Lockheed Martin Corporation
6801 Rockledge Drive MP: CCT-246
Bethesda, MD 20817
Telephone (301) 548-2227

February 10, 2016

VIA PRIVATE CARRIER

Mr. James R. Carroll
Program Administrator
Land Restoration Program
Land Management Administration
Maryland Department of the Environment
1800 Washington Boulevard, Suite 625
Baltimore, Maryland 21230

Subject: Transmittal of the Groundwater Remediation O&M Manual, Appendix A1—Block E Tracer Testing Work Plan
Lockheed Martin Corporation; Middle River Complex
2323 Eastern Boulevard, Middle River, Baltimore County, Maryland

Dear Mr. Carroll:

For your information, please find enclosed two hard copies with CD of the above-referenced document. The enclosed work plan presents the protocols to perform tracer testing in Block E of the Lockheed Martin Corporation Middle River Complex. If possible, we respectfully request to receive MDE's comments by February 23, 2016.

Please let me know if you have any questions. My office phone is (301) 548-2227.

Sincerely,

Lynnette Drake
Remediation Analyst, Environmental Remediation

Enclosures:

cc: (via email without enclosure)
Gary Schold, MDE
Mark Mank, MDE
Tom Blackman, Lockheed Martin
Christine Kline, Lockheed Martin
Norman Varney, Lockheed Martin
John Morgan, LMCPI
Dave Brown, MRAS
Michael Martin, Tetra Tech
Cannon Silver, CDM Smith

cc: (via mail with enclosure)
Tom Green, LMCPI
Mike Musheno, LMCPI
Justin Tetlow, MRAS
Doug Mettee, Lockheed Martin MST

cc: (via mail with CD enclosure)
Jann Richardson, Lockheed Martin

Groundwater Remediation O&M Manual, Appendix A1—Block E Tracer Testing Work Plan Middle River Complex, Middle River, Maryland

Prepared for:

Lockheed Martin Corporation

Prepared by:

Tetra Tech, Inc.

February 2016

Michael Martin, P.G.
Regional Manager

Christopher Pike
Project Manager

TABLE OF CONTENTS

LIST OF TABLES

FIGURES

This page intentionally left blank.

ACRONYMS

CB	catch basin
DO	dissolved oxygen
°F	degrees Fahrenheit
gph	gallon(s) per hour
gpm	gallon(s) per minute
IW	injection well
lbs	pounds
Lockheed Martin	Lockheed Martin Corporation
mg/L	milligram(s) per liter
mL	milliliter
mL/min	milliliters per minute
MP	metering pump
MRC	Middle River Complex
NMW	new monitoring well
O&M	operations and maintenance
ORP	oxidation-reduction potential
psig	pound(s) per square inch gauge
SDS	safety data sheet
TCE	trichloroethene
USEPA	United States Environmental Protection Agency
UST	underground storage tank

This page intentionally left blank.

Section 1
Background

On behalf of Lockheed Martin Corporation (Lockheed Martin), Tetra Tech, Inc. (Tetra Tech) has prepared the following work plan to perform tracer testing in Block E of the Lockheed Martin Corporation Middle River Complex (MRC) at 2323 Eastern Boulevard in Middle River, Maryland. This work plan is an addition to Appendix A of the *Groundwater Remediation System Operations and Maintenance Manual* (O&M manual) for the Lockheed Martin Middle River Complex (Tetra Tech, 2014). Refer to the appropriate sections of the operations and maintenance manual for background information, remediation system process-equipment and controls descriptions, and for specific operation and maintenance procedures.

The groundwater response action at the Middle River Complex implements enhanced anaerobic bioremediation-processes in three areas that have high concentrations of trichloroethene (TCE) in groundwater: the southeastern trichloroethene area (Block E), the southwestern trichloroethene area (Block G), and the northern trichloroethene area (Block I). Amendments are injected into the subsurface using rows of semi-permanent injection wells connected (via underground conveyance piping) to injection equipment in each of the three TCE areas (Appendix C of the operations and maintenance manual, Drawings C-2, C-3, C-4). Field tracer-testing was performed at Blocks G and I before system startup because injected fluid pathways are difficult to predict accurately for the low permeability, heterogeneous geology of the Middle River Complex. However, the remedy implementation (including tracer test) at Block E was delayed due to the discovery of underground tanks and the source removal action associated with the TCE source. The tracer testing to be conducted at Block E is very similar to that completed at Blocks G and I.

