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Demonstration of Resistive Heating Treatment of DNAPL Source Zone at Launch Complex 34 in Cape Canaveral Air Force Station, Florida

Final Innovative Technology Evaluation Report

Appendices A through Appendix H

Appendix A. Performance Assessment Methods

A.1 Statistical Design and Data Analysis Methods
A.2 Sample Collection and Extraction Methods
A.3 List of Standard Sample Collection and Analytical Methods

A.1 Statistical Design and Data Analysis Methods

Estimating TCE/DNAPL mass removal due to the in situ chemical oxidation (ISCO) technology application was a critical objective of the IDC demonstration at Launch Complex 34. Analysis of TCE in soil samples collected in the ISCO plot before and after the demonstration was the main tool used to make a determination of the mass removal. Soil sampling was used to obtain pre- and postdemonstration data on the TCE distribution in the ISCO plot. Three data evaluation methods were used for estimating TCE/DNAPL masses in the ISCO plot before and after the demonstration:

- Linear interpolation by contouring
- Kriging

Section 4.1 (in Section 4.0 of the report) contains a general description of these two methods. Section 5.1 (in Section 5.0 of this report) summarizes the results.

The *contouring* method is the most straightforward and involves determining TCE concentrations at unsampled points in the plot by linear interpolation (estimation) of the TCE concentrations between sampled points. The contouring software EarthVision™ uses the same methodology that is used for drawing water level contour maps based on water level measurements at discrete locations in a region. The only difference with this software is that the TCE concentrations are mapped in three dimensions to generate iso-concentration shells. The TCE concentration in each shell is multiplied by the volume of the shell (as estimated by the software) and the bulk density of the soil (1.59 g/cc, estimated during preliminary site characterization) to estimate a mass for each shell. The TCE mass in each region of interest (Upper Sand Unit, Middle-Fine-Grained Unit, Lower Sand Unit, and the entire plot) is obtained by adding up the portion of the shells contained in that region. The DNAPL mass is obtained by adding up the masses in only those shells that have TCE concentrations above 300 mg/kg. Contouring provides a single mass estimate for the region of interest.

The contouring method relies on a high sampling density (collecting a large number of samples in the test plot) to account for any spatial variability in the TCE concentration distribution. By collecting around 300 samples in the plot during each event (before and after treatment) the expectation is that sufficient coverage of the plot has been obtained to make a reliable determination of the true TCE mass in the region of interest. Section A.1.1 of this appendix describes how the number of samples and appropriate sampling locations were determined to obtain good coverage of the 75 ft x 50 ft plot.

Kriging is a statistical technique that goes beyond the contouring method described above and addresses the spatial variability of the TCE distribution by taking into account the uncertainties associated with interpolating between sampled points. Unlike contouring, which provides a single mass estimate, Kriging provides a range of estimated values that take into account the uncertainties (variability) in the region of interest. Section A.1.2 describes the kriging approach and results

A.1.1 Sampling Design to Obtain Sufficient Coverage of the ISCO plot

Selection of the sampling plan for this particular test plot was based, in part, on the objectives of the study for which the samples were being collected. In this study, the objectives were:

- **Primary objective:** To determine the magnitude of the reduction in the levels of TCE across the entire test plot.

- **Secondary objectives:**

  - To determine whether remediation effectiveness differs by depth (or stratigraphic unit such as the upper sand unit [USU], middle fine-grained unit [MFGU], or lower sand unit [LSU]).
  - To determine whether the three remediation technologies demonstrated differ in their effectiveness at removing chlorinated volatile organic compounds (CVOCs).

Four alternative plans for selecting the number and location of sampling in the test plot were examined. These four plans were designated as simple random sampling (SRS), paired sampling, stratified sampling, and systematic sampling. Each plan is discussed in brief detail below.

Simple Random Sampling

The most basic statistical sampling plan is SRS, in which all locations within a given sampling region are equally likely to be chosen for sampling. For this study, using SRS would require developing separate SRS plans for each of the three test plots. In addition, because two sampling events were planned for the test plot, using SRS would involve determining two sets of unrelated sampling locations for the test plot.

The main benefit of using SRS is that the appropriate sample size can be determined easily based on the required power to detect a specific decrease in contaminant levels. In addition, SRS usually involves a reasonable number of samples. However, a key disadvantage of using SRS is that it would not guarantee complete coverage of the test plot; also, if contaminant levels are spatially correlated, SRS is not the most efficient sampling design available.

Paired Sampling

Paired sampling builds on SRS methods to generate one set of paired sampling locations for a given test plot rather than two separate sets. Instead of sampling from each of two separate random sample locations for pre- and post-remediation sampling, paired sampling involves the positioning of post-remediation sample locations near the locations of pre-remediation sampling. The number of samples required to meet specific power and difference requirements when using this design would be similar to the number of locations involved using SRS; the exact sample size cannot be determined because information is required about contaminant levels at collocated sites before and after remediation.

Paired sampling offers three significant benefits to this particular study. First, the work of determining the sampling locations is reduced in half. Second, the comparison of contaminant levels before and after remediation is based on the differences in levels at collocated sites. Third, the variability of the difference should be less than the variability associated with the SRS, which would result in a more accurate test. The disadvantages of this sampling procedure are the same as with the SRS: there is no guarantee of complete coverage of the test plot, and the plan is inefficient for spatially correlated data.

Stratified Sampling

Stratified sampling guarantees better coverage of the plot than either SRS or paired sampling: to ensure complete coverage of a given test plot, it is divided into a regular grid of cells, and random samples are drawn from each of the grid cells. Samples then are selected within each grid cell either using SRS or paired sampling. The number of samples required to meet specific power and difference requirements would be slightly greater than that for SRS, although the difference would not be great. For this study, which involves test plots 50 × 75 ft in size, the most effective grid size would be 25 × 25 ft, which results in six grid cells per test plot.

Again, the main benefit of stratified sampling is that it guarantees more complete coverage of the test plot than SRS or paired sampling. Also, if any systematic differences in contaminant levels exist across the site, stratified sampling allows for separate inferences by sub-plot (i.e., grid cell). Disadvantages of stratified sampling are that the method requires a slightly larger number of samples than SRS or paired sampling methods, and that stratified sampling performs poorly when contaminant levels are spatially correlated.

Systematic Sampling

The samples for the ISCO techonology demonstration were collected using a systematic sampling plan. Systematic sampling is the term applied to plans where samples are located in a regular pattern. In geographic applications such as this study, the systematic sampling method involves the positioning of sampling locations at the nodes of a regular grid. The grid need not be square or rectangular; in fact, a grid of equilateral triangles is the most efficient grid design. (Regular hexagonal grids also have been used regularly and are nearly as efficient as triangles and squares.) The number of samples and the size of the area to be sampled determine the dimensions of the grid to be used. With systematic sampling, the selection of initial (e.g., pre-remediation) set of sampling locations requires the random location of only one grid node, because all other grid nodes will be determined based on the required size of the grid and the position of that first node. A second (e.g., post-remediation) set of sampling locations can be either chosen using a different random placement of the grid or collocated with the initial set of sampling locations.

One variation of the systematic sampling method worth consideration is *unaligned* sampling. Under this method, a given test plot is divided into a grid with an equal number of rows and columns. One sample per grid cell then is selected by:

- Assigning random horizontal coordinates for each row of the grid;
- Assigning random vertical coordinates for each column of the grid;
- Determining the sampling locations for a cell by using the horizontal and vertical coordinates selected for the corresponding row and column.

In other words, every cell in a row shares a horizontal coordinate, and every cell in a column shares a vertical coordinate. Figure A-1 illustrates the locations generated using unaligned systematic sampling with a 3 × 3 grid.

The major benefit of systematic sampling was that it is the most efficient design for spatially correlated data. In addition, coverage of the entire plot was guaranteed. One disadvantage of systematic sampling was that determining the required sample size was more difficult than the other three methods discussed in this appendix.

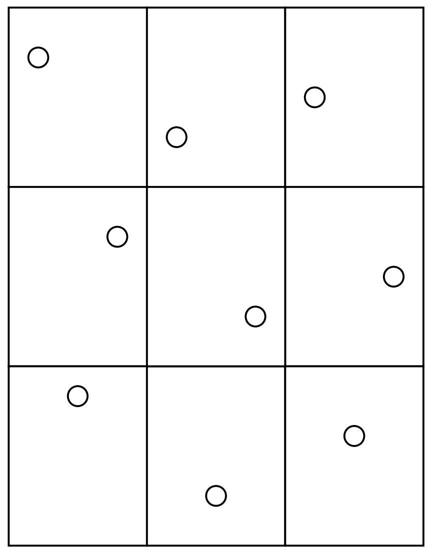


Figure A.1-1. Unaligned Systematic Sampling Design for a 3 × 3 Grid

A.1.2 Kriging Methods and Results

The geostatistical analysis approach was to utilize kriging, a statistical spatial interpolation procedure, to estimate the overall average TCE concentration in soil before and after remediation, and then determine if those concentrations were significantly different.

To meet the objectives of this study, it is sufficient to estimate the overall mean TCE concentration across an entire test plot, rather than estimating TCE concentrations at various spatial locations within a test plot. In geostatistical terms, this is known as global estimation. One approach, and in fact the simplest approach, for calculating a global mean estimate is to calculate the simple arithmetic average (i.e., the equally weighted average) across all available TCE concentrations measured within the plot. However, this approach is appropriate only in cases where no correlation is present in the measured data. Unfortunately, this is a rare situation in the environmental sciences.

A second approach, and the approach taken in this analysis, is to use a spatial statistical procedure called kriging to take account of spatial correlation when calculating the global average. Kriging is a statistical interpolation method for analyzing spatially varying data. It is used to estimate TCE concentrations (or any other important parameter) on a dense grid of spatial locations covering the region of interest, or as a global average across the entire region. At each location, two values are calculated with the kriging procedure: the estimate of TCE concentration (mg/kg), and the standard error of the estimate (also in mg/kg). The standard error can be used to calculate confidence intervals or confidence bounds for the estimates. It should be noted that this calculation of confidence intervals and bounds also requires a serious distributional assumption, such as a normality assumption, which is typically more reasonable for global estimates than for local estimates.

The kriging approach includes two primary analysis steps:

1. Estimate and model spatial correlations in the available monitoring data using a semivariogram analysis.
2. Use the resulting semivariogram model and the available monitoring data to interpolate (i.e., estimate) TCE values at unsampled locations; calculate the statistical standard error associated with each estimated value.

A.1.2.1 Spatial Correlation Analysis

The objective of the spatial correlation analysis is to statistically determine the extent to which measurements taken at different locations are similar or different. Generally, the degree to which TCE measurements taken at two locations are different is a function of the distance and direction between the two sampling locations. Also, for the same separation distance between two sampling locations, the spatial correlation may vary as a function of the direction between the sampling locations. For example, values measured at each of two locations, a certain distance apart, are often more similar when the locations are at the same depth, than when they are at the same distance apart but at very different depths.

Spatial correlation is statistically assessed with the semivariogram function, $(\,(\underline{h})$, which is defined as follows (Journel and Huijbregts, 1981):

$$2(\,(\underline{h}) = E\ \{[Z(\underline{x}) - Z(\underline{x} + \underline{h})]^2\}$$

where $Z(\underline{x})$ is the TCE measured at location $\underline{x}$, $\underline{h}$ is the vector of separation between locations $\underline{x}$ and $\underline{x} + \underline{h}$, and E represents the expected value or average over the region of interest. Note that the location $\underline{x}$ is typically defined by an easting, northing, and depth coordinate. The vector of separation is typically defined as a three-dimensional shift in space. The semivariogram is a measure of spatial differences, so that small semivariogram values correspond to high spatial correlation, and large semivariogram values correspond to low correlation.

As an initial hypothesis, it is always wise to assume that the strength of spatial correlation is a function of both distance and direction between the sampling locations. When the spatial correlation is found to depend on both separation distance and direction, it is said to be anisotropic. In contrast, when the spatial correlation is the same in all directions, and therefore depends only on separation distance, it is said to be isotropic.

The spatial correlation analysis is conducted in the following steps using the available measured TCE data:

- Experimental semivariogram curves are generated by organizing all pairs of data locations into various separation distance and direction classes (e.g., all pairs separated by 20-25 ft. in the east-west direction ∀ 22.5º), and then calculating within each class the average squared-difference between the TCE measurements taken at each pair of locations. The results of these calculations are plotted against separation distance and by separation direction.

- To help fully understand the spatial correlation structure, a variety of experimental semivariogram curves may be generated by subsetting the data into discrete zones, such as different depth horizons. If significant differences are found in the semivariograms they are modeled separately; if not, the data are pooled together into a single semivariogram.
- After the data have been pooled or subsetted accordingly, and the associated experimental semivariograms have been calculated and plotted, a positive-definite analytical model is fitted to each experimental curve. The fitted semivariogram model is then used to input the spatial correlation structure into the subsequent kriging interpolation step.

A.1.2.2 Interpolation Using Ordinary Kriging

Ordinary kriging is a linear geostatistical estimation method which uses the semivariogram function to determine the optimal weighting of the measured TCE values to be used for the required estimates, and to calculate the estimation standard error associated with the estimates (Journel and Huijbregts, 1981). In a sense, kriging is no different from other classical interpolation and contouring algorithms. However, kriging is different in that it produces statistically optimal estimates and associated precision measures. It should be noted that the ordinary kriging variance, while easy to calculate and readily available from most standard geostatistical software packages, may have limited usefulness in cases where local estimates are to be calculated, and the data probability distribution is highly skewed or non-gaussian. The ordinary kriging variance is more appropriately used for global estimates and symmetric or gaussian data distributions. The ordinary kriging variance provides a standard error measure associated with the data density and spatial data arrangement relative to the point or block being kriged. However, the ordinary kriging variance is independent of the data values themselves, and therefore may not provide an accurate measure of local estimation precision.

A.1.2.3 TCE Data Summary

Semivariogram and kriging analyses were conducted on data collected from two test plots; one plot used ISCO technology, and the other used a standard Resistive Heating technology to remove TCE. Each plot was approximately 50 by 75 feet in size, and was sampled via 25 drill holes, half before and half after remediation. The location of each drill hole was recorded by measuring the distance in the northing and easting directions from a designated point on the Cape Canaveral Air Station. The documented coordinates for each drill hole on the ISCO and Resistive Heating plots are defined within Figure A.1-2. The same locations are also shown in Figure A.1-3 after we rotated both plots by 30 degrees and shifted the coordinates in order to produce a posting map that was compatible with the kriging computer software.

Each point within Figures A.1-2 and A.1-3 represents a single drill hole. Recall that pre- and post-remediation TCE measurements were collected in order to analyze the effectiveness of the contaminant removal methods. Thus, the drill holes were strategically placed so that pre and post information could be gathered within a reasonable distance of one another (i.e., the holes were approximately paired). In addition, for both the ISCO and the Resistive Heating plots, an extra or twinned post-remediation hole was drilled (see pre/post pair # 10B and 17B on Figures A.1-2 and A.1-3). Since our approach for the kriging analysis considered the pre- and post-remediation data as independent data sets (see Section 1.0), we included the duplicate holes in our analyses, even though a corresponding pre-remediation hole did not exist.

The cores were drilled at least 44 feet deep; and the largest drill hole extends 48 feet. With few exceptions, TCE measurements were collected every two feet. Thus, approximately 20 to 25 two-foot core sections were analyzed from each drill hole. The vertical location of each core section was identified by the elevation of the midpoint of the section above sea level. At the time of data collection, the surface elevation at the location of the drill hole, as well as the top and bottom depths of each core section (rounded to the nearest half of a foot), were recorded. Hence, the elevation of each sample was calculated by the subtracting the average of the top and bottom depths from the surface elevation. For example, if a sample was collected from a core section that started and ended at 20 and 22 feet below a ground surface elevation of 5.2 feet, then the sample elevation equaled 5.2 - (20+22)/2=15.8 feet above sea level.

In some cases, field duplicate samples were collected by splitting an individual two-foot core section. In order to optimize the additional data, we used all measurements when evaluating spatial correlation with the semivariogram analysis, and when conducting the kriging analysis. However, to remain compatible with the kriging software, it was necessary to shift the location of the duplicate data slightly, by adding one-tenth of a foot to the easting coordinate. Table A.1-1 summarizes the number of two-foot sections from which more than one sample was collected.

Table A.1-1. Number of Field Duplicate Measurements Collected from the Resistive Heating and ISCO Plots

Plot	Pre/Post	Number of Two-Foot Sections From Which		Total
		1 Sample was Drawn	> 1 Sample was Drawn	
Resistive Heating	Pre	242	20	262
	Post	246	28	292
ISCO	Pre	251	16	267
	Post	276	12	288

There were also cases where the observed TCE concentration for a particular sample occurred below the analytical method detection limit (MDL). In such cases, the measurement that was included in our analyses equaled one-half of the given MDL. Table A.1-2 summarizes the number of observations that were below the MDL.

Table A.1-2. Number of Measurements (including Duplicates) Below the Minimum Detection Limit

Plot	Pre/Post	Number of Samples		Total
		Below MDL	Above MDL	
Resistive Heating	Pre	47	231	278
	Post	29	276	305
ISCO	Pre	20	266	286
	Post	156	144	300

When a two-foot section was removed from the core, the sample was identified by the easting, northing, and elevation coordinates. In addition, the geologic stratum, or soil type of the sample, was also documented. These strata and soil types included the vadose zone, upper sand unit (USU), middle fine-grained unit (MFGU), and lower sand unit (LSU). Note that the stratum of the sample was not solely determined by depth, but also by inspection by a geologist.

Tables A.1-3 and A.1-4 provide summary statistics by layer and depth for pre- and post-remediation measurements. The minimum and maximum values provide the overall range of the data; the mean or average TCE measurement estimates (via simple arithmetic averaging) the amount of TCE found within the given layer and depth; and the standard deviation provides a sense of the overall spread of the data. Note that our analyses focus on the three deepest layers, USU, MFGU and LSU.

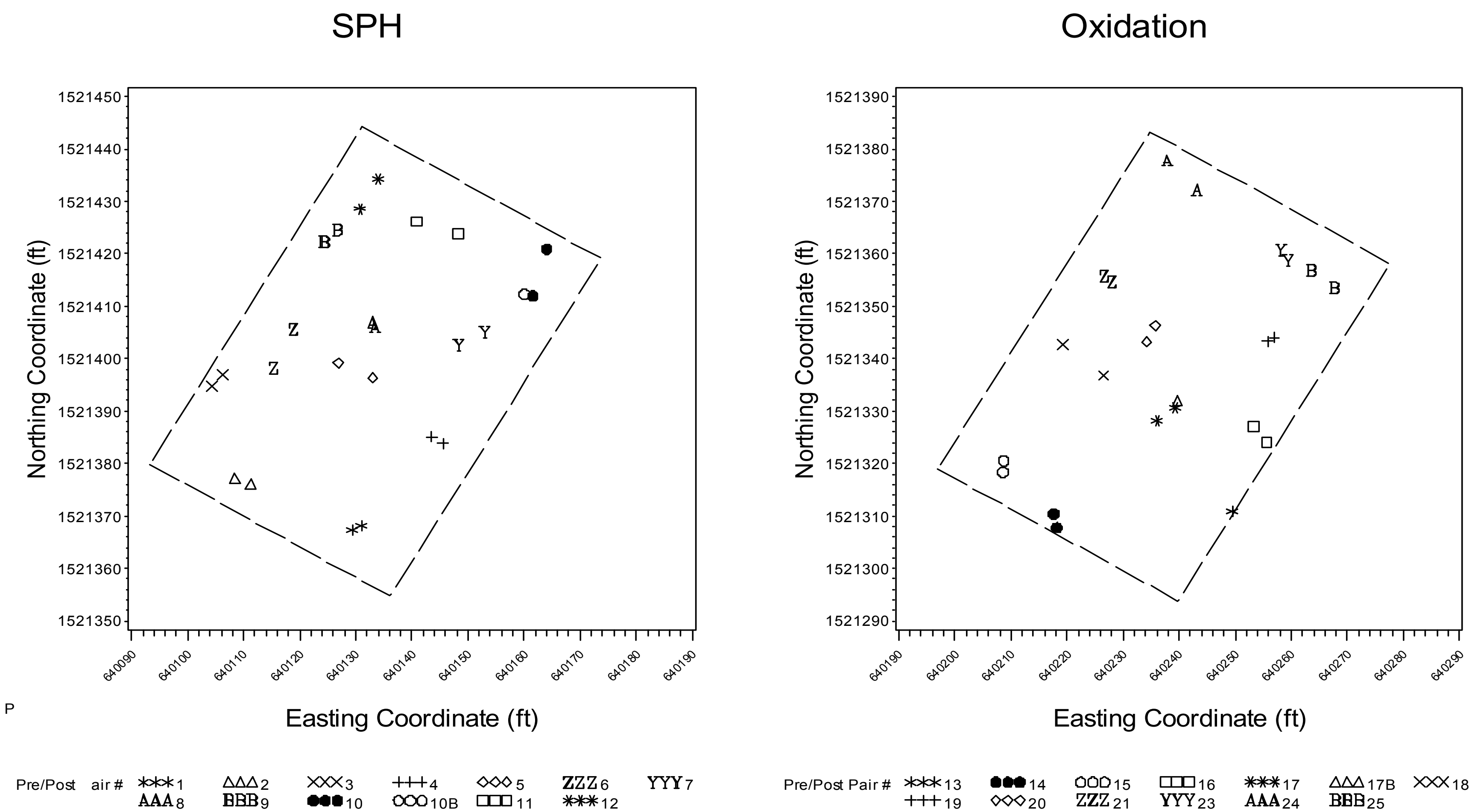


Figure A.1-2. Original Posting Maps of Resistive Heating (SPH) and ISCO plots
(Note that pre/post pair # 13 has two drill holes that are extremely close to one another)

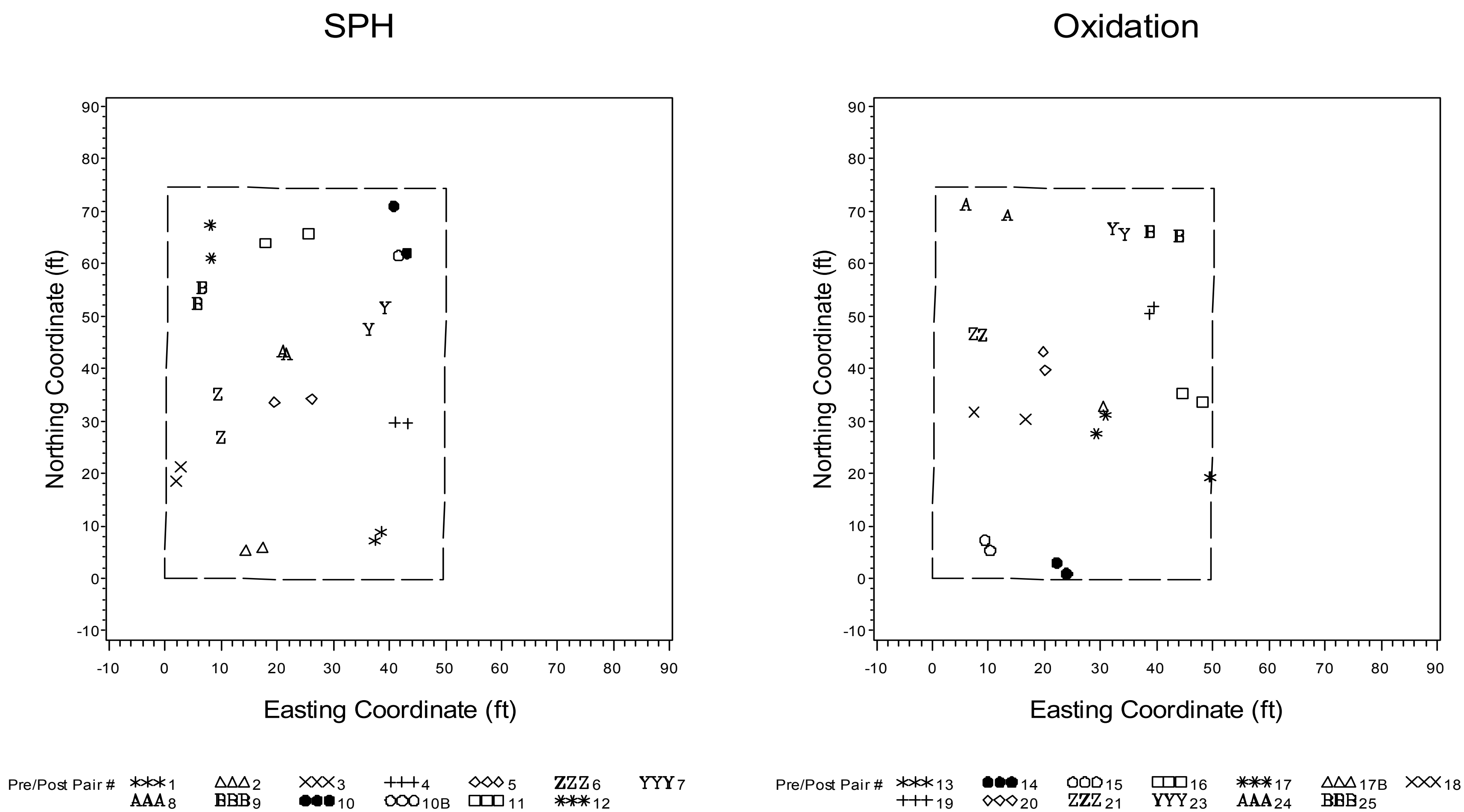


Figure A.1-3. Rotated Posting Maps of Resistive Heating (SPH) and ISCO plots
(Note that pre/post pair # 13 has two drill holes that are extremely close to one another)

Table A.1-3. Summary Statistics for Data Collected From Resistive Heating Plot by Layer and Depth

Layer	Feet Above Sea Level (MSL)	Pre-Treatment N	Pre-Treatment Minimum (mg/kg)	Pre-Treatment Maximum (mg/kg)	Pre-Treatment Mean (mg/kg)	Pre-Treatment Std. Dev. (mg/kg)	Post-Treatment N	Post-Treatment Minimum (mg/kg)	Post-Treatment Maximum (mg/kg)	Post-Treatment Mean (mg/kg)	Post-Treatment Std. Dev. (mg/kg)
VADOSE	10 to 12	1	7.78	7.78	7.78	.	2	0.26	0.77	0.51	0.36
	8 to 10	1	5.29	5.29	5.29	.	6	0.25	6.00	2.67	2.62
	6 to 8	6	0.14	9.24	2.01	3.59	12	0.25	6.00	1.84	1.77
	4 to 6	12	0.14	4.63	1.25	1.63	13	0.21	12.00	2.61	3.53
	2 to 4	12	0.10	10.52	1.75	3.16	13	3.00	40.22	9.32	11.22
	0 to 2	10	0.17	48.74	5.26	15.29	3	10.00	72.00	47.67	33.08
	-2 to 0	2	0.20	1.10	0.65	0.64	.	.	.	.	.
	Total	44	0.10	48.74	2.61	7.55	49	0.21	72.00	6.88	14.23
USU	0 to 2	2	0.71	8.84	4.77	5.75	10	5.00	90.00	30.31	27.06
	-2 to 0	9	0.18	12.46	2.27	4.06	12	0.22	114.00	20.85	35.55
	-4 to -2	11	0.18	6.46	1.65	2.09	9	0.22	71.00	18.84	27.65
	-6 to -4	10	0.18	4.01	1.05	1.24	12	0.16	126.00	36.26	47.60
	-8 to -6	13	0.17	121.67	10.73	33.41	12	0.26	197.00	50.52	72.10
	-10 to -8	13	0.20	341.80	51.64	122.88	13	1.00	4295.43	358.08	1183.66
	-12 to -10	11	0.19	1935.01	182.22	581.52	11	0.17	1248.08	154.42	368.78
	-14 to -12	12	0.20	107.82	22.01	32.52	11	5.00	135.00	62.56	45.67
	-16 to -14	10	9.20	1835.15	224.50	569.37	10	4.00	213.00	96.89	80.34
	-18 to -16	5	10.77	259.76	86.43	101.53	2	6.00	64.00	35.00	41.01
	-20 to -18	2	26.27	112.13	69.20	60.71	1	20.00	20.00	20.00	.
	Total	98	0.17	1935.01	60.75	271.45	103	0.16	4295.43	95.78	437.80
MFGU	-14 to -12	1	820.43	820.43	820.43	.	1	3927.05	3927.05	3927.05	.
	-16 to -14	2	292.17	526.14	409.16	165.45	5	12.00	401.30	252.87	150.23
	-18 to -16	5	183.22	9050.90	2192.46	3844.52	12	4.00	5560.77	704.64	1539.34
	-20 to -18	13	26.37	19090.91	3314.22	6670.74	12	13.00	403.00	215.36	159.67
	-22 to -20	10	54.64	541.79	196.80	148.15	8	10.00	319.00	131.66	102.29
	-24 to -22	8	17.00	11085.00	1533.59	3871.12	4	7.00	140.00	55.25	61.99
	-26 to -24	3	2.24	5345.08	1783.27	3084.62	2	3.00	19.00	11.00	11.31
	-28 to -26	2	0.39	0.39	0.39	0.00	2	5.00	23.00	14.00	12.73
	-30 to -28	2	0.20	1.40	0.80	0.85	2	1.00	1.00	1.00	0.00
	-32 to -30	1	0.68	0.68	0.68	.	1	3.00	3.00	3.00	.
	Total	47	0.20	19090.91	1601.61	4152.73	49	1.00	5560.77	358.38	942.46
LSU	-20 to -18	.	.	.	.	.	1	1217.00	1217.00	1217.00	.
	-22 to -20	3	34.76	349.12	186.05	157.51	5	34.00	464.64	233.38	158.60
	-24 to -22	6	4.79	623.63	176.84	231.51	10	20.70	287.00	139.97	101.17
	-26 to -24	9	0.18	1024.58	213.91	332.94	11	35.00	429.15	192.80	145.10
	-28 to -26	11	0.28	23361.76	4599.56	8705.84	12	63.00	473.85	279.32	148.04
	-30 to -28	10	0.23	8061.67	1430.78	2922.44	12	2.00	264.00	143.55	86.98
	-32 to -30	9	0.21	28167.63	3338.38	9314.75	11	9.00	335.08	123.18	107.14
	-34 to -32	12	0.43	33099.93	3357.69	9549.49	12	0.17	511.00	167.27	179.23
	-36 to -34	12	5.75	41043.56	7635.34	15205.72	12	0.19	364.00	144.99	126.21
	-38 to -36	12	11.76	37104.00	6980.34	12891.67	3	2.00	59.00	23.00	31.32
	-40 to -38	1	1.46	1.46	1.46	.	.	.	.	.	.
	Total	85	0.18	41043.56	3696.17	9459.97	89	0.17	1217.00	181.46	176.47

Table A.1-4. Summary Statistics for Data Collected From ISCO Plot by Layer and Depth

Layer	Feet Above Sea Level (MSL)	Pre-Treatment					Post-Treatment				
		N	Minimum (mg/kg)	Maximum (mg/kg)	Mean (mg/kg)	Std. Dev. (mg/kg)	N	Minimum (mg/kg)	Maximum (mg/kg)	Mean (mg/kg)	Std. Dev. (mg/kg)
VADOSE	10 to 12	2	0.16	0.20	0.18	0.03	2	0.15	0.40	0.28	0.18
	8 to 10	4	0.13	0.37	0.26	0.11	13	0.15	0.55	0.35	0.14
	6 to 8	12	0.15	4.72	0.68	1.28	13	0.10	0.60	0.31	0.16
	4 to 6	12	0.17	1.81	0.52	0.47	13	0.15	2.30	0.50	0.57
	2 to 4	10	0.15	7.83	1.25	2.37	3	0.20	1.00	0.52	0.43
	0 to 2	1	0.38	0.38	0.38	.	.	.	.	.	.
	Total	41	0.13	7.83	0.70	1.38	44	0.10	2.30	0.39	0.35
USU	2 to 4	2	0.30	6.69	3.50	4.52	10	0.20	5.30	1.23	1.65
	0 to 2	11	0.15	2.94	0.65	0.86	12	0.20	57.30	6.28	16.24
	-2 to 0	11	0.18	8.56	2.27	3.13	13	0.15	42.70	10.49	15.72
	-4 to -2	13	0.20	7.40	0.94	1.95	13	0.15	44.80	5.59	13.39
	-6 to -4	12	0.21	8.71	1.89	2.57	13	0.15	39.30	5.13	12.34
	-8 to -6	12	0.25	28.48	3.71	8.05	13	0.15	83.60	8.55	23.19
	-10 to -8	13	0.74	114.31	16.49	31.41	14	0.15	14.70	1.75	4.05
	-12 to -10	14	1.33	240.81	70.76	93.31	13	0.20	246.70	26.03	70.59
	-14 to -12	12	11.63	4412.37	727.60	1563.26	12	0.20	31.00	3.06	8.82
	-16 to -14	10	57.93	3798.38	518.42	1153.89	7	0.15	1.80	0.72	0.76
	-18 to -16	6	59.30	304.19	201.89	85.59	.	.	.	.	.
	Total	116	0.15	4412.37	141.81	632.82	120	0.15	246.70	7.33	26.46
MFGU	-14 to -12	1	3033.83	3033.83	3033.83	.	1	2261.90	2261.90	2261.90	.
	-16 to -14	2	6898.91	13323.58	10111.24	4542.92	5	3.60	9726.77	1948.95	4347.93
	-18 to -16	7	65.10	17029.53	2798.69	6291.82	13	0.20	390.90	55.47	113.84
	-20 to -18	14	191.64	2261.17	488.48	520.49	15	0.20	4200.90	528.16	1335.90
	-22 to -20	10	137.28	30056.10	3288.71	9406.06	10	0.20	288.32	74.66	113.85
	-24 to -22	12	56.54	331.59	179.64	102.19	8	0.20	8.50	2.20	2.82
	-26 to -24	5	23.41	201.95	121.61	76.42	4	0.20	36.50	12.51	17.10
	-28 to -26	3	7.31	226.99	121.81	110.13	1	0.20	0.20	0.20	.
	-30 to -28	1	13.15	13.15	13.15	.	.	.	.	.	.
	Total	55	7.31	30056.10	1558.46	4916.03	57	0.20	9726.77	376.57	1471.04
LSU	-22 to -20	1	664.18	664.18	664.18	.	3	0.60	3887.58	2537.03	2198.15
	-24 to -22	2	19.52	8858.93	4439.23	6250.41	6	0.20	3279.60	798.48	1300.99
	-26 to -24	8	62.29	17686.46	4421.24	7446.19	10	0.20	4132.90	551.82	1301.99
	-28 to -26	10	95.48	11322.78	2479.58	3951.42	13	0.20	8313.75	976.92	2326.32
	-30 to -28	10	117.45	8374.13	2024.60	3194.20	14	0.30	1256.50	212.43	374.85
	-32 to -30	12	19.92	7397.80	1232.98	2289.02	13	0.20	583.10	63.21	157.71
	-34 to -32	13	6.75	8911.22	1883.02	3113.33	11	0.15	211.40	53.79	79.33
	-36 to -34	10	40.98	10456.12	2073.13	4030.31	9	0.20	857.60	189.68	323.49
	-38 to -36	6	48.87	8349.02	1521.04	3345.73	.	.	.	.	.
	Total	72	6.75	17686.46	2209.54	3943.33	79	0.15	8313.75	464.74	1260.41

A.1.2.4 Semivariogram Results

In this study, the computer software used to perform the geostatistical calculations was Battelle's BATGAM software, which is based on the GSLIB Software written by the Department of Applied Earth Sciences at Stanford University, and documented and released by Prof. Andre Journel and Dr. Clayton Deutsch (Deutsch and Journel, 1998). The primary subroutine used to calculate experimental semivariograms was GAMV3, which is used for three-dimensional irregularly spaced data.

For the three-dimensional spatial analyses, horizontal separation distance classes were defined in increments of 5 ft. with a tolerance of 2.5 ft., while vertical distances were defined in increments of 2 ft. with a tolerance of 1 ft. Horizontal separation directions were defined, after rotation 30º west from North (see Figures A.1-2 and A.1-3), in the four primary directions of north, northeast, east, and southeast with a tolerance of 22.5º.

