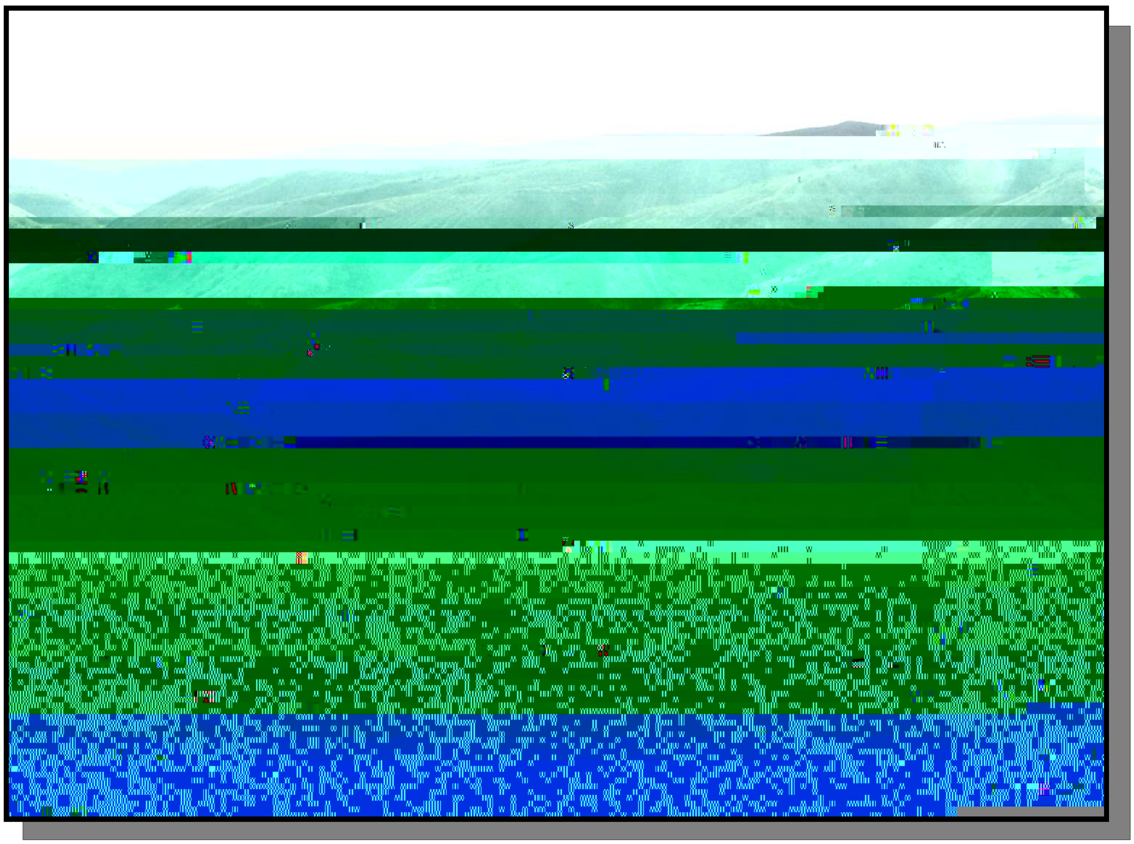
Revised

Soil Treatability Study and Hydraulic Testing Report
Laborde Canyon (Beaumont Site 2)
Beaumont, California



Prepared for:

LOCKHEED MARTIN

Prepared by:

TETRA TECH
301 E. Vanderbilt, Suite 450
San Bernardino, California 92408

TC# 26205 02.0508 / March 2013

Department of Toxic Substances Control

Matthew Rodriquez
Secretary for
Environmental Protection

Deborah 0. Raphael, Director
5796 Corporate Avenue
Cypress, California 90630

Edmund G. Brown Jr.
Governor

February 13, 2013

Mr. Brian T. Thorne
Remediation Analyst Senior Staff
Lockheed Martin Corporation
Energy, Environment, Safety & Health
2950 North Hollywood Way, Suite 125

cc: Mr. Gene Matsushita
Senior Manager
Environmental Remediation
Lockheed Martin Corporation
Energy, Environment, Safety & Health
2950 North Hollywood Way, Suite 125
Burbank, California 91505

RESPONSES TO DTSC COMMENTS ON THE SOIL T

TECH, INC
DECEMBER 2012

Comments from Thomas M. Seckington, C.HG., Geology and Remediation Engineering Branch Transmitted December 6, 2012		
Comment	**Response**	**Proposed Action**
General Comment: In general the report effectively presents the activities and results of the soil treatability study and the hydraulic testing. However, the potential effects of displacement and dilution in the vadose zone	We acknowledge that the reduction in perchlorate concentrations observed during the test could be attributed to displacld BT /F4 BT /F4 9.96 Tf 1 0 0 1 315.84 350.28 Tm [(c) effective, then we would expect to see increasing perchlorate concentrations along with the TOC, since the infiltrating fluids would be mobilizing perchlorate from the vadose zone. With respect to the question of transfer of perchlorate mass from the vadose zone to groundwater, we note that a significant excess of organic carbon substrate was transported to groundwater during the test. However, we concur that the question of whether additional groundwater treatment would be necessary during full-scale implementation would be better addressed after a remedy has been selected.	No changes to text are proposed.

ETRA

Comments from Thomas M. Seckington, C.HG., Geology and Remediation Engineering Branch Transmitted December 6, 2012		
Comment	**Response**	**Proposed Action**
Specific Comment 4 (Page 4-6): Have the variations in flow rates been calculated for the changes in volume (head) in the tank? Please provide the calculations and results.	We note that flow rates are controlled by a float valve	

RESPONSES TO DTSC C

RESPONSES TO DTSC COMMENTS ON THE SOIL TREATABILITY STUDY AND HYDRAULIC TESTING REPORT
LABORDE CANYON (BEAUMONT SITE 2), BEAUMONT, CALIFORNIA
TETRA TECH, I

Well ID	Date

Department of Toxic Substances Control

Deborah O. Raphael, Director

cc: Mr. Gene Matsushita
Senior Manager
Environmental Remediation

Lockheed Martin Corporation
Energy, Environment, Safety & Health

2950 North Hollywood Way, Suite 125

Burbank, California 91505

Department of Toxic Substances Control

Matthew Rodriquez
Secretary for

Deborah O. Raphael, Director
5796 Corporate Avenue

Edmund G. Brown Jr.
Governor

[redacted]

MEMORANDUM

To: Dan Zogaib
Project Manager
Brownfields and Environmental Restoration Program

[redacted]

[redacted]

Daniel Zogaib
November 29, 2012 [redacted]

Specific Comments

1. **2.2.2 Hydrogeology**

[redacted]

"Vertical gradients are generally downward at -0.1 to -0.2 ft/ft over most of the [redacted]

Please indicate which monitoring wells were used to calculate the vertical [redacted]

[redacted]

(head) in the tank? Please provide the calculations and results.