The main objectives of tracer testing at Block E are to:

- evaluate preferential pathways for injected fluid
- determine optimal injection rates
- verify achievable design-injection volumes

- verify the performance and design of injection wells
- determine injection effects on the aquifer
- determine if injected material is being transported via flow through utilities or utility bedding, and if such transport is occurring, determine how to prevent it from occurring during enhanced anaerobic bioremediation
- test and confirm the full functionality of the injection system, including the process equipment, controls, and communications

This work plan provides the rationale, methodology, data collection requirements, and safety protocols for tracer testing.

Tracer testing will involve the following:

- using the same processing equipment and controls as will be used in the enhanced anaerobic bioremediation work
- communications testing and de-bugging
- performing tracer tests using treated pH-adjusted, chlorine- and oxygen-free potable water with added sodium-bromide tracer
- reporting results

Section 2
General Approach and Methodology

Tracer testing in Block E will entail the following general components:

a) The injection equipment module will be placed in the Block E test area as shown on Figure 2-1. The final module location will be predicated on site conditions at the time of the container move.

b) The underground injection lines, potable-water line, and power supply will be connected to the equipment container.

c) Baseline performance-monitoring sampling will be performed, including bromide sampling.

d) Process equipment, controls, and communications will be configured and tested.

e) Test injections will be performed using water (with chlorine and dissolved oxygen removed), tracer, and pH buffer (sodium bicarbonate). The following general procedure will be used:

- The system will be configured to simultaneously inject fluid with tracer into several selected injection wells; two well sets will be tested in Block E.
- Injection rates will be set as indicated in Section 3.
- Groundwater-table mounding and pressure heads in the injection interval will be measured, and injection rates adjusted as necessary.
- Stormwater utilities and outfalls will be visually examined and monitored.
- Samples will be collected to detect the tracer in monitoring wells, stormwater utilities, and outfalls.

Note that some parameter values (such as achievable injection rates and injection wellhead pressures) are preliminary and should not be viewed as final operational parameters. Tracer testing results will be used to determine operational injection rates and wellhead pressures for the full-scale injection events.

2.1 LOGISTICS AND EQUIPMENT

Tracer test equipment and logistics are selected to ensure safety during field procedures and to minimize risk while achieving the stated test objectives. The following steps summarize tracer test general logistics and equipment:

1) Injection equipment module designed to perform full-scale injection events will be used for tracer injection. The injection module will be moved from Block I to Block E. The equipment module will be positioned approximately as shown in Figure 2-1.

2) The pH adjustment tank (T-2) in the equipment module will be filled with 330 gallons of treated (deoxygenated and dechlorinated) potable water, and the design quantity of sodium bromide tracer will be added. Sodium bromide is a common nontoxic tracer for groundwater studies. Refer to Appendix E of the operations and maintenance (O&M) manual (Tetra Tech, 2014) for the sodium-bromide safety data sheet (SDS). The rationale for the selection of the bromide tracer-concentration is in Section 2.2.

3) The design quantity of buffer (sodium bicarbonate) will be added to tank T-2. Sodium bicarbonate is a common nontoxic chemical often used as a gentle pH-buffering agent. Appendix E of the O&M manual (Tetra Tech, 2014) contains the SDS for sodium bicarbonate. The mixing pump in T-2 will be activated for approximately 4-8 hours to dissolve the added chemicals.

4) Operation of the injection system will be started per the start-up procedures described in Section 3.1 of the O&M manual (Tetra Tech, 2014). Injection system equipment will be configured as described in Section 3.1.3 of the O&M manual (Tetra Tech, 2014). Injection well configurations for each specific test area are described in Section 3 below.

5) Before starting the injection test at each location, data-logging liquid-level transducers will be placed in selected wells to automatically measure liquid levels. Following each test in each area, the data will be downloaded and used to determine the injections' effects on groundwater levels in the injection area. Two injection events at two sets of selected wells are proposed for Block E.

6) During injection, stormwater utilities and the outfall in the injection areas will be visually inspected upon arrival at the site and at the end of the day to note any change in flow or water characteristics. The active injection wellheads and all wells near the injection wells will also be checked for leaks and daylighting of tracer fluid.

7) The presence of bromide tracer will be determined by collecting analytical samples from monitoring wells at each injection location and from various stormwater utility locations. Sampling locations specific to each test area are described in Section 3 of this document.

8) Injection equipment is designed to operate automatically, with little involvement from the system operator. However, field personnel will monitor injections at least three times during the first week of operation at each area, and then weekly for the remaining study

period. Additionally, monitoring via remote computer access will be performed daily when the operator is not present at the site.