Data were analyzed separately for the Resistive Heating and ISCO plots, and vertically the data were considered separately by layer (i.e., USU, MFGU and LSU layers). Semivariogram and kriging analyses were not performed with the vadose data since the pre-remediation TCE concentrations were already relatively low and insignificant. Results from the semivariogram analyses are presented in Figures A.1-4 to A.1-15, as well as Table A.1-5. The key points indicated in the semivariogram analysis results are as follows:

(a) For all experimental semivariograms calculated with the TCE data, no horizontal directional differences (i.e., anisotropies) were observed; however, strong anisotropy for the horizontal versus vertical directions was often observed. Therefore, in Figures 3 through 14 the omni-directional horizontal semivariogram (experimental and model) is shown along with the vertical semivariogram (experimental and model).

(b) In all cases, the experimental semivariograms are relatively variable due to high data variability and modest sample sizes. As a result, the semivariogram model fitting is relatively uncertain, meaning that a relatively wide range of semivariogram models could adequately fit the experimental semivariogram points. This probably does not affect the TCE estimates (especially the global estimates), but could significantly affect the associated confidence bounds.

(c) The models shown in Figures 3 through 14 are all gaussian semivariogram models, chosen to be consistent with the experimental semivariogram shapes found for all twelve TCE data sets at this Cape Canaveral site. The fitted semivariograms model parameters are listed in Table 5.

Table A.1-5. Fitted Semivariogram Model Parameters for TCE at Cape Canaveral

	Data Set			Semivariogram				
Figure No.	Plot	Layer	Pre- or Post-Remediation	Gaussian Type	Nugget Var. $(mg/kg)^2$	Total Sill Var. $(mg/kg)^2$	Omni-Horizontal Range (ft.)	Vertical Range (ft.)
3	Resistive Heating	USU	PRE	Anisotropic	6.0×10^3	6.4×10^4	23	3
4	Resistive Heating	USU	POST	Anisotropic	2.0×10^4	1.9×10^5	35	3
5	Resistive Heating	MFGU	PRE	Anisotropic	1.0×10^6	2.0×10^7	35	5
6	Resistive Heating	MFGU	POST	Anisotropic	5.0×10^4	6.0×10^5	35	5
7	Resistive Heating	LSU	PRE	Isotropic	2.5×10^7	8.5×10^7	9	9
8	Resistive Heating	LSU	POST	Anisotropic	4.0×10^3	2.0×10^4	23	3
9	ISCO	USU	PRE	Anisotropic	5.0×10^4	3.0×10^5	12	3
10	ISCO	USU	POST	Isotropic	5.0×10^1	4.0×10^2	3	3
11	ISCO	MFGU	PRE	Anisotropic	2.5×10^6	2.0×10^7	35	3
12	ISCO	MFGU	POST	Anisotropic	2.0×10^5	1.4×10^6	52	3
13	ISCO	LSU	PRE	Anisotropic	1.0×10^6	1.0×10^7	23	3
14	ISCO	LSU	POST	Anisotropic	7.0×10^4	6.7×10^5	35	3

A.1.2.5 Kriging Results

The kriging analysis was performed using the BATGAM software and GSLIB subroutine KT3D. To conduct this analysis, each plot was defined as a set of vertical layers and sub-layers. Estimated mean TCE concentrations were then calculated via kriging for each sub-layer separately, as well as across the sub-layers. The vertical layering for kriging was consistent with the semivariogram modeling:

(a) Kriging the Resistive Heating plot was performed separately for the USU, MFGU and LSU layers. The USU layer was sub-divided into 11 two-foot sub-layers extending across elevations from –20 to +2 ft. The MFGU layer was sub-divided into 10 two-foot sub-layers extending across elevations from –32 to –12 ft. The LSU layer was sub-divided into 11 two-foot sub-layers from elevations of –40 to –18 ft.

(b) Kriging of the ISCO plot was also done separately for the USU, MFGU and LSU layers. The USU layer consisted of 11 two-foot sub-layers across elevations from –18 to +4 ft. The MFGU layer consisted of 9 sub-layers across elevations from –30 to –12 ft. The LSU layer consisted of 9 sub-layers across elevations from –38 to –20 ft.

(c) For kriging of the two-foot sub-layers, the data search was restricted to consider only three sub-layers, the current sub-layer and that immediately above and below. The data search was not restricted horizontally.

(d) For kriging of an entire layer (i.e., USU or MFGU or LSU separately), the data search considered all available data at all elevations. Note that by extending the data search radius to include all data within a plot, an implicit assumption is made that the semivariogram model holds true for distances up to about 100 ft., which are distances beyond those observable with this dataset in the experimental semivariograms. This assumption seems reasonable given the relatively short dimensions of the Resistive Heating and ISCO plots.

Results from the kriging analysis are presented in Tables A.1-6 and A.1-7 for the Resistive Heating and ISCO pre- and post-remediation data, and for each of USU, MFGU and LSU layers, as well as by sub-layer within each layer. Because of the shortcomings of using the ordinary kriging variance (discussed in Section 1.0) for local estimates, confidence bounds are only presented in Tables 6 and 7 for the global layer estimates (shaded rows). In cases where the upper confidence bound for the post-remediation average TCE concentration falls below the lower confidence bound for the pre-remediation average TCE concentration, the post-remediation TCE concentrations are statistically significantly lower than the pre-remediation TCE concentrations (denoted with a * in the tables). The estimated TCE reductions, expressed on a percentage basis, are also shown in Tables A.1-6 and A.1-7 and generally (with the exception of the TCE increase in the Resistive Heating USU layer) vary between 70% and 96%, based on the global estimates.

Table A.1-8 shows how the TCE concentration estimates (average, lower bound, and upper bound as determined in Table A.1-7) for ISCO plot are weighted and converted into TCE masses. The concentration estimates in the three stratigraphic units are multiplied by the number of grid cells sampled (N) in each stratigraphic unit and the mass of dry soil in each cell (26,831.25 kg). The mass of soil in each grid cell is the volume of each 18.75 ft x 16.67 ft x 2 ft grid cell (the area of the plot divided into a 4 x 3 grid; the thickness of each grid cell is 2 ft).

Table A.1-6. Kriging Results for TCE in the Resistive Heating Plot

Layer	Feet Above Sea Level (MSL)	Pre-Remediation TCE (mg/kg)	Post-Remediation TCE (mg/kg) / Percent Reduction
USU	0 to 2	3	32
	-2 to 0	2	21
	-4 to -2	2	18
	-6 to -4	1	32
	-8 to -6	14	46
	-10 to -8	31	297
	-12 to -10	124	325
	-14 to -12	118	122
	-16 to -14	182	78
	-18 to -16	245	61
	-20 to -18	88	41
	Total	64	112 / -75%
	95% C.I.	(19, 110)	(38, 186)
	90% C.I.	(26, 103)	(49, 174)
	80% C.I.	(34, 94)	(63, 160)
MFGU	-14 to -12	.	1450
	-16 to -14	412	606
	-18 to -16	1375	635
	-20 to -18	2125	478
	-22 to -20	1765	181
	-24 to -22	1419	119
	-26 to -24	2809	54
	-28 to -26	1705	12
	-30 to -28	1	3
	-32 to -30	1	.
	Total	1655	408 / 75%
	95% C.I.	(251, 3059)	(165, 650)
	90% C.I.	(473, 2837)	(204, 612)
	80% C.I.	(731, 2579)	(248, 567)*
LSU	-20 to -18	.	512
	-22 to -20	140	204
	-24 to -22	151	166
	-26 to -24	207	180
	-28 to -26	2394	239
	-30 to -28	2462	189
	-32 to -30	2246	135
	-34 to -32	3190	153
	-36 to -34	7241	154
	-38 to -36	8225	118
	-40 to -38	5615	.
	Total	4092	183 / 96%
	95% C.I.	(1463, 6721)	(154, 212)*
	90% C.I.	(1879, 6305)	(159, 208)*
	80% C.I.	(2362, 5822)	(164, 202)*

* TCE reduction is statistically significant.

Table A.1-7. Kriging Results for TCE in the ISCO Plot

Layer	Feet Above Sea Level (MSL)	Pre-Remediation TCE (mg/kg)	Post-Remediation TCE (mg/kg) / Percent Reduction
USU	2 to 4	2	1
	0 to 2	1	5
	-2 to 0	1	6
	-4 to -2	2	7
	-6 to -4	3	9
	-8 to -6	9	5
	-10 to -8	31	12
	-12 to -10	53	16
	-14 to -12	613	6
	-16 to -14	760	4
	-18 to -16	167	.
	Total	146	8 / 95%
	95% C.I.	(45, 246)	(4, 11)*
	90% C.I.	(61, 230)	(4, 11)*
	80% C.I.	(80, 212)	(5, 10)*
MFGU	-14 to –12	7963	3593
	-16 to –14	9414	1501
	-18 to –16	2684	135
	-20 to -18	1508	619
	-22 to -20	2655	196
	-24 to -22	220	30
	-26 to -24	150	8
	-28 to -26	97	.
	-30 to -28	71	.
	Total	1922	570 / 70%
	95% C.I.	(712, 3133)	(230, 909)
	90% C.I.	(903, 2942)	(284, 856)*
	80% C.I.	(1126, 2719)	(346, 793)*
LSU	-22 to -20	4665	2021
	-24 to -22	10048	954
	-26 to -24	4796	846
	-28 to -26	2036	823
	-30 to -28	1876	245
	-32 to -30	1780	102
	-34 to -32	1453	73
	-36 to -34	1972	183
	-38 to -36	2491	.
	Total	2282	486 / 79%
	95% C.I.	(1578, 2986)	(311, 660)*
	90% C.I.	(1690, 2875)	(339, 632)*
	80% C.I.	(1819, 2746)	(371, 600)*

* TCE reduction is statistically significant.

Table A.1-8. Calculating Total TCE Masses based on TCE Average Concentrations and Upper and Lower Bounds

ISCO Plot Geology Units	Pre-Demonstration							Post-Demonstration						
		TCE Concentration			TCE Mass *				TCE Concentration			TCE Mass *		
		Average	Lower Bound	Upper Bound	Average	Lower Bound	Upper Bound		Average	Lower Bound	Upper Bound	Average	Lower Bound	Upper Bound
	N	(mg/kg)	(mg/kg)	(mg/kg)	(kg)	(kg)	(kg)	N	(mg/kg)	(mg/kg)	(mg/kg)	(kg)	(kg)	(kg)
Upper Sand Unit	116	146	80	212	454	250	659	120	8	5	10	26	18	34
Middle Fine-Grained Unit	55	1,922	1,126	2,719	2,836	1,668	4,005	57	570	346	793	872	532	1,211
Lower Sand Unit	72	2,282	1,819	2,746	4,408	3,519	5,298	79	486	371	600	1,030	788	1,272
Total ISCO Plot	243	-	-	-	7,699	6,217	9,182	256	-	-	-	1,928	1,511	2,345

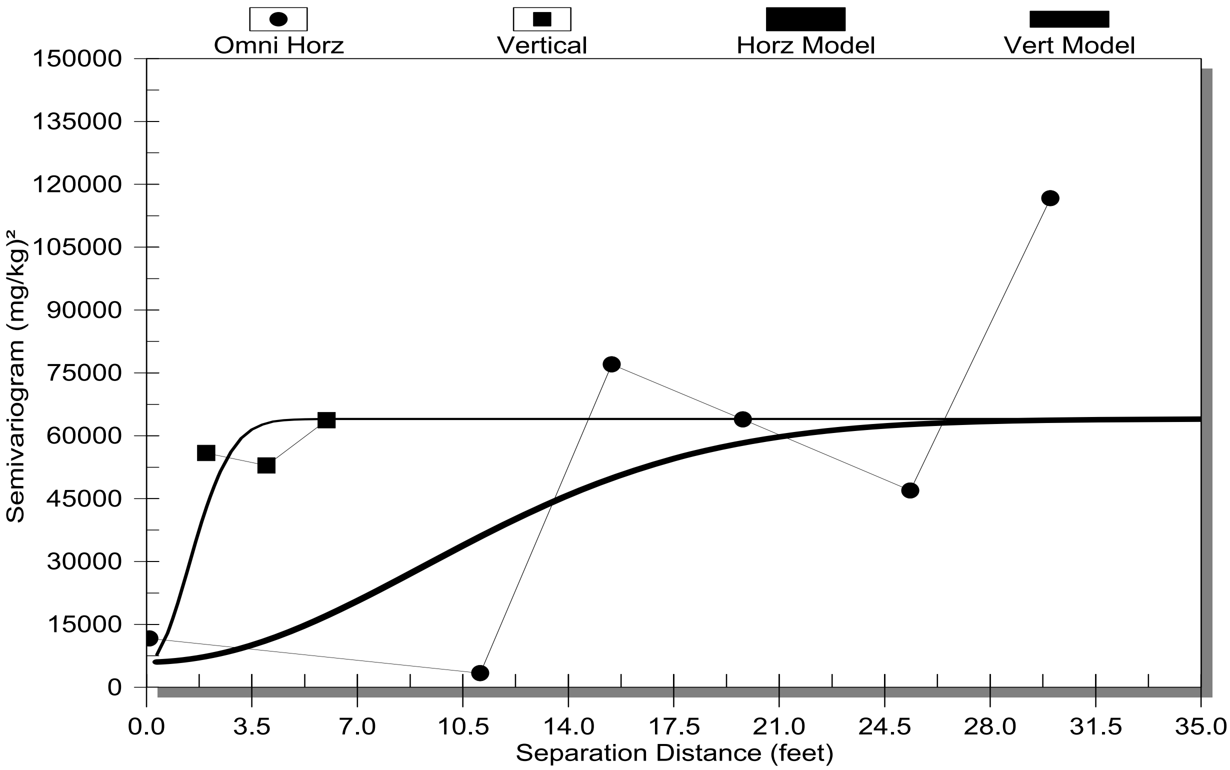


Figure A.1-4. Pre-Remediation TCE Semivariograms for Resistive Heating Plot and USU

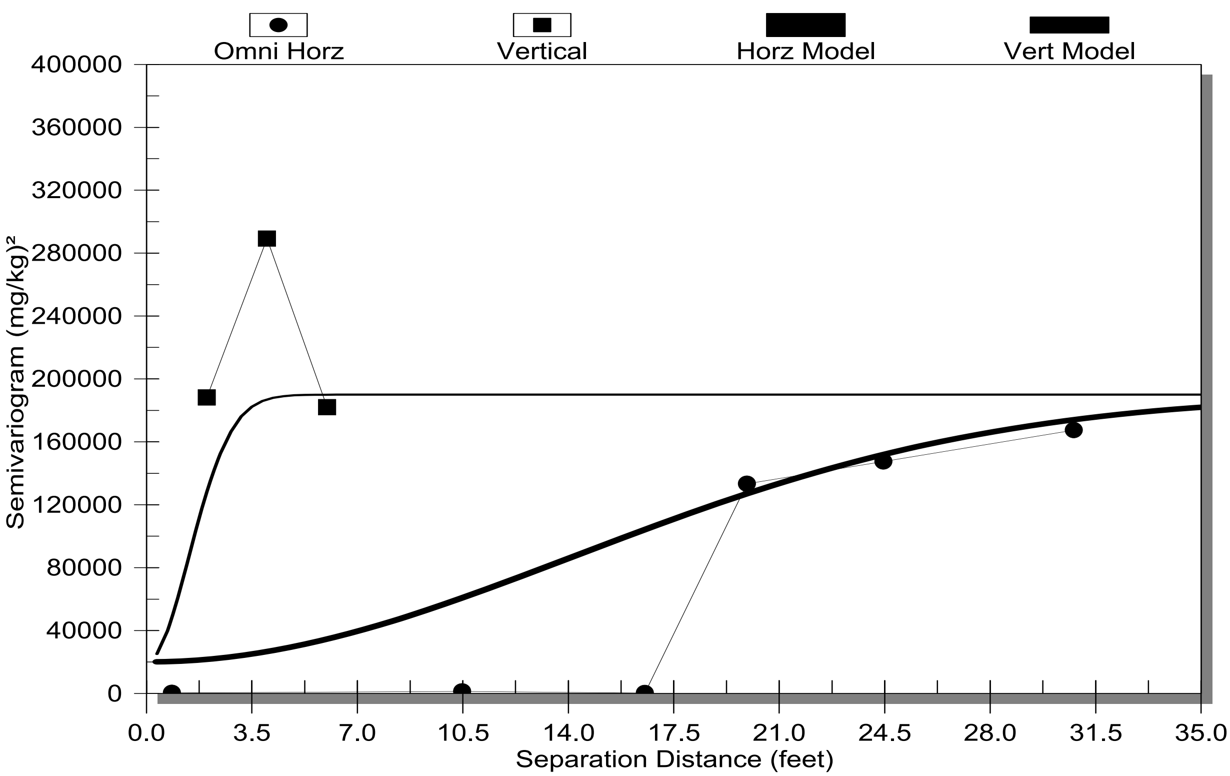


Figure A.1-5. Post-Remediation TCE Semivariograms for Resistive Heating Plot and USU

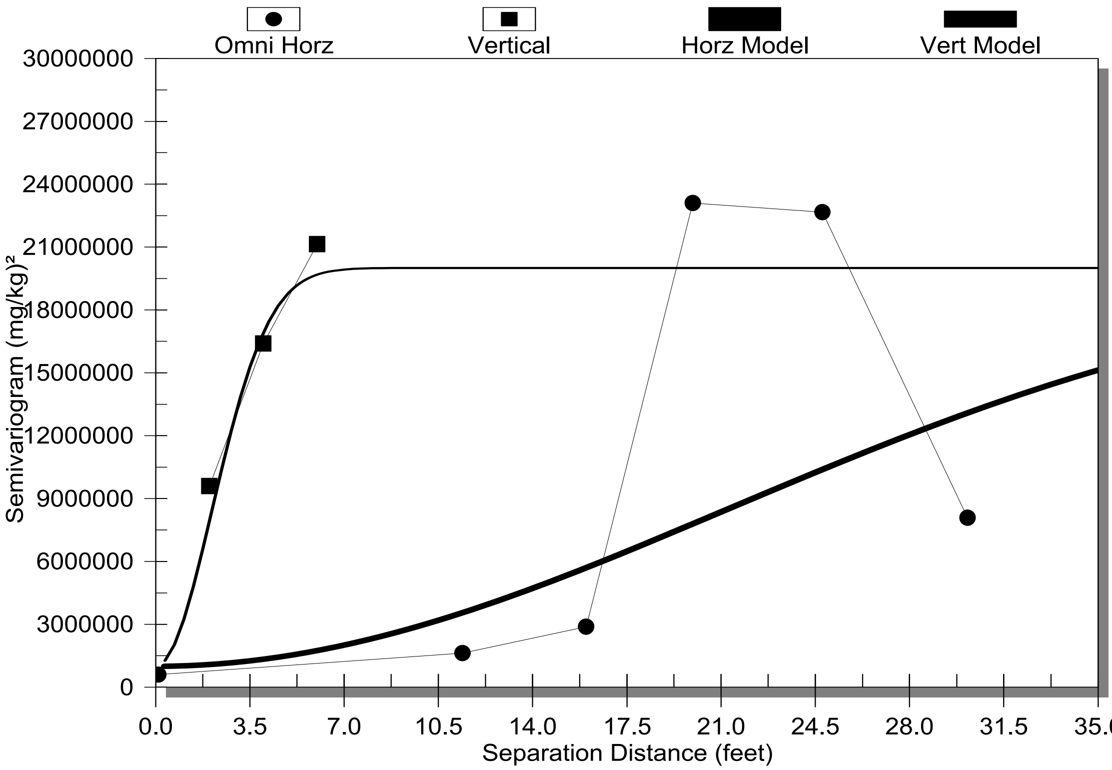


Figure A.1-6. Pre-Remediation TCE Semivariograms for Resistive Heating Plot and MFGU

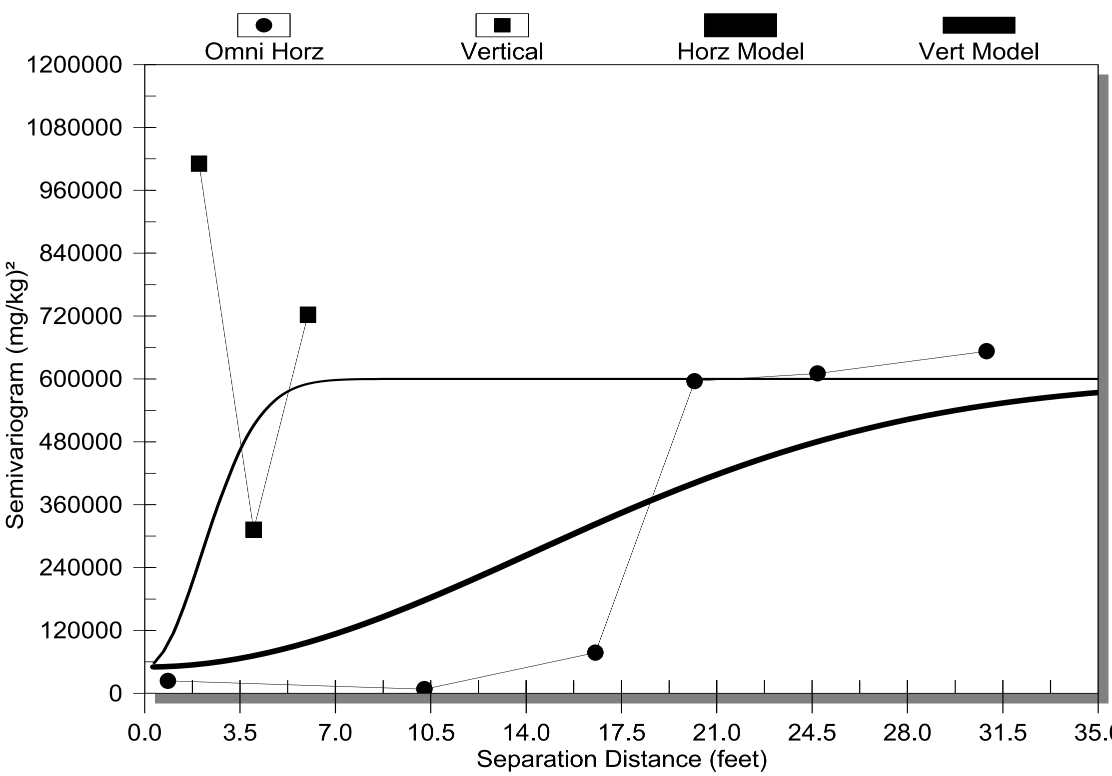


Figure A.1-7. Post-Remediation TCE Semivariograms for Resistive Heating Plot and MFGU

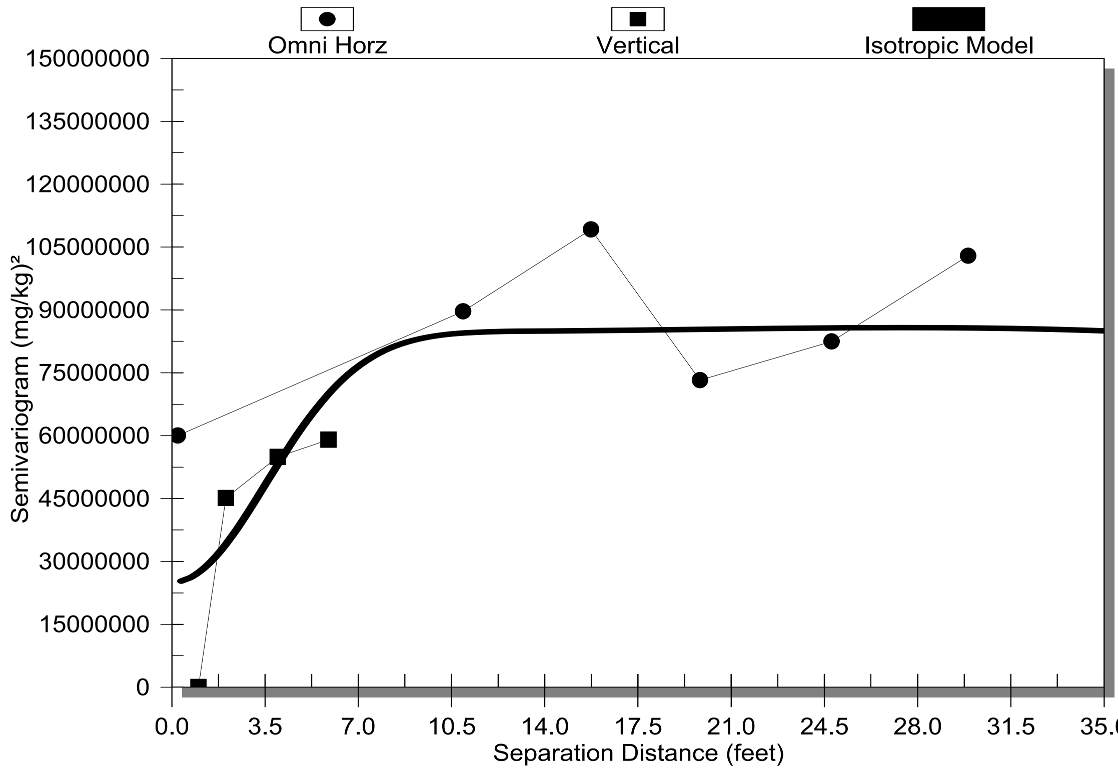


Figure A.1-8. Pre-Remediation TCE Semivariograms for Resistive Heating Plot and LSU

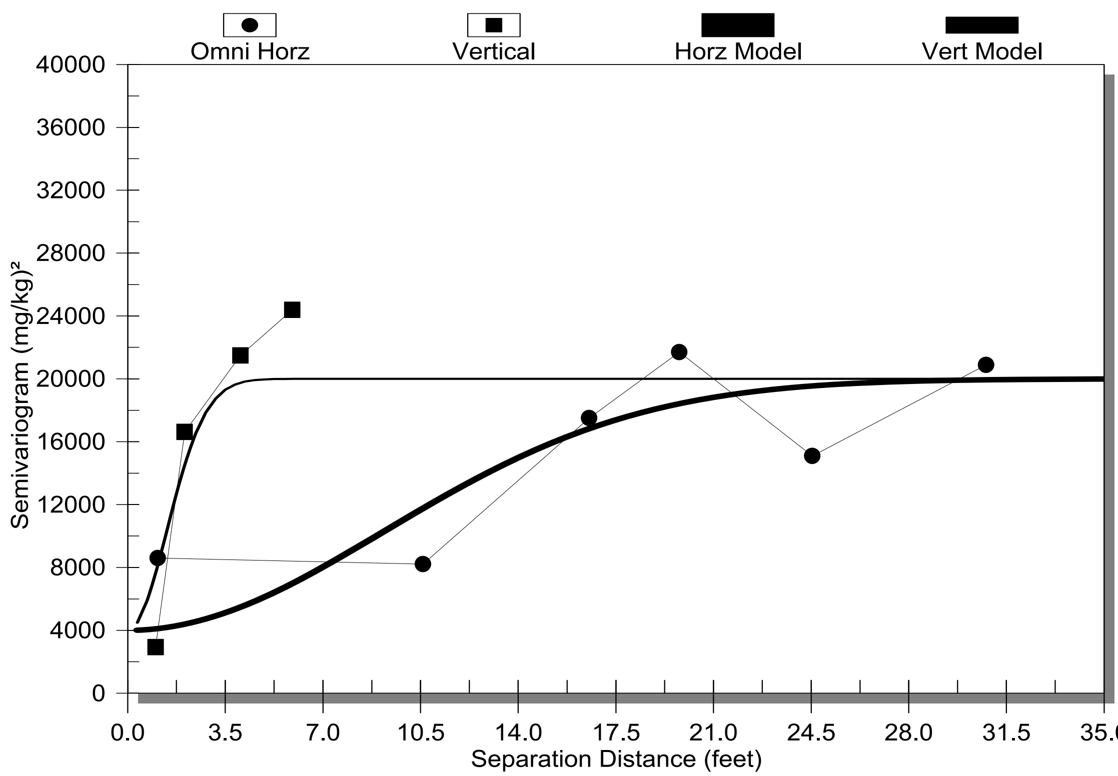


Figure A.1-9. Post-Remediation TCE Semivariograms for Resistive Heating Plot and LSU