5. **4.5.4 Effectiveness Sampling**
page 4-13
"In accordance with the Work Plan (Tetra Tech, 2011a), the pre-treatment soil

[redacted]

REVISED

Lockheed Martin Corporation

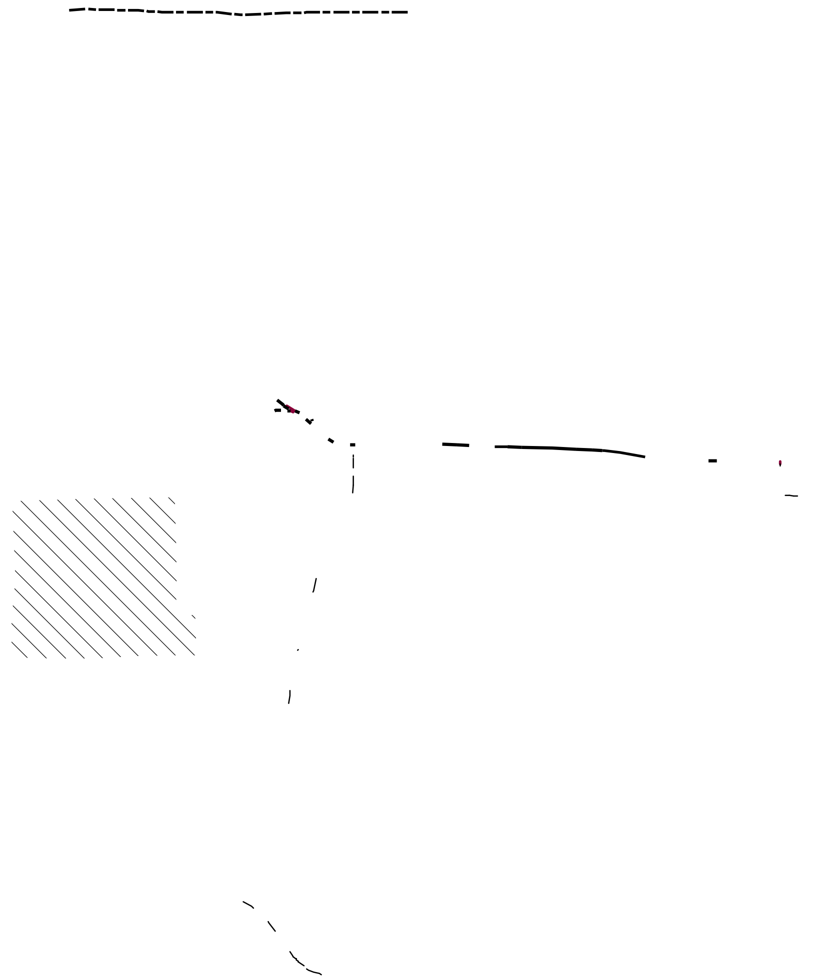
TABLE OF CONTENTS

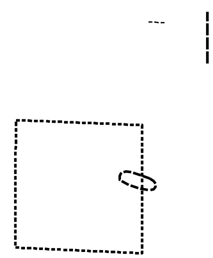
ACRONYMS

a	This data validation qualifier means the analyte was found in the method blank.
ASTM	American Society for Testing and Materials
B	This data validation qualifier means the sample result is < 5 times (10 times for common organic laboratory contaminants) the blank contamination. Cross contamination is suspected.
bgs	below ground surface
d	This data validation qualifier means the laboratory control sample recovery was outside control limits.

k	This data validation qualifier means the analyte was found in a field blank.
LCS	laboratory control sample
LMC	Lockheed Martin Corporation
LPC	Lockheed Propulsion Company
MW	monitoring well
MCL	California Department of Public Health maximum contaminant level
mg/L	milligrams per liter
MS	matrix spike
MSD	matrix spike duplicate

SKR	Stephens' Kangaroo rat
STF	San Timoteo formation
TD	total depth
TCE	trichloroethene
TOC	total organic carbon
US	United States
USCS	Unified Soil Classification System
USFWS	United States Fish and Wildlife Service
VOCs	volatile organic compounds
WDA	Waste Discharge Area
wSTF	weathered San Timoteo formation





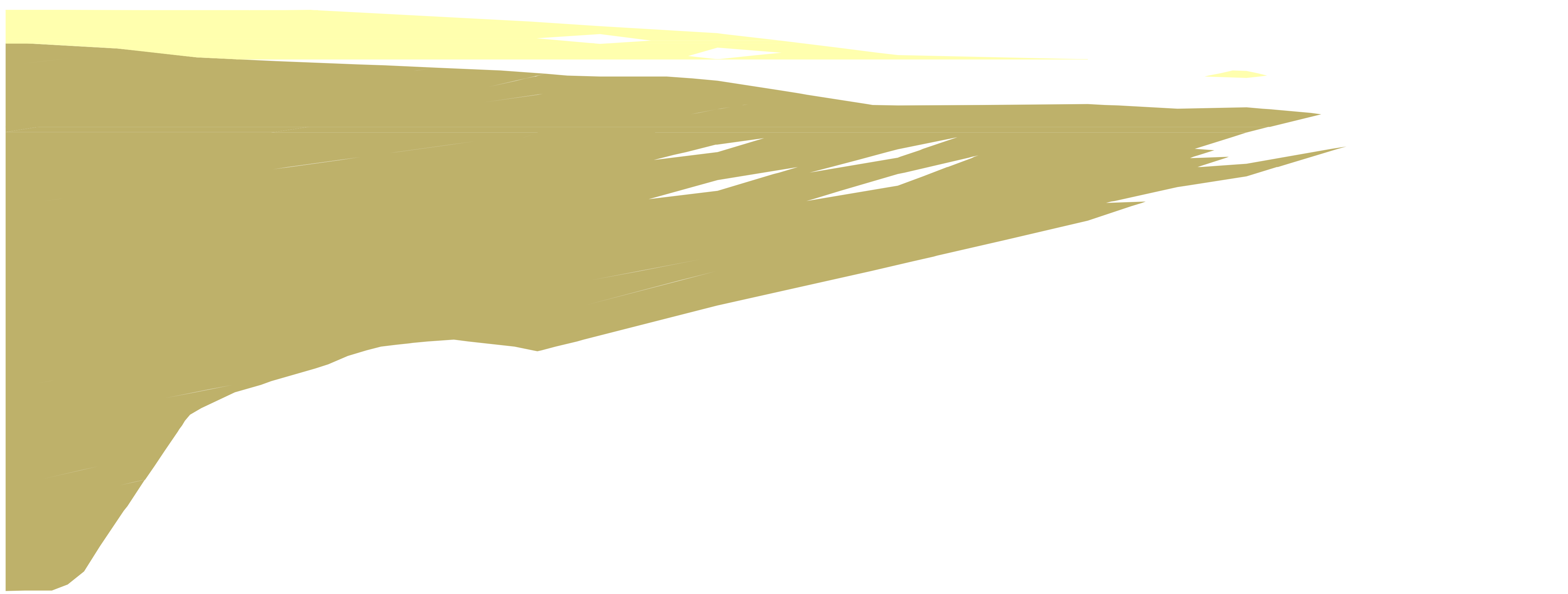
2.2 GEOLOGY AND HYDROGEOLOGY

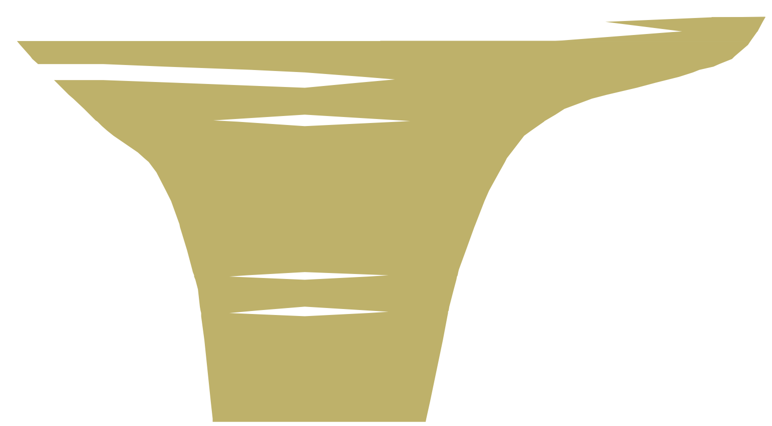
2.2.1 Geology

The surface geology of southern Test Bay Canyon, which includes the Test Bay area, is shown in Figure 2-3. Geologic units encountered at the site include Quaternary surficial deposits (alluvium and colluvium) and the San Timoteo formation (STF). These units are described below.

