41	15,721,215		9.28		9.87		0.68		0.33

White = Measured Concentration
Yellow = Interpolated Concentration

Table 2
2008 Aquifer Plume Volume and Mass Estimates
Beaumont Sites 1 and 2

Site and COCs	Area above MCL (acres)	Water Volume above MCL (acre-feet)	Mass (pounds) using maximum concentration at any depth	Mass (pounds) using depth averaged concentration	Comment
Site 1					
Perchlorate	227	2,529	5,083	3,364	
1,1-DCE	154	1,742	496	312	
TCE	145	1,550	365	249	
1,4-dioxane	179	2,081	147	102	
All COCs	278	3,018	5,943	3,925	All COCs driven by Perchlorate except in the Riparian Areas where it drops below MCL
All VOCs	154	1,742	861	561	All VOCs driven by TCE and 1,1-DCE
Site 2					
Perchlorate-All Areas	68	748	30,468	18,395	
Perchlorate-Centrifuge	1	4	0.5	0	
Perchlorate-Test Bays	20	308	28,253	17,058	Mass driven by high concentrations of up to 700,000 ug/L and thick plume; If assume one 720,000 ug/L grab sample has value of 200,000 ug/L, then mass still is 21,100 pounds
Perchlorate-Solid Waste Disposal Area	3	32	8	5	
Perchlorate-Liquid Waste Discharge Area	45	405	2,205	1,331	