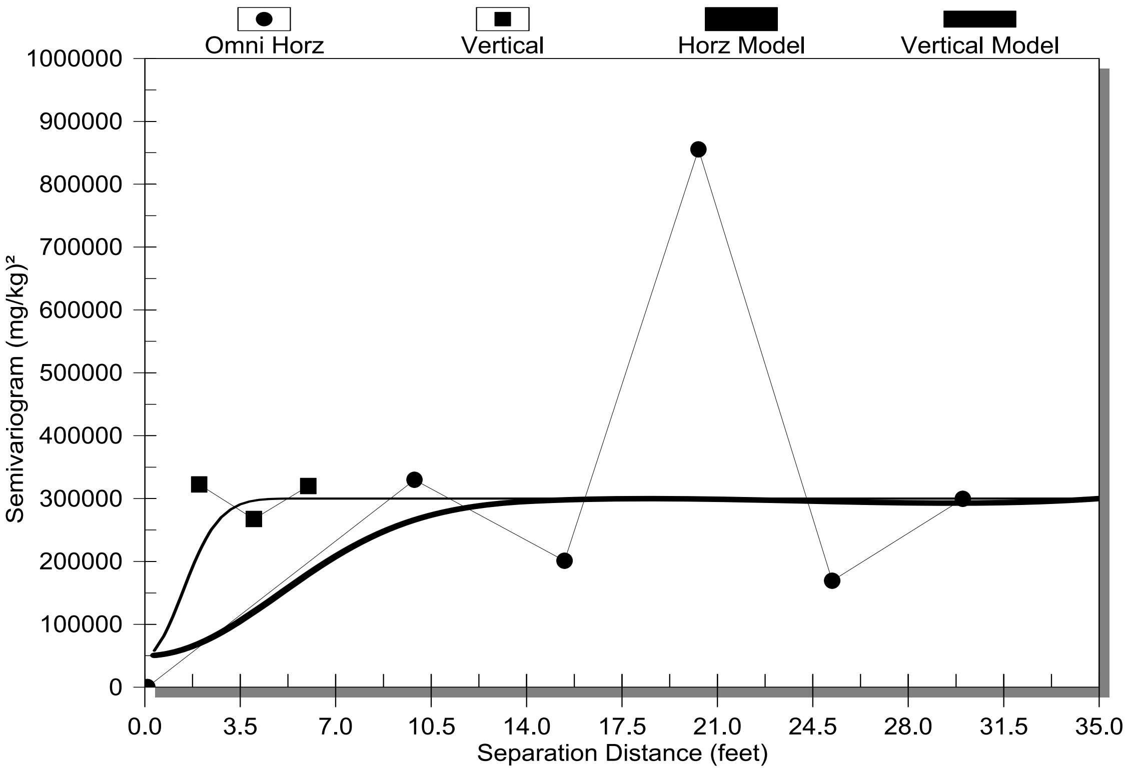


Figure A.1-10. Pre-Remediation TCE Semivariograms for ISCO Plot and USU

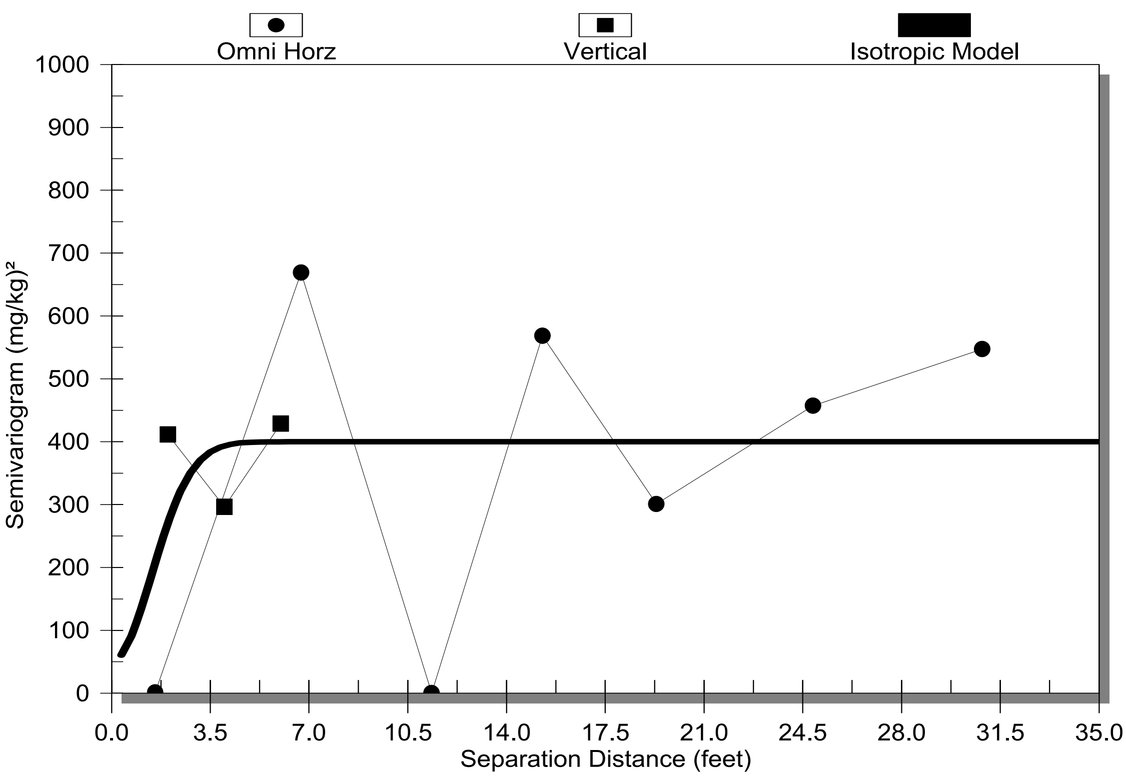


Figure A.1-11. Post-Remediation TCE Semivariograms for ISCO Plot and USU

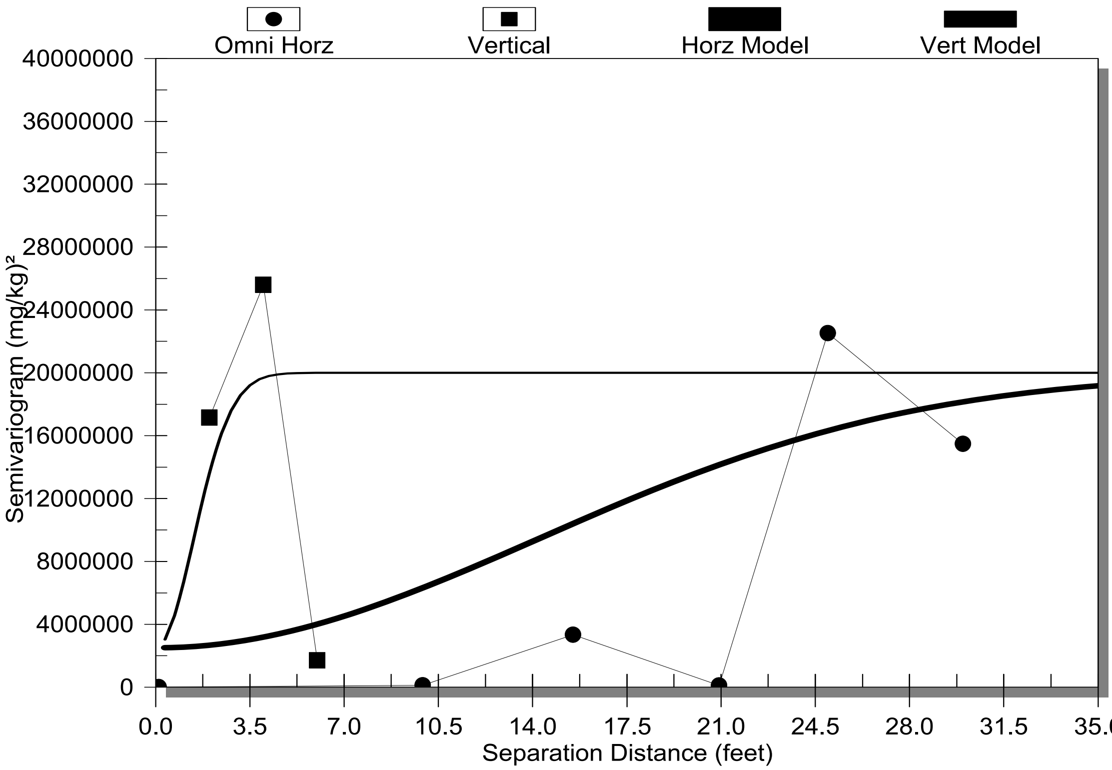


Figure A.1-12. Pre-Remediation TCE Semivariograms for ISCO Plot and MFGU

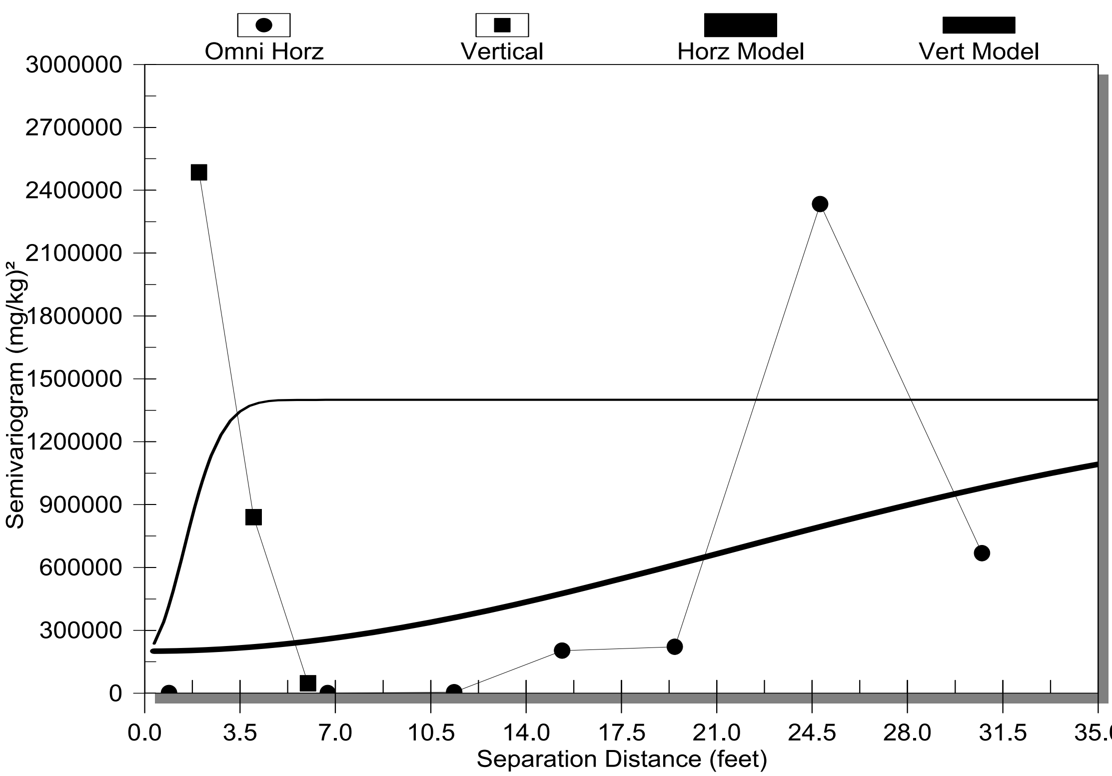


Figure A.1-13. Post-Remediation TCE Semivariograms for ISCO Plot and MFGU

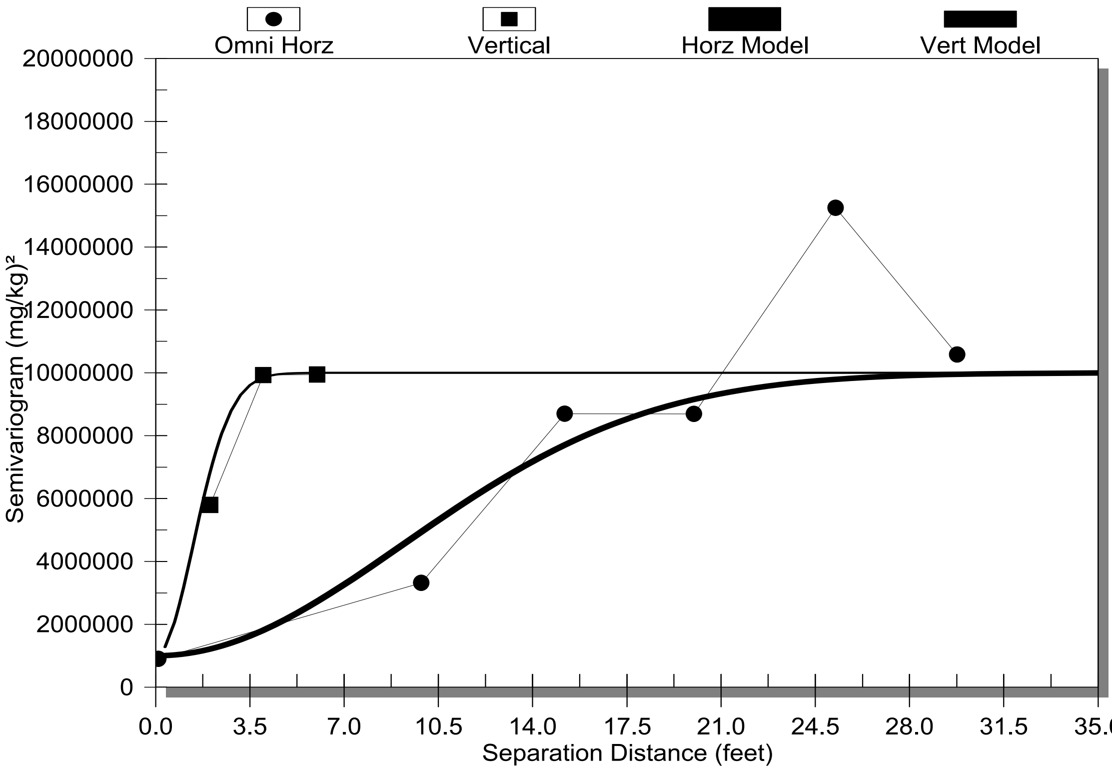


Figure A.1-14. Pre-Remediation TCE Semivariograms for ISCO Plot and LSU

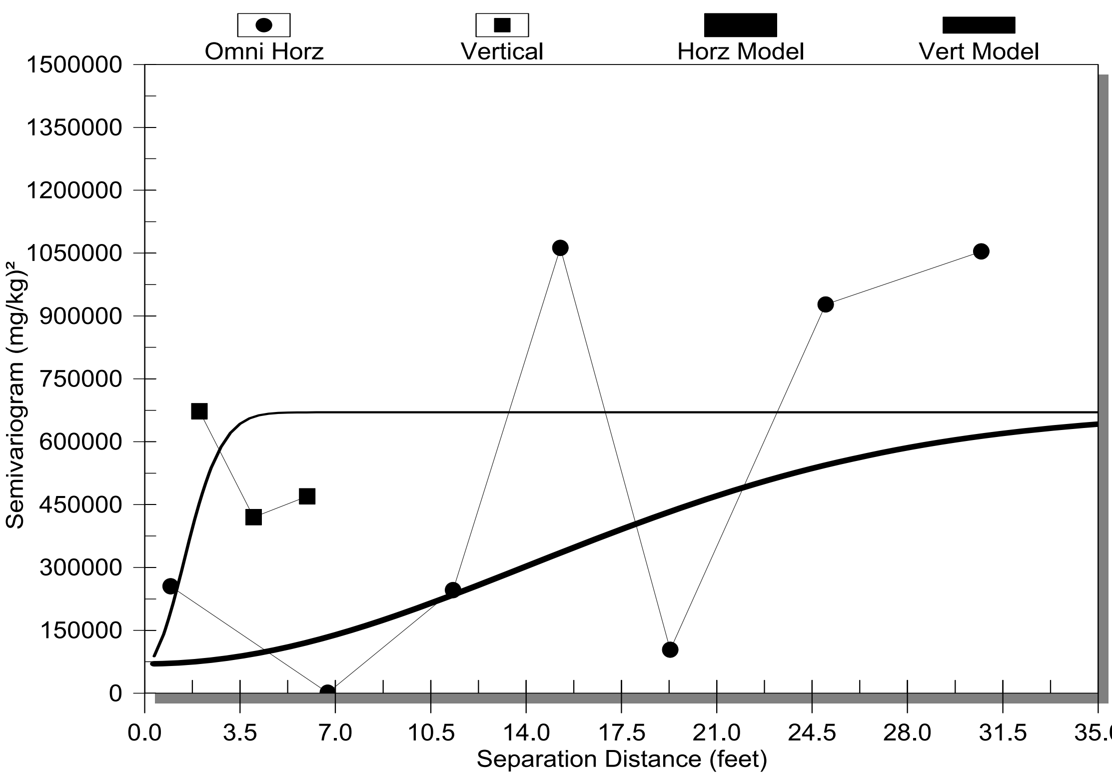


Figure A.1-15. Post-Remediation TCE Semivariograms for ISCO Plot and LSU

A.2 Sample Collection and Extraction Methods

This section describes the modification made to the EPA standard methods to address the lithologic heterogeneities and extreme variability of the contaminant distribution expected in the DNAPL source region at Launch Complex 34. Horizontal variability was addressed by collecting a statistically determined number (12) of soil cores in the ISCO Plot. The vertical variability at each soil coring location was addressed with this modified sampling and extraction procedure, which involved extraction of much larger quantities of soil in each extracted sample, as well as allowed collection and extraction of around 300 samples in the field per event. This extraction allowed the extraction and analysis of the entire vertical column of soil at a given coring location.

A.2.1 Soil Sample Collection (Modified ASTM D4547-91) (1997b)

The soil samples collected before and after the demonstration were sampled using a stainless steel sleeve driven into the subsurface by a cone penetrometer test (CPT) rig. After the sleeve had been driven the required distance, it was brought to the surface and the soil sample was examined and characterized for lithology. One quarter of the sample was sliced from the core and placed into a pre-weighed 500-mL polyethylene container. At locations where a field duplicate sample was collected, a second one-quarter sample was split from the core and placed into another pre-weighed 500-mL polyethylene container. The remaining portion of the core was placed into a 55-gallon drum and disposed of as waste. The samples were labeled with the date, time, and sample identification code, and stored on ice at 4°C until they were brought inside to the on-site laboratory for the extraction procedure.

After receiving the samples from the drilling activities, personnel staffing the field laboratory performed the methanol extraction procedure as outlined in Section A.2.2 of this appendix. The amount of methanol used to perform the extraction technique was 250 mL. The extraction procedure was performed on all of the primary samples collected during drilling activities and on 5% of the field duplicate samples collected for quality assurance. Samples were stored at 4°C until extraction procedures were performed. After the extraction procedure was finished, the soil samples were dried in an oven at 105°C and the dry weight of each sample was determined. The samples were then disposed of as waste. The remaining three-quarter section of each core previously stored in a separate 500-mL polyethylene bottle were archived until the off-site laboratory had completed the analysis of the methanol extract. The samples were then disposed of in an appropriate manner.

A.2.2 Soil Extraction Procedure (Modified EPA SW846-Method 5035)

After the soil samples were collected from the drilling operations, samples were placed in pre-labeled and pre-weighed 500-mL polyethylene containers with methanol and then stored in a refrigerator at 4°C until the extraction procedure was performed. Extraction procedures were performed on all of the “A” samples from the outdoor and indoor soil sampling. Extraction procedures also were performed on 5% of the duplicate (or “B”) samples to provide adequate quality assurance/quality control (QA/QC) on the extraction technique.

Extreme care was taken to minimize the disturbance of the soil sample so that loss of volatile components was minimal. Nitrile gloves were worn by field personnel whenever handling sample cores or pre-weighed sample containers. A modification of EPA SW846-Method 5035 was used to procure the cored samples in the field. Method 5035 lists different procedures for processing samples that are expected to contain low concentrations (0.5 to 200 μg/kg) or high concentrations

(>200 μg/kg) of volatile organic compounds (VOCs). Procedures for high levels of VOCs were used in the field because those procedures facilitated the processing of large-volume sample cores collected during soil sampling activities.

Two sample collection options and corresponding sample purging procedures are described in Method 5035; however, the procedure chosen for this study was based on collecting approximately 150 to 200 g of wet soil sample in a pre-weighed bottle that contains 250 mL of methanol. A modification of this method was used in the study, as described by the following procedure:

- The 150 to 200 g wet soil sample was collected and placed in a pre-weighed 500 mL polypropylene bottle. After capping, the bottle was reweighed to determine the wet weight of the soil. The container was then filled with 250 ml of reagent grade methanol. The bottle was weighed a third time to determine the weight of the methanol added. The bottle was marked with the location and the depth at which the sample was collected.

- After the containers were filled with methanol and the soil sample they were placed on an orbital shaker table and agitated for approximately 30 min.

- Containers were removed from the shaker table and reweighed to ensure that no methanol was lost during the agitation period. The containers were then placed upright and suspended soil matter was allowed to settle for approximately 15 min.

- The 500 mL containers were then placed in a floor-mounted centrifuge. The centrifuge speed was set at 3,000 rpm and the samples were centrifuged for 10 min.

- Methanol extract was then decanted into disposable 20-mL glass volatile organic analysis (VOA) vials using 10-mL disposable pipettes. The 20-mL glass VOA vials containing the extract then were capped, labeled, and stored in a refrigerator at 4°C until they were shipped on ice to the analytical laboratory.

- Methanol samples in VOA vials were placed in ice chests and maintained at approximately 4°C with ice. Samples were then shipped with properly completed chain-of-custody forms and custody seals to the subcontracted off-site laboratory.

- The dry weight of each of the soil samples was determined gravimetrically after decanting the remaining solvent and drying the soil in an oven at 105°C. Final concentrations of VOCs were calculated per the dry weight of soil.

Three potential concerns existed with the modified solvent extraction method. The first concern was that the United States Environmental Protection Agency (U.S. EPA) had not formally evaluated the use of methanol as a preservative for VOCs. However, methanol extraction often is used in site characterization studies, so the uncertainty in using this approach was reasonable. The second concern was that the extraction procedure itself would introduce a significant dilution factor that could raise the method quantitation limit beyond that of a direct purge-and-trap procedure. The third concern was that excess methanol used in the extractions would likely fail the ignitability characteristic, thereby making the unused sample volume a hazardous waste. During characterization activities, the used methanol extract was disposed of as hazardous waste into a 55-gallon drum. This methanol extraction method was tested during preliminary site characterization activities at this site (see Appendix G, Table G-1) and, after a few refinements, was found to perform acceptably in terms of matrix spike recoveries. Spiked TCE recoveries in replicate samples ranged from 72 to 86%.

The analytical portion of Method 5035 describes a closed-system purge-and-trap process for use on solid media such as soils, sediments, and solid waste. The purge-and-trap system consists of a unit that automatically adds water, surrogates, and internals standards to a vial containing the sample. Then the process purges the VOCs using an inert gas stream while agitating the contents of the vial, and finally traps the released VOCs for subsequent desorption into a gas chromatograph (GC). STL Environmental Services performed the analysis of the solvent extraction samples. Soil samples were analyzed for organic constituents according to the parameters summarized in Table A.2-1. Laboratory instruments were calibrated for VOCs listed under U.S. EPA Method 601 and 602. Samples were analyzed as soon as was practical and within the designated holding time from collection (14 days). No samples were analyzed outside of the designated 14-day holding time.

Table A.2-1. Soil Sampling and Analytical Parameters

Analytes	Extraction Method	Analytical Method	Sample Holding Time	Matrix
VOCs[(a)]	SW846-5035	SW846-8260	14 days	Methanol

(a) EPA 601/602 list.

A.3 List of Standard Sample Collection and Analytical Methods

Table A.3-1. Sample Collection Procedures

Measurements	Task/Sample Collection Method	Equipment Used
Primary Measurements		
CVOCs	Soil sampling/ Mod.[a] ASTM D4547-98 (1997c)	Stainless steel sleeve 500-mL plastic bottle
CVOCs	Groundwater sampling/ Mod.[a] ASTM D4448-01 (1997a)	Peristaltic pump Teflon™ tubing
Secondary Measurements		
TOC	Soil sampling/ Mod.[a] ASTM D4547-91 (1997c)	Stainless steel sleeve
Field parameters[b] TOC BOD Inorganics–cations Inorganics–anions TDS Alkalinity	Groundwater sampling/ Mod.[a] ASTM D4448-01 (1997a)	Peristaltic pump Teflon™ tubing
Hydraulic conductivity	Hydraulic conductivity/ ASTM D4044-96 (1997d)	Winsitu® troll Laptop computer
Groundwater level	Water levels	Water level indicator
CVOCs	Vapor Sampling/Tedlar Bag, TO-14	Vacuum Pump

(a) Modifications to ASTM are detailed in Appendix B.
(b) Field parameters include pH, ORP, temperature, DO, and conductivity. A flowthrough well will be attached to the peristaltic pump when measuring field parameters.
ASTM = American Society for Testing and Materials.

Table A.3-2. Sample Handling and Analytical Procedures

Measurements	Matrix	Amount Collected	Analytical Method	Maximum Holding Time[a]	Sample Preservation[b]	Sample Container	Sample Type
Primary Measurements							
CVOCs	Soil	250 g	Mod. EPA 8260[c]	14 days	4°C	Plastic	Grab
CVOCs	Groundwater	40-mL × 3	EPA 8260[d]	14 days	4°C, pH < 2 HCl	Glass	Grab
Secondary Measurements							
CVOCs	Groundwater	40-mL × 3	EPA 8021/8260[d]	14 days	4°C, pH < 2 HCl	Glass	Grab
CVOCs	Vapor	1 L	TO-14	14 days	NA	Tedlar™ Bag	Grab
pH	Soil	50 g	Mod. EPA 9045c	7 days	None	Plastic	Grab
pH	Groundwater	50 mL	EPA 150.1	1 hour	None	Plastic	Grab
TOC	Soil	20 g	SW 9060	28 days	None	Plastic	Grab
TOC	Groundwater	125 mL	EPA 415.1	28 days	4°C, pH < 2 H_2SO_4	Plastic	Grab
BOD	Groundwater	1,000 mL	EPA 405.1	48 hours	4°C	Plastic	Grab
Hydraulic conductivity	Aquifer	NA	ASTM D4044-96 (1997d)	NA	NA	NA	NA
Inorganics–cations[e]	Groundwater	100 mL	SW 6010	28 days	4°C, pH<2, HNO3	Plastic	Grab
Inorganics–anions[e]	Groundwater	50 mL	EPA 300.0	28 days	4°C	Plastic	Grab
TDS	Groundwater	500 mL	EPA 160.1	7 days	4°C	Plastic	Grab
Alkalinity	Groundwater	200 mL	EPA 310.1	14 days	4°C	Plastic	Grab
Water levels	Aquifer	NA	Water level from the top of well casing	NA	NA	NA	NA

(a) Samples will be analyzed as soon as possible after collection. The times listed are the maximum holding times which samples will be held before analysis and still be considered valid. All data obtained beyond the maximum holding times will be flagged.
(b) Samples will be preserved immediately upon sample collection, if required.
(c) Samples will be extracted using methanol on site. For the detailed extraction procedure see Appendix B.
(d) The off-site laboratory will use EPA 8260.
(e) Cations include Ca, Mg, Fe, Mn, Na, and K. Anions include Cl, SO_4, and NO_3/ NO_2.
HCl = Hydrochloric acid.
NA = Not applicable.

Appendix B. Hydrogeologic Measurements and Lithologic Logs

B.1 Data Analysis Methods and Results for Slug Tests
B.2 Site Assessment Well Completion Diagrams for Shallow, Intermediate, and Deep Wells
B.3 LC34 IDC Coring Logsheets for Site Assessment Wells
B.4 LC34 IDC Coring Logsheets for Semi-Confined Aquifer Wells

B.1 Data Analysis Methods and Results for the Slug Tests

Slug tests were performed on well clusters PA-13 and PA-14 within the resistive heating plot for pre-demonstration and post-demonstration to determine if the remediation system affected the permeability of the aquifer. The tests consisted of placing a pressure transducer and 1.5-inch-diameter by 5-ft-long solid PVC slug within the well. After the water level reached an equilibrium, the slug was removed rapidly. Removal of the slug created approximately 1.6 ft of change in water level within the well. Water level recovery was then monitored for 10 minutes using a TROLL pressure transducer/data logger. The data was then downloaded to a notebook computer. Replicate tests were performed for each well.

The recovery rates of the water levels were analyzed with the Bouwer (1989) and Bouwer and Rice (1976) methods for slug tests in unconfined aquifers. Graphs were made showing the changes in water level versus time and curve fitted on a semi-logarithmic graph. The slope of the fitted line then was used in conjunction with the well parameters to provide a value of the permeability of the materials surrounding the well. Tests showed very high coefficient of determinations (R^2), with all R^2s above 0.95. The results also showed a very good agreement between the replicate tests. However, in wells PA-14S and PA-14I some unclear response was observed, where the water levels never returned to the original levels or started decreasing again after reaching equilibrium. It should be noted that during the demonstration, the wells became pressurized, and some residual effects of the pressurization may still be present within the resistive heating plot wells.

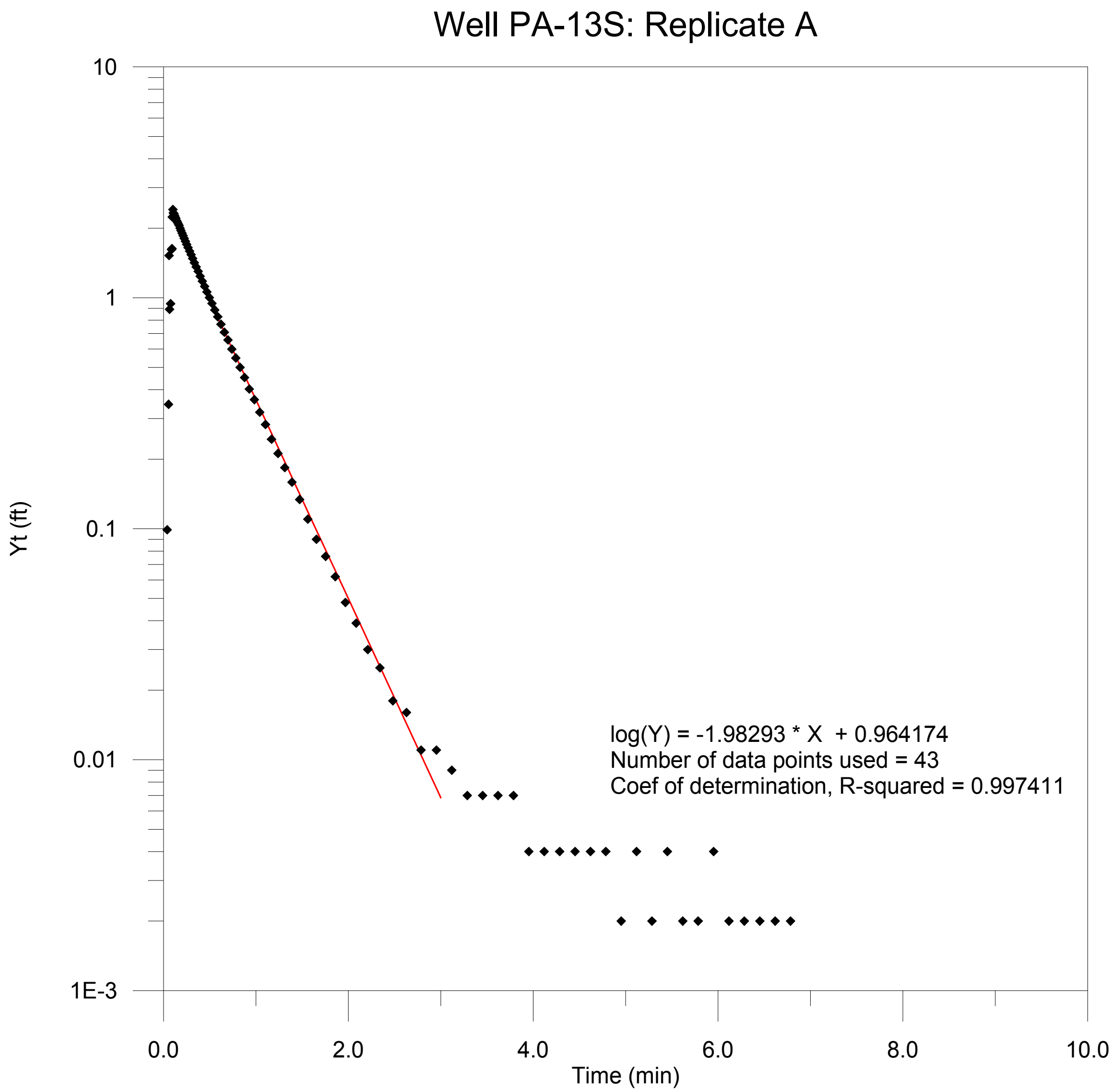
The tests are subject to minor variations. As such, a change of more than a magnitude of order would be required to indicate a change in the permeability of the sediments. Keeping this in mind, no tests showed a substantial change in permeability as shown on Table 1. However, five of the six tests indicated a net increase in permeability. Overall, this would suggest that the resistive heating plot technology had a small effect on the sediments in the test plot, increasing the overall permeability of the plot, but not significantly.

Table 1. Slug Test Results in Resistive Heating Plot

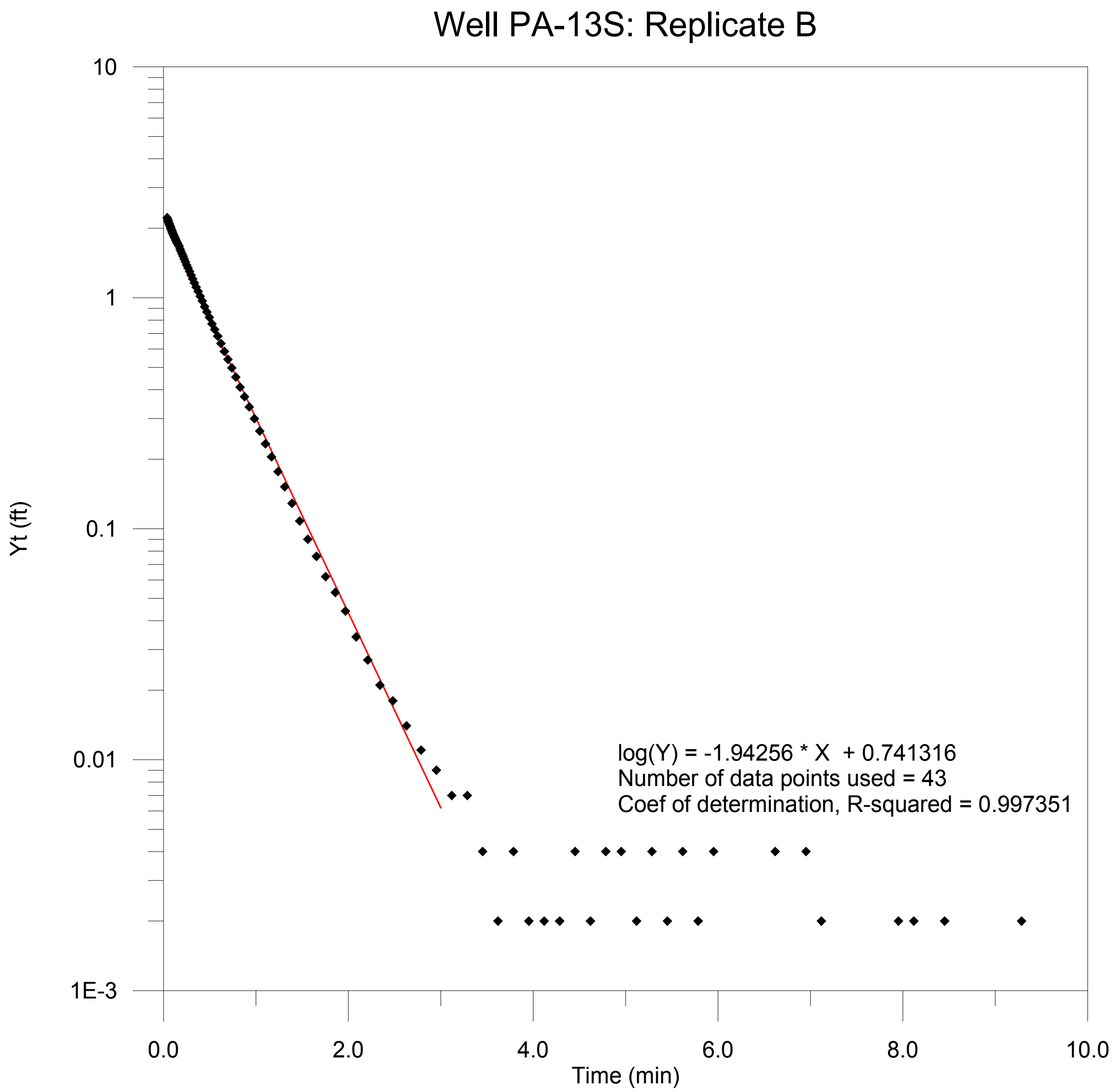
Well	Predemo	Postdemo	Change	Response
PA-13S	14.1	17.4	negligible	excellent
PA-13I	2.4	1.2	(slight decrease)	good
PA-13D	1.1	5.4	(slight increase)	excellent
PA-14S	10.3	23.6	(slight increase)	excellent
PA-14I	4.1	11.4	(slight increase)	good
PA-14D	1.9	7.3	(slight increase)	good

Bouwer, H., and R.C. Rice, 1976, A slug test for determining hydraulic conductivity of unconfined aquifers with completely or partially penetrating wells, Water Resources Research, v.12, n.3, pp. 423-428.

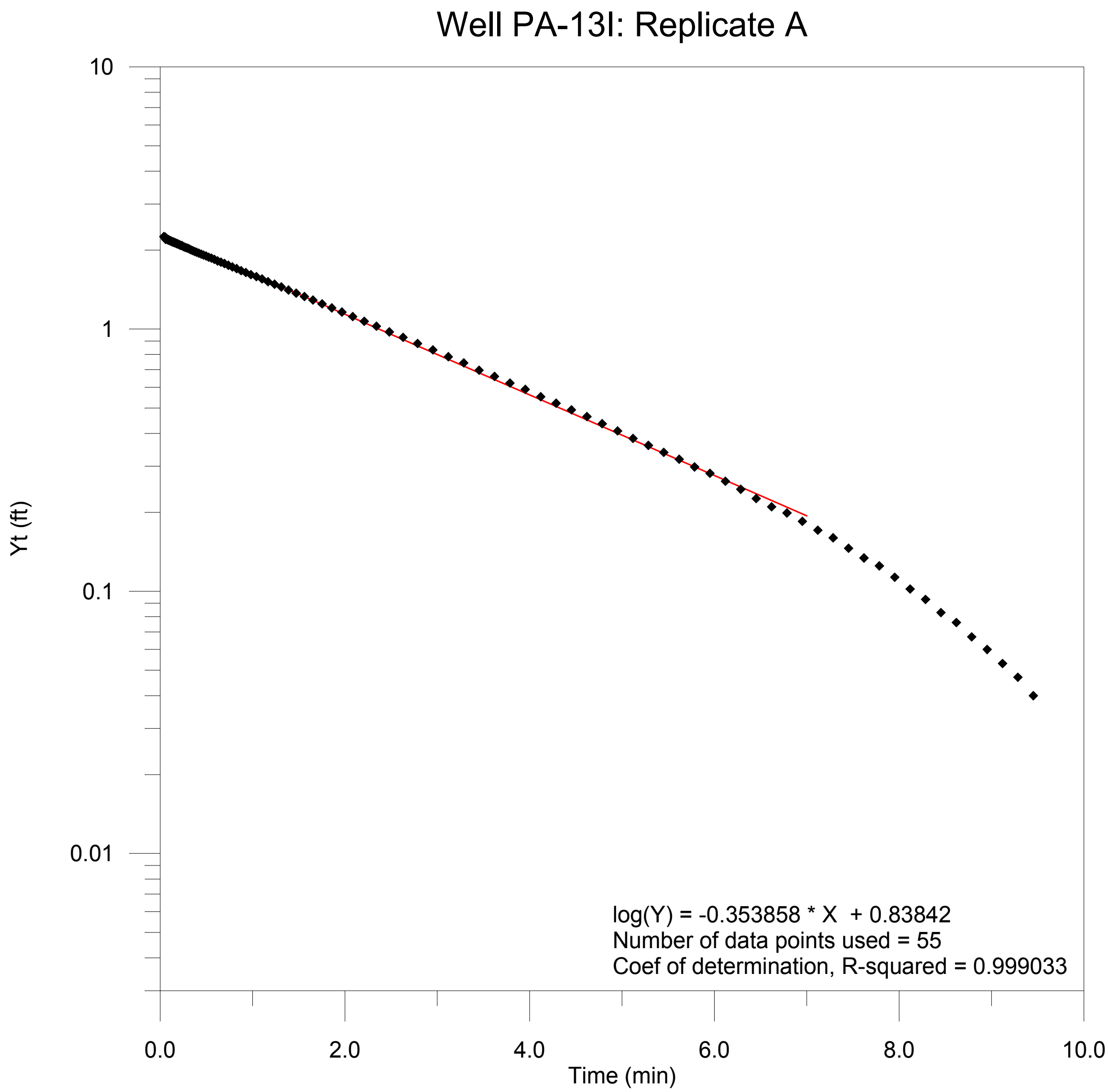
Bouwer, H., 1989, The Bouwer and Rice slug test- an update, Ground Water, v. 27, n.3., pp. 304-309.



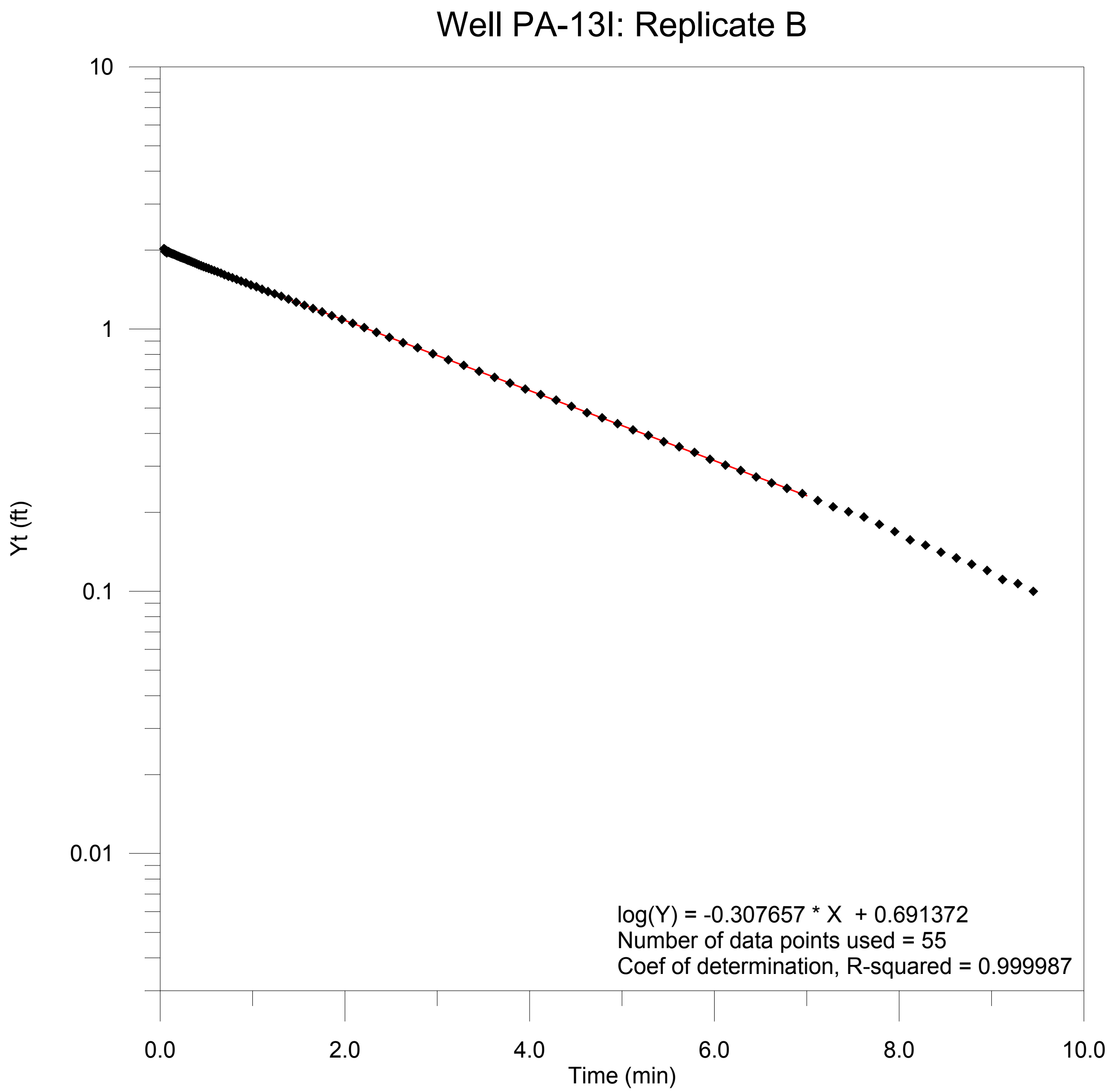
Pre-demonstration Slug Test Results: Well PA-13S.