¶ San Timoteo formation: The STF consists primarily of poorly-indurated grayish-brown fine-grained sandstones and mudstones, with localized conglomerate lenses. Well indurated beds of carbonate-cemented medium- to coarse-grained sandstone are occasionally encountered at depth. The degree of induration of the STF generally tends to increase with depth, although poorly indurated beds are encountered throughout the section to a depth of at least 250 feet. Drilling observations and seismic refraction data both suggest that the STF is most deeply weathered near the bThep2.0(e)-0(ne)4.0(a2.0(o4.0(a)4.0(r)-337.0

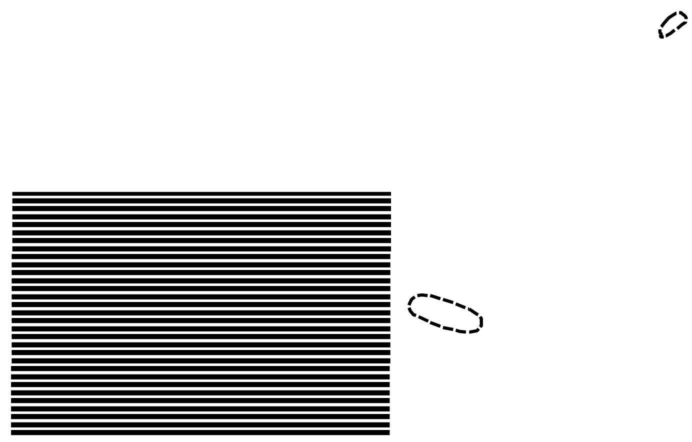
Prism

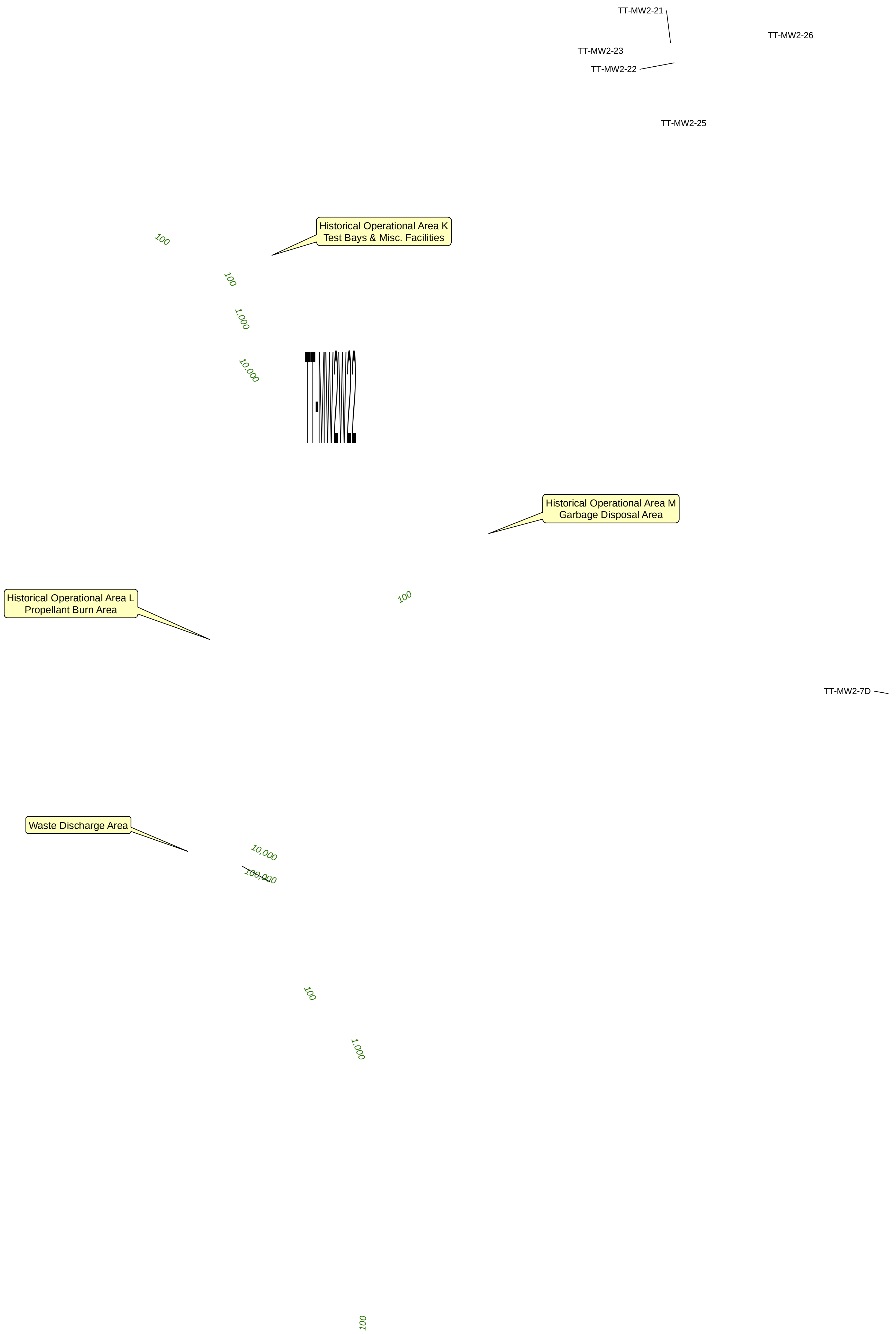




2.2.2 Hydrogeology

Groundwater at the site occurs mainly in sandstones and mudstones within the STF. The STF is