2.2 TRACER DOSAGE

Proposed sodium-bromide tracer quantities will be selected based on baseline bromide levels measured at various Middle River Complex (MRC) locations before the tracer test. A lower concentration of bromide tracer can generally be used if low baseline-bromide levels are found in the groundwater. Sodium-bromide tracer was successfully used during the November 2011 injection test (Tetra Tech, 2011). Background bromide levels measured in MRC groundwater before the November 2011 pilot injection-test range from below 0.05 milligrams per liter (mg/L) to 0.34 mg/L. Approximately 10 pounds (lbs) of sodium bromide tracer were introduced in each injection well test location during the November 2011 test. Therefore, elevated bromide concentrations might persist near the 2011 injection well test locations.

The dosages and injection rates proposed in this work plan may be changed in response to groundwater mounding, and daylighting or leakage of tracer as the testing proceeds.

For design purposes, bromide tracer quantities for each injection well are assumed to be approximately the same as the quantities used during the 2014 tracer tests in Blocks G and I (approximately 10 lbs of sodium bromide per injection well). This will result in a concentration of approximately 200 to 250 mg/L of bromide in the injected solution.

The duration of tracer injection (as compared to the overall injection duration) can be varied; for example, the entire design quantity of tracer (10 lbs per well) can be injected at the beginning of the injection process and then "chased" by fluid without tracer, until the entire design volume has been injected. The advantage of this approach is that it uses higher tracer concentrations, making differentiation of the tracer from background levels easier. However, tracer can be missed in sampling locations if sampling frequency is insufficient. This approach is better suited to locations with relatively high background tracer-concentrations.

In contrast, the same tracer quantity (10 lbs per well) can be injected uniformly during the entire injection process. The advantage of this approach is that it reduces the likelihood of missing the tracer due to insufficient sampling frequency. However, differentiating tracer concentrations from background levels can be more difficult to discern (as compared to the previous approach). This

approach is better suited to locations with relatively low background tracer concentrations. A combination of these two approaches will be used; tracer injection time is estimated to be approximately 75% of the entire injection time, corresponding to tracer injection concentration of 500 mg/L (similar to the 2011 injection test). A final decision regarding injection protocol will be made and discussed during a regular Lockheed Martin Corporation (Lockheed Martin) conference call after the pre-test background-bromide concentration data become available.

2.3 BROMIDE SAMPLING PROCEDURE

The results of the bromide tracer analyses will be used to estimate each injection well's effects on the aquifer, and to determine if transport via site utilities is occurring. This information will be used later to plan the full-scale injection events. Collecting representative-formation groundwater samples is therefore important for tracer analyses, so a standard low-flow sampling technique will be used.

Monitoring wells will be purged using a peristaltic pump and disposable polyethylene tubing placed in the middle of the screen. The pumping rate will range between 100–300 milliliters per minute (mL/min). The final adjustment of the purge rate will depend on water stabilization and how fast the well recharges without drawdown below the initial static water level.

During groundwater purging, water-level-drawdown measurements and groundwater parameters (such as pH, temperature, specific conductance, dissolved oxygen [DO], and oxidation-reduction potential [ORP]) will be collected every five to 10 minutes or after each purge volume, whichever is quicker, until purging is complete. These data will be recorded in the appropriate site-specific logbook, as well as on low-flow-purge data sheets. Water-quality parameters will be measured using an inline water-quality meter.