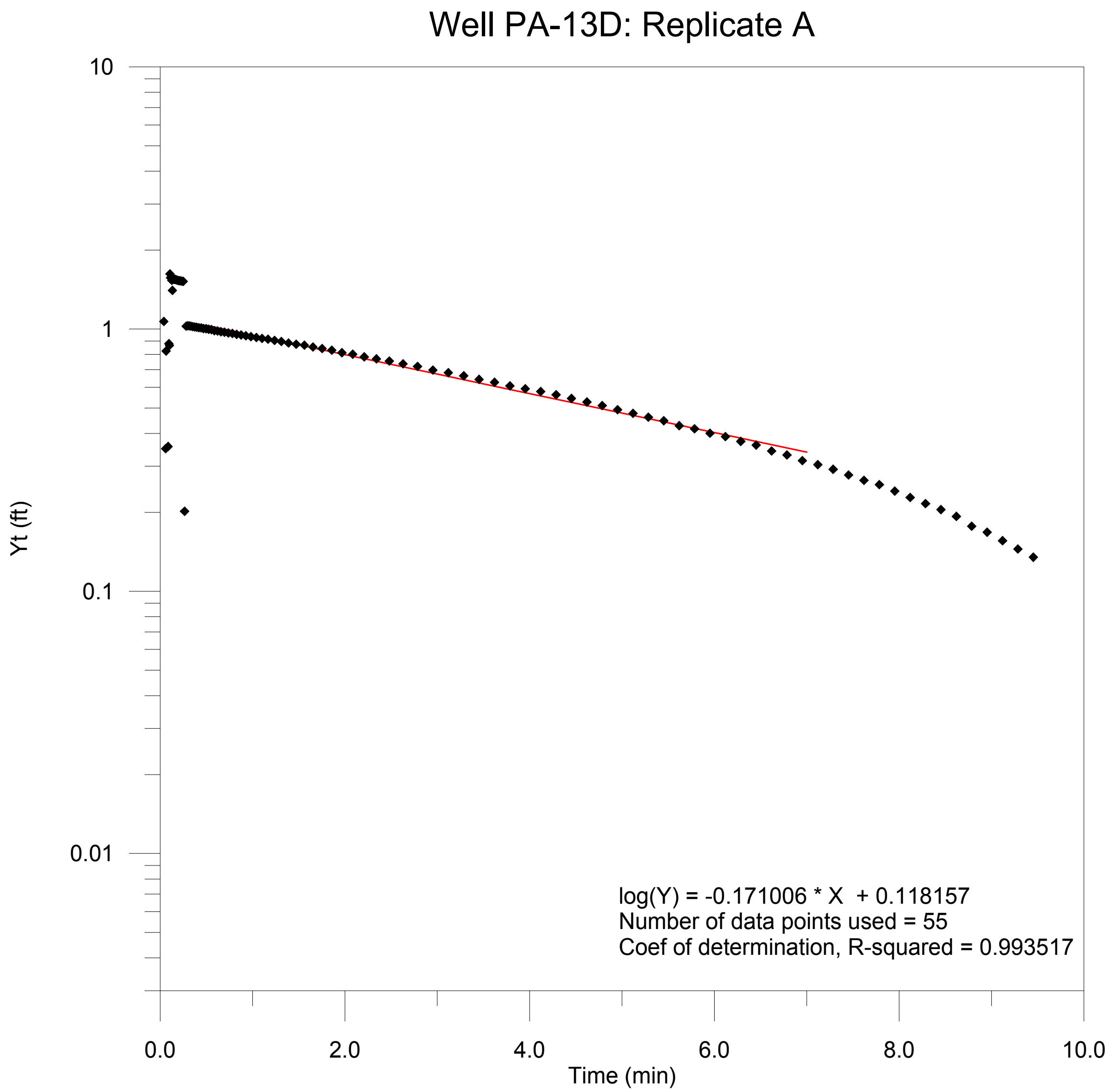
Pre-demonstration Slug Test Results: Well PA-13S.



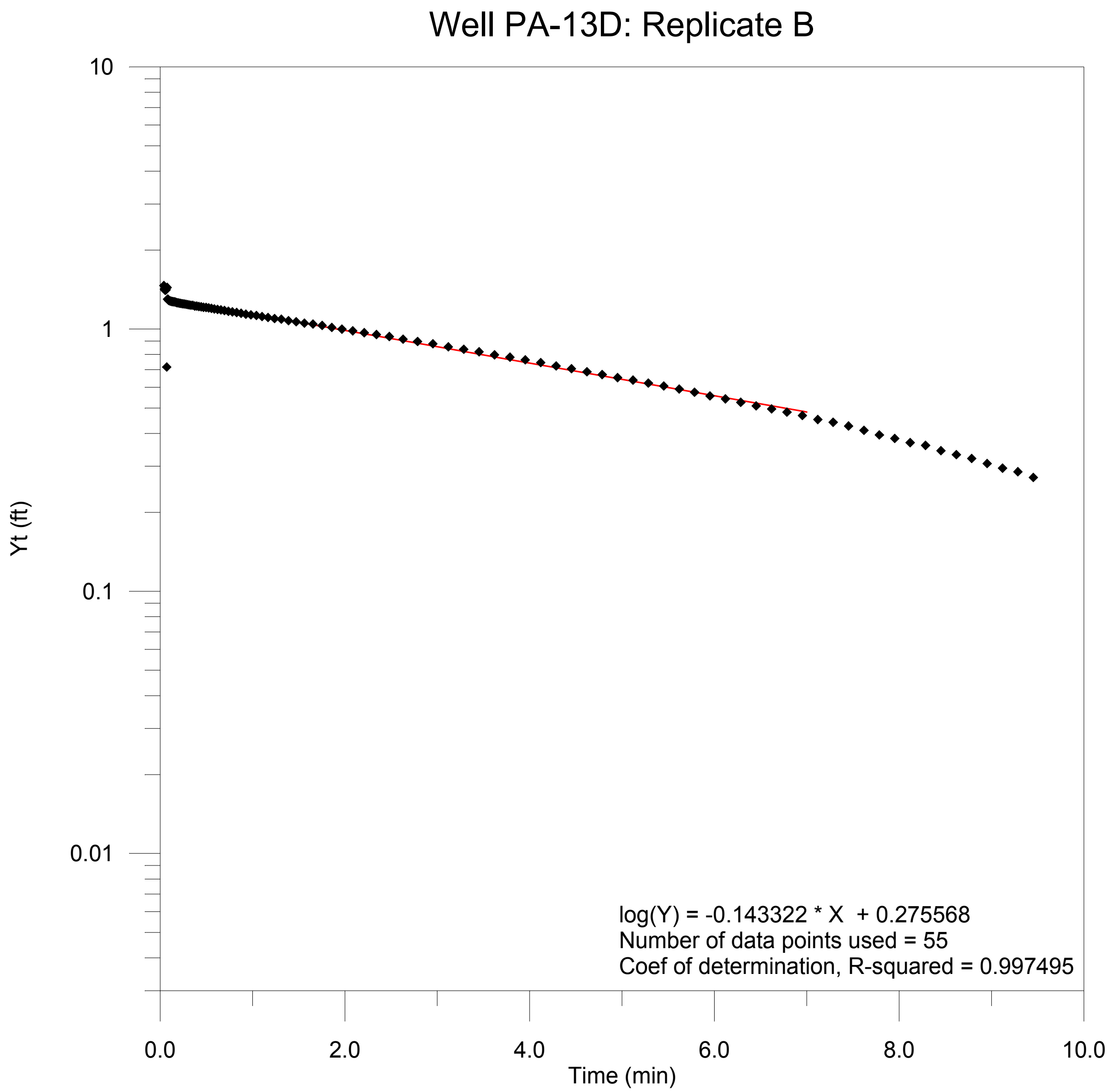
Pre-demonstration Slug Test Results: Well PA-13I.



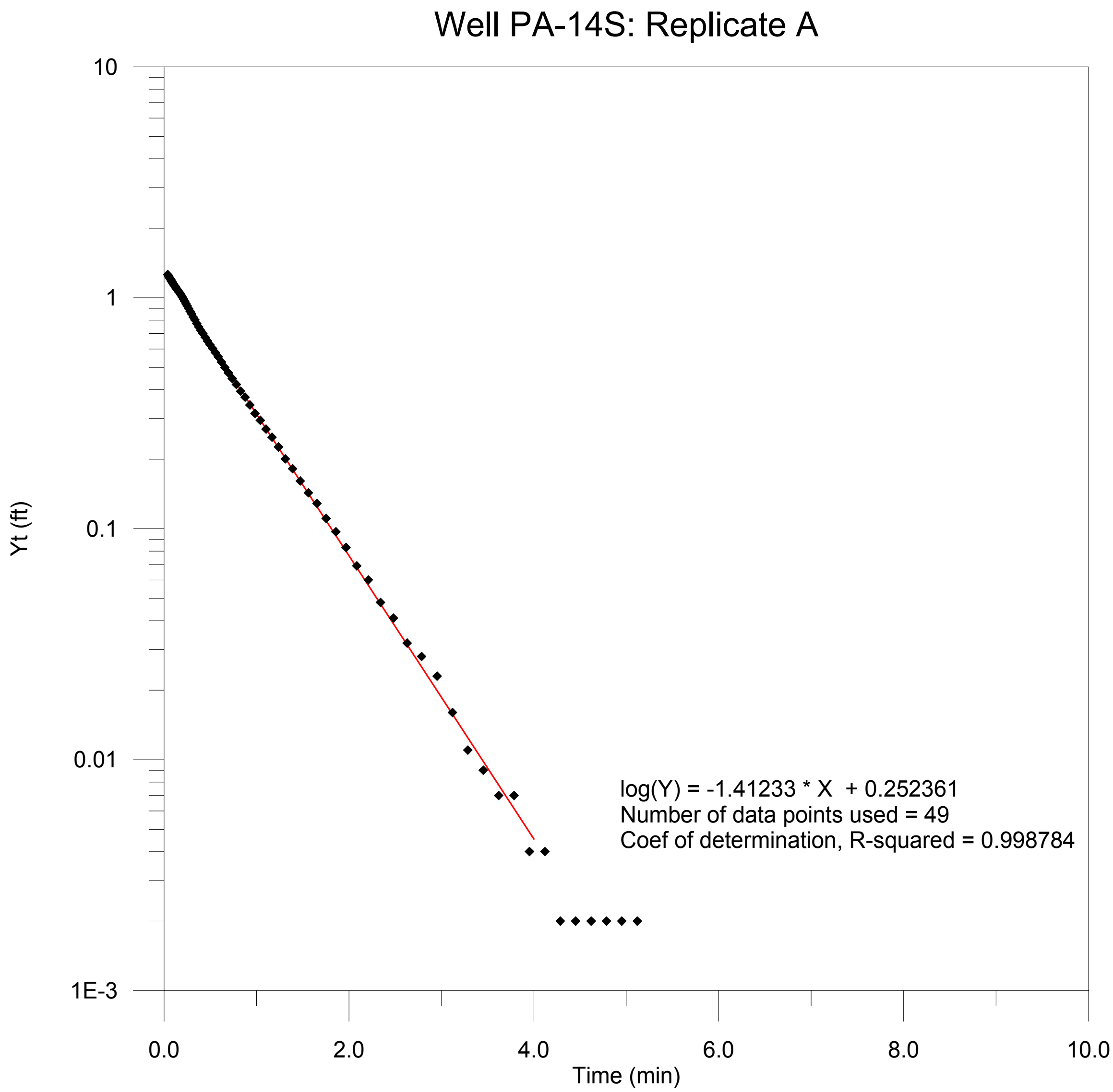
Pre-demonstration Slug Test Results: Well PA-13I.



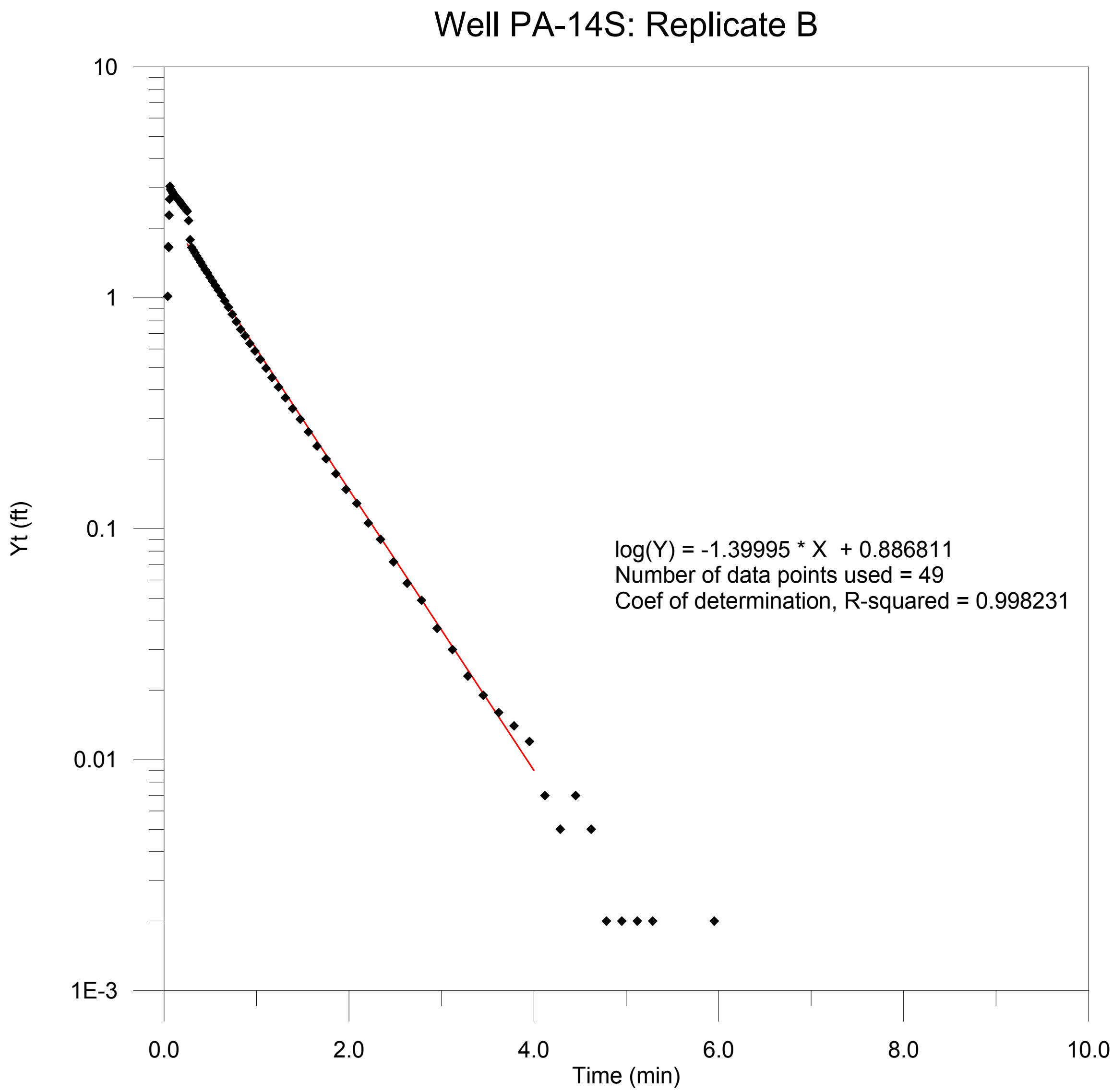
Pre-demonstration Slug Test Results: Well PA-13D.



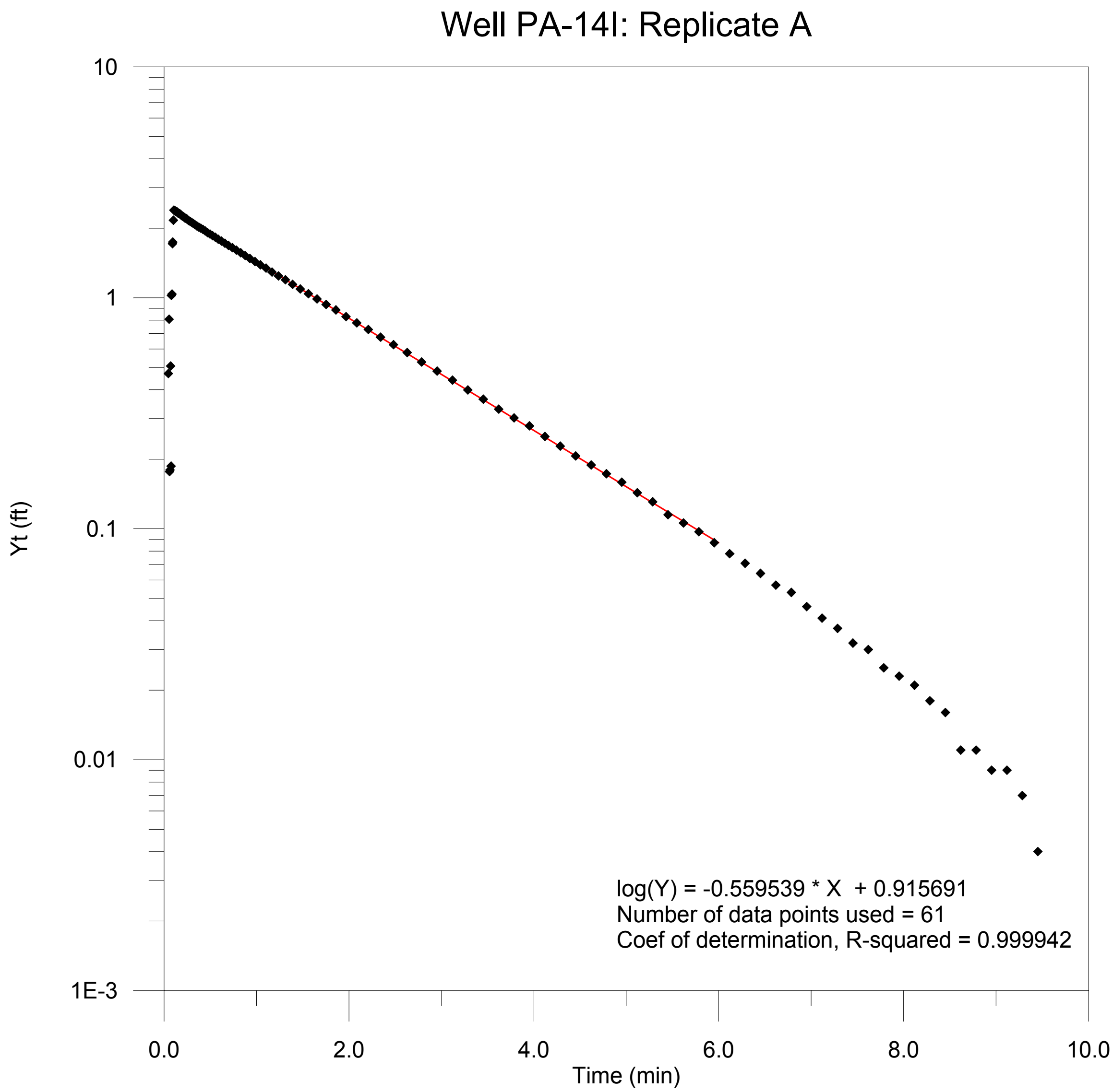
Pre-demonstration Slug Test Results: Well PA-13D.



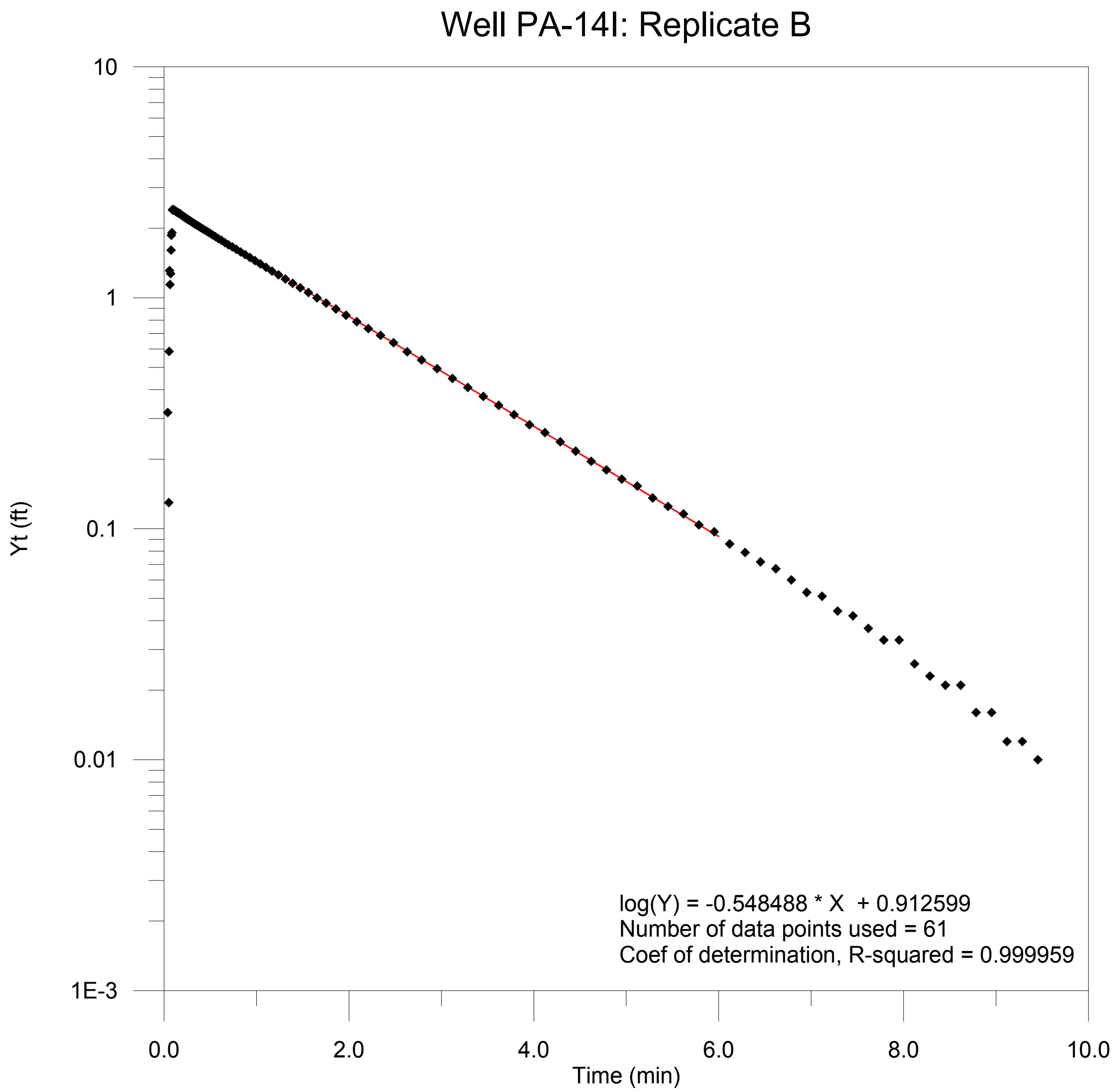
Pre-demonstration Slug Test Results: Well PA-14S.



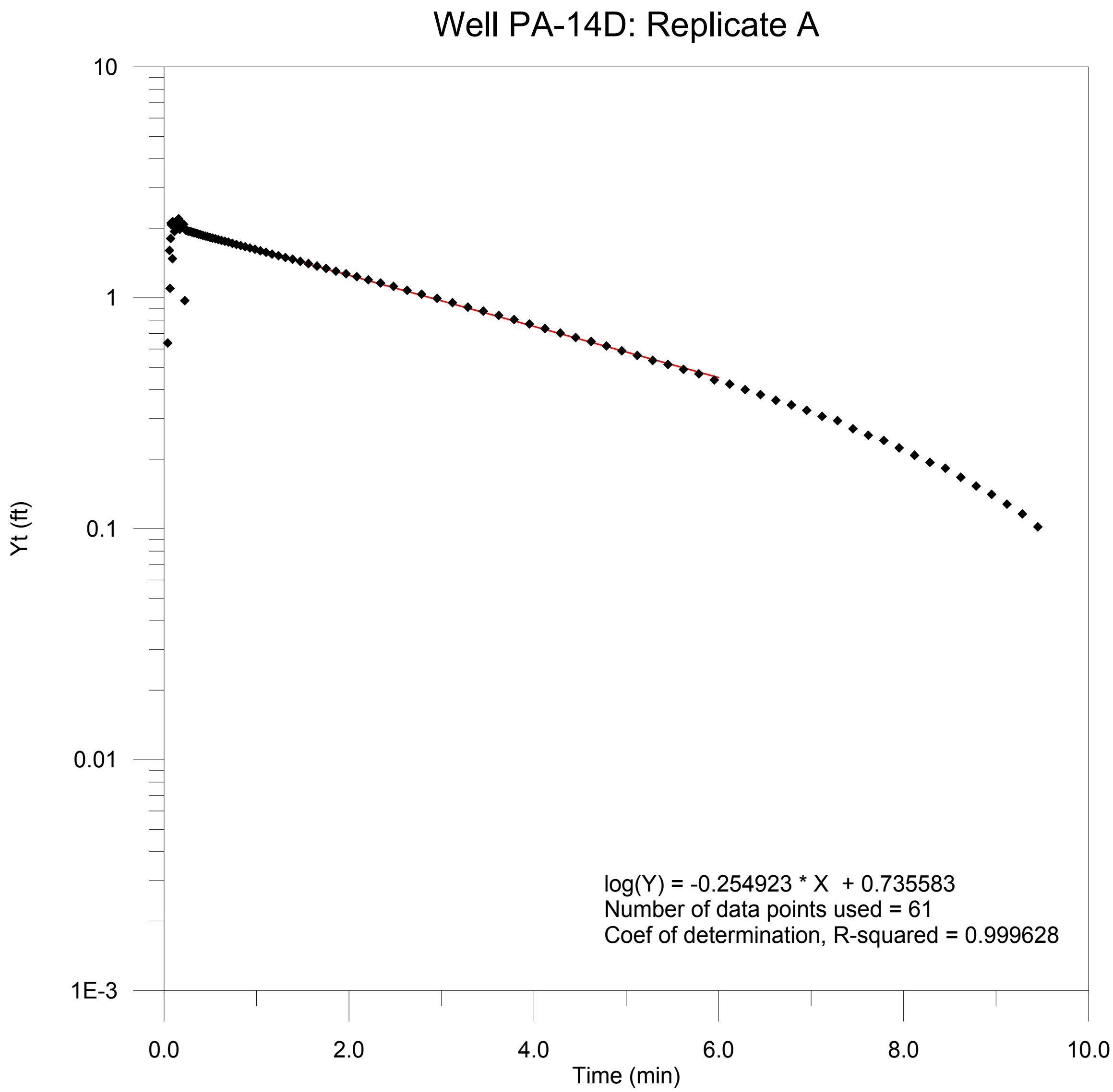
Pre-demonstration Slug Test Results: Well PA-14S.



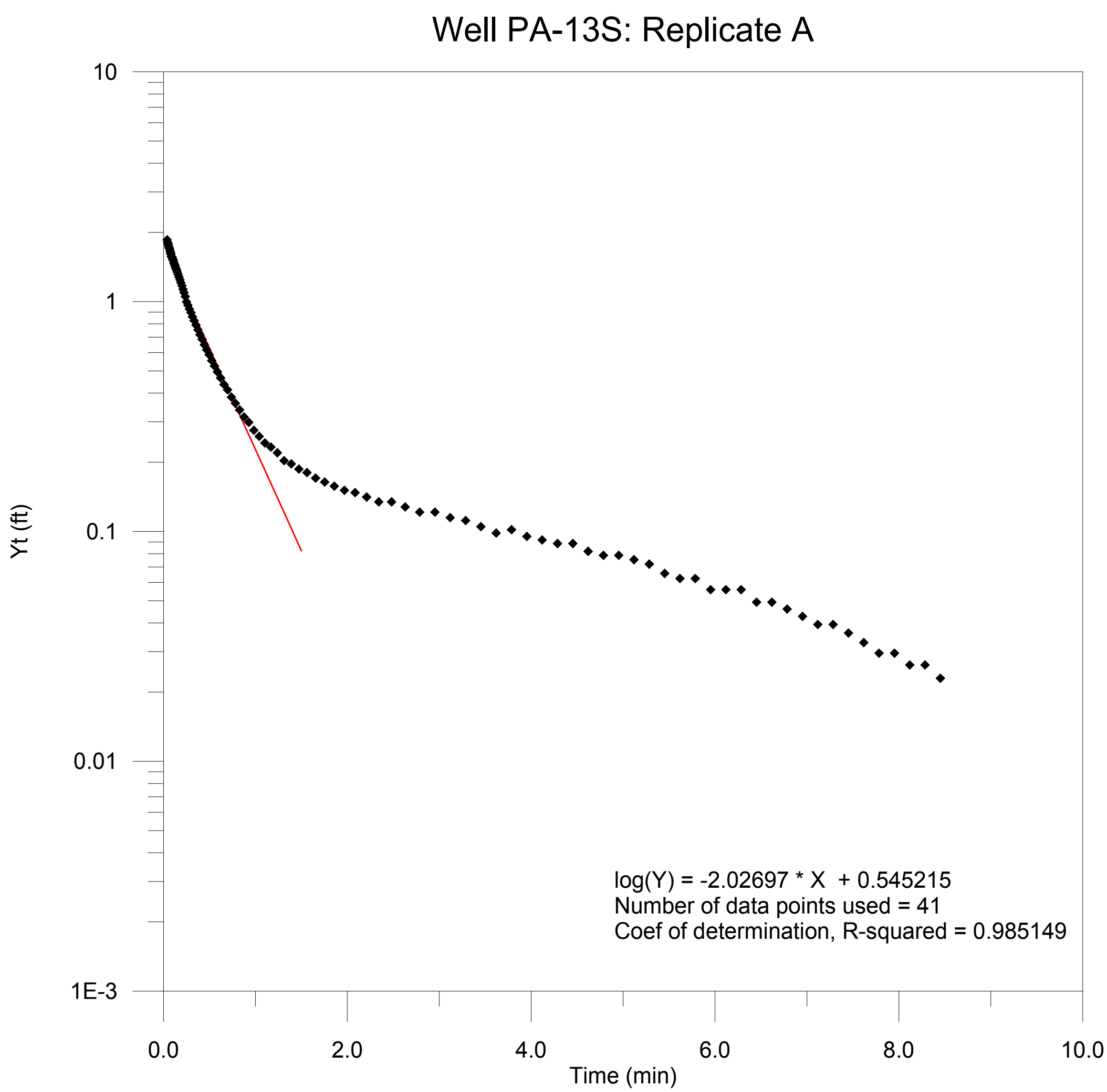
Pre-demonstration Slug Test Results: Well PA-14I.



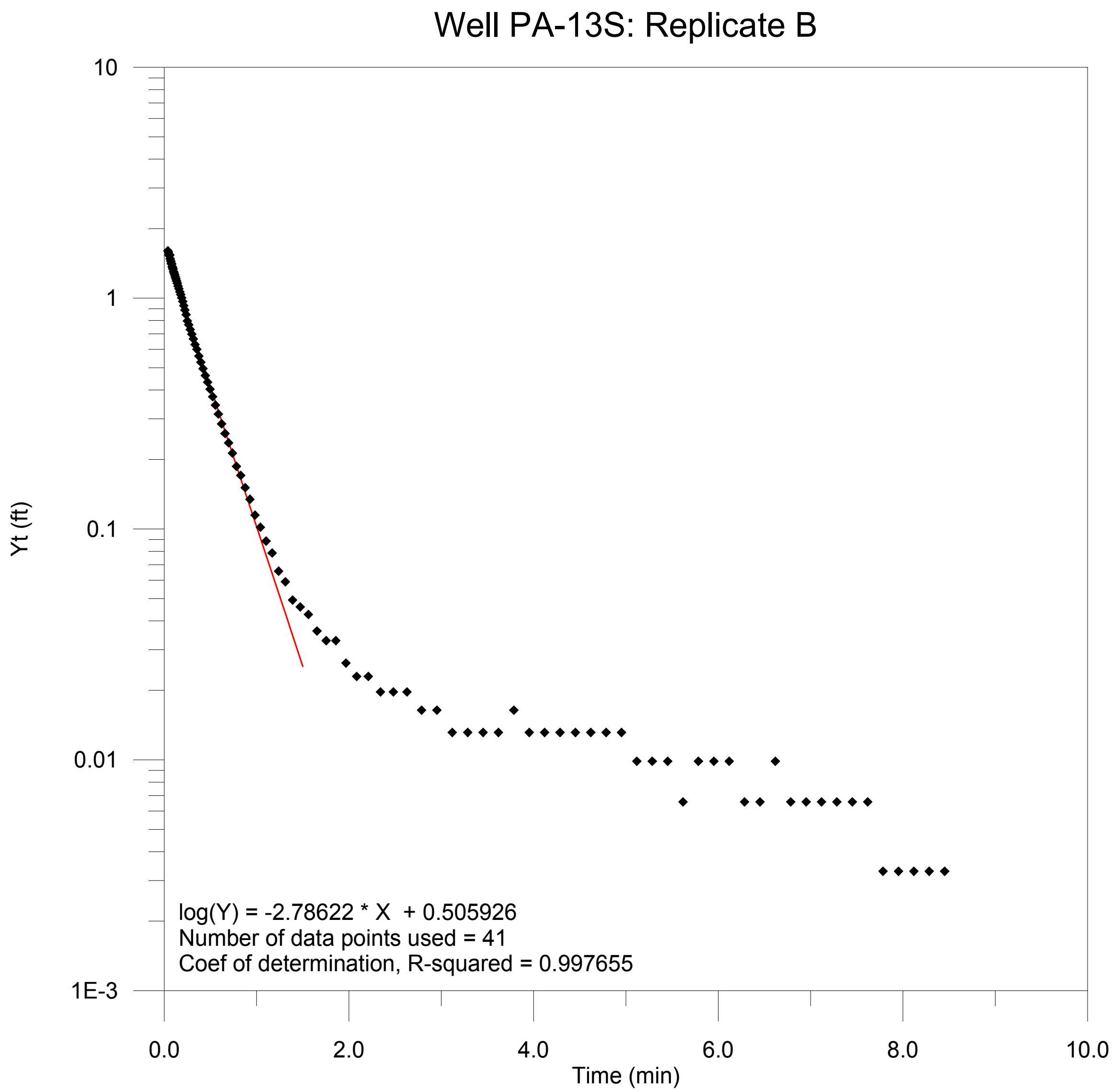
Pre-demonstration Slug Test Results: Well PA-14I.