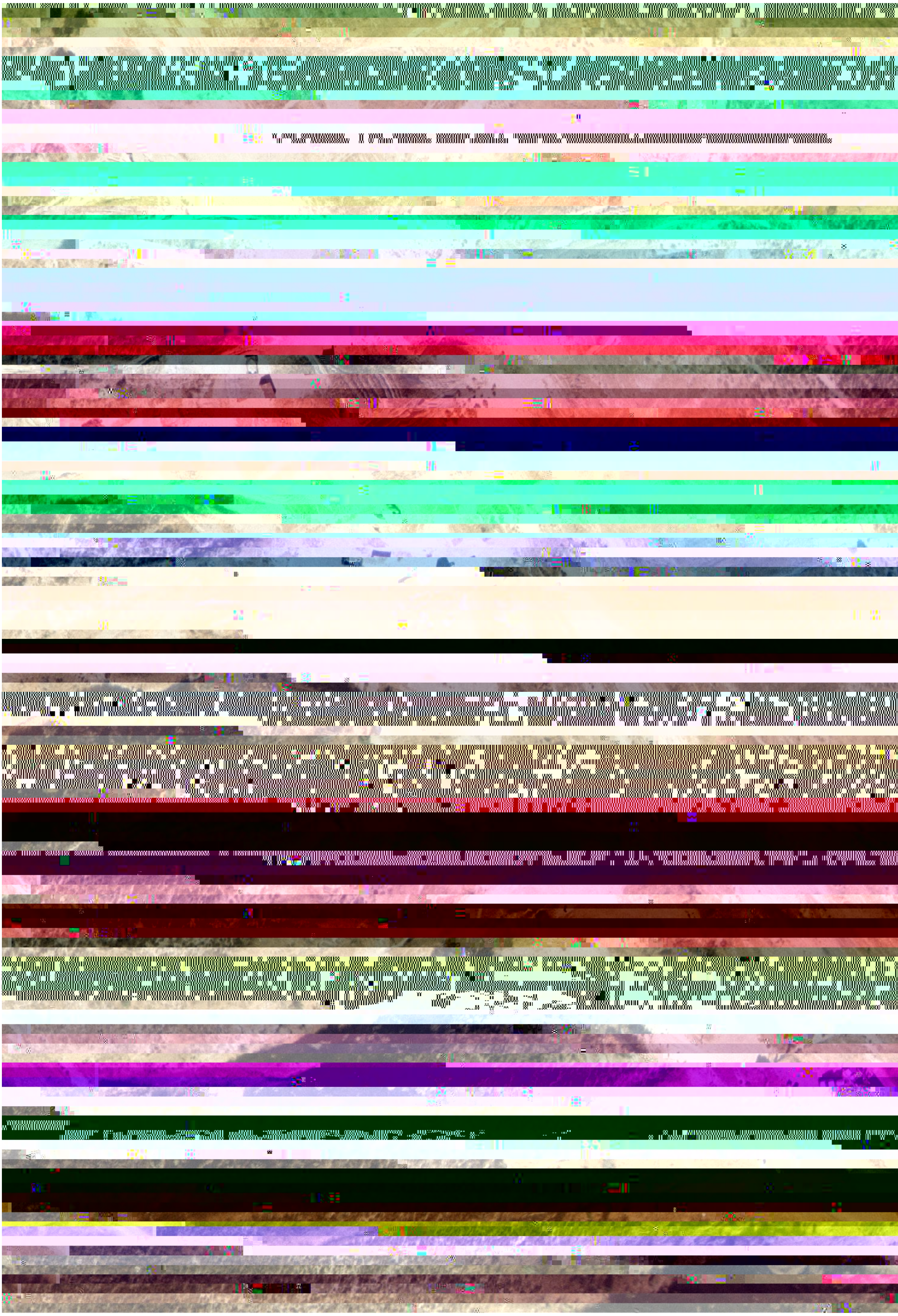




TT-MW2-21
TT-MW2-26
TT-MW2-23
TT-MW2-22
TT-MW2-25
Historical Operational Area K
Test Bays & Misc. Facilities
100
100
1,000
10,000
Historical Operational Area M
Garbage Disposal Area
Historical Operational Area L
Propellant Burn Area
100
TT-MW2-7D
Waste Discharge Area
10,000
100,000
100
1,000
100

Adapted from:

Laborde Canyon
(Lockheed Martin Beaumont Site 2)



SECTION 3 METHODOLOGY

Well ID	Date Installed	Date Destroyed	Well Type	Ground Surface Elevation (feet msl)	TOC Elevation (feet msl)	Depth to TOS (feet bgs)	Depth to BOS (feet bgs)	Screen Length (feet)	Measured Depth of Well (feet btoc)	Reported Depth of Borehole (feet bgs)	Casing Diameter (inches)	Screen Material/ Slot Size (inches)	Drilling Method	Filter Pack	Northing Coordinate	Easting Coordinate
TT-MW2-44	8/29/2011	NA	M	2082.70	2085.22	55.0	65.0	10	67.48	65.5	2	PVC 0.020	HSA	#2/16	2274660.62	6324624.59

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tube. Immediately after rewetting, the lysimeter was evacuated and was observed to hold vacuum, suggesting that the lysimeter and tubing were both intact. A likely explanation for these observations is that the matric potential of the soil surrounding the lysimeter is greater than that of the porous cup and silica flour backfill. When this is the case, it is not possible to use a lysimeter to induce pore water flow.

3.5 HYDRAULIC TESTING

3.5.1 Slug Tests

Slug test procedures are described in Tetra Tech (2010d). Slug tests were conducted in wells TT-MW2-21, TT-MW2-22, and TT-MW2-23, all of which are located in the WDA.

Prior to conducting each slug test, water levels were measured manually with an electronic water level meter to determine the static groundwater level. An electronic pressure transducer was then suspended in the well, and water levels were monitored manually until static conditions were reestablished. A falling-head test was then conducted by smoothly lowering a weighted slug into the well and securing it in place above the transducer. Once the water level had recovered to static conditions, a rising-head test was conducted by removing the slug and allowing the water level to recover to static conditions.

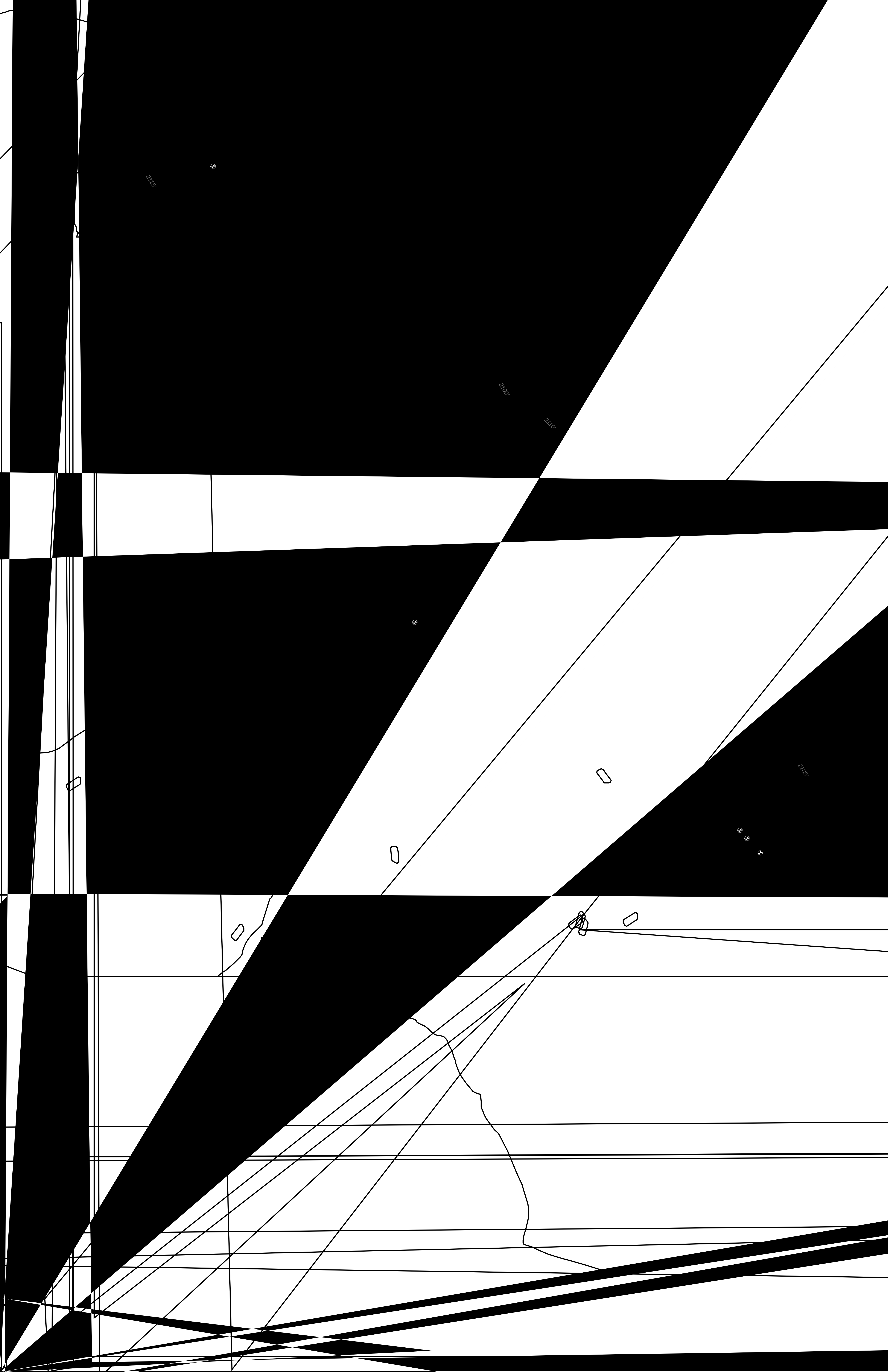
Barometric pressure was monitored throughout each test using a dedicated pressure transducer. At the end of the rising-head test, water level data from the pressure transducer were downloaded to a laptop computer and compensated for barometric pressure effects prior to interpretation. The slug test data were interpreted using AQTESOLV aquifer test interpretation software (Duffield and

Revised

environmental remediation at the site, biological surveys were conducted in the areas surrounding proposed drilling locations, equipment lay down areas, and roll-off bins prior to initiating field activities. The surveys were conducted to evaluate the potential for impacts to sensitive species/habitats, including SKR, during field activities. The surveys were performed by a USFWS-approved biologist.