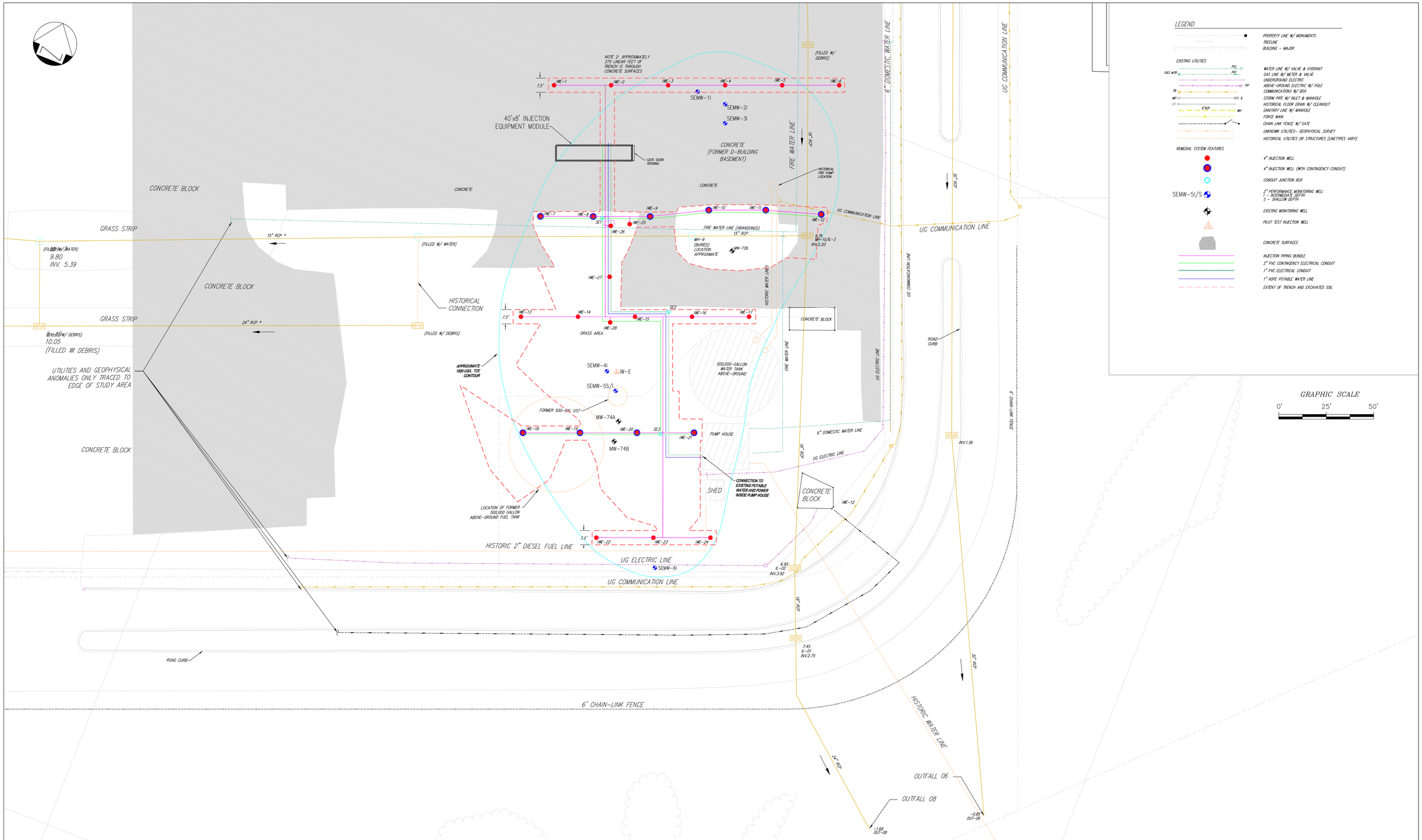
Purging will be considered complete when the monitored water quality parameters have stabilized, when the well has been purged dry, or when purging has occurred for one hour. Stabilization will have been achieved when three consecutive readings, taken at five-minute intervals, are within the following parameters:

- ±0.2 standard units for pH
- ±5% for specific conductance and temperature

- ±20% for DO and ORP
- less than 20 nephalometric turbidity units for turbidity
- for a maximum of one hour

If a monitoring well is purged dry, the water level in the well will be allowed to recover a minimum of 80% of its initial static water level before groundwater sampling begins. Samples from utilities will be collected by filling the sample bottle directly from the water flow in the utility; field parameters will not be collected for those samples.

The samples will be shipped to a fixed-based laboratory (Analytical Laboratory Services, Middletown, Pennsylvania) to be analyzed for bromide using United States Environmental Protection Agency (USEPA) Method 300.0 ("Anions, Ion Chromatography"). The method detection-limit for bromide samples will be 0.050 mg/L. Sampling containers will be 250 milliliter (mL)-volume plastic bottles, unpreserved, and will be shipped cooled on ice. The samples for bromide must be analyzed within 28 days of sampling.



REFERENCE PLANS & DATA:

1. UTILITY CROSS CONNECTION SURVEY PERFORMED BY TETRA TECH CREW: RAB & AN, DATED 10/6,10/10 & 10/11/2011
2. SURVEYED LOCATIONS OF UNDERGROUND ELECTRIC, WATER, COMMUNICATION LINES, ARE BASED ON GEOPHYSICAL SURVEYS CONDUCTED BY ENVIROSCAN, INC. LANCASTER, PA, AND UNKNOWN FEATURES.
3. SEWER PIPE CCTV REPORTS PREPARED BY VIDEO PIPE SERVICES, INC. DATED 9/26 & 10/12/2011
4. BLOCK G TOPOGRAPHIC SURVEY UPDATE PREPARED BY TETRA TECH CREW: RAB & AN, DATED: 06/07 & 06/08/2011
5. PRE-CONSTRUCTION SURVEY OF STORM DRAIN LINES FOR BLOCK E PREPARED BY TETRA TECH CREW: RAB & AN, DATED 08/15 & 08/16/ 2011.
6. BACKGROUND BASEMAP AND PROPERTY LINES ARE FROM CHESAPEAKE PARK SITE PLAN - LMC PROPERTIES, INC PREPARED BY TAI CONSULTING ENGINEERS, DATED 4/15/01. BACKGROUND DATA IS NOT FIELD VERIFIED AND FOR REFERENCE ONLY.