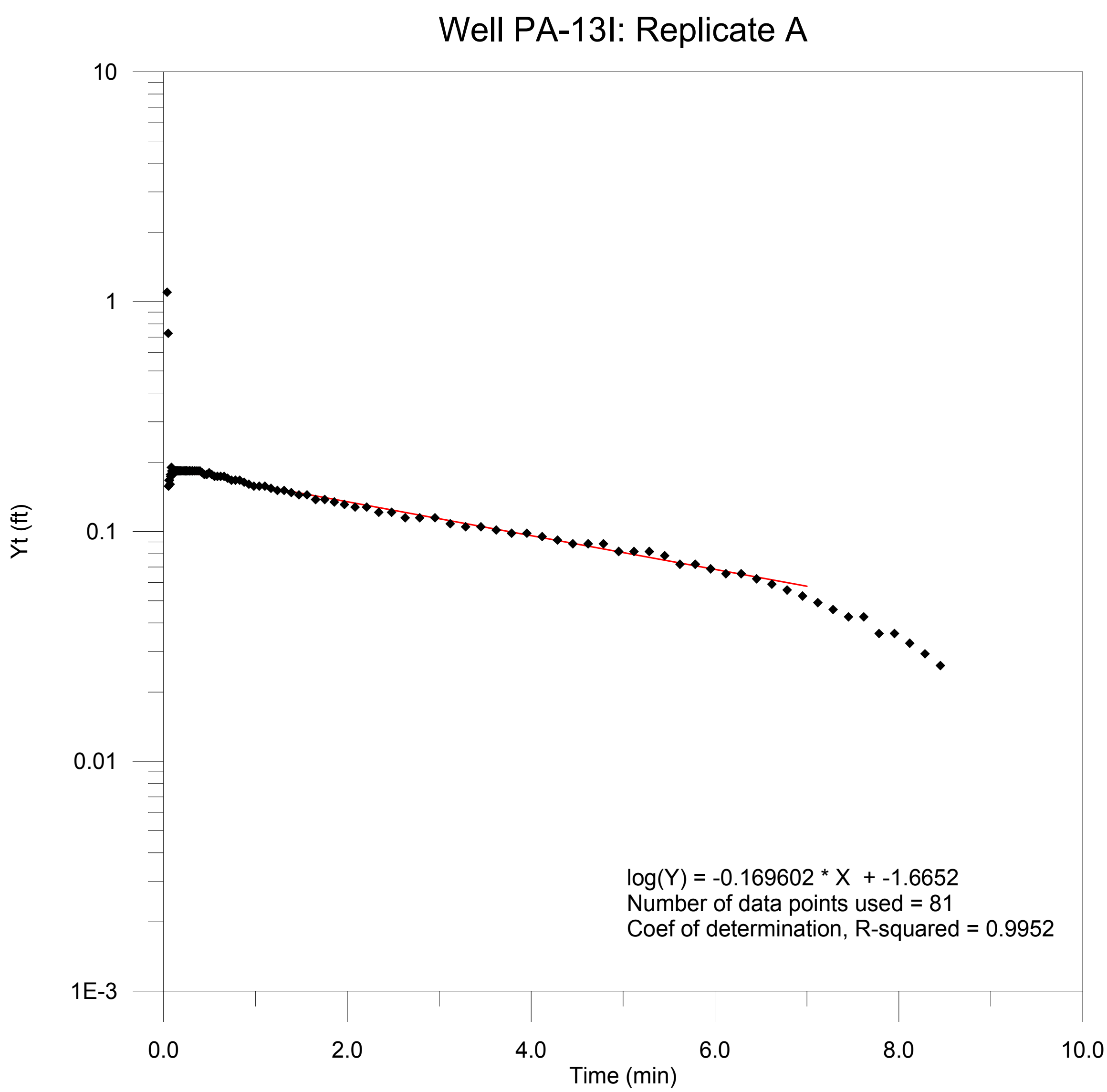
Pre-demonstration Slug Test Results: Well PA-14D.



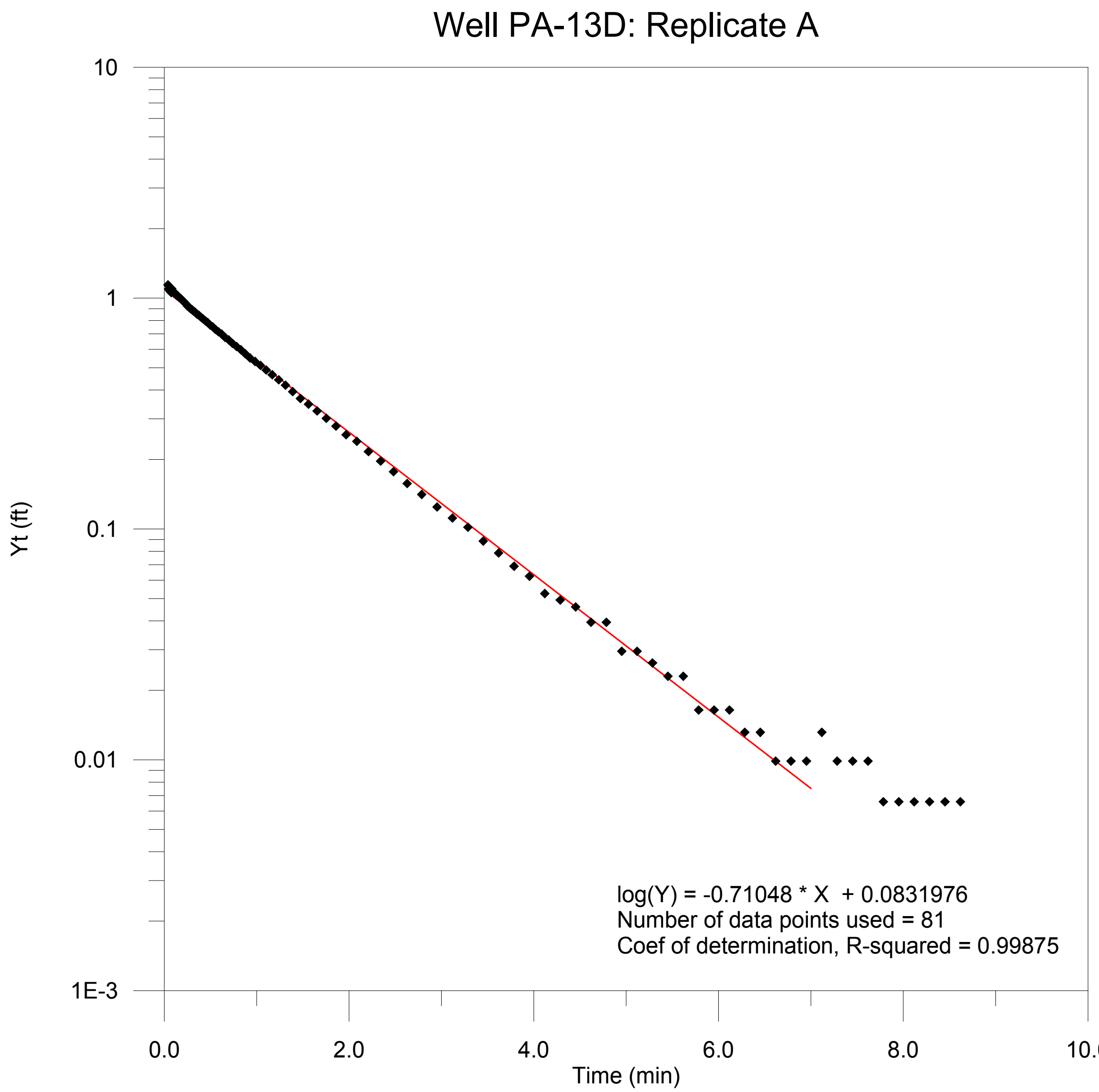
Post-demonstration Slug Test Results: Well PA-13S.



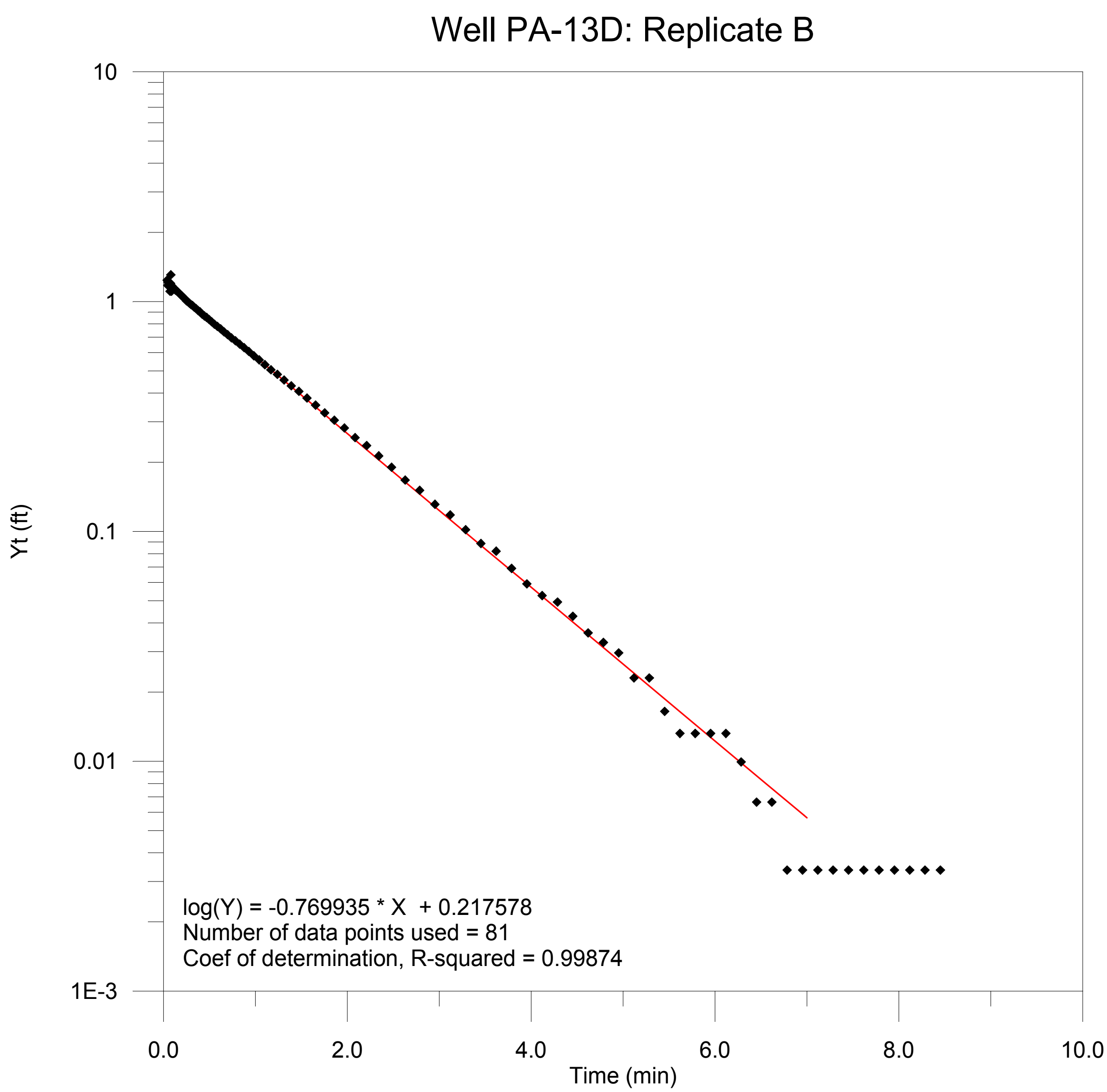
Post-demonstration Slug Test Results: Well PA-13S.



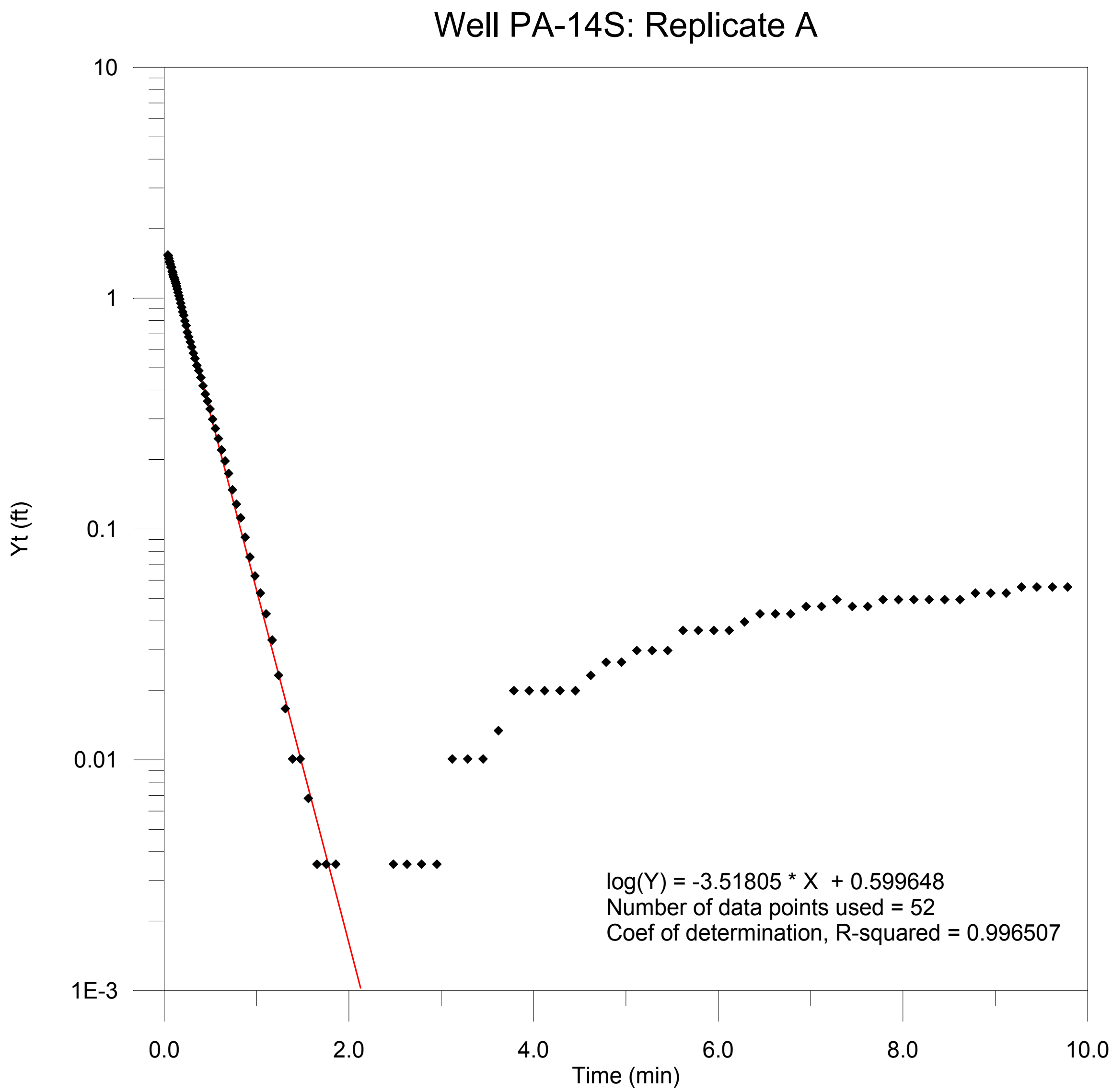
Post-demonstration Slug Test Results: Well PA-13I.



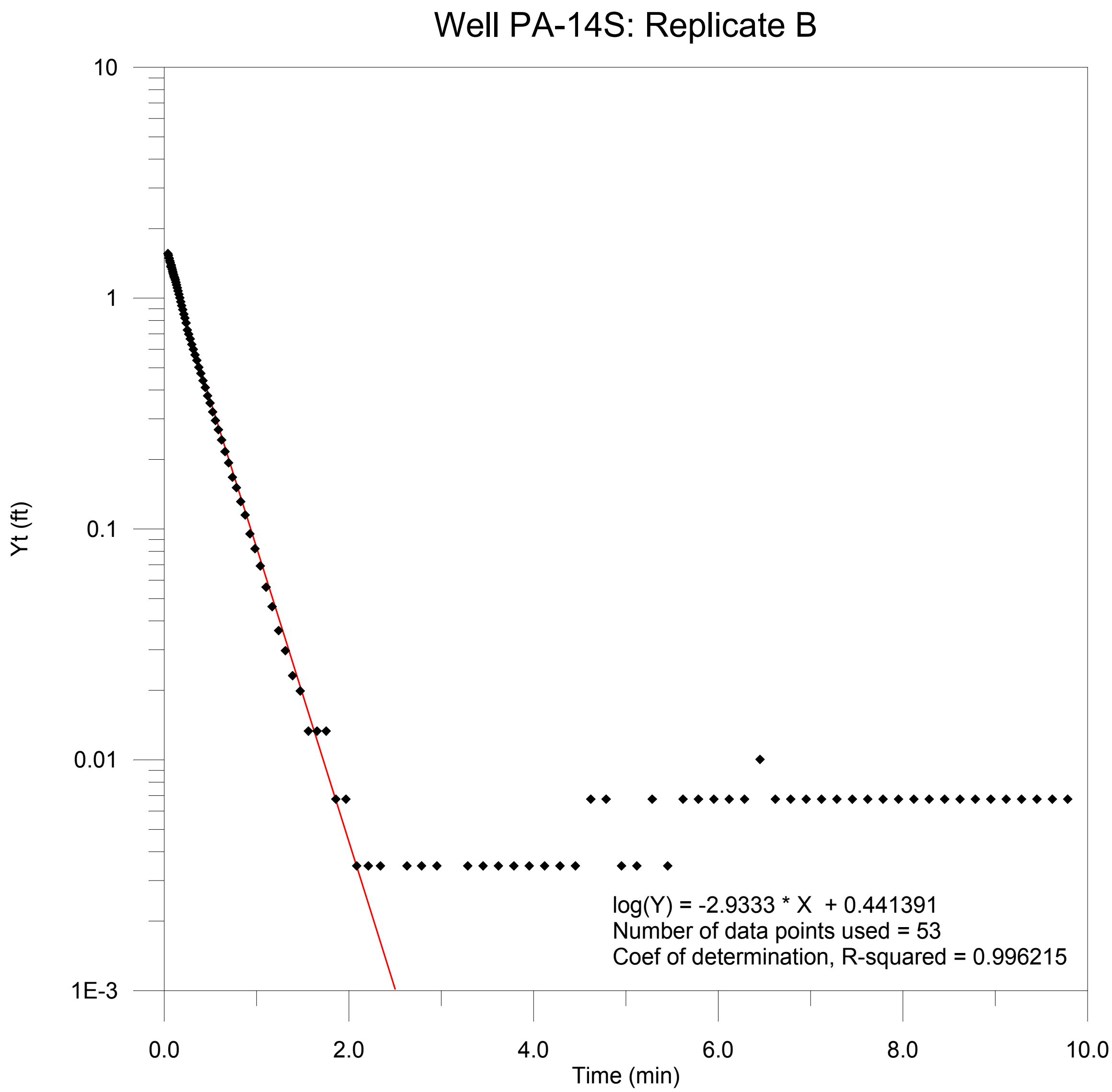
Post-demonstration Slug Test Results: Well PA-13D.



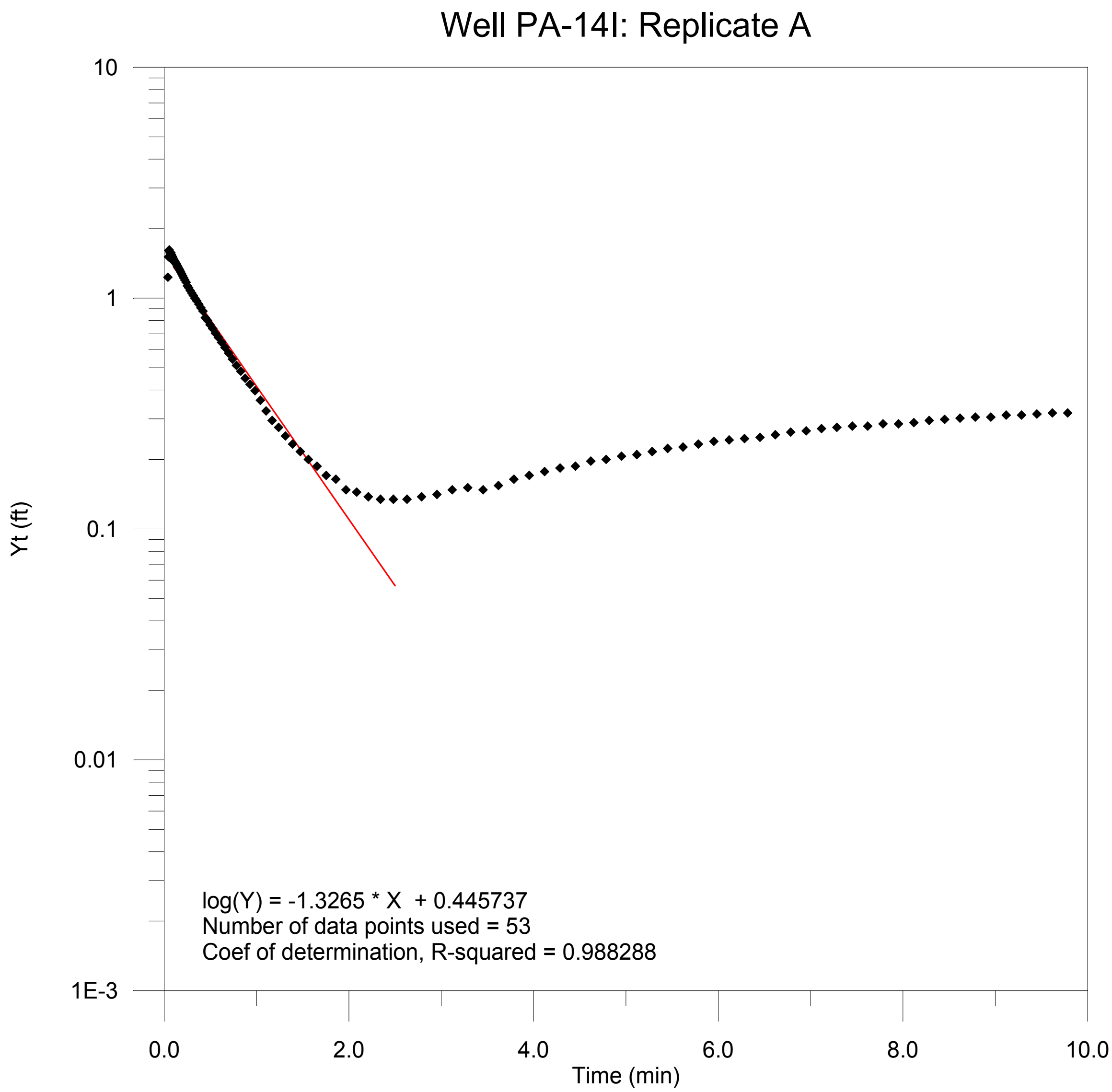
Post-demonstration Slug Test Results: Well PA-13D.



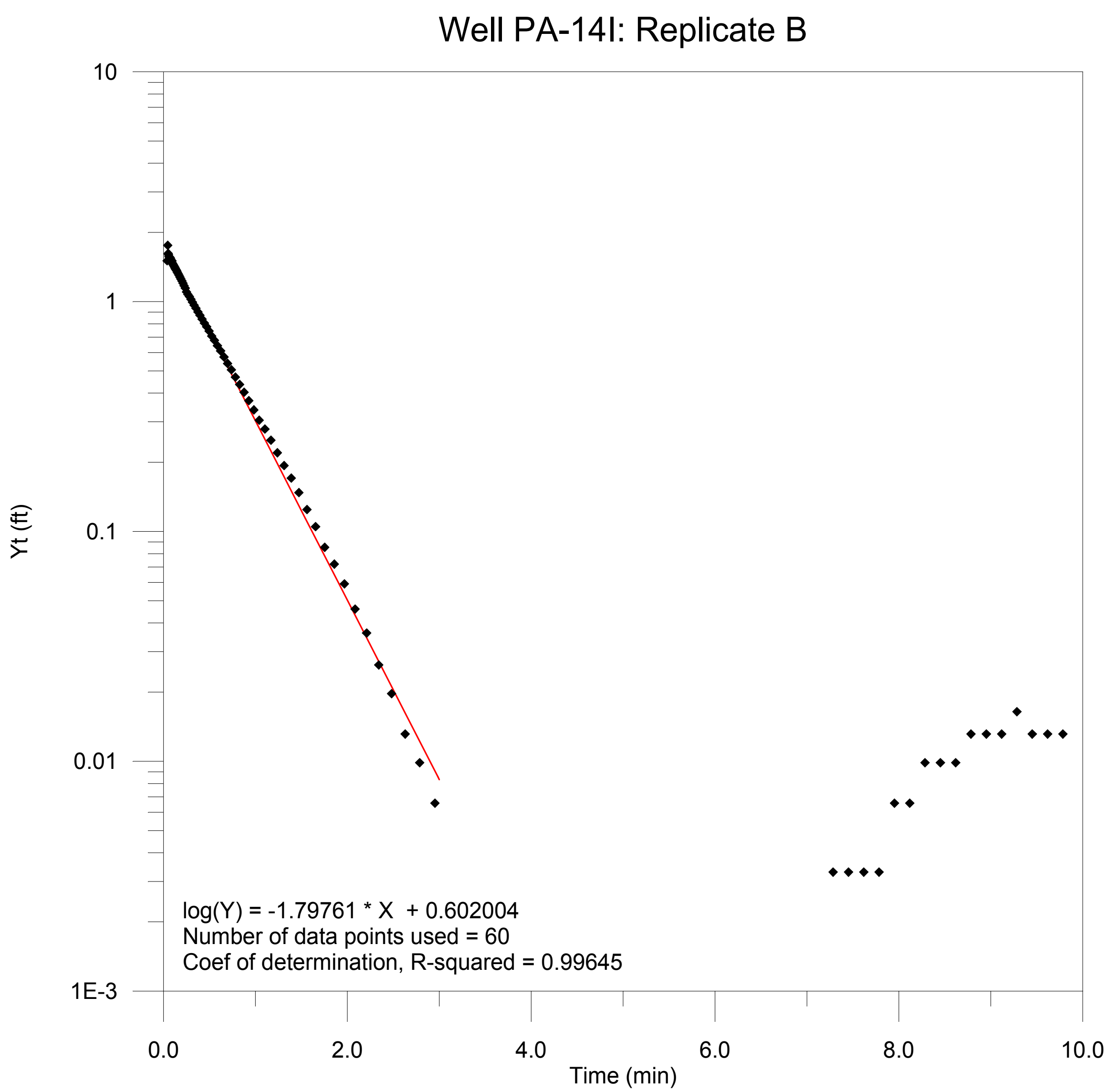
Post-demonstration Slug Test Results: Well PA-14S.



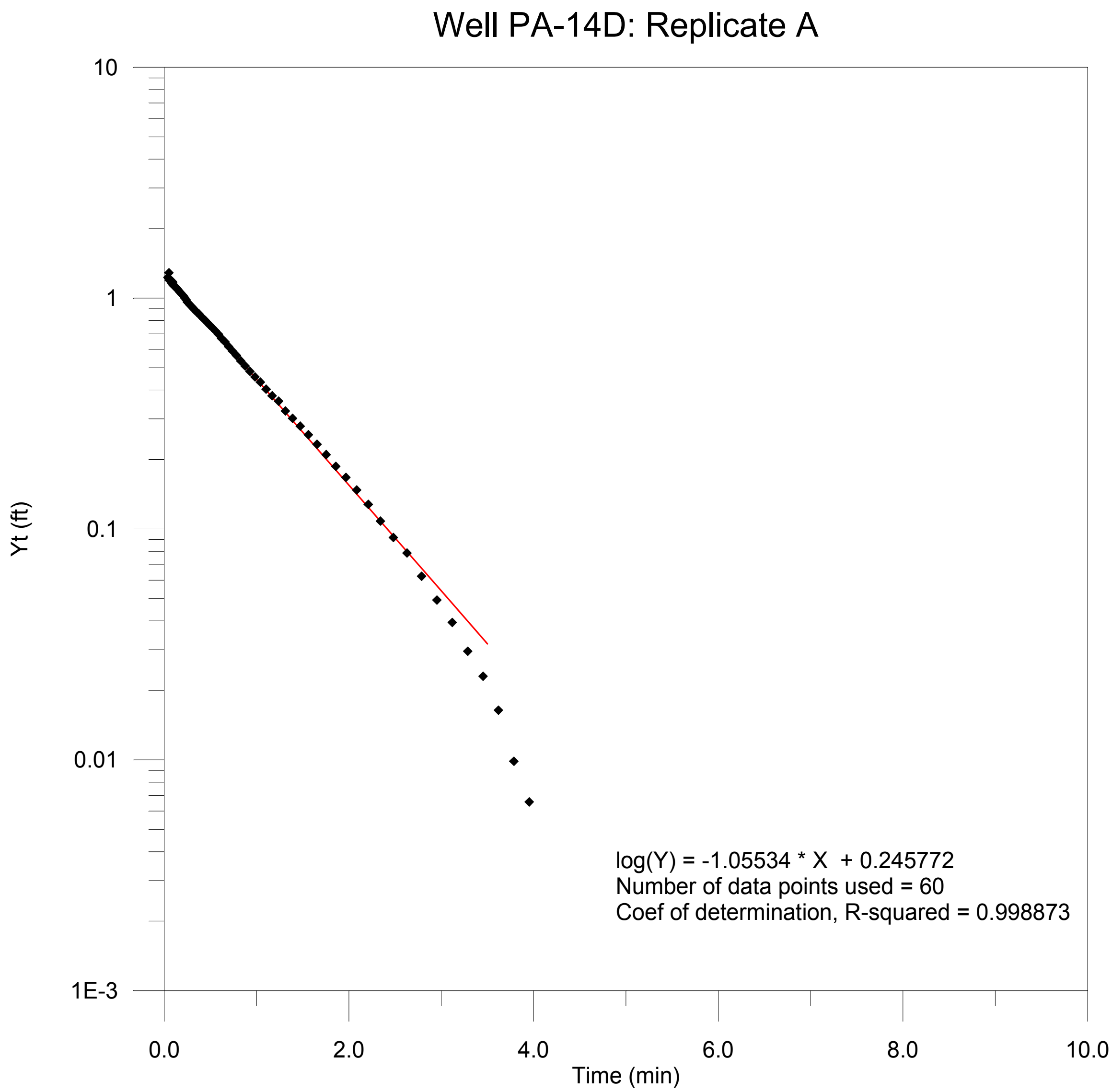
Post-demonstration Slug Test Results: Well PA-14S.



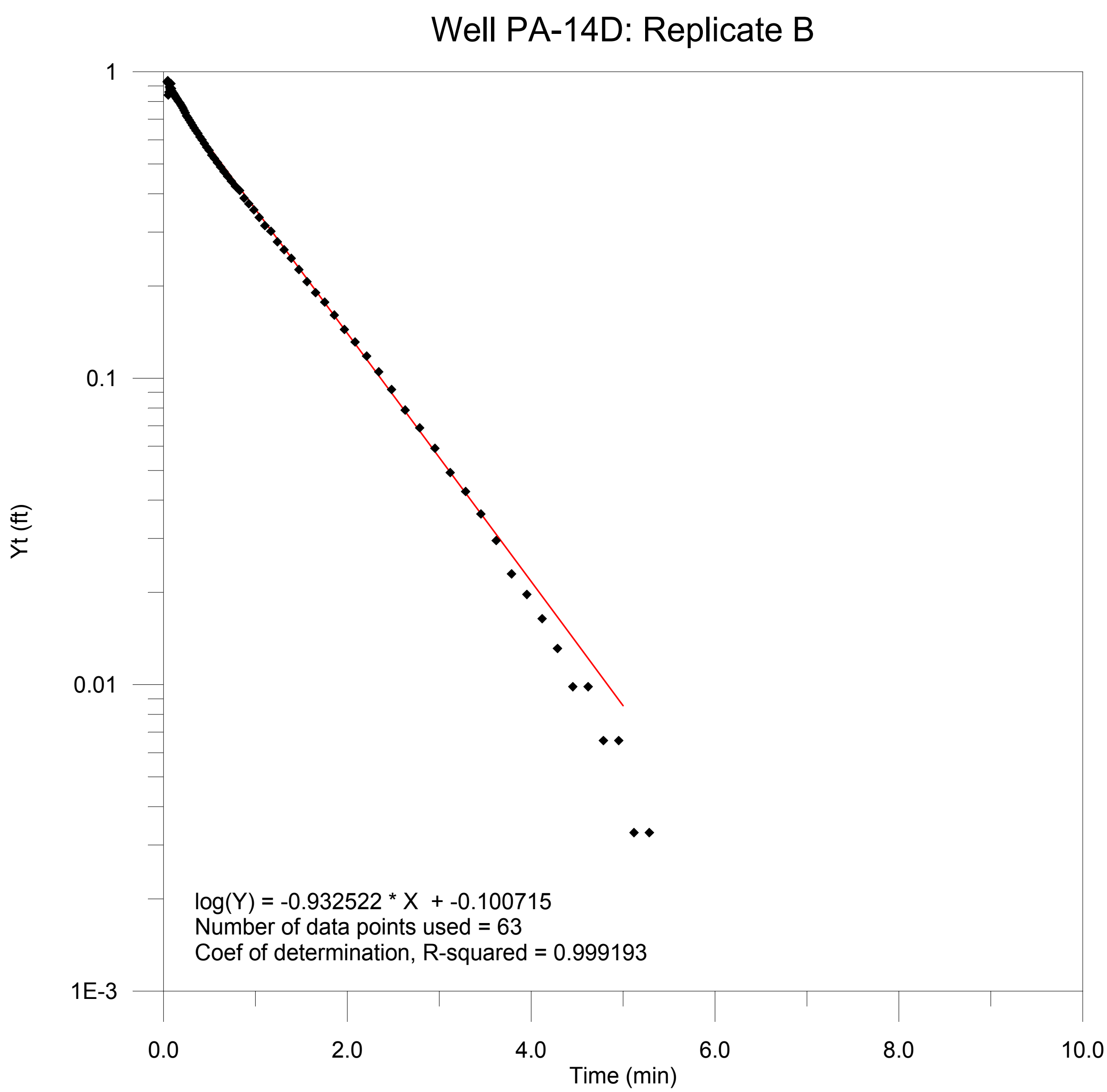
Post-demonstration Slug Test Results: Well PA-14I.



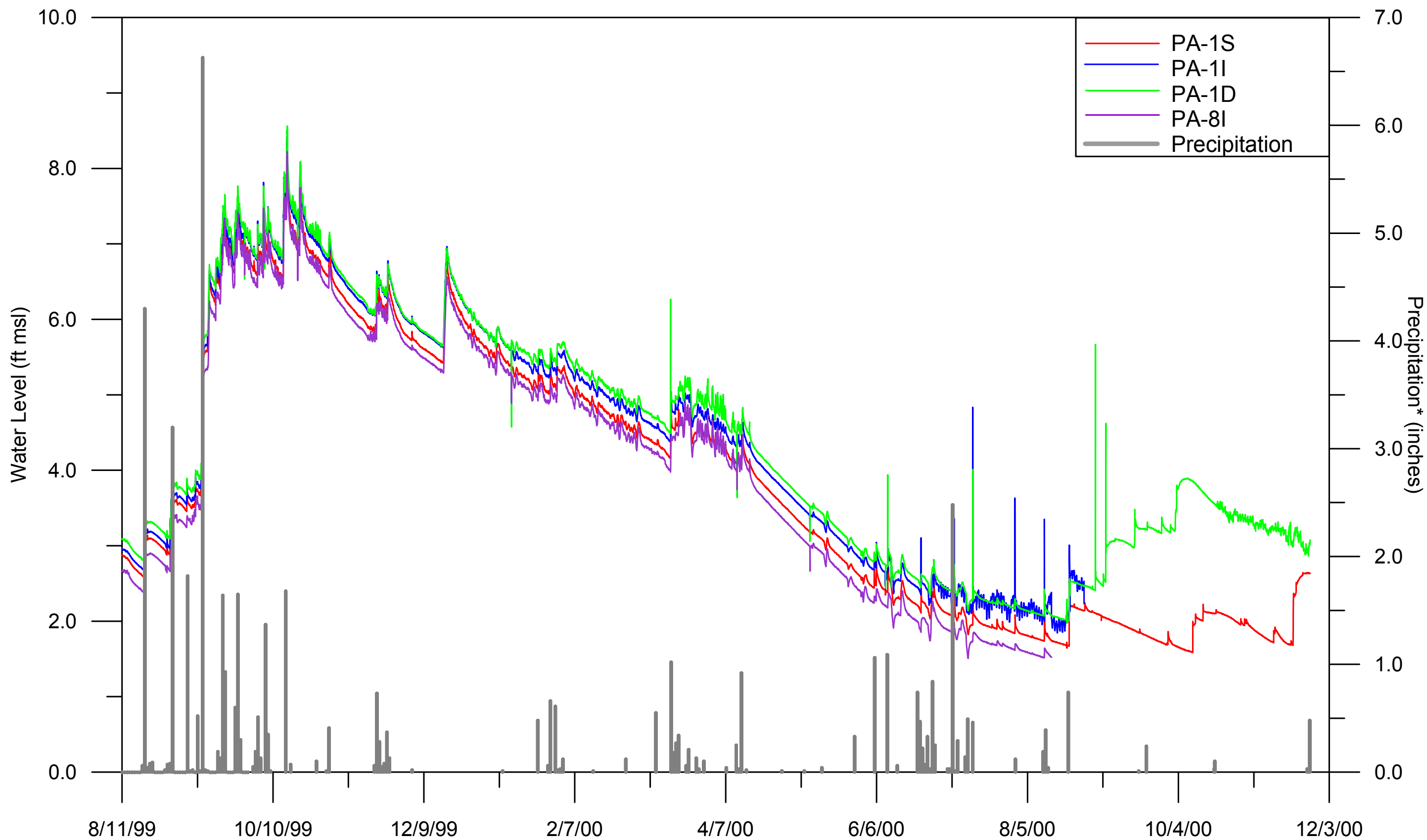
Post-demonstration Slug Test Results: Well PA-14I.