As part of the biological surveys, the biologist identified and marked potential or suspected SKR burrows that were located in the vicinity of proposed drilling locations to avoid the “take”ad in the bur436 74

Flow sensor: The Work Plan described a high-flow sensor consisting of a venturi and pressure switch to detect flooding of the test area in the event of a float valve or piping


2115'
2100'
2110'
2105'

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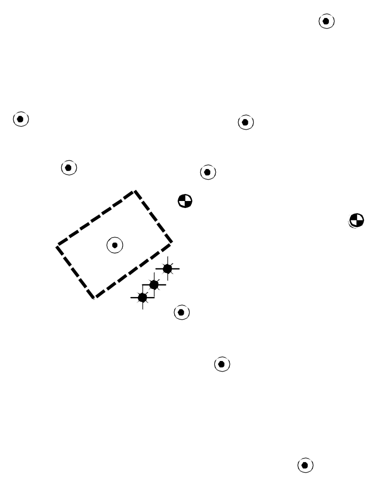
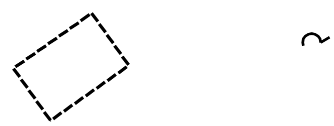




developed using Mining Visualization System (MVS), a geostatistical data visualization software package. MVS utilizes kriging to interpolate data between sampled locations. Mathematically, kriging computes the "best linear unbiased estimator" of a spatially regionalized variable, and is recognized by the USEPA as the best means for interpolation of measured data.

4.5.2 Pore Water Sampling

Weekly pore water sampling consisted of checking lysimeters TT-LY2-1, TT-LY2-2, and TT-LY2-3 for the presence of moisture and collecting pore water samples, if samples could be recovered. As discussed in Section 3.4.2, no pore water samples were recovered from lysimeter TT-LY2-1 during this study.

Pore water samples were initially collected from lysimeter TT-LY2-2 (completed at 35 feet bgs) on September 15, 2011, approximately 9 days after start-up. Fluorescein was detected in the initial sample collected from TT-LY2-2. Sampling and analysis of pore water samples from TT-LY2-2 were conducted on an approximate weekly basis for the remainder of the study.

Pore water samples were initially collected from lysimeter TT-LY2-3 (completed at 50 feet bgs) prior to the start of the test. The presence of pore water in the lysimeter prior to the start of the test is likely due to proximity to the water table at approximately 55.5 feet bgs. Laboratory analysis of the pore water samples collected from TT-LY2-3 was initiated on September 29, 2011, and continued on an approximately weekly basis for the remainder of the study.

The pore water samples were analyzed by the laboratory for perchlorate using Method E332.0 and for TOC using Method SM5310B. Due to the limited size of the pore water samples, temperature, pH, electrical conductivity (EC), dissolved oxygen (DO), and oxidation/reduction potential (ORP) were not measured in the groundwater samples.

4.5.3 Groundwater Sampling

Groundwater was checked for the presence of fluorescein on a weekly basis from the start of the test. Laboratory analysis of the groundwater samples was initiated on November 7, 2011, and continued through the end of the test on March 30, 2012. Groundwater properties, including temperature, pH, EC, DO, and ORP were measured during well purging. The groundwater samples were analyzed for perchlorate using Method E332.0 and for TOC using Method SM5310B.

4.5.4 Effectiveness Sampling

Ten pre-treatment soil borings (TT-MW2-44, TT-LY2-3, and VB2-1A to TT-VB2-8A) were drilled in the vicinity of the infiltration gallery from August 29 to September 3, 2011. The boring locations are shown in Figure 4-4. The boring locations were selected to account for the possibility that subsurface permeability contrasts could potentially result in significant lateral spreading of water at depth, as well as potential directional heterogeneities. Soil samples were collected from the borings at five-foot depth intervals. In accordance with the Work Plan (Tetra Tech, 2011a), the pre-treatment soil samples were frozen by the laboratory and held pending the selection of post-treatment soil sampling locations. Because perchlorate is a salt, the primary processes which could alter perchlorate concentrations during sample storage are biodegradation and chemical reaction with other constituents in the soil or in air. Storage at freezing temperatures reduces the rate at which these processes occur.

Five post-test soil borings (TT-MW2-44B, TT-LY2-3B, TT-VB2-3B, TT-VB2-6B, and TT-VB2-7B) were drilled immediately adjacent (i.e., within approximately 2 feet) to five of the pre-test borings from April 9 to 11, 2012. A sixth soil boring (TT-VB2-9B) was also drilled through the center of the infiltration gallery. These locations were selected based on the ERT results, which indicated that lateral spreading of water during the test was limited to within approximately 15 feet of the infiltration gallery footprint.

The soil samples were analyzed for perchlorate using Method E332.0, for TOC using Method SM5310B, and for moisture content using ASTM Method D2216.

SECTION 5 TREATABILITY STUDY RESULTS

5.1 DATA QUALITY EVALUATION

The quality control samples were reviewed as described in the PSAP (Tetra Tech, 2010d). The data for the pore water, groundwater, and soil sampling activities were contained in analytical data packages generated by E.S. Babcock and Sons Laborat2.04.0(t)--2.0(e)4.0(s)-531.0Ic. The5..0(s)-11.0ne d

Method SW8260B for VOCs had field blank contamination that caused 3.1 percent (4 analytes of 129 analytes) of the total SW8260B data to be qualified for blank contamination. The blank qualified results should be considered not detected at elevated detection levels.

Method E332.0 for perchlorate had field duplicate RPD errors that qualified as estimated 3.5 percent (8 samples out of 229 samples) of the total E332.0 data. The data qualified as estimated are usable for the intended purpose.

There were anomalies with the Method E332.0 holding times. The normal holding time for perchlorate analysis is 28 days, and the soil samples were analyzed in excess of two times the holding time. Normally, this would result in the perchlorate data being rejected. However,

The average flow rate for the entire duration of the test was approximately 0.40 gpm, which corresponds to an average infiltration rate of 0.26 in/hr. For the initial two weeks of operation, the

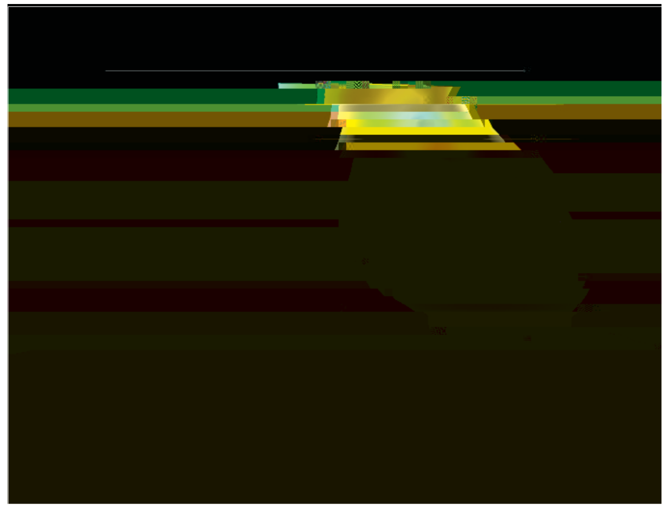


Table 5-1
Summary of Analytical Results
Pore Water Samples

Date[1]	TT-LY2-2			TT-LY2-3		
	Fluorescein	TOC (mg/L)	Perchlorate (µg/L)	Fluorescein	TOC (mg/L)	Perchlorate (µg/L)
09/09/11	Dry	Dry	Dry	ND	NS	NS
09/15/11	+	210	14,000	ND	NS	NS
09/22/11	+	640	3,000	ND	NS	NS
09/29/11	+	660 Jd	140	ND	9.2	210,000
10/06/11	+	660	5.8	ND	14	240,000
10/14/11	+	800	2.3	ND	25	200,000
10/21/11	+	810	4.3	ND	28	150,000
10/28/11	+	800	2.1	ND	32	72,000
11/07/11	+	1,000	3.1	ND	30	72,000
11/11/11	+	790	0.67	ND	24	81,000
11/17/11	+	620	0.85	ND	32	6,800
11/22/11	+	470	0.22	ND	35	48,000
12/02/11	+	230	0.93	+	210	12,000
12/09/11	+	97	<0.071	+	900	1,800
12/16/11	+	34	0.46	+	1,300	18
12/23/11	+	41	<0.071	+	1,600	1.1
12/30/11	NS	NS	NS	NS	NS	NS
01/06/12	+	390	0.29	+	1,700	7.1
01/16/12	+	400	0.11	+	1,700	13
01/21/12	+	330	0.091 Jq	+	1,700	1.5
01/27/12	+	270	2.2	+	1,700	5.6
02/06/12	+	150	0.8	+	1,500	0.82
02/10/12	+	71	0.51	+	1,400	0.79
02/17/12	+	23	0.42	+	1,100	0.67
02/24/12	+	7.6	0.48	+	860	0.5
03/02/12	+	7.9	3.6	+	720	0.33
03/09/12	Dry	Dry	Dry	+	550	0.28
03/16/12	+	7.4	3.1	+	400	0.24
03/23/12	+	6	0.53	+	290	0.49
03/30/12	+	5.8	0.43	+	210	0.2