FIGURES

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Monitoring Wells

Particle Pathlines

1

Travel Time in years

Plume Extents

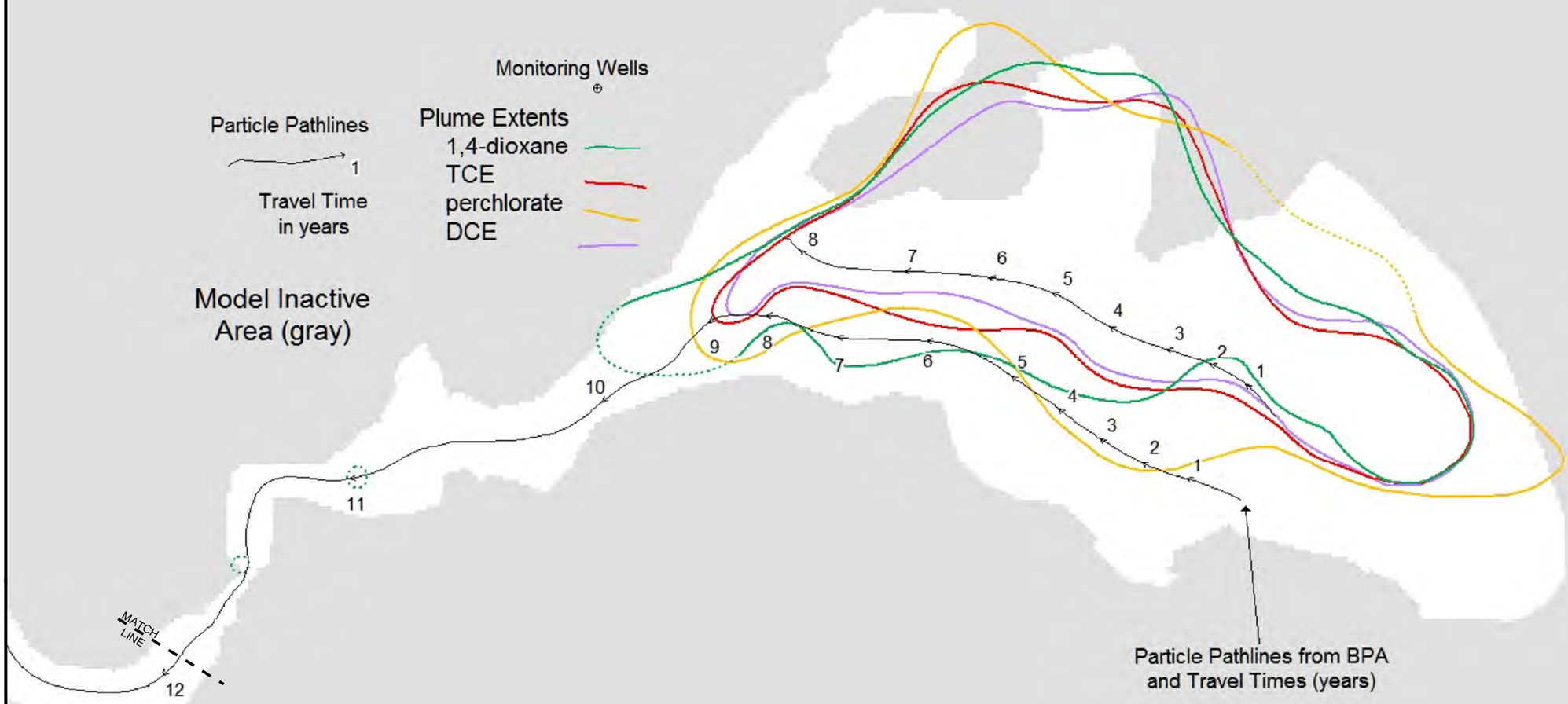
1,4-dioxane

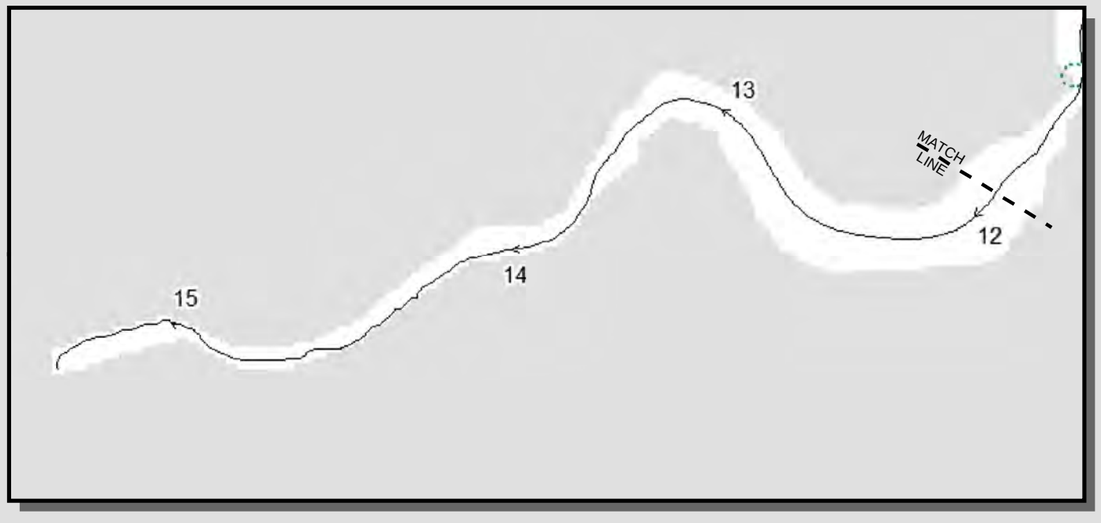
TCE

perchlorate

DCE

Model Inactive Area (gray)





Particle Pathlines from BPA and Travel Times (years)

N

0 500 1,000 Feet

Beaumont Site 1

Figure 1

Simulated Pathlines and Travel Times for Groundwater Flow at Site 1 (Tetra Tech, Inc., 2009)

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APPENDICES

APPENDIX A
Plume Contour Maps For Site 1

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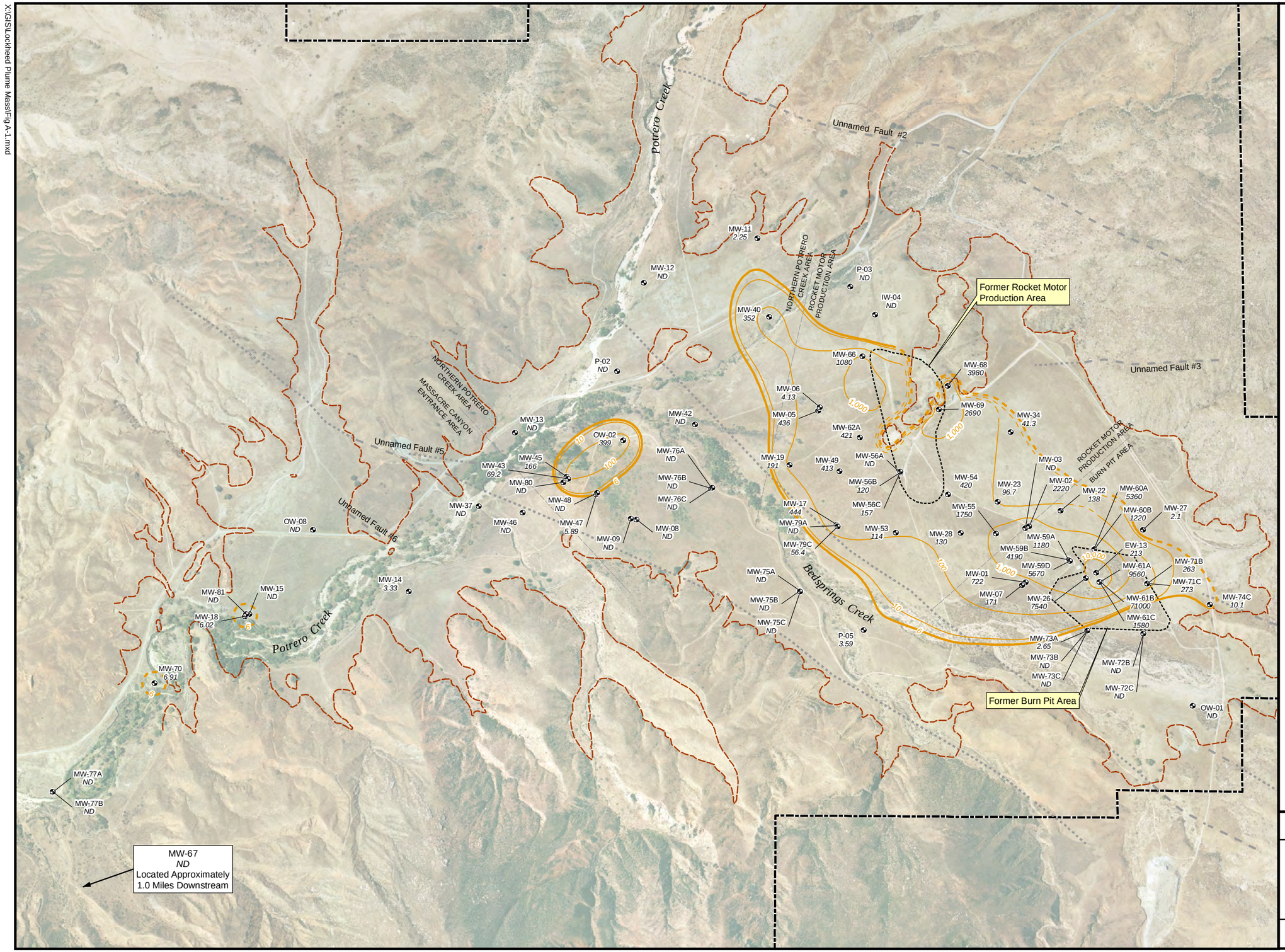


0 500 1,000 Feet

Adapted from: March 2007 aerial photograph.

LEGEND

- MW-01 / 600 — Well ID / Perchlorate Concentration
- Perchlorate Concentration Contour (Depth Maximum) (µg/L) - Dashed Where Inferred
- DWNL Contour (Depth Maximum) (6.0 µg/L) - Dashed Where Inferred
- Approximate Location of Fault
- Approximate Location of Buried Fault
- Mt. Eden/Alluvium Surface Contact
- Beaumont Site 1 Property Boundary

Notes:
Beaumont Site 1 property boundary is approximate.
Concentrations shown are in micrograms per liter (µg/L)
Highest concentration shown is contoured for clustered or nested well locations.

DWNL - Drinking Water Notification Level.