TETRA TECH

www.tetratech.com

MARK	DATE	DESCRIPTION	BY

SOUTHEAST TCE AREA REMEDY LAYOUT
BLOCK E TRACER TEST WORK PLAN
LOCKHEED MARTIN CORPORATION
MIDDLE RIVER COMPLEX, MIDDLE RIVER, MARYLAND

DATE:	12/22/15
PROJECT NO.:	112IC03835
DRAWING SIZE:	ARCH E
DRAWN BY:	DWM
CHECKED BY:	BD

FIGURE 2-1

C:\USERS\BORIS.DYNKIN\DOCUMENTS\LMC MRC\O&M MANUAL\BLOCK E TRACER TEST\FIGURE 1SE LAYOUT.DWG DWM 12/22/15

Section 3
Block E Tracer Testing

This section describes the layout for the tracer test, field procedures, and monitoring that will be performed for the tracer test in the Block E area of the Middle River Complex (MRC).

3.1 FIXED-BASE LABORATORY SAMPLING

Baseline groundwater samples will be collected from the following wells before tracer testing begins: SEMW-1I, SEMW-2I, SEMW-3I, SEMW-4I, SEMW-5S, SEMW-5I, SEMW-6I, IWE-25, IWE-28, MW-72B, MW-74A, and MW-74B. The baseline testing parameters for Block E are summarized in Table 3-1. Appendix B of the operations and maintenance (O&M) manual (Tetra Tech, Inc. [Tetra Tech], 2014) contains procedures for baseline sampling. Groundwater samples from the following wells near the tracer injection areas will also be analyzed for bromide: SEMW-1I, SEMW-2I, SEMW-3I, SEMW-6I, and MW-72B. Additionally, bromide samples will be collected from three catch basins (MH-10/IL-3, IL-2, IL-1) and one outfall (Outfall 8). Bromide levels will be measured several times during the tracer test. A baseline sample will be collected before tracer testing begins, and several samples will be collected at various times during the tracer test. A static sample will be collected after the tracer test is complete. Bromide sampling locations and sampling frequency are summarized in Table 3-2. Bromide sampling procedure and analytical laboratory requirements are described in Section 2-3.

3.2 GROUNDWATER TABLE MEASUREMENTS

Groundwater levels will be monitored periodically via manual gauging of monitoring wells and via pressure transducers placed within several injection wells (Table 3-4). Groundwater levels in existing monitoring and injection wells near the active injection location will be manually measured 24-48 hours before tracer testing begins. Groundwater levels within these wells will also be measured three times during the first week of each injection event and weekly thereafter. Table 3-4 lists the groundwater gauging locations for the Block E tracer tests.

Groundwater levels at several locations will be continuously recorded using down-well pressure transducers. Transducers will be installed and will operate throughout the tracer injection testing in wells SEMW-1I, SEMW-3I, SEMW-6I, and MW-72B. Before the transducers are installed and prior to removal, water levels in each well will be measured using an electronic water-level meter. Transducers will collect data for the entire test duration. Transducers will be installed in each location approximately five to 10 feet below the static water level; recording frequency will be set to approximately five minutes. The transducers will be left in place while the wells are being sampled. During sampling, water levels in each well will be measured using an electronic water-level meter.

The transducers will be removed one week after the Block E tracer testing is finished to allow the groundwater table to recover to static conditions. Data from the transducers will be downloaded and assembled in a spreadsheet for analysis.

3.3 INJECTION SOLUTION PREPARATION

The following procedure will be used to prepare the injection solution in tank T-2 during the Block E tracer testing event:

1) Fill tank T-2 with 330 gallons of treated (dechlorinated and deoxygenated, as described in O&M Manual) potable water. Set heating unit AC-1 to 70 degrees Fahrenheit (°F). Allow the water in tank T-2 to warm to room temperature before adding chemicals.

2) Measure out sodium bromide (10 pounds [lbs] per injection well) and place it into tank T-2. Sodium bromide will be delivered in 50-lb bags.

3) Place one bag (50 lbs) of sodium bicarbonate into tank T-2.

4) Activate mixing pump in tank T-2 for 4-8 hours to dissolve the chemicals.