Notes:
1. Infiltration started 09/06/11
mg/L: milligrams per liter
µg/L: micrograms per kilogram.
"<": Analyte not detected above indicated method detection limit.
"-": Not analyzed.
ND: not detected
NS: not sampled
Dry: pore water sample could not be collected from lysimeter
+: fluorescein detected
"J": Analyte was positively identified, but the concentration is an estimated value.
"d": The laboratory control sample recovery was outside control limits.
"q": The analyte detection was below the Practical Quantitation Limit (PQL).

accumulate within this zone as it advances through the subsurface. The perchlorate concentration decline which occurred after TOC breakthrough, and at an increased rate relative to the initial decline, is considered likely to represent perchlorate biodegradation.

Figure 5-5 shows that TOC concentration in TT-LY2-3 gradually increased to a maximum of 1,700 mg/L within four weeks of fluorescein breakthrough, and then generally decreased to 210 mg/L by the end of the test. The TOC concentration fluctuations are generally similar to those observed in TT-LY2-2, and are similarly attributed to aerobic biodegradation of glycerin in the infiltration gallery.

5.2.4 Groundwater Sampling Results

Analytical results for groundwater samples collected from monitoring well TT-MW2-44 are summarized in Table 5-2. A plot of perchlorate and TOC concentrations in groundwater as a function of time is provided in Figure 5-7; a plot of field ORP-taseeles prolected Oin ggelleiurn grlConcentgra

fRP-l

Date[1]	Depth to Groundwater (feet TOC)	Groundwater Elevation (feet msl)	Specific Conductivity (mS/cm)	Dissolved Oxygen (mg/L)	ORP (mV)	Fluorescein	TOC (mg/L)	Perchlorate (µg/L)
09/06/11	-	-	-	-	-	-	9.3 Bk	100,000
11/07/11	58.51	2026.71	2.21	4.1	96	ND	4.2	49,000
11/11/11	58.25	2026.97	2.50	4.3	15	ND	5.5	50,000 Jf
11/17/11	58.14	2027.08	2.51	1.3	-6.0	ND	4.2	45,000
11/22/11	58.25	2026.97	2.66	1.3	57	ND	4.2	43,000
12/02/11	57.80	2027.42	2.91	1.1	97	ND	4	38,000
12/09/11	57.77	2027.45	4.752.7(4)-7.o.9		107	ND	7.1	65,000
12/16/11	57.73	2027.49	3.94	1.1	21	ND	5.2	75,000
12/23/11	58.07	2027.15	6.30	-	-13	ND	10	82,000
12/30/11	57.75	2027.47	7.142.7(4)-7.o.3		-211	ND	12	83,000
01/06/12	57.89	2027.33	4.76	1.1	146	+	39	100,000
01/16/12	58.15	2027.07	5.624.8	8.0	+	220	40,000	
01/21/12	58.10	2027.12	5.734.6	-101	+	400	37,000	
01/27/12	58.22	2027.00	5.554.5	-181	+	570	30,000	
02/06/12	58.33	2026.89	5.654.1	-175	+	730	23,000	
02/10/12	-	-	-	-	-	-	790	13,000
02/17/12	58.61	2026.61	5.45	1.7	-361	+	630	5,800
02/24/12	58.66	2026.56	5.344.1	-320	+	590	720	
03/02/12	58.81	2026.41	5.17	1.7	-325	+	650	410
03/09/12	58.94	2026.28	4.89	1.7	-331	+	850	33
03/16/12	58.86	2026.36	4.76	2.0	-341	+	950	<.071
03/23/12	58.96	2026.26	4.68	2.2	-343	+	1000	<.071
03/30/12	58.98	2026.24	4.30	2.4	-352	+	1000	11

Notes:

1. Infiltration started 09/06/11

feet TOC: feet below top of well casing

Feet msl: feet above mean sea level

mS/cm: millisemens per centimeter

mg/L: milligrams per liter

mV: millivolts

µg/L: micrograms per kilogram.

"<: Analyte not detected above indicated method detection limit.

"-": Not analyzed.

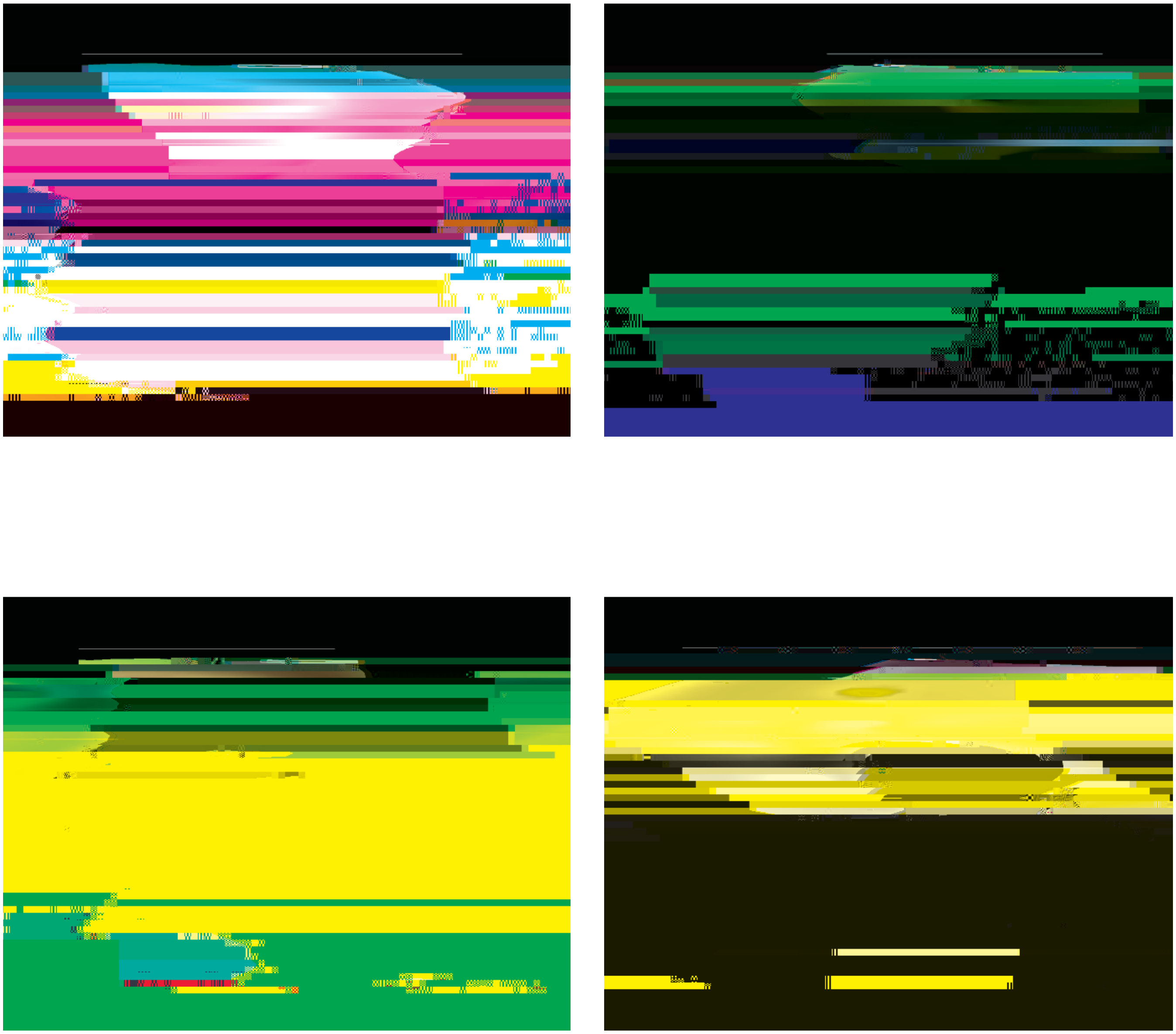
ND: note detected

+ fluorescein detected

"B": Sample result is less than 5 times (10 times for common organic laboratory contaminants) the blank contamination.