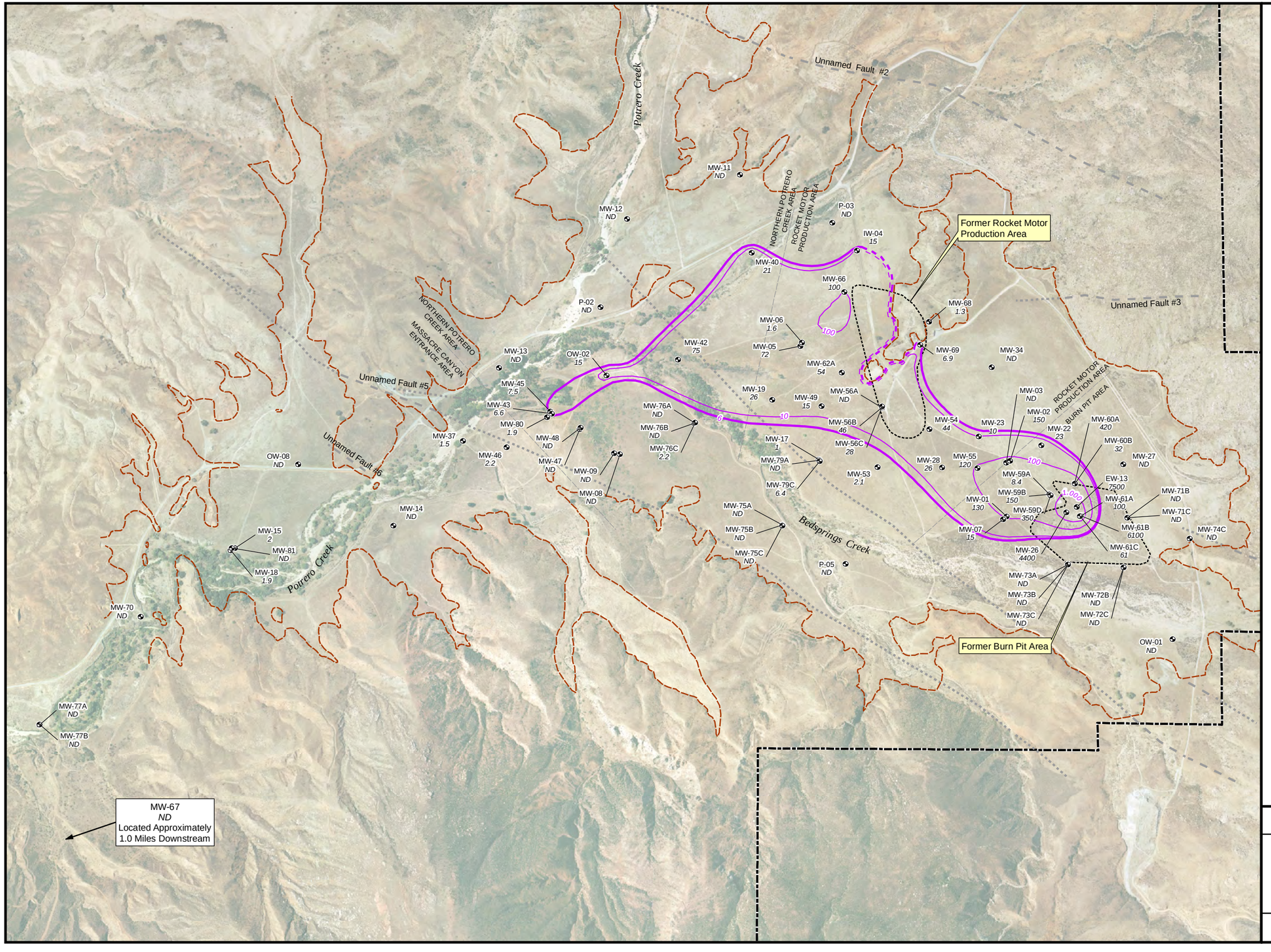
Beaumont Site 1

Figure A-1

Aquifer Perchlorate Concentrations for Site 1: Depth Maximum Values

TETRA TECH

X:\GIS\Lockheed Plume Mass\Fig A-2.mxd



Adapted from: March 2007 aerial photograph.

LEGEND

- MW-01 / 600 — Well ID / 1,1 DCE Concentration
- 1,1 DCE Concentration Contour (Depth Maximum) (µg/L) - Dashed Where Inferred
- MCL Contour (Depth Maximum) (6.0 µg/L) - Dashed Where Inferred
- Approximate Location of Fault
- Approximate Location of Buried Fault
- Mt. Eden/Alluvium Surface Contact
- Beaumont Site 1 Property Boundary

Notes:

Beaumont Site 1 property boundary is approximate.

Concentrations shown are in micrograms per liter (µg/L)

Highest concentration shown is contoured for clustered or nested well locations.

MCL - maximum contaminant level.