Post-demonstration Slug Test Results: Well PA-14D.



Post-demonstration Slug Test Results: Well PA-14D.



*based on measurements at field mill 30 at Cape Canaveral Air Station

B.2 Site Assessment Well Completion Diagrams for Shallow, Intermediate, and Deep Wells

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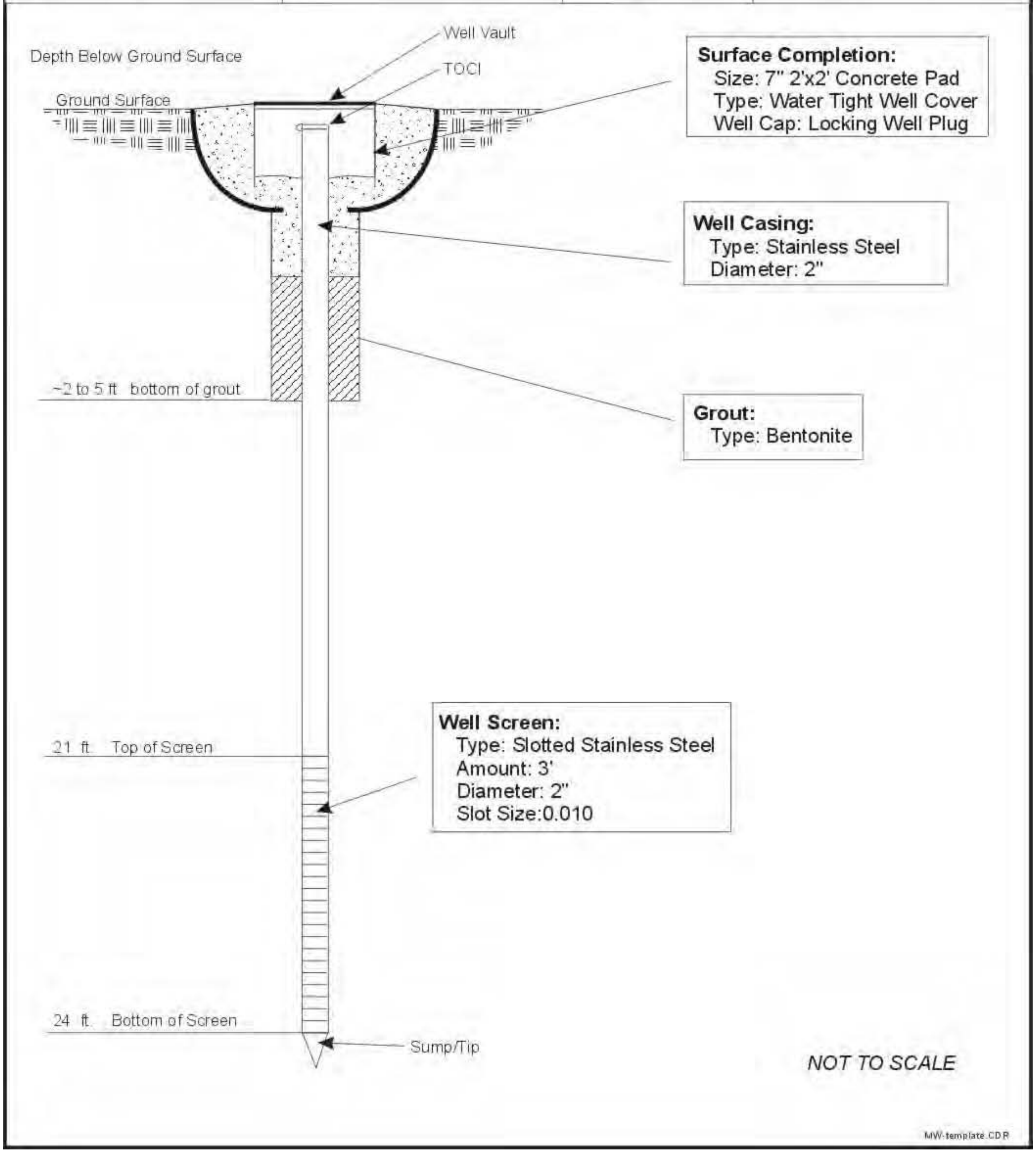
WELL COMPLETION DIAGRAM

Project #: G004065	Site: LC34, CCAS	Well #: Shallow	Northing (NAD 83):
Drilling Contractor:	Rig Type and Drilling Method: Direct Push	Date: 1998-2001	Easting (NAD 83):
Reviewed by: JRS	Driller:	Hydrogeologist: JRS	Surface Elevation (NAVD 88):



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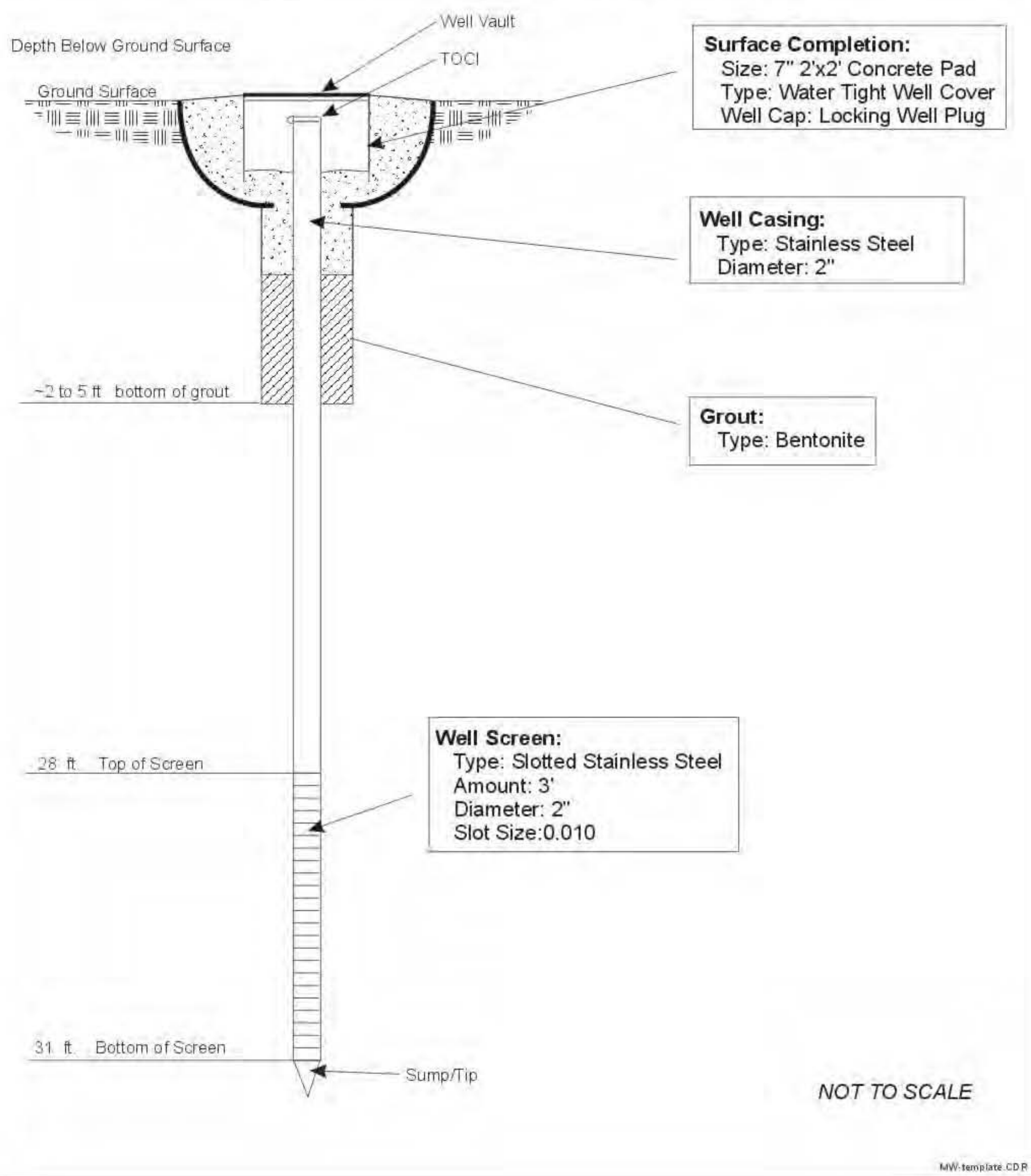
WELL COMPLETION DIAGRAM

Project #: G004065	Site: LC34, CCAS	Well #: Intermediate	Northing (NAD 83):
Drilling Contractor:	Rig Type and Drilling Method: Direct Push	Date: 1998-2001	Easting (NAD 83):
Reviewed by: JRS	Driller:	Hydrogeologist: JRS	Surface Elevation (NAVD 88):



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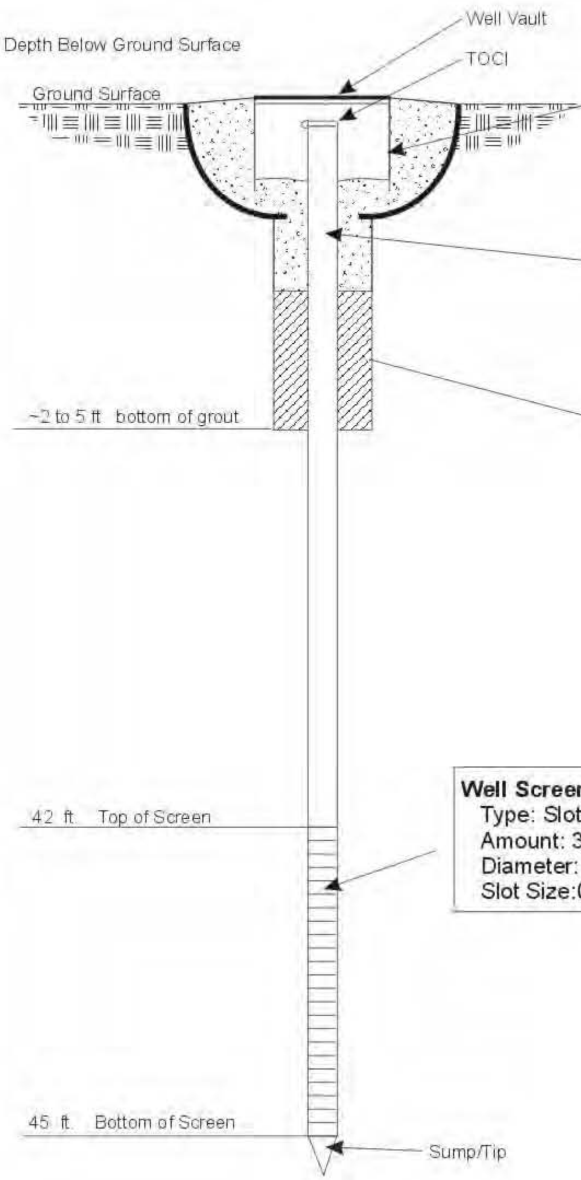
WELL COMPLETION DIAGRAM

Project #: G004065	Site: LC34, CCAS	Well #: Deep	Northing (NAD 83):
Drilling Contractor:	Rig Type and Drilling Method: Direct Push	Date: 1998-2001	Easting (NAD 83):
Reviewed by: JRS	Driller:	Hydrogeologist: JRS	Surface Elevation (NAVD 88):



Surface Completion:
Size: 7" 2'x2' Concrete Pad
Type: Water Tight Well Cover
Well Cap: Locking Well Plug

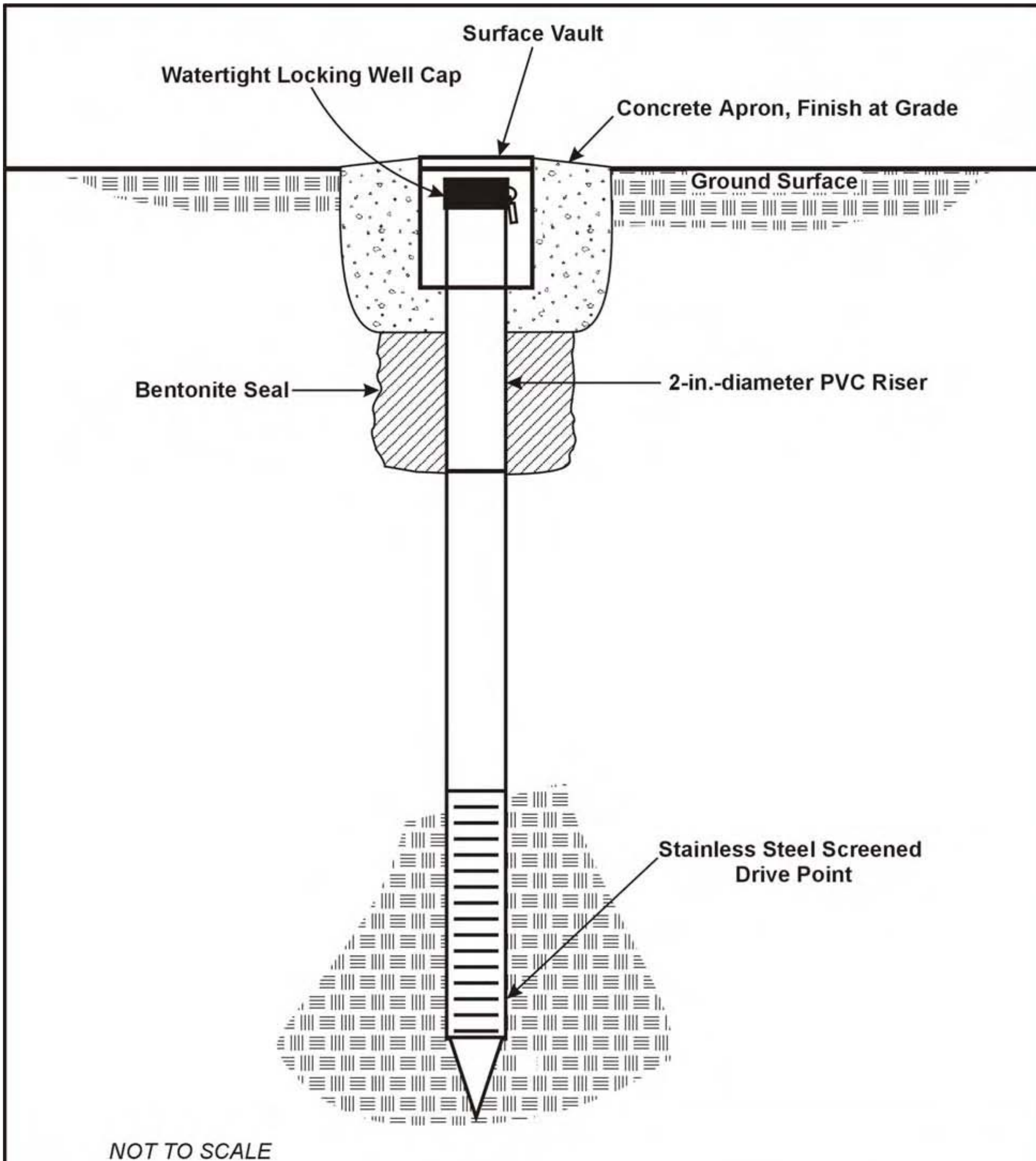
Well Casing:
Type: Stainless Steel
Diameter: 2"

Grout:
Type: Bentonite

Well Screen:
Type: Slotted Stainless Steel
Amount: 3'
Diameter: 2"
Slot Size:0.010

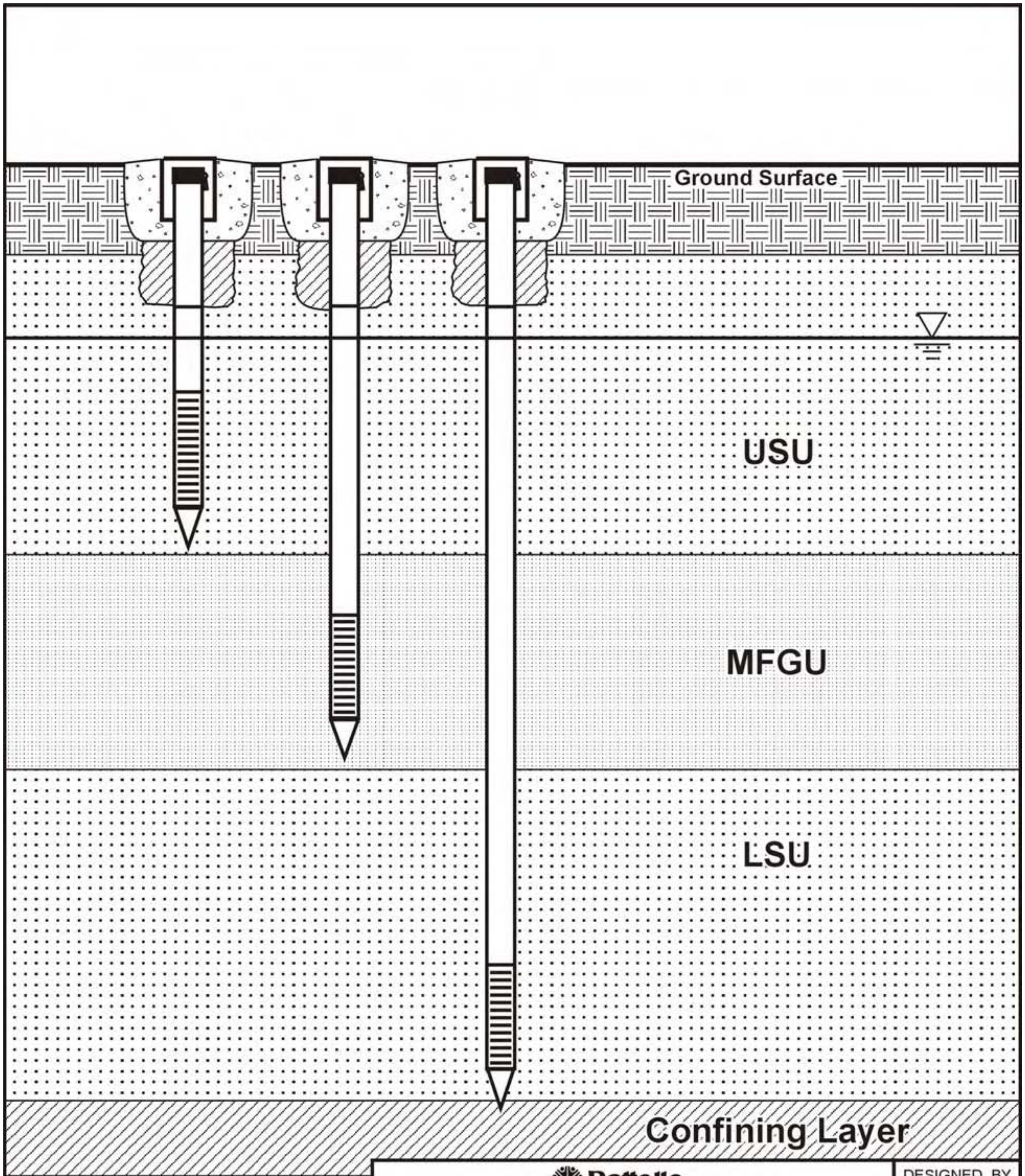
NOT TO SCALE

MW-template.CDR



Battelle ... Putting Technology To Work	DESIGNED BY JS
Figure 3-4. PASC Groundwater Monitoring Well Construction Diagram	DRAWN BY VS
CAPE CANAVERAL AIR STATION – FLORIDA	CHECKED BY TL
PROJECT G331505-11 / DATE 12/98	

DSGWMWCAPE_C01.CDR



Battelle ... Putting Technology To Work	DESIGNED BY JS
Figure 3-5. PASC Monitoring Well Cluster Diagram	DRAWN BY VS
CAPE CANAVERAL AIR STATION – FLORIDA	CHECKED BY TL
PROJECT G331505-11 DATE 12/98	

B.3 LC34 IDC Coring Logsheets for Site Assessment Wells

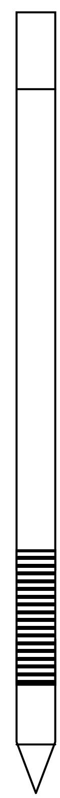
LC34 IDC Coring Logsheet

Boring ID **PA-1S**

Date 2/17/99

Location LC34 E. of ESB

Boring Diameter	2 3/8 in	Total Depth	26.1 ft
Casing Outer Diameter	2 3/8 in	Sand Pack	---
Casing Inner Diameter	1 7/8 in	Sand Pack Depth	from --- to --- ft
Casing Material	stainless steel	Grout Material	bentonite chips
Screen Type	stainless steel	Grout Depth	from 2 to 3 ft
Screen Slot	0.010	Surface Completion	flush vault w/ concrete pad
Screen Length	2 2/3 ft	Drilling Method	CPT
Screen Depth	from 21.7 to 24.4 ft	Driller	John Hoggatt

Lithologic Description	Depth	Sample	USCS	Well	Other
Post hole loose tan sands	0-5	---	---		PVC riser
No sampling, direct push.	5-26.1	---	---		
					2 2/3 ft screen
					1 ft sump
					6 7/8 in. tip

Logged by: J Sminchak

Completion Date: 2/17/99

Construction Notes: Completion depths based on previous borings in the area (LC34-B13).

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LC34 IDC Coring Logsheet

Boring ID **PA-1I**

Date 2/19/99

Location LC34 E. of ESB

Boring Diameter	2 3/8 in	Total Depth	31 ft
Casing Outer Diameter	2 3/8 in	Sand Pack	---
Casing Inner Diameter	1 7/8 in	Sand Pack Depth	from --- to --- ft
Casing Material	stainless steel	Grout Material	bentonite chips
Screen Type	stainless steel	Grout Depth	from 2 to 3 ft
Screen Slot	0.010	Surface Completion	flush vault w/ concrete pad
Screen Length	2 2/3 ft	Drilling Method	CPT
Screen Depth	from 26.6 to 29.3 ft	Driller	John Hoggatt

Lithologic Description	Depth	Sample	USCS	Well	Other
Post hole loose tan sands	0-4	---	---		PVC riser
No sampling, direct push.	4-31	---	---		
					2 2/3 ft screen
					1 ft sump
					6 7/8 in. tip

Logged by: J Sminchak

Completion Date: 2/19/99

Construction Notes: Completion depths based on previous borings in the area (LC34-B13).

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LC34 IDC Coring Logsheet

Boring ID **PA-1D**

Date 2/18/99

Location LC34, ESB

Boring Diameter	2 3/8 in	Total Depth	46.5 ft
Casing Outer Diameter	2 3/8 in	Sand Pack	---
Casing Inner Diameter	1 7/8 in	Sand Pack Depth	from --- to --- ft
Casing Material	stainless steel	Grout Material	bentonite chips
Screen Type	stainless steel	Grout Depth	from 2 to 3 ft
Screen Slot	0.010	Surface Completion	flush vault w/ concrete pad
Screen Length	2 2/3 ft	Drilling Method	CPT
Screen Depth	from 43.3 to 45.9 ft	Driller	John Hoggatt

Lithologic Description	**Depth**	**Sample**	**USCS**	**Well**	**Other**
post hole to 4 ft bgs soil, loose tan sands	0-4	---	---		PVC riser
direct push, no sampling	4-25	---	---		
gray fine sand, some silt <30%	25-26.5	PA-1D-26.5	SM		
direct push, no sampling	26.5-35	---	---		
gray fine sand, some silt <30%	35-36	PA-1D-36.5	SM		
gray med to fine sand, shells 40%, some silts	36-36.5	PA-1D-36.5	SW		
gray fine to medium sand, 40-50%, some silts	37-38.5	PA-1D-38.5	SW		
gray med to fine sand, shells < 10%, some silts	39.5-39.8	PA-1D-40.5	SW		
gray med to fine sand, shells 40-50%, some silts	39.8-40.5	PA-1D-40.5	SW		
gray med to fine sand grading into more shell content >50% w/ some silts	41-42.5	PA-1D-42.5	SW		

Logged by: J Sminchak

Completion Date: 2/19/99

Construction Notes: soil sampling 2/18, left tip in hole overnight and completed 2/19/99

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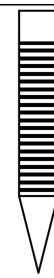
LC34 IDC Coring Logsheet

Date 2/18/99

Boring ID PA-1D

Location LC34 ESB

Lithologic Description	Depth	Sample	USCS	Well	Water Level	Other
gray fine sands, some silts, shell frags finer sands + silts at bottom of sample	43-44.5	PA-1D-44.5	SM			
fine silt and sands, gray, very little shell frags	44.5-45.5	PA-1D-46	ML			2 2/3 ft screen
silty gray clay, med. plasticity	45.5-46	PA-1D-46	CL			6 7/8 in. tip

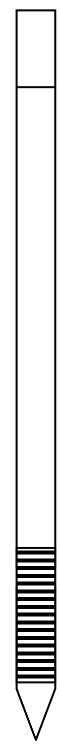
LC34 IDC Coring Logsheet

Boring ID **PA-2S**

Date 2/22/99

Location LC34, ESB

Boring Diameter	2 3/8 in	Total Depth	21 ft
Casing Outer Diameter	2 3/8 in	Sand Pack	---
Casing Inner Diameter	1 7/8 in	Sand Pack Depth	from --- to --- ft
Casing Material	stainless steel	Grout Material	bentonite chips
Screen Type	stainless steel	Grout Depth	from 2 to 3 ft
Screen Slot	0.010	Surface Completion	flush vault w/ concrete pad
Screen Length	2 2/3 ft	Drilling Method	CPT
Screen Depth	from 17.7 to 20.3 ft	Driller	John Hoggatt

Lithologic Description	Depth	Sample	USCS	Well	Other
Post hole loose tan sands	0-4	---	---		PVC riser
No sampling, direct push.	4-21	---	---		
					2 2/3 ft screen
					6 7/8 in. tip

Logged by: J Sminchak

Completion Date: 2/22/99

Construction Notes:

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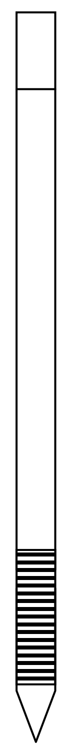
LC34 IDC Coring Logsheet

Boring ID **PA-2I**

Date 2/22/99

Location LC34, ESB

Boring Diameter	2 3/8 in	Total Depth	27 ft
Casing Outer Diameter	2 3/8 in	Sand Pack	---
Casing Inner Diameter	1 7/8 in	Sand Pack Depth	from --- to --- ft
Casing Material	stainless steel	Grout Material	bentonite chips
Screen Type	stainless steel	Grout Depth	from 2 to 3 ft
Screen Slot	0.010	Surface Completion	flush mounted vault .
Screen Length	2 2/3 ft	Drilling Method	CPT
Screen Depth	from 23.7 to 26.3 ft	Driller	John Hoggatt

Lithologic Description	**Depth**	**Sample**	**USCS**	**Well**	**Other**
post hole soil, loose tan sands	0-4	---	---		PVC riser
direct push, no sampling	4-27	---	---		
					2 2/3 ft screen
					6 7/8 in. tip

Logged by: J Sminchak

Completion Date: 2/22/99

Construction Notes: Two pilot hole pushes and a well push .

Battelle
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LC34 IDC Coring Logsheet

Boring ID PA-2D

Date 2/19/99

Location LC34, ESB

Boring Diameter	2 3/8 in	Total Depth	45 ft
Casing Outer Diameter	2 3/8 in	Sand Pack	---
Casing Inner Diameter	1 7/8 in	Sand Pack Depth	from --- to --- ft
Casing Material	stainless steel	Grout Material	bentonite chips
Screen Type	stainless steel	Grout Depth	from 2 to 3 ft
Screen Slot	0.010	Surface Completion	flush vault w/ concrete pad
Screen Length	2 2/3 ft	Drilling Method	CPT
Screen Depth	from 41.7 to 44.3 ft	Driller	John Hoggatt

Lithologic Description	Depth	Sample	USCS	Well	Other
post hole to 4 ft bgs soil, loose tan sands	0-4	---	---		PVC riser
direct push, no sampling	4-15	---	---		
medium to fine sand, gray, trace of shell material, wet	15-15.5	PA-2D-16.6	SP		
gray fine sand and silt, trace of shell material	15.5-16.6	PA-2D-16.6	SP		
no recovery	16.6-17	PA-2D-16.6			
gray fine sand and silt, trace shell material	17-17.25	PA-2D-18.5	SP		
gray fine to medium sand, 20-30% shells, 10-20% silts	17.25-18.5	PA-2D-18.5	SP		
no recovery	18.5-19				
gray silty fine sand, trace of shells	19-20	PA-2D-20.5	SP		
gray med to fine to med sand, 50-70% shells, some silts	20-20.5	PA-2D-20.5	SP		

Logged by: J Sminchak

Completion Date: 2/19/99

Construction Notes:

Battelle
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LC34 IDC Coring Logsheet

Boring ID PA-2D

Date 2/20/99

Location LC34 ESB

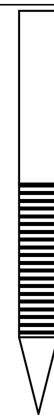
Lithologic Description	Depth	Sample	USCS	Well	Water Level	Other
gray medium to fine sands with abundant shell material >70%	21-21.5	PA-2D-22.5	SW			
gray silty fine sand, little shell material	21.5-22.5	PA-2D-22.5	SP			
gray silty fine sand, little shell material 10-20%	23-24.5	PA-2D-24.5	SP			
graly clayey fine sand	25-26.5	PA-2D-26.5	SM			
gray clayey fine sand, shells <10%	27-28.2	PA-2D-28.5	SM			
gray fine to medium sand, shells <20%	28.2-28.5	PA-2D-28.5	SP			
gray fine silty sand, little % of shells	29-29.5	PA-2D-30.5	SM			
gray fine to medium sand, some silts	29.5-30	PA-2D-30.5	SP			
mostly shells and gray fine sand with trace of silt <10%	30-30.5	PA-2D-30.5	SW			
no recovery (piston on sampler jammed)	31-32.5	PA-2D-30.5				
fine to med. gray sands, 30-40% shells	33.3-34.1	PA-2D-34.5	SW-GM			
silty fine sand to med. sand, some shells	34.1-34.5	PA-2D-34.5	SP			
silty fine sand, little shells	35-35.3	PA-2D-36.5	SM			
clay, medium plasticity	35.3-35.4	PA-2D-36.5	CL			
medium to fine sand, mostly >75% gravel sized shell material	35.4-36.5	PA-2D-36.5	SW			
gray silty fine sand, trace of shell material	37-38.5	PA-2D-38.5	SM			
gray fine silty sand, trace of shell material	39-39.3	PA-2D-40.5	SM			
fine sand, mostly shell frags, trace of silt	39.3-40.5	PA-2D-40.5	SP			

LC34 IDC Coring Logsheet

Boring ID PA-2D

Date 2/20/99

Location LC34 ESB

Lithologic Description	Depth	Sample	USCS	Well	Water Level	Other
fine silty gray sand, with 10-20% shells	41-41.5	PA-2D-42.5	SM			
clay, med plasticity	41.5-41.6	PA-2D-42.5	CL			
fine silty sand with abundant shell fragments	41.6-42.5	PA-2D-42.5	GS-SP			2 2/3 ft screen
fine sand and silts, wet and loose, some shells 20%	43-44.5	PA-2D-44.5	SM			6 7/8 in. tip

LC34 IDC Coring Logsheet

Boring ID: **PA-3S**

Date: 2/24/99

Location: LC34, ESB

Boring Diameter	2 3/8 in	Total Depth	24 ft
Casing Outer Diameter	2 3/8 in	Sand Pack	---
Casing Inner Diameter	1 7/8 in	Sand Pack Depth	from --- to --- ft
Casing Material	stainless steel	Grout Material	bentonite chips
Screen Type	stainless steel	Grout Depth	from 2 to 3 ft
Screen Slot	0.010	Surface Completion	flush mount vault
Screen Length	2 2/3 ft	Drilling Method	CPT
Screen Depth	from 19.6 to 22.3 ft	Driller	John Hoggatt

Lithologic Description	**Depth**	**Sample**	**USCS**	**Well**	**Other**
Post hole loose tan sands	0-4	---	---		PVC riser
No sampling, direct push.	4-24	---	---		
					2 2/3 ft screen
					1 ft sump
					6 7/8 in. tip

Logged by: J Sminchak

Completion Date: 2/24/99

Construction Notes:

LC34 IDC Coring Logsheet

Boring ID: **PA-3I**

Date: 2/24/99

Location: LC34, ESB

Boring Diameter	2 3/8 in	Total Depth	30.3 ft
Casing Outer Diameter	2 3/8 in	Sand Pack	---
Casing Inner Diameter	1 7/8 in	Sand Pack Depth	from --- to --- ft
Casing Material	stainless steel	Grout Material	bentonite chips
Screen Type	stainless steel	Grout Depth	from 2 to 3 ft
Screen Slot	0.010	Surface Completion	flush mounted vault .
Screen Length	2 2/3 ft	Drilling Method	CPT
Screen Depth	from 26.1 to 28.7 ft	Driller	John Hoggatt

Lithologic Description

Lithologic Description	Depth	Sample	USCS	Well	Other
post hole soil, loose tan sands	0-4	---	---		PVC riser
direct push, no sampling	4-30.3	---	---		
					2 2/3 ft screen
					1 ft sump
					6 7/8 in. tip

Logged by: J Sminchak

Completion Date: 2/24/99

Construction Notes: ______________________

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LC34 IDC Coring Logsheet

Boring ID PA-3D

Date 2/23/99

Location LC34, ESB

Boring Diameter	2 3/8 in	Total Depth	46.5 ft
Casing Outer Diameter	2 3/8 in	Sand Pack	---
Casing Inner Diameter	1 7/8 in	Sand Pack Depth	from --- to --- ft
Casing Material	stainless steel	Grout Material	bentonite chips
Screen Type	stainless steel	Grout Depth	from 2 to 3 ft
Screen Slot	0.010	Surface Completion	flush mount vault
Screen Length	2 2/3 ft	Drilling Method	CPT
Screen Depth	from 42.2 to 44.8 ft	Driller	John Hoggatt