The result is not considered to have originated from the environmental sample because cross-contamination is suspectedation is sutetrtt.6Qt(se)-241.7(c)-3.8(r)4.6(

Sample No.	Sample Date	Depth (feet bgs)	Perchlorate (µg/kg)	TOC (mg/L)	Moisture (wt %)	Sample No.	Sample Date	Depth (feet bgs)	Perchlorate (µg/kg)	TOC (mg/L)	Moisture (wt %)
TT-MW2-44-5'	08/29/11	5	300 Jp	<500	4.6	TT-MW2-44B-5'	04/09/12	5	<4.6	<500	14.8
TT-MW2-44-10'	08/29/11	10	130 Jp	-	5.9	TT-MW2-44B-10'	04/09/12	10	<4.5	-	15.0
TT-MW2-44-15'	08/29/11	15	<4.3 UJp	-	8.3	TT-MW2-44B-15'	04/09/12	15	<4.6	-	14.9
TT-MW2-44-20'	08/29/11	20	33 Jp	-	7.8	TT-MW2-44B-20'	04/09/12	20	<4.5	-	13.3
TT-MW2-44-25'	08/29/11	25	76 Jp	870 Jq	8.3	TT-MW2-44B-25'	04/09/12	25	<4.5	<500	12.4
TT-MW2-44-30'	08/29/11	30	46 Jp	-	5.0	TT-MW2-44B-30'	04/09/12	30	<4.4	-	7.4
TT-MW2-44-35'	08/29/11	35	26 Jp	-	10.1	TT-MW2-44B-35'	04/09/12	35	<4.6	-	9.5
TT-MW2-44-40'	08/29/11	40	490 Jp	-	6.0	TT-MW2-44B-40'	04/09/12	40	<4.4	-	8.7
TT-MW2-44-45'	08/29/11	45	28 Jp	<500	7.4	TT-MW2-44B-45'	04/09/12	45	7.1	<500	10.5
TT-MW2-44-50'	08/29/11	50	38 Jp	-	8.1	TT-MW2-44B-50'	04/09/12	50	110	-	8.7
TT-MW2-44-55'	08/29/11	55	94 Jp	-	5.6	TT-MW2-44B-55'	04/09/12	55	310 Jf	-	8.2
TT-MW2-44-60'	08/29/11	60	10,000 Jp	-	11.1	TT-MW2-44B-60'	04/09/12	60	1,400	-	13.2
TT-LY2-3-5'	08/30/11	5	27,000 Jp	-	5.1	TT-LY2-3B-5'	04/10/12	5	340,000	-	13.0
TT-LY2-3-10'	08/30/11	10	23,000 Jp	-	5.9	TT-LY2-3B-10'	04/10/12	10	84	-	16.7
TT-LY2-3-15'	08/30/11	15	21,000 Jp	<500	8.7	TT-LY2-3B-15'	04/10/12	15	19	<500	14.3
TT-LY2-3-20'	08/30/11	20	7,000 Jp	-	11.4	TT-LY2-3B-20'	04/10/12	20	11	-	12.9
TT-LY2-3-25'	08/30/11	25	17,000 Jp	-	9.5	TT-LY2-3B-25'	04/10/12	25	6.3	-	15.8
TT-LY2-3-30'	08/30/11	30	19,000 Jp	-	6.5	TT-LY2-3B-30'	04/10/12	30	<4.4	-	9.4
TT-LY2-3-35'	08/30/11	35	3,500 Jp	<500	8.0	TT-LY2-3B-35'	04/10/12	35	<4.3	<500	8.6
TT-LY2-3-40'	08/30/11	40	4,200 Jp	-	6.3	TT-LY2-3B-40'	04/10/12	40	<4.3	-	8.4
TT-LY2-3-45'	08/30/11	45	8,500 Jp	-	18.7	TT-LY2-3B-45'	04/10/12	45	15	-	13.4
TT-LY2-3-50'	08/30/11	50	11,000 Jp	-	9.1	TT-LY2-3B-50'	04/10/12	50	7.6	-	9.6
TT-LY2-3-55'	08/30/11	55	4,100 Jp	<500	8.9	TT-LY2-3B-55'	04/10/12	55	18	<500	8.6
-	-	-	-	-	-	TT-LY2-3B-60'	04/10/12	60	17	-	9.3
TT-VB2-3A-5'	08/30/11	5	540 Jp	-	6.6	TT-VB2-3B-5'	04/10/12	5	470	-	



Perchlorate Concentration Range (µg/kg)	Pre-Treatment Perchlorate Mass9(e)-3.8(n)3.6(t)]TJ	ET	Q	q	BT	/F1 cTf	1 00T	/F1

5.4 DISCUSSION OF RESULTS

5.4.1 Conceptual Model of Infiltration and Soil Treatment

Based on the process monitoring and verification boring results discussed above, a conceptual model for infiltration and soil treatment was developed. Elements of the conceptual model are described below.

- ¶ Infiltration through the upper portion of the vadose zone is dominated by flow through preferential pathways. Flow through preferential pathways is indicated by the very short

- ¶ Sodium metabisulfite amendment rate: An amendment rate of 1 pound per 1,000 gallons was found to be insufficient to inhibit aerobic activity in the infiltration gallery. Modifying the design of the infiltration gallery is recommended in place of increasing the sodium metabisulfite amendment rate.

- ¶ Infiltration gallery design: Due to low flow rates, infiltration galleries should be designed to minimize internal volume and limit contact between water and air. Alternatively, adding a solid organic substrate, such as wood chips or compost, to the bottom of the galleries may also aid in maintaining anaerobic conditions.

- ¶ Infiltration gallery spacing: The ERT results suggest that moisture spreads approximately 10 to 15 feet outward from the infiltration gallery footprint during treatment. An area of influence of approximately 1,000 square feet per 10- by 15-foot infiltration gallery is appropriate for design purposes.

- ¶ Treatment time: Treatment was conducted for a period of 208 days, or slightly more than six months. This time was sufficient to transport substrate to groundwater and induce perchlorate biodegradation. However, the treatability study was conducted near the center of the Test Bay 3 area, and less permeable lithologies are anticipated along the perimeter of the area. Treatment times of up to one year may be more appropriate for Test Bay 3 as a whole.

- ¶ Mass removal efficiency: Verification sampling results and geospatial modeling indicate that the mass removal efficiency of the process at the test location was approximately 50%.

- ¶ Cost estimates: Cost information collected during the treatability study is suitable for developing unit costs for full-scale implementation of *in situ* bioremediation.

SECTION 6 AQUIFER TEST RESULTS

6.1 WASTE DISCHARGE AREA AQUIFER TESTS

Aquifer testing activities at the WDA consisted of conducting slug tests in three monitoring wells (TT-MW2-21 to TT-MW2-23), and conducting a constant-rate aquifer test using newly-installed well TT-EW2-3 as an extraction well. The locations of the wells used for aquifer testing are shown in Figure 6-1.

6.1.1 Slug Tests

Hydraulic conductivity values interpreted from the slug test data for wells TT-MW2-21, TT-MW2-22, and TT-MW2-23 are summarized in Table 6-1. Hydraulic conductivities for all three wells tested are low (less than 0.1 ft/day). Copies of the slug test interpretations are provided in Appendix G.