1,1-DCE - 1,1-Dichloroethene

Beaumont Site 1

Figure A-2

Aquifer 1,1 DCE Concentrations for Site 1: Depth Maximum Values

TETRA TECH

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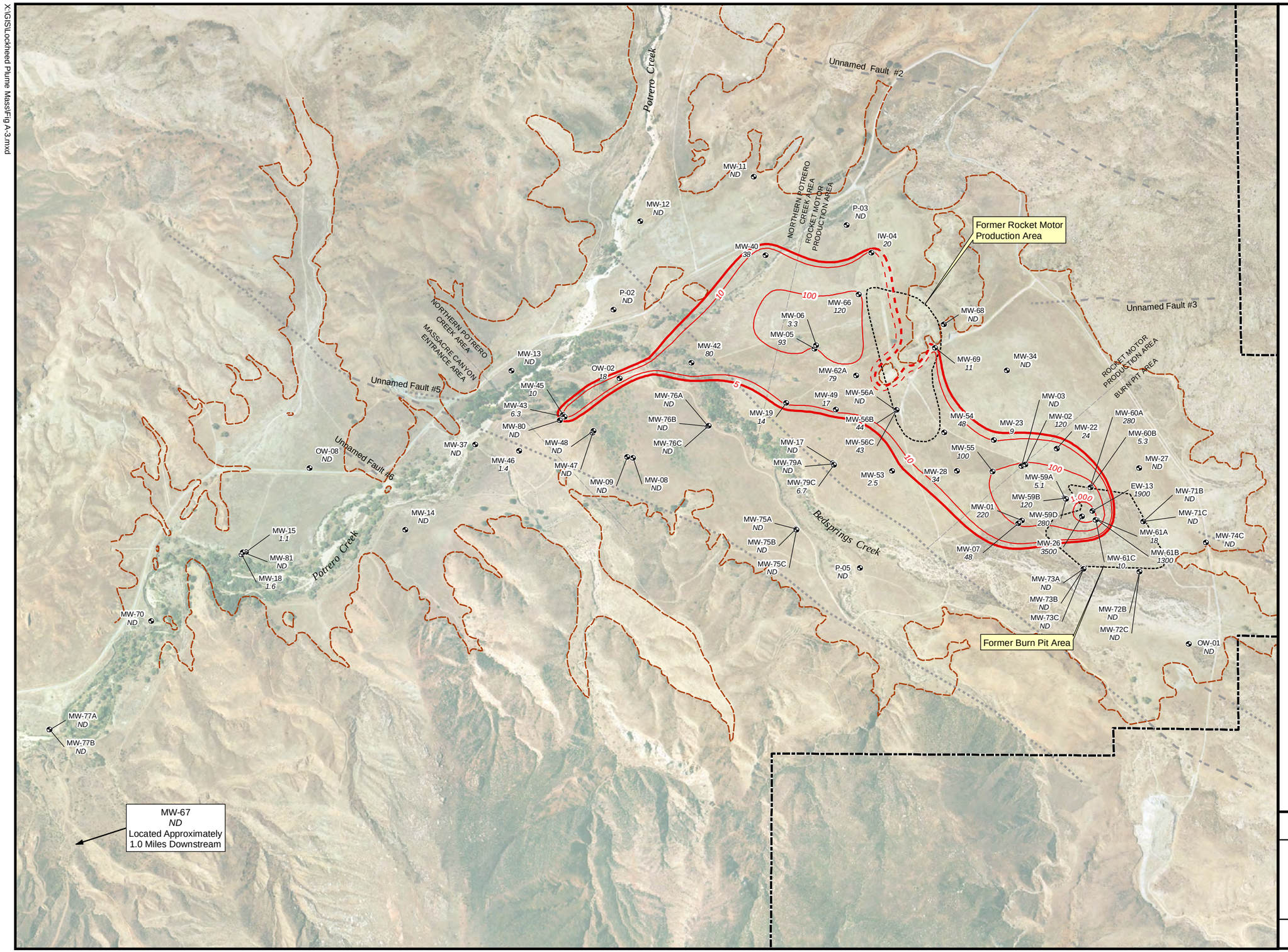

0 500 1,000 Feet

Adapted from: March 2007 aerial photograph.

LEGEND

- MW-01 / 600 — Well ID / Trichloroethene (TCE) Concentration
- TCE Concentration Contour (Depth Maximum) (µg/L) - Dashed Where Inferred
- MCL Contour (Depth Maximum) (5.0 µg/L) - Dashed Where Inferred
- Approximate Location of Fault
- Approximate Location of Buried Fault
- Mt. Eden/Alluvium Surface Contact
- Beaumont Site 1 Property Boundary

Notes:

Beaumont Site 1 property boundary is approximate.

Concentrations shown are in micrograms per liter (µg/L)

Highest concentration shown is contoured for clustered or nested well locations.

MCL - maximum contaminant level.

TCE - Trichloroethene

Beaumont Site 1

Figure A-3

Aquifer TCE Concentrations for Site 1: Depth Maximum Values

TETRA TECH

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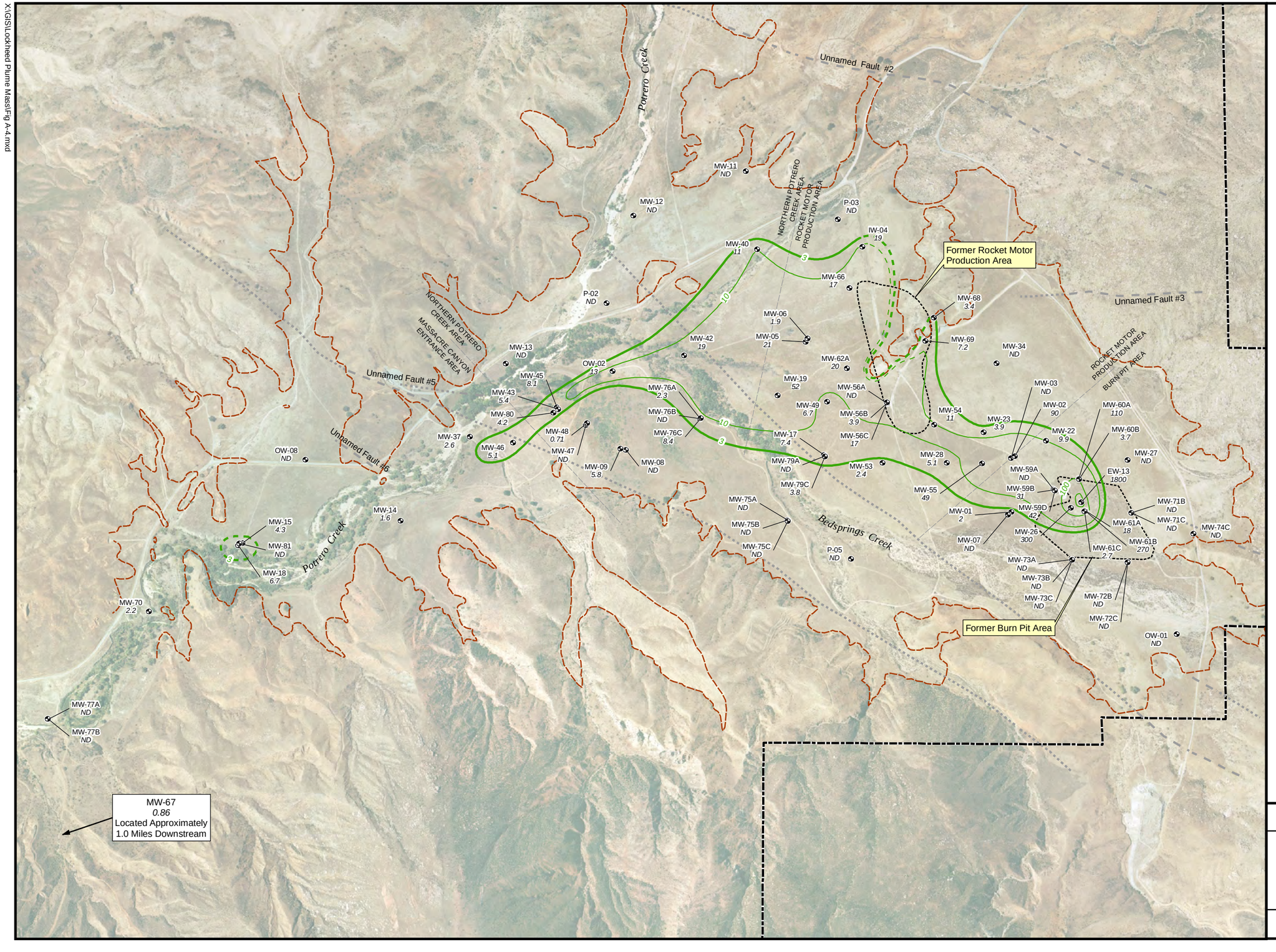