5) Determine the dosage rate for metering pump (MP-2) in gallons per hour (gph), using the following equation:

$$\mathbf{Q_{MP2} = V_{T2}/(T_{inj} \times R_{inj} \times 24\ hours/day)}$$

where:

Q_{MP2} = metering pump MP-2 dosage rate (gph)
V_{T2} = tank T-2 volume (gallons)
T_{inj} = expected injection volume duration (days)
R_{inj} = ratio of tracer injection time to entire injection time (%)

Parameter values and the calculated dosage rate for metering pump MP-2 assume that the tracer is injected continuously over 75% of the entire injection event. Using this assumption, input parameters for the above equation result in following values:

V_{T2}	330 gallons (full tank volume)
T_{inj}	12 days (duration to inject 5,260 gallons per well @ 0.3 gpm injection rate)
R_{inj}	75% (tracer injection will be 75% of injection duration or 9 days)
Q_{MP2}	1.5 gph (metering pump setting at 0.3 gallons per minute [gpm] per well)

Metering pump MP-2 will be set to output the calculated design injection-rate of 0.3 gpm per well. Pump MP-2 will use the signal from electronic flow-meter FMT-1 to automatically maintain a constant tracer concentration in the injected stream.

3.4 INJECTION PROCEDURE

Block E tracer testing will consist of two events:

- *Injection event #1*—injection into six wells in the northern and southern areas of Block E.
- *Injection event #2*—injection into three wells in the central area of Block E.

The injection solution (sodium bromide and sodium bicarbonate) in tank T-2 will be prepared per procedures described in Section 3.3 of this work plan. Injection system equipment will be prepared for operation and configured as described in Sections 3.1 and 3.1.3 of the O&M manual (Tetra Tech, 2014). Six injection wells (IWE-3, IWE-4, IWE-5, IWE-22, IWE-23, and IWE-24) will be connected to the injection manifold for injection event #1. These wells are selected to avoid tracer injection in the area of high trichloroethene (TCE) concentration (near and downgradient of former TCE tank); results from the nearby testing will be used to design the injection in this area. The injection system will be activated and the injection rate for each connected well will be set to approximately 0.3 gpm, for a total injection rate of approximately 1.8 gpm (six wells connected).

Metering pump MP-2 will be activated to begin injection of the bromide tracer/sodium bicarbonate solution from tank T-2 into the injection manifold. Settings for metering pump MP-2 are described in Section 3.3 of this work plan.

The entire full-scale design volume (5,260 gallons per well, for a total volume of approximately 31,500 gallons) will be injected. The flow rate for injection event #1 will be set to 0.3 gpm per well for approximately 12 days. However, the injection flow might vary, because flow might be adjusted in response to changing wellhead pressures. The site operator will visit the site at least three times during the first week of testing, then weekly thereafter.

Injection event #1 will be finished when approximately 31,500 gallons of treated potable-water (based on mechanical totalizer FT-1) with bromide tracer and sodium bicarbonate have been injected into six wells (IWE-3, IWE-4, IWE-5, IWE-22, IWE-23, and IWE-24). The entire volume of tank T-2 (approximately 330 gallons) with 60-lbs of sodium bromide tracer and 50-lbs of sodium bicarbonate will be injected by metering pump MP-2 into the treated water stream during injection event #1.

Injection event #2 will begin immediately after injection event #1 is finished. The injection system equipment will be deactivated, and the injection wells connected for injection event #1 will be disconnected from the injection manifold. Injection wells IWE-10, IWE-11, and IWE-12 will then be connected for injection event #2. The injection solution (sodium bromide and sodium bicarbonate) in tank T-2 will again be prepared according to the procedures described in Section 3.3 of this work plan. The system will be re-activated, and injection event #2 will then be performed in the same manner as injection event #1. The entire full-scale design volume (5,260 gallons per well, or approximately 16,000 gallons total) will be injected. The entire volume of tank T-2 (approximately 330 gallons) with 30-lbs of sodium bromide tracer and 50-lbs of sodium bicarbonate will injected by metering pump MP-2 into the treated water stream during injection event #1. During the second injection event, the system operator will visit the site three times during the first week of injections, and weekly thereafter.

3.5 PARAMETER MONITORING

Injection system parameters inside the equipment container will be monitored and recorded at least twice daily during each site visit while tracer testing is underway. The on-site operator and, if necessary, a remote operator via an Internet connection, will monitor and control the operation of the injection system. The injection system will be accessed daily via remote connection. The procedures for remote monitoring and control of the system are described in Section 3.2.2 of the O&M manual (Tetra Tech, 2014). A summary of the process-equipment parameters inside the equipment module is in Table 3-3. Wellhead pressures for injection wells, changes in the groundwater table, bromide concentrations in wells, catch basins, and outfalls, observations of any liquid daylighting, and other visible potential effects of injection will be monitored and recorded. If daylighting is observed or significant tracer is measured in the catch basins or outfalls, the injection will be stopped, Lockheed Martin will be notified, and alternative injection protocol will be considered and initiated. A summary of these field parameters is in Table 3-4.