6.1.2 Constant-Rate Aquifer Test

The WDA constant-rate aquifer test included a one-day step drawdown test to evaluate pumping rates, and a long-term (72-hour) constant-rate aquifer test. The step test consisted of pumping extraction well TT-EW2-3 at rates of 0.06 and 0.14 gpm for a total time period of approximately 7.5 hours. Drawdowns measured in the extraction well were 3 and 8 feet, respectively, and did not stabilize by the end of each step. Based on these results, a pumping rate of approximately 0.075 gpm was selected for the long-term aquifer test.

The long-term constant-rate aquifer test was conducted by pumping extraction well TT-EW2-3 at a steady rate of 0.075 gpm for a period of 72 hours (3 days). Drawdown in the extraction well

Table 6-1
Summary of Slug Test Results

Well	Hydraulic Conductivity (ft/day)		
	Falling Head[1]	Rising Head[2]	Average[3]
TT-MW2-21	0.11	0.097	0.10
TT-MW2-22	0.097	0.11	0.10
TT-MW2-23	0.016	0.017	0.017

Notes:

ft/day: feet per day

1. Data collected during falling-head (slug-in) phase of test.
2. Data collected during rising-head (slug-out) phase of test.
3. Mean of hydraulic conductivity values for falling- and rising-head tests.

drawdown was observed during the pumping cycle in wells TT-EW2-3, TT-PZ2-4, and TT-MW2-24; no response was observed in wells TT-MW2-37A, TT-MW2-37B, and TT-MW2-26. The response to pumping in well TT-MW2-24 was relatively weak, which is attributed to this well being somewhat isolated from the pumping zone, either by being screened in a slightly different water-bearing zone or due to lateral heterogeneities in the weathered San Timoteo formation.

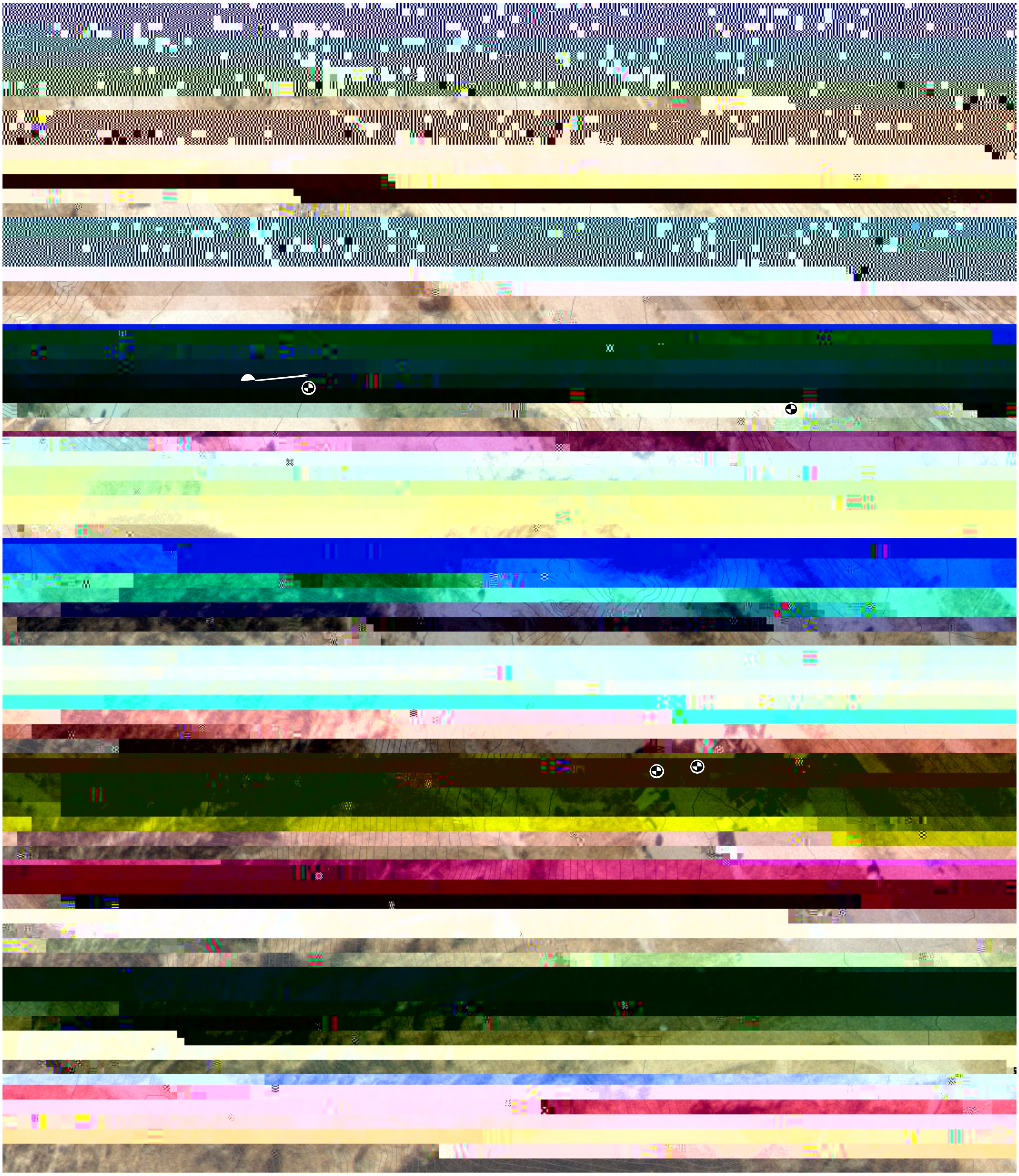
During the drawdown phase of the constant-rate test, relatively large water level fluctuations (as much as 0.4 feet) were observed between sequential transducer readings in the extraction well. The fluctuations are attributed to a combination of the use of a bladder pump, which extracts water in a pulsed (as opposed to continuous) manner, and the low recovery rate of the extraction well. Due to the water level fluctuations in the extraction well, the data for the drawdown phase of the test was judged to be unsuitable for interpretation using transient drawdown methods. Data

6.1.2.3 Transient Drawdown Interpretation

The transient drawdown analysis results are summarized in Table 6-2. A more detailed discussion of the test interpretation, aquifer test interpretation figures, and AQTESOLV input and output files is provided in Appendix H. Based on the observed pumping test response and hydrogeologic conditions at the site, the data were tested against both the Theis aquifer model and the Hantush leaky aquifer model. Aquifer transmissivity values for wells TT-EW2-3 and TT-PZ2-4, which showed a strong drawdown response, ranged from 0.12 to 0.28 ft^2/day, with a geometric mean of 0.19 ft^2/day. Aquifer transmissivity values for well TT-MW2-24, which showed a weak drawdown response, ranged from 6.5 to 13 ft^2/day. Using a saturated thickness of 15 feet, the aquifer hydraulic conductivity is estimated to be 0.008 to 0.84 ft/day. Storage values for observation well TT-PZ2-4 were in the confined range (less than 0.002), and in the unconfined range for

6.2 TEST BAY CANYON AQUIFER TEST

Aquifer testing activities at Test Bay Canyon consisted of conducting a constant-rate aquifer test



		Transmissivity (ft^2/day)	Storativity	Transmissivity (ft^2/day)	Storativity	Transmissivity (ft^2/day)	Storativity	r/B
P	14.6	6.5	-	6.3	-	6.1	-	0.027

¶ 11 ft^2/day (based on specific capacity values)

¶ 5.7 to 17 ft^2day (based on drawdown-distance analysis)

¶ 3.3 to 59 ft^2/day, with a geometric mean of 9.6 ft^2/day (based on transient pumping test analysis)

Based on these results, the most likely average aquifer transmissivity value is estimated to be approximately 10 ft^2/day. However, given the variation in estimated aquifer parameters between wells, as well as slug test data that showed a hydraulic conducti0a-p (t)-2.0(e)-5.9(rd7a)4.0(s3ao1.9(0-10.0(r

SECTION 7 CONCLUSIONS AND RECOMMENDATIONS

The conclusions of this report are as follows:

¶ The results of the soil treatability study indicate that *in situ* bioremediation of perchlorate

SECTION 8 REFERENCES

1.