0 500 1,000 Feet

Adapted from: March 2007 aerial photograph.

LEGEND

- MW-01 / 600 — Well ID; 1,4-Dioxane Concentration
- 1,4-Dioxane Concentration Contour (Depth Maximum) (µg/L) - Dashed Where Inferred
- DWNL Contour (Depth Maximum) (3.0 µg/L) - Dashed Where Inferred
- Approximate Location of Fault
- Approximate Location of Buried Fault
- Mt. Eden/Alluvium Surface Contact
- Beaumont Site 1 Property Boundary

Notes:
Beaumont Site 1 property boundary is approximate.
Concentrations shown are in micrograms per liter (µg/L)
Highest concentration shown is contoured for clustered or nested well locations.

DWNL - Drinking Water Notification Limit.

Beaumont Site 1

Figure A-4
Aquifer 1,4 Dioxane Concentrations for Site 1: Depth Maximum Values

TETRA TECH

X:\GIS\Lockheed Plume Mass\Fig A-5.mxd

Potrero Creek
Unnamed Fault #2
Unnamed Fault #3
Unnamed Fault #5
Unnamed Fault #6
Bedsprings Creek
NORTHERN POTRERO CREEK AREA
MASSACRE CANYON ENTRANCE AREA
ROCKET MOTOR PRODUCTION AREA
BURN PIT AREA
Former Rocket Motor Production Area
Former Burn Pit Area

MW-11 2.25
MW-12 ND
P-03 ND
IW-04 ND
MW-40 352
P-02 ND
MW-66 1080
MW-68 3980
MW-06 4.13
MW-05 436
MW-69 2690
MW-34 41.3
MW-62A 421
MW-42 ND
MW-13 ND
OW-02 399
MW-76A ND
MW-45 166
MW-43 69.2
MW-80 ND
MW-48 ND
MW-76B ND
MW-76C ND
MW-37 ND
MW-46 ND
MW-47 5.89
MW-08 ND
MW-09 ND
MW-19 191
MW-49 413
MW-56A ND
MW-56B 120
MW-56C 157
MW-03 ND
MW-02 2220
MW-54 420
MW-23 96.7
MW-22 138
MW-60A 5360
MW-60B 1220
MW-27 2.1
MW-17 444
MW-79A ND
MW-79C 56.4
MW-53 114
MW-28 130
MW-55 1750
MW-59A 1180
MW-59B 4190
MW-59D 5670
EW-13 213
MW-61A 9560
MW-71B 263
MW-71C 273
MW-01 722
MW-07 171
MW-26 7540
MW-61B 71000
MW-74C 10.1
MW-61C 1580
MW-73A 2.65
MW-73B ND
MW-73C ND
MW-72B ND
MW-72C ND
OW-01 ND
MW-75A ND
MW-75B ND
MW-75C ND
P-05 3.59
OW-08 ND
MW-14 3.33
MW-81 ND
MW-15 ND
MW-18 6.02
MW-70 6.91
MW-77A ND
MW-77B ND

1,000
100
10
6

MW-67
ND
Located Approximately
1.0 Miles Downstream

0 500 1,000
Feet

Adapted from: March 2007 aerial photograph.

LEGEND

- MW-01 / *600* — Well ID / Perchlorate Concentration
- Depth Averaged Concentration (µg/L)
- Perchlorate Concentration Contour (Depth Maximum) (µg/L) - Dashed Where Inferred
- DWNL Contour (Depth Maximum) (6.0 µg/L) - Dashed Where Inferred
- Approximate Location of Fault
- Approximate Location of Buried Fault
- Mt. Eden/Alluvium Surface Contact
- Beaumont Site 1 Property Boundary

Notes:
Beaumont Site 1 property boundary is approximate.

Concentrations shown are in micrograms per liter (µg/L)

Highest concentration shown is contoured for clustered or nested well locations.

DWNL - Drinking Water Notification Level.

Beaumont Site 1

Figure A-5
Aquifer Perchlorate Concentrations for Site 1: Depth Maximum and Depth Average Values