Table 3-1
Block E Baseline Sampling Summary
Tracer Testing Work Plan
Lockheed Martin Middle River Complex, Middle River, Maryland

Sampling event	Baseline						
Monitoring Well	Bromide	VOCs	TOC	Chem	MEE	DHC	Field
SEMW-1I	1	1	1	1			1
SEMW-2I	1	1	1	1	1	1	1
SEMW-3I	1	1	1	1			1
SEMW-4I		1	1	1	1	1	1
IWE-2	1						
IWE-6	1						
IWE-25		1	1	1	1	1	1
IWE-28		1	1	1	1	1	1
SEMW-5S		1	1	1			1
SEMW-5I		1	1	1			1
SEMW-6I	1	1	1	1	1	1	1
MW-72B	1	1	1	1	1	1	1
MW-74A		1	1				1
MW-74B		1	1	1	1	1	1
MH-10	1		1				1
IL-2	1		1				1
IL-1	1		1				1
Outfall 8	1		1				1
Totals	11	12	16	11	7	7	16

Definitions:

Total bromide
VOCs - volatile organic compounds
TOC - total organic carbon
Chem - sulfates, alkalinity, total dissolved solids, total iron, total manganese
MEE - gases (methane, ethane, ethene)
DHC and functional genes - *dehalococcoides*, trichloroethene (TCE) reductase, vinyl chloride (VC) reductase
Field – temperature, pH, oxidation-reduction potential, dissolved oxygen, specific conductance

Table 3-2
Block E Bromide Sampling Summary
Tracer Testing Work Plan
Lockheed Martin Middle River Complex, Middle River, Maryland
Page 1 of 2

Sampling Location	Sampling Events					
	Event 1	Event 2	Event 3	Event 4	Event 5	Event 6
SEMW-1I	Baseline	1st injection Week 1	1st injection Week 2		Static - Week 2 after 1st injection	
SEMW-2I	Baseline	1st injection Week 1	1st injection Week 2		Static - Week 2 after 1st injection	
SEMW-3I	Baseline	1st injection Week 1	1st injection Week 2		Static - Week 2 after 1st injection	
IWE-2	Baseline	1st injection Week 1	1st injection Week 2		Static - Week 2 after 1st injection	
IWE-6	Baseline	1st injection Week 1	1st injection Week 2		Static - Week 2 after 1st injection	
SEMW-6I	Baseline	1st injection Week 1	1st injection Week 2		Static - Week 2 after 1st injection	
MW-72B	Baseline			2nd injection Week 1	2nd injection Week 2	Static - Week 2 after 2nd injection

Table 3-2
Block E Bromide Sampling Summary
Tracer Testing Work Plan
Lockheed Martin Middle River Complex, Middle River, Maryland
Page 2 of 2

Sampling Location	Sampling Events					
	Event 1	Event 2	Event 3	Event 4	Event 5	Event 6
MH-10/IL-3	Baseline	1st injection Week 1	1st injection Week 2	2nd injection Week 1	2nd injection Week 2	Static - Week 2 after 2nd injection
IL-2	Baseline	1st injection Week 1	1st injection Week 2	2nd injection Week 1	2nd injection Week 2	Static - Week 2 after 1st injection
IL-1	Baseline	1st injection Week 1	1st injection Week 2	2nd injection Week 1	2nd injection Week 2	Static - Week 2 after 2nd injection
Outfall 8	Baseline	1st injection Week 1	1st injection Week 2	2nd injection Week 1	2nd injection Week 2	Static - Week 2 after 2nd injection

Table 3-3
Block E Equipment Module Process Equipment Monitoring
Tracer Testing Work Plan
Lockheed Martin Middle River Complex, Middle River, Maryland
Page 1 of 2