Lithologic Description	Depth	Sample	USCS	Well	Other
post hole soil, loose tan sands	0-4	---	---		PVC riser
direct push, no sampling	4-15	---	---		
fine silty sand, gray, 10% shells	15-16.2	PA-2D-16.6	SP		
abundant shells and medium to fine gray sands	16.2-16.5	PA-2D-16.6	SP		
fine gray silty sand, trace shells	17-18.5	PA-2D-16.6	SP		
fine to medium gray sand, 20% shell fragments	19-20. 5	PA-2D-18.5	SP		
fine gray sand, some silts <10% and shells <10%	21-22.5	PA-2D-18.5	SP		
fine gray sand, some silts 10-20% and shell material <10%	23-24.5	PA-2D-18.5	SP		
fine gray sand, some silts and shell and shell material	25-26.5	PA-2D-20.5	SP		
fine gray sand, little silt, 20-30% shell (wet)	27-28.2	PA-2D-20.5	SP		

Logged by: J Sminchak

Completion Date: 2/23/99

Construction Notes:

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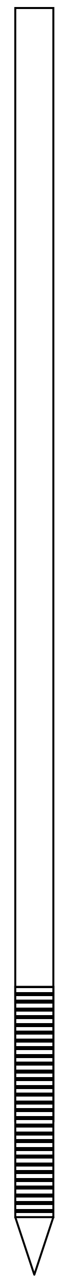
LC34 IDC Coring Logsheet

Date 2/23/99

Boring ID PA-3D

Location LC34 ESB

Lithologic Description	**Depth**	**Sample**	**USCS**	**Well**	**Water Level**	**Other**
shelly layer, mostly shells and fine sand and silts (wet)	28.2-28.5	PA-3D-28.5	SP			
shelly layer, mostly shells and fine sand and silts (wet)	29-29.2	PA-3D-30.5	SP			
fine silty/clayey sand, trace of shells	29.2-30.5	PA-3D-30.5	SM			
abundant shells and fine gray sands and silts 20-30%	31-32.1	PA-3D-32.5	SP-GM			
fine silty sand and 20-30% shells	32.1-32.5	PA-3D-32.5	SM			
fine silty sand and 20-30% shells	33.2-33.6	PA-3D-34.5	SM			
mostly shells and gray fine sand (20%)	33.6-34.5	PA-3D-34.5	SP-GM			
mostly shells and gray fine sand (20%)	35.3-36.3	PA-3D-36.5	SP-GM			
clayey fine sand, med-low plasticity	36.3-36.5	PA-3D-36.5	SC			
abundant shells, fine sands and silts 20-30%, loose wet	37-38.5	PA-3D-38.5	SP-GM			
abundant shells, fine sands and silts 20-30%, loose wet	39-40.5	PA-3D-40.5	SP-GM			
abundant shells, fine sands and silts 20-30%, loose wet	41-42.5	PA-3D-42.5	SP-GM			
fine silty sand and small amount of shells 10%	43.2-43.5	PA-3D-44.5	SM			
fine sand and shell frag 20% wet and loose	43.5-44.5	PA-3D-44.5	SP			2 2/3 ft screen
gray clay with some silt and fine sand, med-low plasticity	45-46.5	PA-3D-46.5	CL			6 7/8 in. tip

LC34 IDC Coring Logsheet

Boring ID: PA-4S

Date: 2/26/99

Location: LC34, ESB

Boring Diameter	2 3/8 in	Total Depth	22 ft
Casing Outer Diameter	2 3/8 in	Sand Pack	---
Casing Inner Diameter	1 7/8 in	Sand Pack Depth	from --- to --- ft
Casing Material	stainless steel	Grout Material	bentonite chips
Screen Type	stainless steel	Grout Depth	from 2 to 3 ft
Screen Slot	0.010	Surface Completion	flush mount vault
Screen Length	2 2/3 ft	Drilling Method	CPT
Screen Depth	from 17.7 to 20.4 ft	Driller	John Hoggatt

Lithologic Description	Depth	Sample	USCS	Well	Other
Post hole soil and loose tan sands	0-4	---	---		PVC riser
No sampling, direct push.	4-22	---	---		
					2 2/3 ft screen
					1 ft sump
					6 7/8 in. tip

Logged by: J Sminchak

Completion Date: 2/26/99

Construction Notes:

LC34 IDC Coring Logsheet

Boring ID PA-4I

Date 2/26/99

Location LC34, ESB

Boring Diameter	2 3/8 in	Total Depth	28 ft
Casing Outer Diameter	2 3/8 in	Sand Pack	---
Casing Inner Diameter	1 7/8 in	Sand Pack Depth	from --- to --- ft
Casing Material	stainless steel	Grout Material	bentonite chips
Screen Type	stainless steel	Grout Depth	from 2 to 3 ft
Screen Slot	0.010	Surface Completion	flush mount vault .
Screen Length	2 2/3 ft	Drilling Method	CPT
Screen Depth	from 23.7 to 26.4 ft	Driller	John Hoggatt

Lithologic Description	Depth	Sample	USCS	Well	Other
post hole soil and loose tan sands	0-4	---	---		PVC riser
direct push, no sampling	4-28	---	---		
					2 2/3 ft screen
					1 ft sump
					6 7/8 in. tip

Logged by: J Sminchak

Completion Date: 2/26/99

Construction Notes:

Battelle
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LC34 IDC Coring Logsheet

Boring ID **PA-4D**

Date 2/25/99

Location LC34, ESB

Boring Diameter	2 3/8 in	Total Depth	47.5 ft
Casing Outer Diameter	2 3/8 in	Sand Pack	---
Casing Inner Diameter	1 7/8 in	Sand Pack Depth	from --- to --- ft
Casing Material	stainless steel	Grout Material	bentonite chips
Screen Type	stainless steel	Grout Depth	from 2 to 3 ft
Screen Slot	0.010	Surface Completion	flush mount vault
Screen Length	2 2/3 ft	Drilling Method	CPT
Screen Depth	from 43.2 to 45.9 ft	Driller	John Hoggatt

Lithologic Description	Depth	Sample	USCS	Well	Other
post hole soil, loose tan sands	0-4	---	---		PVC riser
direct push, no sampling	4-15	---	---		
silty fine gray sand with 10-20% shells	15-15.3	PA-4D-16.5	SP		
abundant shell frags, some silty fine sand	15.3-16	PA-4D-16.5	SP		
silty fine to medium gray sand, 20-30% shells	16-16.5	PA-4D-16.5	SP		
fine gray sand, with little silt and shells <5%	17-18. 5	PA-4D-18.5	SP		
fine gray sand with more silt 10-20%	19-20.5	PA-4D-20.5	SP		
fine gray sand, with silt 10% and some shell material (well sorted)	21-22.5	PA-4D-22.5	SP		
fine gray sand, with silt 10% and some shell material (well sorted)	23-24.5	PA-4D-24.5	SP		
fine gray sand with 5% silt and shells, well sorted	25-26.5	PA-4D-26.5	SP		

Logged by: J Sminchak

Completion Date: 2/25/99

Construction Notes:

Battelle
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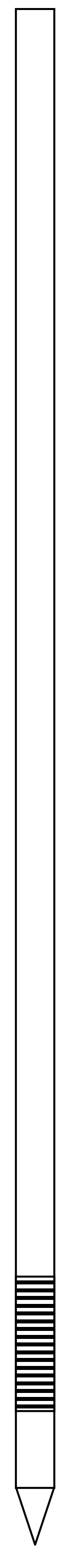
LC34 IDC Coring Logsheet

Boring ID PA-4D

Date 2/23/99

Location LC34 ESB

Lithologic Description	Depth	Sample	USCS	Well	Water Level	Other
fine gray sand and 40% shells with some silts	27-27.4	PA-4D-28.5	SP			
silty fine gray sand, some clay	27.4-28.5	PA-4D-28.5	SM			
fine to med sand with abundant shell material	29-29.4	PA-4D-30.5	SP			
gray silty sand	29.4-30.0	PA-4D-30.5	SM			
wet silty fine sand with 20% shells	30.0-30.5	PA-4D-30.5	SP			
wet silty fine sand with 10-20% shells	31-32	PA-4D-32.5	SP-GM			
abundant shells with gray fine silty sand (10%)	32-32.5	PA-4D-32.5	SP-GM			
abundant shells with gray fine silty sand (10%), wet	33-34.5	PA-4D-34.5	SP-GM			
abundant shells with gray fine silty sand (10%), wet	35-36	PA-4D-36.5	SP			
silty gray sand, some shells	36-36.5	PA-4D-36.5	---			
no recovery	37-38.5	PA-4D-36.5	SP-GM			
abundant shells with gray silty sand	38.5-38.8	PA-4D-40	SP-GM			
fine silty gray sand with 40-50% shells	38.8-39.7	PA-4D-40	SP-GM			
sandy clay with some shells med-low plasticity	39.7-40	PA-4D-40	SC			
abundant shells with fine gray silty sand 30-40%	40.5-42	PA-4D-42	SP-GM			
abundant shells with fine gray silty sand 30%	42.5-44	PA-4D-44	SP-GM			2 2/3 ft screen
silty gray fine sand	44.5-46	PA-4D-46	SP			
clayey sand and silt, some shells	46.5-46.8	PA-4D-47.5	SC			1 ft sump
sandy clay, some shell material	46.8-47.5	PA-4D-47.5	CL			6 7/8 in. tip



LC34 IDC Coring Logsheet

Boring ID PA-5S

Date 3/1/99

Location LC34, ESB

Boring Diameter	2 3/8 in	Total Depth	17 ft
Casing Outer Diameter	2 3/8 in	Sand Pack	---
Casing Inner Diameter	1 7/8 in	Sand Pack Depth	from --- to --- ft
Casing Material	stainless steel	Grout Material	bentonite chips
Screen Type	stainless steel	Grout Depth	from 2 to 3 ft
Screen Slot	0.010	Surface Completion	flush mount vault
Screen Length	2 2/3 ft	Drilling Method	CPT
Screen Depth	from 13.7 to 16.3 ft	Driller	John Hoggatt

Lithologic Description	Depth	Sample	USCS	Well	Other
Post hole loose tan sands	0-5	---	---		PVC riser
No sampling, direct push.	5-17	---	---		
					2 2/3 ft screen
					6 7/8 in. tip

Logged by: J Sminchak

Completion Date: 3/1/99

Construction Notes:

Battelle
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LC34 IDC Coring Logsheet

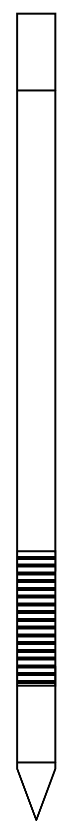
Boring ID **PA-5I**

Date 3/1/99

Location LC34, ESB

Boring Diameter	2 3/8 in	Total Depth	22 ft
Casing Outer Diameter	2 3/8 in	Sand Pack	---
Casing Inner Diameter	1 7/8 in	Sand Pack Depth	from --- to --- ft
Casing Material	stainless steel	Grout Material	bentonite chips
Screen Type	stainless steel	Grout Depth	from 2 to 3 ft
Screen Slot	0.010	Surface Completion	flush mount vault .
Screen Length	2 2/3 ft	Drilling Method	CPT
Screen Depth	from 17.8 to 20.4 ft	Driller	John Hoggatt

Lithologic Description	**Depth**	**Sample**	**USCS**	**Well**	**Other**
post hole soil and loose tan sands	0-4	---	---		PVC riser
direct push, no sampling	4-22	---	---		
					2 2/3 ft screen
					1 ft sump
					6 7/8 in. tip



Logged by: J Sminchak

Completion Date: 3/1/99

Construction Notes:

Battelle . . . Putting Technology To Work

LC34 IDC Coring Logsheet

Boring ID **PA-5D**

Date 2/26/99

Location LC34, ESB

Boring Diameter	2 3/8 in	Total Depth	45.6 ft
Casing Outer Diameter	2 3/8 in	Sand Pack	---
Casing Inner Diameter	1 7/8 in	Sand Pack Depth	from --- to --- ft
Casing Material	stainless steel	Grout Material	bentonite chips
Screen Type	stainless steel	Grout Depth	from 2 to 3 ft
Screen Slot	0.010	Surface Completion	flush mount vault
Screen Length	2 2/3 ft	Drilling Method	CPT
Screen Depth	from 42.2 to 44.9 ft	Driller	John Hoggatt

Lithologic Description	**Depth**	**Sample**	**USCS**	**Well**	**Other**
post hole soil, loose tan sands	0-5	---	---		PVC riser
direct push, no sampling	5-15	---	---		
fine gray sand with 20-30% shell material	15-15.7	PA-5D-16.5	SP		
mostly shell frags with 20-30% fine gray sand	15.7-16.5	PA-5D-16.5	SP		
well graded yellowish-orange fine sand with dark brown mottling (no shells gray plug)	17-18.5	PA-5D-18.5	SP		
gray silty fine sand, well sorted, trace of shell frags	19-20. 5	PA-5D-20.5	SP		
well graded yellowish-orange fine sand with dark brown mottling	21-22.3	PA-5D-20.5	SP		
gray silty fine sand in plug of sampler	22.3-22.5	PA-5D-22.5	SP		
gray silty fine sand, trace of shell fragments	23-24.5	PA-5D-24.5	SP		
gray silty fine sand, trace of shell fragments	25-26.5	PA-5D-26.5	SP		

Logged by: J Sminchak

Completion Date: 2/27/99

Construction Notes:

Battelle
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LC34 IDC Coring Logsheet

Date 2/27/99

Boring ID PA-5D

Location LC34 ESB

Lithologic Description	Depth	Sample	USCS	Well	Water Level	Other
silty fine gray sand, trace of shell fragments	27-28.1	PA-5D-28.5	SM			
silty fine gray sand, 10% shells	28.1-28.5	PA-5D-28.5	SM			
yellowish-orange fine to medium sand w/ abundant shells (sluff?)	29-30	PA-5D-30.5	SP			
silty fine gray sand, trace of shell fragments	30-30.5	PA-5D-30.5	SM			
abundant shell fragments and fine gray sand, trace silt	31-32.5	PA5-D-32.5	SP-GM			
yellowish orange fine to med. sand w/ abundant shells	33.5-34	PA-5D-34.5	SP			
silty fine gray sand, trace shell frags	34-34.2	PA-5D-34.5	SM			
abundant shells frags. and gray fine sand, trace silt	34.2-34.5	PA-5D-34.5	SP-GM			
silty fine gray sand, trace of clay and shell frags	35-35.4	PA-5D-36.5	SM			
silty gray clay low plasticity, trace sand	35.4-35.9	PA-5D-36.5	CL			
abundant shells, trace of fine silty sand (10%)	35.9-36.5	PA-5D-36.5	SP-GM			
silty gray clay, trace shells med-low plasticity, (1-2” stiff gray plug)	37 - 37.6	PA-5D-38.5	CL-ML			
clayey gray silt, shells 10-20%	37.6-38.5	PA-5D-38.5	SM			
silty gray clay, trace shells med-low plasticity	39-39.3	PA-5D-40.5	CL-ML			
silty-clayey fine sand and shell frags	39.3-39.8	PA-5D-40.5	SP-sM			
silty gray clay, trace shells med-low plasticity	39.8-40.2	PA-5D-40.5	CL-ML			
silty fine sand, mostly shells 60-80%	40.2-40.5	PA-5D-40.5	SP-GM			2 2/3 ft screen
sandy silty gray clay with trace of shell ftags. (some stiffness)	41.5-42	PA-5D-42.5	CL-ML			
silty sandy gray shell frags and shells (75% shells)	42-42.5	PA-5D-42.5	SP-GM			1 ft sump
gray fine sand, trace of silt and shells but overall well sorted	43-44.5	PA-5D-44.5	SP			6 7/8 in. tip
gray sandy clay, trace of shells	45-46.5	PA-5D-46.5	CL			

LC34 IDC Coring Logsheet

Boring ID: BAT-6S

Date: 7/12/99

Location: LC34

Boring Diameter: 2 1/2 in

Casing Outer Diameter: 2 1/2 in

Casing Inner Diameter: 2 in

Casing Material: stainless steel

Screen Type: stainless steel, slotted

Screen Slot: 0.010

Screen Length: 3 ft

Screen Depth from 23 to 26 ft

Total Depth: 26.5 ft

Sand Pack: ---

Sand Pack Depth from --- to --- ft

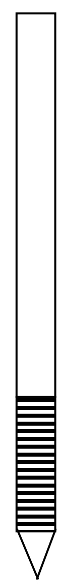
Grout Material: bentonite

Grout Depth from 0 to ~2 ft

Surface Completion: flush mount

Drilling Method: CPT

Driller: Ruperto Aquilar

Lithologic Description	Depth	Sample	USCS	Well	Other
Direct push- no sampling	0-26.5	---	---		PVC Riser 3 ft screen 0.5 ft tip

Logged by: L. Cumming

Completion Date: 7/12/99

Construction Notes:

Battelle
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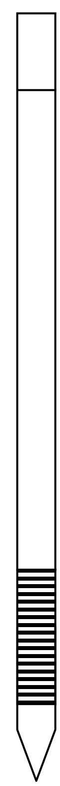
LC34 IDC Coring Logsheet

Boring ID **PA-6I**

Date 3/2/99

Location LC34, ESB

Boring Diameter	2 3/8 in
Casing Outer Diameter	2 3/8 in
Casing Inner Diameter	1 7/8 in
Casing Material	stainless steel
Screen Type	stainless steel
Screen Slot	0.010
Screen Length	2 2/3 ft
Screen Depth	from 23.5 to 26.2 ft
Total Depth	26.8 ft
Sand Pack	---
Sand Pack Depth	from --- to --- ft
Grout Material	bentonite chips
Grout Depth	from 2 to 3 ft
Surface Completion	flush mount vault .
Drilling Method	CPT
Driller	John Hoggatt

Lithologic Description	**Depth**	**Sample**	**USCS**	**Well**	**Other**
post hole soil and loose tan sands (tar/rock layer at 2 ½ ft)	0-5	---	---		PVC riser
direct push, no sampling	4-26.8	---	---		
					2 2/3 ft screen
					6 7/8 in. tip

Logged by: J Sminchak

Completion Date: 3/2/99

Construction Notes:

Battelle
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LC34 IDC Coring Logsheet

Boring ID **PA-6D**

Date 3/1/99

Location LC34, ESB

Boring Diameter	2 3/8 in	Total Depth	46.2 ft
Casing Outer Diameter	2 3/8 in	Sand Pack	---
Casing Inner Diameter	1 7/8 in	Sand Pack Depth	from --- to --- ft
Casing Material	stainless steel	Grout Material	bentonite chips
Screen Type	stainless steel	Grout Depth	from 2 to 3 ft
Screen Slot	0.010	Surface Completion	flush mount vault
Screen Length	2 2/3 ft	Drilling Method	CPT
Screen Depth	from 42 to 44.6 ft	Driller	John Hoggatt

Lithologic Description	**Depth**	**Sample**	**USCS**	**Well**	**Other**
post hole soil, loose tan sands	0-5	---	---		PVC riser
direct push, no sampling	5-15	---	---		
fine gray sand, well sorted, trace of shell material and silts	15-15.7	PA-6D-16.5	SP		
fine gray sand, well sorted, trace of shell material and silts	15.7-16.5	PA-6D-18.5	SP		
fine gray sand, (30-40%) shell fragments	17-18.5	PA-6D-20.5	SP		
fine gray sand with some silt (<10%) and trace shell frag	19-20. 5	PA-6D-20.5	SP		
fine gray sand with some shell frag (10-15%) and trace silt	21-22.3	PA-6D-22.5	SP		
gray silt with fine sand	22.3-22.5	PA-6D-22.5	SM		
no recovery	23-24.5	---	---		
fine gray silty fine sand, trace of shell fragments	25-26.5	PA-6D-26.5	SM		

Logged by: J Sminchak

Completion Date: 3/2/99

Construction Notes:

Battelle
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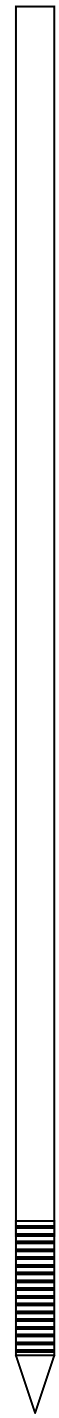
LC34 IDC Coring Logsheet

Date 3/2/99

Boring ID PA-6D

Location LC34 ESB

Lithologic Description	Depth	Sample	USCS	Well	Water Level	Other
silty fine gray sand, trace of shell fragments	27-28	PA-5D-28.5	SM			
gray fine sand with 30-40% shell fragments	28-28.2	PA-5D-28.5	S9			
gray sandy silt, trace of shell fragments	28.2-28.5	PA-5D-30.5	SM			
gray sandy silt, trace of shell fragments	29-29.7	PA-5D-30.5	SM			
fine gray sand with 30-40% shell frags, trace silt	29.7-30.3	PA5-D-32.5	SP			
gray sandy silt, trace of shell fragments	30.3-30.5	PA-5D-34.5	SM			
gray sandy silt, trace of shell fragments	31-31.4	PA-5D-34.5	SM			
abundant shells frags. and gray fine silty sand	31.4-32.5	PA-5D-34.5	SP-GM			
abundant shells frags. and gray fine silty sand	33.5-34.5	PA-5D-36.5	SP-GM			
silty fine gray sand, trace shell frags	35-35.3	PA-5D-36.5	SP			
silty sandy clay, low plast.	35.3-35.6	PA-5D-36.5	SC			
clayey, silty sand w/ shell material 20%	35.6 - 36.5	PA-5D-38.5	SM			
abundant shells w/ silty-fine sands	37-38.5	PA-5D-38.5	SP-SM			
silty clayey fine sand w/ 10-20% shell frags	39.5-39.7	PA-5D-40.5	SP-SM			
abundant large shells + frags in a silty clayey matirix	39.3-40.5	PA-5D-40.5	SP-SM			
clayey silt and fine sand with 20-30% shell frags	41.5-42.5	PA-6D-42.5	SM			2 2/3 ft screen
silty fine gray sand with 10-20% shell frags	43-44.5	PA-6D-44.5	SP			
sandy clay with trace of shell ftags.	45-46.2	PA-6D-46.2	CL			6 7/8 in. tip

LC34 IDC Coring Logsheet

Boring ID **PA-7S**

Date 3/3/99

Location LC34, ESB

Boring Diameter	2 3/8 in	Total Depth	23.25 ft
Casing Outer Diameter	2 3/8 in	Sand Pack	---
Casing Inner Diameter	1 7/8 in	Sand Pack Depth	from --- to --- ft
Casing Material	stainless steel	Grout Material	bentonite chips
Screen Type	stainless steel	Grout Depth	from 2 to 3 ft
Screen Slot	0.010	Surface Completion	flush mount vault
Screen Length	2 2/3 ft	Drilling Method	CPT
Screen Depth	from 19 to 21.6 ft	Driller	John Hoggatt

Lithologic Description	**Depth**	**Sample**	**USCS**	**Well**	**Other**
Post hole loose tan sands	0-4	---	---		PVC riser
No sampling, direct push.	4-17	---	---		
fine gray sand, some shell fragments + silts	15-16.5	PA-7D(s)-18.5	SP		
fine gray sand, well sorted, trace shells	17-18.5	PA-7D(s)-18.5	SP		
shell fragments and fine to medium gray sands	19-20.5	PA-7D(s)-20.5	SP-GM		2 2/3 ft screen
abundant shell fragments and fine to coarse gray sands	21-22.5	PA-7D(s)-22.5	SP-GM		1ft sump 6 7/8 in. tip

Logged by: J Sminchak

Completion Date: 3/3/99

Construction Notes: ____________________

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LC34 IDC Coring Logsheet

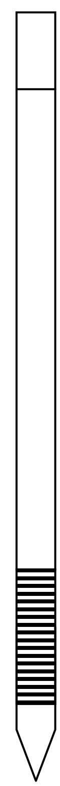
Boring ID **PA-7I**

Date 3/8/99

Location LC34, ESB

Boring Diameter	2 3/8 in	Total Depth	26.8 ft
Casing Outer Diameter	2 3/8 in	Sand Pack	---
Casing Inner Diameter	1 7/8 in	Sand Pack Depth	from --- to --- ft
Casing Material	stainless steel	Grout Material	bentonite chips
Screen Type	stainless steel	Grout Depth	from 2 to 3 ft
Screen Slot	0.010	Surface Completion	flush mount vault .
Screen Length	2 2/3 ft	Drilling Method	CPT
Screen Depth	from 23.6 to 26.2 ft	Driller	John Hoggatt

Lithologic Description	**Depth**	**Sample**	**USCS**	**Well**	**Other**
saw 2” asphalt, post hole loose tan sands	0-6	---	---		PVC riser
direct push, no sampling	6-26.8	---	---		
					2 2/3 ft screen
					6 7/8 in. tip



Logged by: J Sminchak

Completion Date: 3/8/99

Construction Notes:

Battelle
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LC34 IDC Coring Logsheet

Boring ID **PA-7D**

Date 3/5/99

Location LC34, ESB

Boring Diameter	2 3/8 in	Total Depth	45.5 ft
Casing Outer Diameter	2 3/8 in	Sand Pack	---
Casing Inner Diameter	1 7/8 in	Sand Pack Depth	from --- to --- ft
Casing Material	stainless steel	Grout Material	bentonite chips
Screen Type	stainless steel	Grout Depth	from 2 to 3 ft
Screen Slot	0.010	Surface Completion	flush mount vault
Screen Length	2 2/3 ft	Drilling Method	CPT
Screen Depth	from 41.3 to 43.9 ft	Driller	John Hoggatt

Lithologic Description	**Depth**	**Sample**	**USCS**	**Well**	**Other**
saw 2 " asphalt, post hole soil, loose tan sands	0-5	---	---		PVC riser
direct push, no sampling, continue from PA-7S	5-23	---	---		
fine gray sand, w/ some silts and trace of shell material	23-23.7	PA-6D-16.5	SP		
fine gray silty sand 10% shell material	23.7-24.5	PA-6D-18.5	SP		
shelly fine gray sand	25-25.2	PA-6D-20.5	SP		
fine gray sand, trace shell frags, well sorted	25.2-26.1		SP		
sandy gray silt, trace shell frags	26.1-26.3	PA-6D-22.5	SP		
silty fine gray sand, trace shell frags	27-28.5		SM		
fine gray sand, 5% shells, well sorted	29-29.5	---	---		
silty fine gray sand, trace of shell fragments	29.5-30.5	PA-6D-26.5	SM		

Logged by: J Sminchak

Completion Date: 3/5/99

Construction Notes: ______

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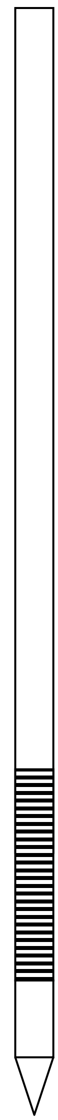
LC34 IDC Coring Logsheet

Boring ID PA-7D

Date 3/5/99

Location LC34 ESB

Lithologic Description	Depth	Sample	USCS	Well	Water Level	Other
silty fine gray sand, trace of shell fragments	31-31.2	PA-7D-32.5	SM			
abundant shells + fragments with silty gray fine sand	31.2-32.5		GM-SM			
abundant coarse shells + frag with fine sand, some silts	33-33.6	PA-7D-34.5	GM			
silty fine gray sand, trace shell frags	33.6-34.5		SM			
shell frags in silty clay matrix (very slight to no stiffness)	35-35.7	PA7D-36.5	SC			
shell fragments in clayey matirx, low plasticity	35.7-36.5		SC			
light gray fine sand, trace shells	37.5-38.5	PA7D-38.5	SP			
abundant shells (70%) in silty fine gray sand matrix	39-39.8	PA7D-40.5	SP-GM			
gray silty fine sand, trace shells (10-15%)	39.8-40.5		SP-GM			
yellowish brown tan fine sand, trace shells	41-41.7	PA7D-42.5	SP			
gray fine to med sand, trace shells	41.7-42.5		SP			2 2/3 ft screen
clayey sand, some stiffness, silty	44 – 44.5	PA7D-45.5	SC			
sandy gray clay, med plasticity	44.5-45.5		CL			1 ft sump 6 7/8 in. tip

LC34 IDC Coring Logsheet

Boring ID PA-8S

Date 3/3/99

Location LC34, ESB

Boring Diameter	2 3/8 in	Total Depth	20 ft
Casing Outer Diameter	2 3/8 in	Sand Pack	---
Casing Inner Diameter	1 7/8 in	Sand Pack Depth	from --- to --- ft
Casing Material	stainless steel	Grout Material	bentonite chips
Screen Type	stainless steel	Grout Depth	from 2 to 3 ft
Screen Slot	0.010	Surface Completion	flush mount vault
Screen Length	2 2/3 ft	Drilling Method	CPT
Screen Depth	from 15.8 to 18.4 ft	Driller	John Hoggatt

Lithologic Description	Depth	Sample	USCS	Well	Other
Post hole loose tan sands	0-6	---	---		PVC riser
No sampling, direct push.	4-20	---	---		
					2 2/3 ft screen
					1ft sump 6 7/8 in. tip

Logged by: J Sminchak

Completion Date: 3/3/99

Construction Notes: ______________________

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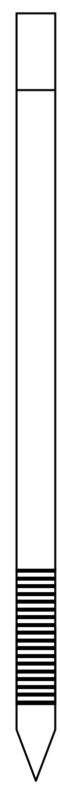
LC34 IDC Coring Logsheet

Boring ID **PA-8I**

Date 3/8/99

Location LC34, ESB

Boring Diameter	2 3/8 in	Total Depth	26.8 ft
Casing Outer Diameter	2 3/8 in	Sand Pack	---
Casing Inner Diameter	1 7/8 in	Sand Pack Depth	from --- to --- ft
Casing Material	stainless steel	Grout Material	bentonite chips
Screen Type	stainless steel	Grout Depth	from 2 to 3 ft
Screen Slot	0.010	Surface Completion	flush mount vault .
Screen Length	2 2/3 ft	Drilling Method	CPT
Screen Depth	from 23.6 to 26.2 ft	Driller	John Hoggatt

Lithologic Description	**Depth**	**Sample**	**USCS**	**Well**	**Other**
saw 2” asphalt, post hole loose tan sands	0-6	---	---		PVC riser
direct push, no sampling	6-26.8	---	---		
					2 2/3 ft screen
					6 7/8 in. tip

Logged by: J Sminchak

Completion Date: 3/8/99

Construction Notes: .

LC34 IDC Coring Logsheet

Boring ID **PA-8D**

Date 3/4/99

Location LC34, ESB

Boring Diameter	2 3/8 in	Total Depth	46.5 ft
Casing Outer Diameter	2 3/8 in	Sand Pack	---
Casing Inner Diameter	1 7/8 in	Sand Pack Depth	from --- to --- ft
Casing Material	stainless steel	Grout Material	bentonite chips
Screen Type	stainless steel	Grout Depth	from 2 to 3 ft
Screen Slot	0.010	Surface Completion	flush mount vault
Screen Length	2 2/3 ft	Drilling Method	CPT
Screen Depth	from 42.3 to 44.9 ft	Driller	John Hoggatt

Lithologic Description	Depth	Sample	USCS	Well	Other
saw 2 " asphalt, post hole soil, loose tan sands	0-6	---	---		PVC riser
direct push, no sampling	6-15	---	---		
fine gray sand, well sorted, trace of shell frags	15-16.5	PA-8D-16.5	SP		
coarse shell fragments (90%) and fine gray sand trace silt	17-18.5	PA-7D-18.5	SP-GM		
fine gray sand, well sorted, 5-10% shell frags.	19-20.5	PA-8D-20.5	SP		
silty fine gray sand, 5-10% shell frags	21-22.5	PA-8D-22.5	SP		
yellowish brown fine sand and shell fragments	23.5-24.3	PA-8D-24.5	SP		
clayey gray silt with some fine sand	24.3-24.5		SM		
silty fine gray sand with 5% shells	25-26.5	PA-8D-26.5	SM		
silty fine gray sand with 5% shells	27-28.3	PA-8D-28.5	SM		

Logged by: J Sminchak

Completion Date: 3/4/99

Construction Notes:

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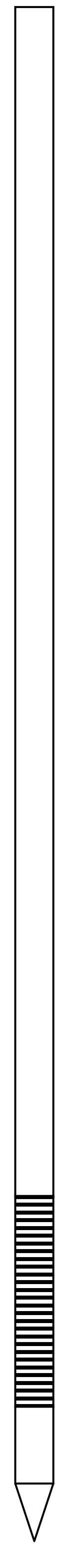
LC34 IDC Coring Logsheet

Boring ID PA-8D

Date 3/4/99

Location LC34 ESB

Lithologic Description	Depth	Sample	USCS	Well	Water Level	Other
sandy silty gray clay	28.3-28.5	PA-8D-28.5	SC			
sandy silty gray clay	29-29.3	PA-8D-30.5	SC			
clayey-silty fine sand with some shell frags (5%)	29.3-30.5		SM			
silty fine gray sand	31-31.1	PA-8D-32.5	SM			
abundant shells w/ silty fine gray sand	31.1-31.3		SP-GM			
mostly shells/fragments with in silty fine gray sands (30-40%)	31.3-32.5		SP			
silty fine gray sand with 20% coarse shell frag	33-33.4	PA-8D-34.5	SP-GM			
mostly shells with silty fine gray sand	33.4-33.8		SP			
gray silty fine sand with trace shell frags	33.8-34.5		SP-GM			
silty-clayey fine sand, trace shells	35-35.6	PA-8D-36.5	SP			
silty clayey fine sand wi 10-20% shells +fragments	35.6-36.5		SM			
shells, shell frags in silty clayey matirx	37-38.5	PA-8D-38.5	SM			
fine gray to brown sand, trace of shell fragments	39-39.7	PA-8D-40.5	GM			
silty clayey fine sand w/ 10-20% shells	39.7-40.3		SP			
sandy-silty clay	40.3-40.5		SP-SM			
silty clayey fine sand w/ 30% shells + shell frags	41-42.5	PA-8D-42.5	SC			
gray silty sand with 20-30% shell frags	43-44	PA-8D-44.5	SM			2 2/3 ft screen
clayey sitl and fine sand	44-44.5	PA-8D-44.5	SM			
sandy gray clay, med-low plasticity	44.7-45.7	PA-8D-45.7	CL			1 ft sump
						6 7/8 in. tip



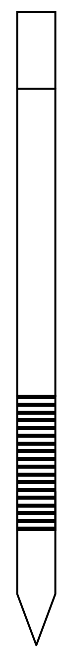
LC34 IDC Coring Logsheet

Boring ID __PA-9S__

Date __3/8/99__

Location __LC34, ESB__

Boring Diameter	2 3/8 in	Total Depth	22.7 ft
Casing Outer Diameter	2 3/8 in	Sand Pack	---
Casing Inner Diameter	1 7/8 in	Sand Pack Depth	from --- to --- ft
Casing Material	stainless steel	Grout Material	bentonite chips
Screen Type	stainless steel	Grout Depth	from 2 to 3 ft
Screen Slot	0.010	Surface Completion	flush mount vault
Screen Length	2 2/3 ft	Drilling Method	CPT
Screen Depth	from 18.5 to 21.1 ft	Driller	John Hoggatt

Lithologic Description	**Depth**	**Sample**	**USCS**	**Well**	**Other**
Post hole soil, loose tan sands	0-6	---	---		PVC riser
No sampling, direct push.	6-22.7	---	---		
					2 2/3 ft screen
					1ft sump 6 7/8 in. tip

Logged by: __J Sminchak__

Completion Date: __3/8/99__

Construction Notes: ____________________

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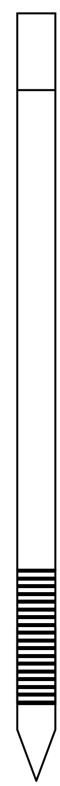
LC34 IDC Coring Logsheet

Boring ID **PA-9I**

Date 3/8/99

Location LC34, ESB

Boring Diameter	2 3/8 in	Total Depth	26.8 ft
Casing Outer Diameter	2 3/8 in	Sand Pack	---
Casing Inner Diameter	1 7/8 in	Sand Pack Depth	from --- to --- ft
Casing Material	stainless steel	Grout Material	bentonite chips
Screen Type	stainless steel	Grout Depth	from 2 to 3 ft
Screen Slot	0.010	Surface Completion	flush mount vault .
Screen Length	2 2/3 ft	Drilling Method	CPT
Screen Depth	from 23.6 to 26.2 ft	Driller	John Hoggatt