TETRA TECH

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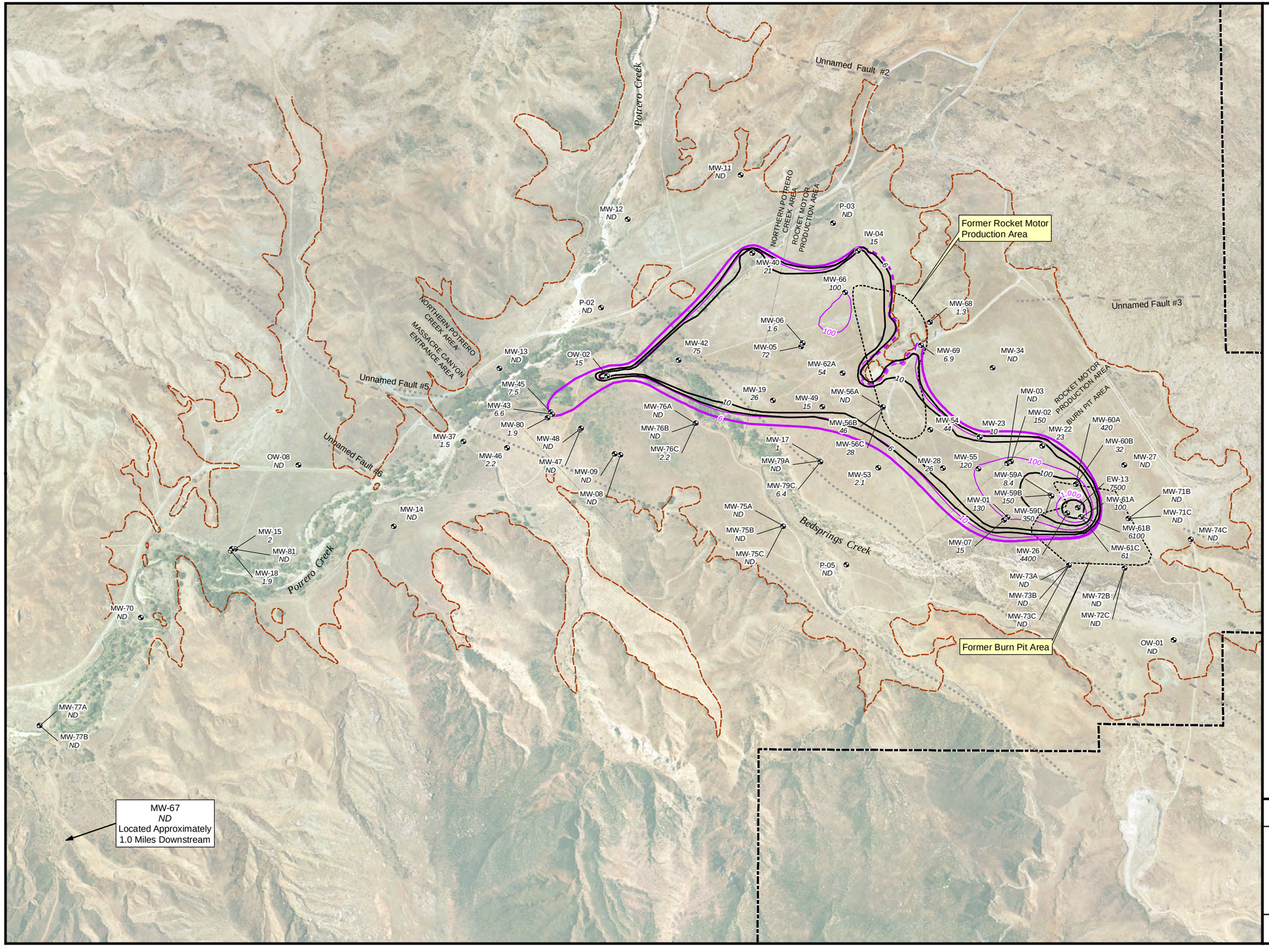

0 500 1,000 Feet

Adapted from: March 2007 aerial photograph.

LEGEND

- MW-01 / 600 — Well ID; 1,1 DCE Concentration
- Depth Averaged Concentration (µg/L)
- 1,1 DCE Concentration Contour (Depth Maximum) (µg/L) - Dashed Where Inferred
- MCL Contour (Depth Maximum) (6.0 µg/L) - Dashed Where Inferred
- Approximate Location of Fault
- Approximate Location of Buried Fault
- Mt. Eden/Alluvium Surface Contact
- Beaumont Site 1 Property Boundary

Notes:

Beaumont Site 1 property boundary is approximate.

Concentrations shown are in micrograms per liter (µg/L)

Highest concentration shown is contoured for clustered or nested well locations.

MCL - maximum contaminant level.

1,1-DCE - 1,1-Dichloroethene

Beaumont Site 1

Figure A-6

Aquifer 1,1 DCE Concentrations for Site 1: Depth Maximum and Depth Average Values

TETRA TECH

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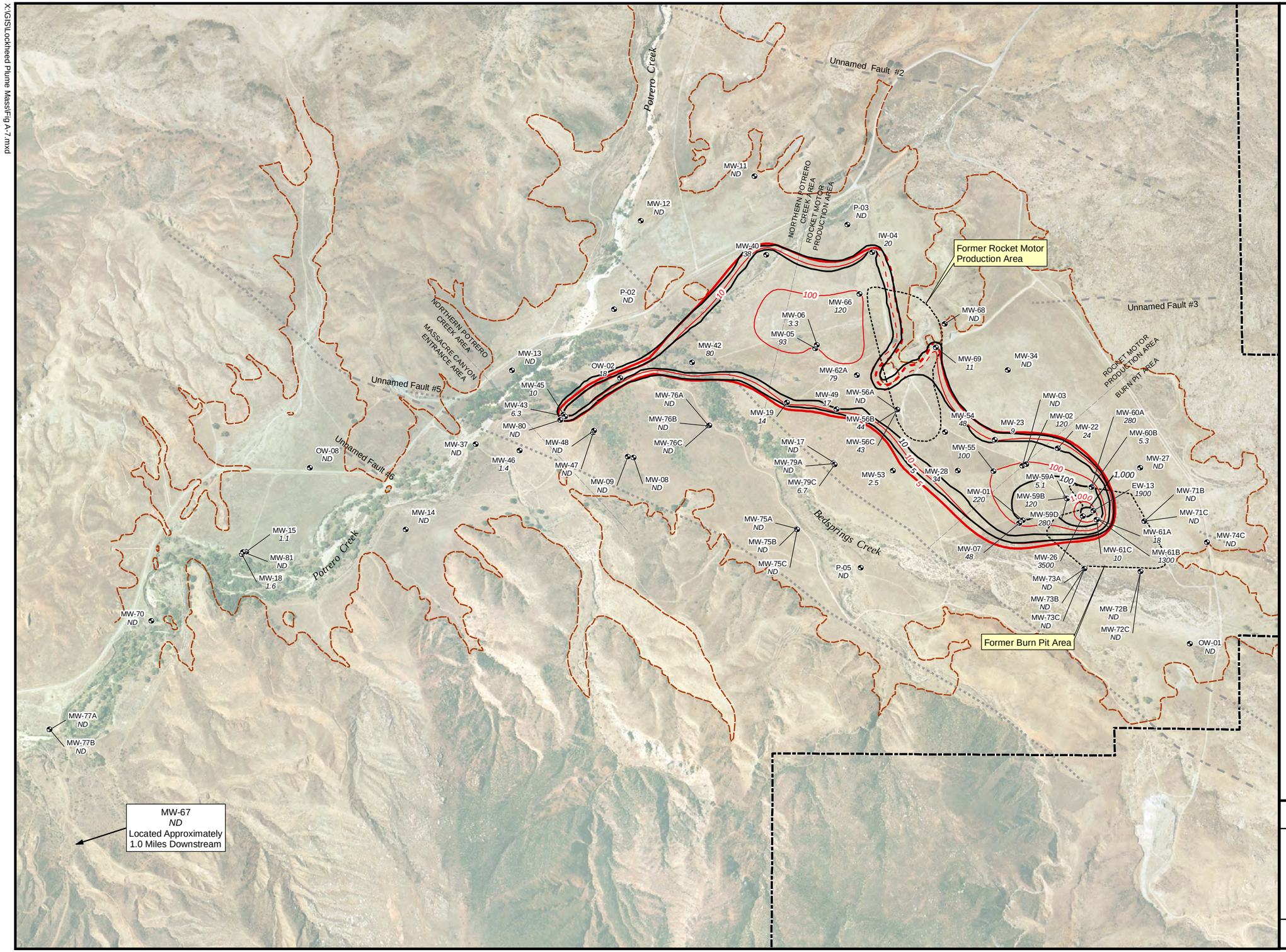