Parameter	Instrument or Formula	Expected Range/Adjustment	Units
Date/time of observation	clock	NA	NA
Injection wells connected	Manifold	**1st injection event:** IWE-3, IWE-4, IWE-5, IWE-22, IWE-23, IWE-24 **2nd injection event:** IWE-10, IWE-11, IWE-12	NA
Potable water inlet pressure	PG-1	50 to 100	psig
Pressure regulator PR-1 outlet pressure	PG-2	Adjust pressure in PG-2 between 10- 20 psig using PR-1.	psig
GAC-1 outlet pressure	PG-3	1-2 psig below PG-2. Check GAC-1 at over 3 psig difference from PG-2.	psig
Filter PF-1 outlet pressure	PG-4	0-2 psig below PG-3. PF-1 (replace filter bag) at over 3 psig difference from PG-3.	psig
Injection manifold pressure	PG-5	1-2 psig below PG-4. Check MC-1 at over 3 psig difference from PG-4.	psig
DO removal contactor vacuum	VG-1	25 to 27. Close/open dilution valve to increase/decrease vacuum.	inch Hg
Flow metering valves settings	V-101 to V-106	Open eight (8) full turns for start-up.	# of turns open
Injection wells pressure	PG-101 to PG-106	0 to 5 psig. Decrease injection rate if > 5 psig	psig
Total injected volume mechanical totalizer	FT-1	Approximately 2600/1300 gallons per day increase	gallons
Total injected volume electronic flow meter	FMT-1	Approximately 2600/1300 gallons per day increase	gallons

Table 3-3
Block E Equipment Module Process Equipment Monitoring
Tracer Testing Work Plan
Lockheed Martin Middle River Complex, Middle River, Maryland
Page 2 of 2

Parameter	Instrument or Formula	Expected Range/Adjustment	Units
Total injection flow rate	FMT-1	Approximately 1.8 gpm with 6 injection wells. Adjust injection manifold pressure (PG-5) using PR-1 of maintain desired injection flow (increase pressure for greater flow).	gpm
Total injected volume per well	FT-101 to FT-106	Approximately 450 gallons per day. Adjust # of turns for metering valves V-101 to V-106 in order to equalize injection volumes between wells.	gallons
Sodium bicarbonate solution level	T-2	1 gph dosing rate for MP-2 corresponds to 3 inches per day of liquid level decline in tank T-2. Check metering pump MP-2 setting and scaling factor if the actual dosage rate is different from the set value.	inches
Electrical utilities meter reading	Electrical meter	20- 30 kwh per day	kw-hour
Enclosure temperature	Electrical meter	65 to 75	deg F

Table 3-4
Block E Field Parameters Monitoring
Tracer Testing Work Plan
Lockheed Martin Middle River Complex, Middle River, Maryland

Parameter	Expected Range	Units	Monitoring Frequency
1st injection event			
IWE-3 wellhead pressure	0-5	psig	Every site visit will occur when system is running. Liquid day-lighting and any other visible potential effects of injection near injection wells will also be noted.
IWE-4 wellhead pressure	0-5	psig	
IWE-5 wellhead pressure	0-5	psig	
IWE-22 wellhead pressure	0-5	psig	
IWE-23 wellhead pressure	0-5	psig	
IWE-24 wellhead pressure	0-5	psig	
IWE-2 depth to water	5-10	feet	Four events: baseline; 1st injection week - 3 times; weekly for 2nd week. Liquid day-lighting, surface water infiltration, changes in catch basins and in Outfall 8 and any other visible potential effects of injection will be noted during gauging events and the system stopped and changes to the injection protocol made, if necessary
IWE-6 depth to water	5-10	Feet	
SEMW-1I depth to water	5-10	Feet	
SEMW-2I depth to water	5-10	Feet	
SEMW-3I depth to water	5-10	Feet	
SEMW-6I depth to water	5-10	Feet	
IWW-16 depth to water	5-10	Feet	
2nd injection event			
IWE-10 wellhead pressure	0-5	psig	Every site visit when system is running. Liquid day-lighting and any other visible potential effects of injection near injection wells will also be noted.
IWE-11 wellhead pressure	0-5	psig	
IWE-12 wellhead pressure	0-5	psig	
IWE-9 depth to water	5-10	feet	Four events: baseline; 1st injection week - 3 times; weekly for 2nd week. Liquid day-lighting, surface water infiltration, changes in catch basins and in Outfall 8 and any other visible potential effects of injection will be noted during gauging events.
MW-72B depth to water	5-10	feet	
IWW-37 depth to water	5-10	feet	
MH-10/IL-3	2-3	feet	

This page intentionally left blank.

Section 4
References

1. Tetra Tech, Inc. (Tetra Tech), 2012. *Injection Pilot-Test Report.* March.

2. Tetra Tech Inc. (Tetra Tech), 2014. *Draft Operation and Maintenance Plan for Groundwater Remediation System at Lockheed Martin Middle River Complex, 2323 Eastern Boulevard, Middle River, Maryland.* January.

This page intentionally left blank.