0 500 1,000 Feet

Adapted from: March 2007 aerial photograph.

LEGEND

- MW-01 / 600 — Well ID; Trichloroethene (TCE) Concentration
- Depth Averaged Concentration (µg/L)
- TCE Concentration Contour (Depth Maximum) (µg/L) - Dashed Where Inferred
- MCL Contour (Depth Maximum) (5.0 µg/L) - Dashed Where Inferred
- Approximate Location of Fault
- Approximate Location of Buried Fault
- Mt. Eden/Alluvium Surface Contact
- Beaumont Site 1 Property Boundary

Notes:

Beaumont Site 1 property boundary is approximate.

Concentrations shown are in micrograms per liter (µg/L)

Highest concentration shown is contoured for clustered or nested well locations.

MCL - maximum contaminant level.

TCE - Trichloroethene

Beaumont Site 1

Figure A-7

Aquifer TCE Concentrations for Site 1: Depth Maximum and Depth Average Values

TETRA TECH

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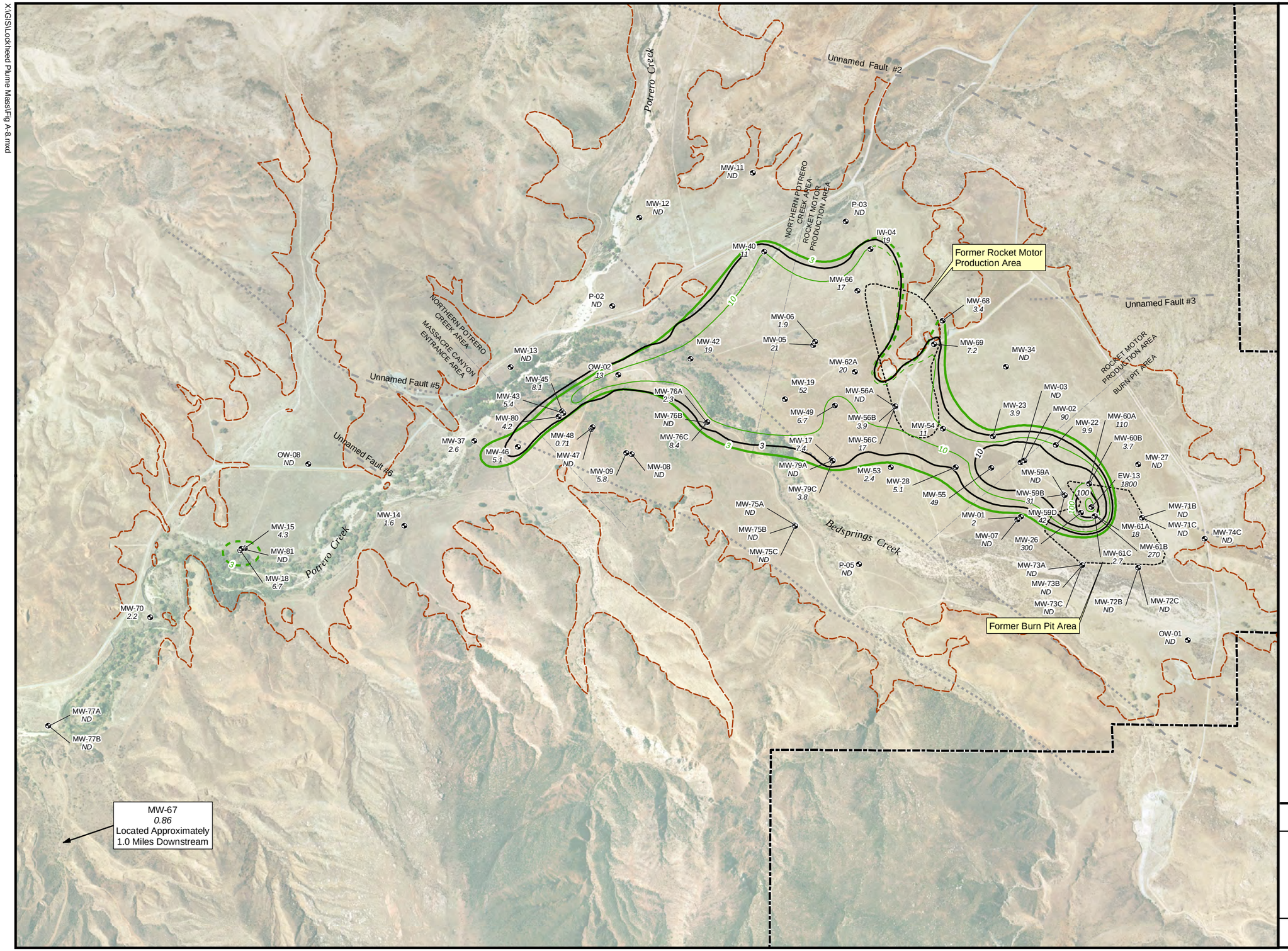

0 500 1,000 Feet

Adapted from: March 2007 aerial photograph.

LEGEND

- MW-01 / 600 — Well ID / 1,4-Dioxane Concentration
- Depth Averaged Concentration (µg/L)
- 1,4-Dioxane Concentration Contour (Depth Maximum) (µg/L) - Dashed Where Inferred
- DWNL Contour (Depth Maximum) (3.0 µg/L) - Dashed Where Inferred
- Approximate Location of Fault
- Approximate Location of Buried Fault
- Mt. Eden/Alluvium Surface Contact
- Beaumont Site 1 Property Boundary

Notes:

Beaumont Site 1 property boundary is approximate.

Concentrations shown are in micrograms per liter (µg/L)

Highest concentration shown is contoured for clustered or nested well locations.

DWNL - Drinking Water Notification Limit.

Beaumont Site 1

Figure A-8
Aquifer 1,4 Dioxane Concentrations for Site 1: Depth Maximum and Depth Average Values

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APPENDIX B
Plume Thickness Contour Map
For Site 1

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Model River Boundary Conditions (green)

Model Horizontal Flow Barrier Boundary Conditions (purple)

Model Evapotranspiration Boundary Conditions (yellow)

Model Head Boundary Conditions (blue)

Monitoring Wells

MW-12, P-03, MW-05, MW-03, MW-44, MW-29, MW-45, EW-02, MW-39, MW-34, MW-52, MW-04, MW-49, MW-54, MW-21, MW-22, MW-10, MW-50, MW-63, MW-53, MW-20, MW-55, MW-02, EW-08, EW-11, MW-71A, MW-01, MW-35, MW-75A, P-05, MW-72A, MW-36, OW-01, MW-13, OW-02, MW-42, MW-43, MW-17, MW-37, MW-46, MW-08, OW-08, MW-38, EW-13, MW-14, MW-15, MW-70, MW-77B, MW-77A, V-67, MW-16

60, 40, 20, 100, 80, 60, 40, 20, 40, 40

MATCH LINE

Model Inactive Area (gray)

Plume Thickness Contours
20 foot intervals
(feet)

0 500 1,000 Feet

Beaumont Site 1

Figure B-1

Contour Map for Thickness of Plume at Beaumont Site 1

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APPENDIX C
Plume Contour and Thickness Maps for Site 2

X:\GIS\Lockheed Plume Mass\Fig C-1A.mxd

Centrifuge Area Plume

50

75

100

125

150

Test Bay Area Plume

125

100

75

Plume Thickness Contours (feet)

50

25

Solid Waste Disposal Area Plume

Liquid Waste Discharge Area Plume

100 µg/L contour assumed to extend to end of riparian area

10 µg/L contour assumed to extend to TT-MW2-19S/D

50

25 foot thickness contour varies down to 10 feet at TT-MW2-19S/D

25

LEGEND

- Previous Sample Location (surveyed)
- Soil Sample Location

Wells

- Monitoring Well Location
- Piezometer Well Location
- Destroyed Production Well Location
- Destroyed Monitoring Well Location
- Reported Production Well Location
- Perchlorate Isoconcentrations in Groundwater
- Perchlorate Isoconcentrations in Soil
- Topographic contour (5-foot interval)
- Beaumont Site 2 Property Boundary

N

0 300 600 Feet

Beaumont Site 2

Figure C-1A
Aquifer Perchlorate Concentrations and Thickness Values for Site 2 (1 of 2)

TETRA TECH

X:\GIS\Lockheed Plume Mass\Prop_Wells 3.mxd

TT-MW2-9S
TT-MW2-9D
TT-MW2-6S
TT-MW2-5
TT-MW2-6D
TT-PZ2-1
TT-MW2-8
TT-MW2-7D
Proposed Piezometer
TT-MW2-7
Proposed Well
25 foot plume thickness
Riparian Corridor
100 µg/L contour assumed extent
10 µg/L contour assumed extent
TT-MW2-19S/D
10 foot plume thickness
SPRING
TT-MW2-20S/D
0 500 1,000 Feet

LEGEND

- Proposed Well Location
- Proposed Piezometer Location
- Well Location
- Spring
- Proposed Geophysical Line (500')
- Faults from Geologic Map of the San Bernardino and Santa Ana 30' x 60' Quadrangles. Morton and Miller 2006.
- Fault (Dibblee)
- Concealed fault (Dibblee)
- Indefinite Fault (Dibblee)
- Faults from 1:250,000 Geologic Map of California, Santa Ana Quadrangle
- Riparian Corridor
- Perchlorate Plume Extent
- San Jacinto Groundwater Basin
- Beaumont Site 2 Property Boundary

Note:
Beaumont Site 2 property boundary from Hillwig-Goodrow survey, May 2004.

Beaumont Site 2

Figure C-1B
Aquifer Perchlorate Concentrations and Thickness Values for Site 2 (2 of 2)

TETRA TECH

X:\GIS\Lockheed Plume Mass\Fig C-2.mxd

Centrifuge
Area Plume

Perchlorate Plume Contours (ug/L)
Depth Maximum - green
Depth Average - black

Test Bay
Area Plume

Solid Waste
Disposal Area
Plume

Liquid Waste
Discharge Area
Plume

LEGEND

- Previous Sample Location (surveyed)
- Soil Sample Location

Wells

- Monitoring Well Location
- Piezometer Well Location
- Destroyed Production Well Location
- Destroyed Monitoring Well Location
- Reported Production Well Location
- Perchlorate Isoconcentrations in Groundwater (Depth Maximum)
- Depth Average
- Perchlorate Isoconcentrations in Soil
- Topographic contour (5-foot interval)
- Beaumont Site 2 Property Boundary

N

0 300 600
Feet

Beaumont Site 2

Figure C-2
Aquifer Perchlorate Concentrations for Site 2: Comparison of Depth-Maximum and Depth Average Values

TETRA TECH