Lithologic Description	**Depth**	**Sample**	**USCS**	**Well**	**Other**
saw 2" asphalt, post hole loose tan sands	0-6	---	---		PVC riser
direct push, no sampling	6-26.8	---	---		
					2 2/3 ft screen
					6 7/8 in. tip

Logged by: J Sminchak

Completion Date: 3/8/99

Construction Notes:

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LC34 IDC Coring Logsheet

Boring ID **PA-9D**

Date 3/6/99

Location LC34, ESB

Boring Diameter	2 3/8 in	Total Depth	45 ft
Casing Outer Diameter	2 3/8 in	Sand Pack	---
Casing Inner Diameter	1 7/8 in	Sand Pack Depth	from --- to --- ft
Casing Material	stainless steel	Grout Material	bentonite chips
Screen Type	stainless steel	Grout Depth	from 2 to 3 ft
Screen Slot	0.010	Surface Completion	flush mount vault
Screen Length	2 2/3 ft	Drilling Method	CPT
Screen Depth	from 41.8 to 44.4 ft	Driller	John Hoggatt

Lithologic Description	Depth	Sample	USCS	Well	Other
post hole soil, loose tan sands	0-6	---	---		PVC riser
direct push, no sampling	6-15	---	---		
coarse shell fragments and coarse gray sand	15-16.5	PA-9D-16.5	SP		
fine gray sand, trace shell frags, well sorted	17-18.5	PA-9D-18.5	SP-GM		
fine gray sand, well sorted, trace shell frags.	19-20.5	PA-9D-20.5	SP		
fine gray sand, well sorted, trace shell frags.	21-22.5	PA-9D-22.5	SP		
fine gray sand, well sorted, trace shell frags.	23-24.5	PA-9D-24.5	SP		
light gray fine to med sand and 5-10% shell frags	25-25.4	PA-9D-26.5	SM		
light gray fine to med. sand w/ abundant shells + frags (30-50%)	25.4-25.9		SM		
light gray fine silty sand, trace shell frags	25.9-26.5		SM		

Logged by: J Sminchak

Completion Date: 3/6/99

Construction Notes:

Battelle . . . Putting Technology To Work

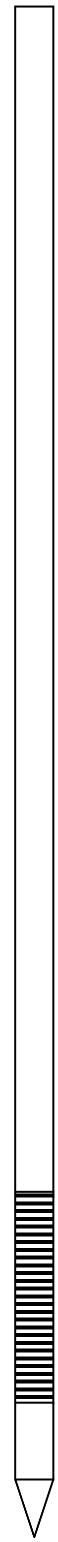
LC34 IDC Coring Logsheet

Boring ID PA-9D

Date 3/6/99

Location LC34 ESB

Lithologic Description	Depth	Sample	USCS	Well	Water Level	Other
silty gray fine sand, trace of shells	27-28.5	PA-9D-28.5	SM			
silty gray fine sand, trace of shells	29-30.5	PA-9D-30.5	SM			
silty clayey fine sand w/ 30% shells	31-31.7	PA-9D-32.5	SM			
mostly shells in a silty fine sand matrix	31.7-32.5		GM			
silty fine sand, trace shells	33-33.5	PA-9D-34.5	SM			
abundant shells in silty fine gray sand matrix	33.5-34		SM-GM			
silty clayey fine gray sand with 20-30% shells	34-34.5		SM			
abundant shells (75%) in a silty matrix w/ fine sand	35-36.5	PA-9D-36.5	GM			
gray clay, trace sands	37-37.5	PA-9D-38.5	CL			
gray sandy silt with 10-20% shells	37.5-37.9		SM			
silty fine sand well sorted	37.9-38.5		SP-SM			
silty fine sand well sorted	39-39.8	PA-8D-40.5	SP-SM			
gray silt with shells 30-40%	39.8-40.2		GM-SM			
sandy clay with 10% shells	40.2-40.5		SC-CL			
silty fine sand, trace shells	42-42.9	PA-9D-43.5	SP-SM			
abundant shells + shell frags (70%) w/ silty fine sand	42.9-43.5		GM			
sandy clay, trace shells	44-45	PA-9D-45.5	CL			2 2/3 ft screen
shells in silty fine sand matrix	45-45.2		GM			
sandy gray clay, low plasticity	45.2-45.5		SC			1 ft sump 6 7/8 in. tip



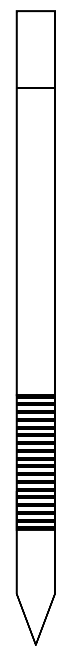
LC34 IDC Coring Logsheet

Boring ID PA-10S

Date 3/18/99

Location LC34, ESB

Boring Diameter	3 1/2 in	Total Depth	22.5 ft
Casing Outer Diameter	2 3/8 in	Sand Pack	---
Casing Inner Diameter	1 7/8 in	Sand Pack Depth	from --- to --- ft
Casing Material	stainless steel	Grout Material	bentonite
Screen Type	stainless steel	Grout Depth	from ____ to ____ ft
Screen Slot	0.010	Surface Completion	flush mount vault
Screen Length	3 ft	Drilling Method	pneumatic hammer
Screen Depth	from 18 to 21 ft	Driller	Rob Hancock (PSI)

Lithologic Description	Depth	Sample	USCS	Well	Other
cement saw 8" concrete, hand-auger loose tan sands	0-6	---	---		PVC riser
No sampling, direct push.	6-22.5	---	---		
					3 ft screen
					1.5 ft sump and tip

Logged by: J Sminchak

Completion Date: 3/18/99

Construction Notes: push sacrificial tip and 3 ½ diameter sections, insert well in hole and let sands collapse

Battelle
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LC34 IDC Coring Logsheet

Date 3/18/99

Boring ID **PA-10I**

Location LC34, ESB

Boring Diameter 3 1/2 in

Casing Outer Diameter 2 3/8 in

Casing Inner Diameter 1 7/8 in

Casing Material stainless steel

Screen Type stainless steel

Screen Slot 0.010

Screen Length 3 ft

Screen Depth from 23.5 to 26.5 ft

Total Depth 28 ft

Sand Pack ---

Sand Pack Depth from --- to --- ft

Grout Material bentonite

Grout Depth from ______ to ______ ft

Surface Completion flush mount vault

Drilling Method pneumatic hammer

Driller Rob Hancock (PSI)

Lithologic Description	**Depth**	**Sample**	**USCS**	**Well**	**Other**
cement drill 8" concrete, hand-auger loose tan sands	0-6	---	---		PVC riser
No sampling, direct push.	6-28	---	---		
					3 ft screen
					1.5 ft sump and tip

Logged by: J Sminchak

Completion Date: 3/18/99

Construction Notes: push rate increases after 22.5 ft

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LC34 IDC Coring Logsheet

Boring ID PA-10D

Date 3/18/99

Location LC34, ESB

Boring Diameter	3 1/2 in	Total Depth	45 ft
Casing Outer Diameter	2 3/8 in	Sand Pack	---
Casing Inner Diameter	1 7/8 in	Sand Pack Depth	from --- to --- ft
Casing Material	stainless steel	Grout Material	bentonite chips
Screen Type	stainless steel	Grout Depth	from --- to --- ft
Screen Slot	0.010	Surface Completion	flush mount vault
Screen Length	3 ft	Drilling Method	Pnuematic Hammer
Screen Depth	from 40.5 to 43.5 ft	Driller	Rob Hancock (PSI)

Lithologic Description	Depth	Sample	USCS	Well	Other
cement drill 8", hand auger loose tan sands	0-6	---	---		PVC riser
direct push, no sampling	6-15	---	---		
no recovery	15-17	---	---		
no recovery	17-18.5	---	---		
silty fine gray sand, trace (5-10%) shell frags.	19-20.5	PA-10D-23.5	SP		
silty fine gray sand, trace (5-10%) shell frags.	21-22.5	PA-10D-25	SP		
silty fine gray sand, trace (5-10%) shell frags.	23-24.5	PA-10D-26.5	SP		
silty fine gray sand, trace (5-10%) shell frags.	25-25.4	PA-10D-28	SP		
skip two ft to prevent sluff from entering sampler	25.4-25.9	---	---		
coarse shell frags (70%) in silty fine gray sand matrix	25.9-26.5	PA-10D-31.5	SP-GM		

Logged by: J Sminchak

Completion Date: 3/25/99

Construction Notes: DI water added to offset heaving sands during soil sampling, switch to 6' sampling method after 22' bgs

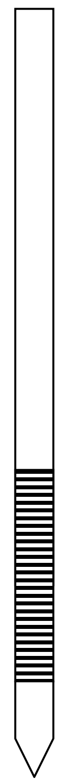
Battelle . . . Putting Technology To Work

LC34 IDC Coring Logsheet

Boring ID PA-10D

Date 3/18/99

Location LC34 ESB



Lithologic Description	Depth	Sample	USCS	Well	Water Level	Other
abundant whole shells (70%) in silty fine sand matrix	31-32.5	PA-10D-33	SP-GM			
abundant whole shells (70%) in silty fine sand matrix	32.5-34	PA-10D-34.5	SP-GM			
abundant whole shells (70%) in silty fine sand matrix	34-36	PA-10D-36	SP-GM			
---	---	---	---			
skip two ft	---	---	---			
coarse shell frags (75%) in gray silty sand matrix	38-39	PA-10D-38.5	SP-GM			
silty-clayey fine gray sand with 30% shells (slight stiffness)	39-40	PA-10-41	SP-SM			
abundant shells in gray fine sand	40-42.5	PA-10D-42.5	SP-GM			3 ft screen
sampler jammed, no further recovery	---	---	---			
						1.5 ft sump and tip

LC34 IDC Coring Logsheet

Boring ID **PA-11S**

Date 3/19/99

Location LC34, ESB

Boring Diameter	3 1/2 in	Total Depth	22.5 ft
Casing Outer Diameter	2 3/8 in	Sand Pack	---
Casing Inner Diameter	1 7/8 in	Sand Pack Depth	from --- to --- ft
Casing Material	stainless steel	Grout Material	bentonite
Screen Type	stainless steel	Grout Depth	from ______ to ______ ft
Screen Slot	0.010	Surface Completion	flush mount vault
Screen Length	3 ft	Drilling Method	pneumatic hammer
Screen Depth	from 18 to 21 ft	Driller	Rob Hancock (PSI)

Lithologic Description	Depth	Sample	USCS	Well	Other
cement drill 8” cement, hand-auger loose tan sands	0-6	---	---		PVC riser
No sampling, direct push.	6-22.5	---	---		
					3 ft screen
					1.5 ft sump and tip

Logged by: J Sminchak

Completion Date: 3/19/99

Construction Notes: ______________________

LC34 IDC Coring Logsheet

Boring ID **PA-11I**

Date 3/19/99

Location LC34, ESB

Boring Diameter	3 1/2 in	Total Depth	28 ft
Casing Outer Diameter	2 3/8 in	Sand Pack	---
Casing Inner Diameter	1 7/8 in	Sand Pack Depth	from --- to --- ft
Casing Material	stainless steel	Grout Material	bentonite
Screen Type	stainless steel	Grout Depth	from ______ to ______ ft
Screen Slot	0.010	Surface Completion	flush mount vault
Screen Length	3 ft	Drilling Method	pneumatic hammer
Screen Depth	from 23.5 to 26.5 ft	Driller	Rob Hancock (PSI)

Lithologic Description	**Depth**	**Sample**	**USCS**	**Well**	**Other**
cement saw 8” concrete, hand-auger loose tan sands	0-6	---	---		PVC riser
No sampling, direct push.	6-28	---	---		
					3 ft screen
					1.5 ft sump and tip

Logged by: J Sminchak

Completion Date: 3/19/99

Construction Notes: middle indoor well cluster

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LC34 IDC Coring Logsheet

Date 3/20/99

Boring ID **PA-11D**

Location LC34, ESB

Boring Diameter	3 1/2 in	Total Depth	45 ft
Casing Outer Diameter	2 3/8 in	Sand Pack	---
Casing Inner Diameter	1 7/8 in	Sand Pack Depth	from --- to --- ft
Casing Material	stainless steel	Grout Material	bentonite chips
Screen Type	stainless steel	Grout Depth	from --- to --- ft
Screen Slot	0.010	Surface Completion	flush mount vault
Screen Length	3 ft	Drilling Method	Pnuematic Hammer
Screen Depth	from 41.0 to 43.5 ft	Driller	Rob Hancock (PSI)

Lithologic Description	**Depth**	**Sample**	**USCS**	**Well**	**Other**
cement drill 8", hand auger loose tan sands	0-6	---	---		PVC riser
direct push, no sampling	6-15	---	---		
no recovery	15-17.5	---	---		
no recovery	17.5-19.0	PA-11D-19	SP		
silty fine gray sand, trace (5-10%) shell frags.	19.5-22	---	---		
silty fine gray sand, trace (5-10%) shell frags.	22-23.5	PA-11D-23.5	SP		
silty fine gray sand, trace (5-10%) shell frags.	23-24.5	PA-11D-25	SP		
silty fine gray sand, trace (5-10%) shell frags.	24.5-26.5	PA-11D-26.5	SP-SM		
skip two ft to prevent sluff from entering sampler	26.5-28.0	PA-11D-28	SP		
coarse shell frags (70%) in silty fine gray sand matrix	29-30.5	PA-11D-29	SM		

Logged by: J Sminchak

Completion Date: 3/25/99

Construction Notes: DI water added to offset heaving sands during soil sampling, switch to 6' sampling method after 22' bgs

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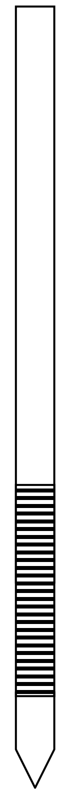
LC34 IDC Coring Logsheet

Boring ID PA-11D

Date 3/20/99

Location LC34 ESB

Lithologic Description	Depth	Sample	USCS	Well	Water Level	Other
coarse grained shell frags (90%) w/ fine gray sand	30.5-31.2	PA-11D-30.5	GP			
silty fine gray sand, some clay and shell frags	31.2-32.1	PA-11D-32	SM			
abundant shells in silty fine gray sand matrix	32.1-32.6	PA-11D-33.5	SP-GM			
silty fine gray sand, some clay 5% ans 10-30% shells	32.6-32.9	PA-11D-35	SM			
abundant shells in silty fine gray sand matrix	32.9-33.5	PA-11D-35	SP			
silty fine gray sand w/ 30-50% shell frags (coarse)	33.5-35	PA-11D-35	SP-GM			
silty fine gray sand, wet, trace shells	35-35.5	PA-11-35.5	SP			
shell hach (5% silty fine gray sand)	35.5-37	PA-11D-37	SP-GM			3 ft screen
sampler jammed, no further recovery	---	---	---			1.5 ft sump and tip



LC34 IDC Coring Logsheet

Date 3/21/99

Boring ID **PA-12S**

Location LC34, ESB

Boring Diameter	3 1/2 in	Total Depth	22.5 ft
Casing Outer Diameter	2 3/8 in	Sand Pack	---
Casing Inner Diameter	1 7/8 in	Sand Pack Depth	from --- to --- ft
Casing Material	stainless steel	Grout Material	bentonite
Screen Type	stainless steel	Grout Depth	from ____ to ____ ft
Screen Slot	0.010	Surface Completion	flush mount vault
Screen Length	3 ft	Drilling Method	pneumatic hammer
Screen Depth	from 18 to 21 ft	Driller	Rob Hancock (PSI)

Lithologic Description	**Depth**	**Sample**	**USCS**	**Well**	**Other**
cement drill 8" concrete, hand auger loose tan to brown sands	0-6	---	---		PVC riser
No sampling, direct push.	6-22.5	---	---		
					2 2/3 ft screen
					1.5 ft sump and tip

Logged by: J Sminchak

Completion Date: 3/21/99

Construction Notes: ______________________________

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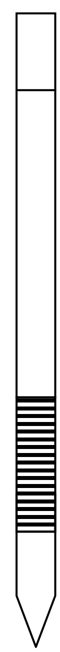
LC34 IDC Coring Logsheet

Boring ID **PA-12I**

Date 3/21/99

Location LC34, ESB

Boring Diameter	3 1/2 in	Total Depth	28.5 ft
Casing Outer Diameter	2 3/8 in	Sand Pack	---
Casing Inner Diameter	1 7/8 in	Sand Pack Depth	from --- to --- ft
Casing Material	stainless steel	Grout Material	bentonite
Screen Type	stainless steel	Grout Depth	from ____ to ____ ft
Screen Slot	0.010	Surface Completion	flush mount vault
Screen Length	3 ft	Drilling Method	pneumatic hammer
Screen Depth	from 24 to 27 ft	Driller	Rob Hancock (PSI)

Lithologic Description	**Depth**	**Sample**	**USCS**	**Well**	**Other**
cement drill 8" concrete, hand-auger loose tan sands	0-6	---	---		PVC riser
No sampling, direct push.	6-28.5	---	---		
					3 ft screen
					1.5 ft sump and tip

Logged by: J Sminchak

Completion Date: 3/21/99

Construction Notes: sand heave forces well from 30' to 28.5' during well placement

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LC34 IDC Coring Logsheet

Boring ID **PA-12D**

Date 3/22/99

Location LC34, ESB

Boring Diameter	3 1/2 in	Total Depth	45 ft
Casing Outer Diameter	2 3/8 in	Sand Pack	---
Casing Inner Diameter	1 7/8 in	Sand Pack Depth	from --- to --- ft
Casing Material	stainless steel	Grout Material	bentonite chips
Screen Type	stainless steel	Grout Depth	from --- to --- ft
Screen Slot	0.010	Surface Completion	flush mount vault
Screen Length	3 ft	Drilling Method	Pnuematic Hammer
Screen Depth	from 40.5 to 43.5 ft	Driller	Rob Hancock (PSI)

Lithologic Description	Depth	Sample	USCS	Well	Other
cement drill 8", hand auger loose tan sands	0-6	---	---		PVC riser
direct push, no sampling	6-15	---	---		
tan to yellowish brown fine sand well sorted, some gray fine sands	15.5-17	PA-12D-17.5	SP		
fine gray fine sand, 10-15% shells	17.5-18.2	PA-12D-20	SP		
fine to med. gray sand, 10-25% shell frags	18.2-19	PA-12D-20	SP		
fine gray sand well sorted, trace silt and shell frags	19.5-20.5	PA-12D-21	SP		
fine to med. gray sand, 10-25% shell frags	20.5-21	PA-12D-21	SP		
fine to med. gray sand, 10-25% shell frags	21.5-23	PA-12D-23	SP		
fine gray sand, wet, well sorted, trace shells	23.5-25	PA-12D-25	SP		
fine gray silty sand w/ trace of shell frags (<10% silt)	25.5-27	PA-12D-27	SP		

Logged by: J Sminchak

Completion Date: 3/23/99

Construction Notes: start w/ 2 ft pin-point sampler on 3/22 to 31' bgs, swithc to 6 ft core barrel sampler on 3/23

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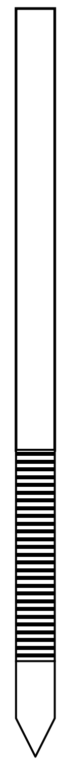
LC34 IDC Coring Logsheet

Date 3/22/99

Boring ID PA-12D

Location LC34 ESB

Lithologic Description	Depth	Sample	USCS	Well	Water Level	Other
silty fine gray sand, trace shells (10-20% silt)	27.5-29	PA-12D-29	SM			
silty fine gray sand, 30-50% shell frags	32-34	PA-12D-33.5	SM			
silty fine gray sand, some shell frags <10%	34-35	PA-12D-35	SM			
abundant shells w/ silty fine sand (10-20%)	35-36.5	PA-12D-36.5	GM			
silty gray fine sand, w/some clay + shells	36.5-38	PA-12D-38	SM			
overpush no sample	---	---	---			
silty fine gray sand, trace shells	41-42	PA-12D-42.5	SP-SM			
ssilty fine gray sand with 20-40% shells	42-44	PA-12D-44	SM			3 ft screen
abundant shells in silty fine gray sand (30-40%)	44-44.5	PA-12D-44.5	GM			
						1.5 ft sump and tip



LC34 IDC Coring Logsheet

Boring ID **PA-13S**

Date 7/13/99

Location LC34

Boring Diameter	2 1/2 in	Total Depth	24.5 ft
Casing Outer Diameter	2 1/2 in	Sand Pack	---
Casing Inner Diameter	2 in	Sand Pack Depth	from --- to --- ft
Casing Material	stainless steel	Grout Material	bentonite
Screen Type	stainless steel, slotted	Grout Depth	from 0 to 2 ft
Screen Slot	0.010	Surface Completion	flush mount vault
Screen Length	3 ft	Drilling Method	CPT
Screen Depth	from 21 to 24 ft	Driller	R. Aguilar

Lithologic Description	Depth	Sample	USCS	Well	Other
No sampling, direct push.	0-24.5	---	---		PVC riser 3 ft screen 6 in. tip

Logged by: L. Cumming

Completion Date: 7/13/99

Construction Notes:

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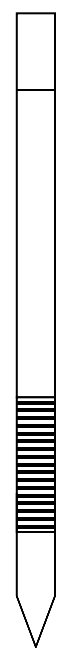
LC34 IDC Coring Logsheet

Boring ID **PA-13I**

Date 7/13/99

Location LC34

Boring Diameter	2 1/2 in	Total Depth	28.5 ft
Casing Outer Diameter	2 1/2 in	Sand Pack	---
Casing Inner Diameter	2 in	Sand Pack Depth	from --- to --- ft
Casing Material	stainless steel	Grout Material	bentonite
Screen Type	stainless steel, slotted	Grout Depth	from 0 to 2 ft
Screen Slot	0.010	Surface Completion	flush mount vault
Screen Length	3 ft	Drilling Method	CPT
Screen Depth	from 25 to 28 ft	Driller	R. Aguilar

Lithologic Description	**Depth**	**Sample**	**USCS**	**Well**	**Other**
					PVC riser
No sampling, direct push.	0-28.5	---	---		
					3 ft screen
					6 in. tip

Logged by: L. Cumming

Completion Date: 7/13/99

Construction Notes:

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LC34 IDC Coring Logsheet

Boring ID: PA-13D
Date: 7/12/99
Location: LC34

Boring Diameter	2 1/2 in	Total Depth	44.5 ft
Casing Outer Diameter	2 1/2 in	Sand Pack	---
Casing Inner Diameter	2 in	Sand Pack Depth	from --- to --- ft
Casing Material	stainless steel	Grout Material	bentonite
Screen Type	stainless steel, slotted	Grout Depth	from 0 to 2 ft
Screen Slot	0.010	Surface Completion	flush mount vault
Screen Length	3 ft	Drilling Method	CPT
Screen Depth	from 41 to 44 ft	Driller	R. Aguilar

Lithologic Description	Depth	Sample	USCS	Well	Other
					PVC riser
No sampling, direct push.	0-44.5	---	---		
					3 ft screen
					6 in. tip

Logged by: L. Cumming
Completion Date: 7/12/99
Construction Notes:

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LC34 IDC Coring Logsheet

Boring ID **PA-14S**

Date 7/13/99

Location LC34

Boring Diameter	2 1/2 in	Total Depth	24.5 ft
Casing Outer Diameter	2 1/2 in	Sand Pack	---
Casing Inner Diameter	2 in	Sand Pack Depth	from --- to --- ft
Casing Material	stainless steel	Grout Material	bentonite
Screen Type	stainless steel, slotted	Grout Depth	from 0 to 2 ft
Screen Slot	0.010	Surface Completion	flush mount vault
Screen Length	3 ft	Drilling Method	CPT
Screen Depth	from 21 to 24 ft	Driller	R. Aguilar

Lithologic Description	**Depth**	**Sample**	**USCS**	**Well**	**Other**
No sampling, direct push.	0-24.5	---	---		PVC riser 3 ft screen 6 in. tip

Logged by: L. Cumming

Completion Date: 7/13/99

Construction Notes:

Battelle
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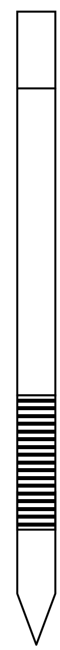
LC34 IDC Coring Logsheet

Boring ID **PA-14I**

Date 7/13/99

Location LC34

Boring Diameter	2 1/2 in	Total Depth	28.5 ft
Casing Outer Diameter	2 1/2 in	Sand Pack	---
Casing Inner Diameter	2 in	Sand Pack Depth	from --- to --- ft
Casing Material	stainless steel	Grout Material	bentonite
Screen Type	stainless steel, slotted	Grout Depth	from 0 to 2 ft
Screen Slot	0.010	Surface Completion	flush mount vault
Screen Length	3 ft	Drilling Method	CPT
Screen Depth	from 25 to 28 ft	Driller	R. Aguilar

Lithologic Description	Depth	Sample	USCS	Well	Other
					PVC riser
No sampling, direct push.	0-28.5	---	---		
					3 ft screen
					6 in. tip

Logged by: L. Cumming

Completion Date: 7/13/99

Construction Notes:

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LC34 IDC Coring Logsheet

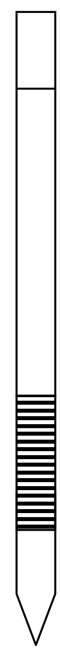
Boring ID **PA-14D**

Date 7/13/99

Location LC34

Boring Diameter	2 1/2 in	Total Depth	44.5 ft
Casing Outer Diameter	2 1/2 in	Sand Pack	---
Casing Inner Diameter	2 in	Sand Pack Depth	from --- to --- ft
Casing Material	stainless steel	Grout Material	bentonite
Screen Type	stainless steel, slotted	Grout Depth	from 0 to 2 ft
Screen Slot	0.010	Surface Completion	flush mount vault
Screen Length	3 ft	Drilling Method	CPT
Screen Depth	from 41 to 44 ft	Driller	R. Aguilar

Lithologic Description	**Depth**	**Sample**	**USCS**	**Well**	**Other**
					PVC riser
No sampling, direct push.	0-44.5	---	---		
					3 ft screen
					6 in. tip



Logged by: L. Cumming

Completion Date: 7/13/99

Construction Notes:

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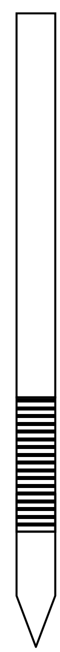
LC34 IDC Coring Logsheet

Boring ID **PA-15S**

Date 8/15/99

Location LC34

Boring Diameter	2 1/2 in	Total Depth	15.5 ft
Casing Outer Diameter	2 1/3 in	Sand Pack	---
Casing Inner Diameter	2 in	Sand Pack Depth	from --- to --- ft
Casing Material	stainless steel	Grout Material	bentonite
Screen Type	stainless steel, slotted	Grout Depth	from 0 to 2 ft
Screen Slot	0.010	Surface Completion	flush mount vault
Screen Length	3 ft	Drilling Method	Direct Push
Screen Depth	from 10 to 15 ft	Driller	

Lithologic Description	**Depth**	**Sample**	**USCS**	**Well**	**Other**
No sampling, direct push.	0-15	---	---		3 ft screen 6 in. tip

Logged by:

Completion Date: 8/15/99

Construction Notes:

Battelle
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LC34 IDC Coring Logsheet

Boring ID PA-16S

Date 5/26/00

Location Steam Plot

Boring Diameter	2 1/2 in	Total Depth	24.75 ft
Casing Outer Diameter	2 1/2 in	Sand Pack	---
Casing Inner Diameter	2 in	Sand Pack Depth	from --- to --- ft
Casing Material	stainless steel	Grout Material	bentonite
Screen Type	stainless steel, slotted	Grout Depth	from 0 to 2 ft
Screen Slot	0.010	Surface Completion	flush mount pad
Screen Length	3 ft	Drilling Method	CPT
Screen Depth	from 21 to 24 ft	Driller	Gregg In-Situ

Lithologic Description	Depth	Sample	USCS	Well	Other
Topsoil, loose sand	0-8	---	SP		
Direct push	8-24.75	---	---		
					3 ft screen
					8 in. tip

Logged by: J. Sminchak

Completion Date: 5/26/00

Construction Notes:

Battelle
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LC34 IDC Coring Logsheet

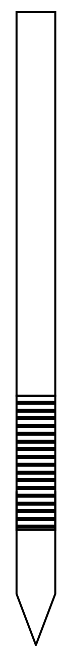
Boring ID **PA-16I**

Date 5/26/00

Location Steam Plot

Boring Diameter	2 1/2 in	Total Depth	28.75 ft
Casing Outer Diameter	2 1/2 in	Sand Pack	---
Casing Inner Diameter	2 in	Sand Pack Depth	from --- to --- ft
Casing Material	stainless steel	Grout Material	bentonite
Screen Type	stainless steel, slotted	Grout Depth	from 0 to 2 ft
Screen Slot	0.010	Surface Completion	flush mount pad
Screen Length	3 ft	Drilling Method	CPT
Screen Depth	from 25 to 28 ft	Driller	Gregg In-Situ

Lithologic Description	Depth	Sample	USCS	Well	Other
Topsoil, loose sand	0-5	---	SP		
Direct push	5-28.75	---	---		
					3 ft screen
					8 in. tip



Logged by: J. Sminchak

Completion Date: 6/2/00

Construction Notes:

Battelle
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LC34 IDC Coring Logsheet

Boring ID **PA-16D**

Date 5/26/00

Location Steam Plot

Boring Diameter	2 1/2 in	Total Depth	45 ft
Casing Outer Diameter	2 1/2 in	Sand Pack	---
Casing Inner Diameter	2 in	Sand Pack Depth	from --- to --- ft
Casing Material	stainless steel	Grout Material	bentonite
Screen Type	stainless steel, slotted	Grout Depth	from 0 to 2 ft
Screen Slot	0.010	Surface Completion	flush mount pad
Screen Length	3 ft	Drilling Method	CPT
Screen Depth	from 41.25 to 44.25 ft	Driller	Gregg In-Situ

Lithologic Description	**Depth**	**Sample**	**USCS**	**Well**	**Other**
Topsoil, loose sand	0-5	---	SP		
Direct push	5-45	---	---		
					3 ft screen
					8 in. tip

Logged by: J. Sminchak

Completion Date: 6/2/00

Construction Notes:

Battelle
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LC34 IDC Coring Logsheet

Date 5/26/00

Boring ID **PA-17S**

Location Steam Plot

Boring Diameter	2 1/2 in	Total Depth	21 ft
Casing Outer Diameter	2 1/2 in	Sand Pack	---
Casing Inner Diameter	2 in	Sand Pack Depth	from --- to --- ft
Casing Material	stainless steel	Grout Material	bentonite
Screen Type	stainless steel, slotted	Grout Depth	from 0 to 2 ft
Screen Slot	0.010	Surface Completion	flush mount pad
Screen Length	3 ft	Drilling Method	CPT
Screen Depth	from 18 to 21 ft	Driller	Gregg In-Situ

Lithologic Description	**Depth**	**Sample**	**USCS**	**Well**	**Other**
Topsoil, loose sand	0-5	---	SP		3 ft screen 8 in. tip
Direct push	5-21	---	---		

Logged by: J. Sminchak

Completion Date: 5/26/00 (8/31/01)

Construction Notes: well casing broken during installation, well not operational, replaced by PSI 8/31/00

Battelle
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LC34 IDC Coring Logsheet

Date 6/2/00

Boring ID **PA-17I**

Location Steam Plot

Boring Diameter	2 1/2 in	Total Depth	28.75 ft
Casing Outer Diameter	2 1/2 in	Sand Pack	---
Casing Inner Diameter	2 in	Sand Pack Depth	from --- to --- ft
Casing Material	stainless steel	Grout Material	bentonite
Screen Type	stainless steel, slotted	Grout Depth	from 0 to 2 ft
Screen Slot	0.010	Surface Completion	flush mount pad
Screen Length	3 ft	Drilling Method	CPT
Screen Depth	from 25 to 28 ft	Driller	Gregg In-Situ

Lithologic Description	**Depth**	**Sample**	**USCS**	**Well**	**Other**
Topsoil, loose sand	0-5	---	SP		
Direct push	5-28.75	---	---		
					3 ft screen
					8 in. tip

Logged by: J. Sminchak

Completion Date: 6/2/00

Construction Notes:

Battelle . . . Putting Technology To Work

LC34 IDC Coring Logsheet

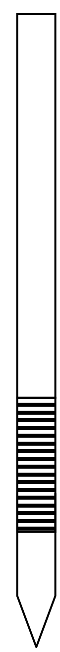
Date 6/2/00

Boring ID **PA-17D**

Location Steam Plot

Boring Diameter	2 1/2 in	Total Depth	45 ft
Casing Outer Diameter	2 1/2 in	Sand Pack	---
Casing Inner Diameter	2 in	Sand Pack Depth	from --- to --- ft
Casing Material	stainless steel	Grout Material	bentonite
Screen Type	stainless steel, slotted	Grout Depth	from 0 to 2 ft
Screen Slot	0.010	Surface Completion	flush mount pad
Screen Length	3 ft	Drilling Method	CPT
Screen Depth	from 41.25 to 44.25 ft	Driller	Gregg In-Situ

Lithologic Description	**Depth**	**Sample**	**USCS**	**Well**	**Other**
Topsoil, loose sand	0-5	---	SP		
Direct push	5-45	---	---		
					3 ft screen
					8 in. tip



Logged by: J. Sminchak

Completion Date: 6/3/00

Construction Notes: ____________________

LC34 IDC Coring Logsheet

Boring ID PA-18S

Date 12/11/00

Location ESB

Boring Diameter	4 in	Total Depth	24 ft
Casing Outer Diameter	2 1/4 in	Sand Pack	---
Casing Inner Diameter	2 in	Sand Pack Depth	from --- to --- ft
Casing Material	stainless steel	Grout Material	cement
Screen Type	stainless steel, slotted	Grout Depth	from 0 to 2 ft
Screen Slot	0.010	Surface Completion	flush
Screen Length	3 ft	Drilling Method	Vibra-Core
Screen Depth	from 21 to 24 ft	Driller	Precision

Lithologic Description	Depth	Sample	USCS	Well	Other
Post-hole, loose tan sand	0-6	---	SP		
Direct push	6-24	---	---		
(pvc riser)					
					3 ft screen

Logged by: J. Sminchak

Completion Date: 12/11/00

Construction Notes:

Battelle
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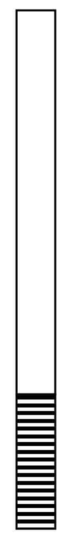
LC34 IDC Coring Logsheet

Boring ID **PA-18I**

Date 12/12/00

Location ESB

Boring Diameter	4 in	Total Depth	28 ft
Casing Outer Diameter	2 1/4 in	Sand Pack	---
Casing Inner Diameter	2 in	Sand Pack Depth	from --- to --- ft
Casing Material	stainless steel	Grout Material	cement
Screen Type	stainless steel, slotted	Grout Depth	from 0 to 2 ft
Screen Slot	0.010	Surface Completion	flush mount
Screen Length	3 ft	Drilling Method	Vibra-Core
Screen Depth	from 25 to 28 ft	Driller	Precision

Lithologic Description	Depth	Sample	USCS	Well	Other
Post-hole, loose tan sand	0-6	---	SP		PVC Riser
Direct push	6-28	---	---		
					3 ft screen

Logged by: J. Sminchak

Completion Date: 12/12/00

Construction Notes:

Battelle . . . Putting Technology To Work

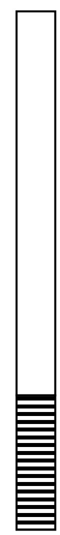
LC34 IDC Coring Logsheet

Boring ID: PA-18D

Date: 12/12/00

Location: ESB

Boring Diameter	4 in	Total Depth	44 ft
Casing Outer Diameter	2 1/4 in	Sand Pack	---
Casing Inner Diameter	2 in	Sand Pack Depth	from --- to --- ft
Casing Material	stainless steel	Grout Material	cement
Screen Type	stainless steel, slotted	Grout Depth	from 0 to 2 ft
Screen Slot	0.010	Surface Completion	flush mount
Screen Length	3 ft	Drilling Method	Vibra-Core
Screen Depth	from 41 to 44 ft	Driller	Precision

Lithologic Description	Depth	Sample	USCS	Well	Other
Post-hole, loose tan sand	0-6	---	SP		PVC Riser
Direct push	6-44	---	---		
					3 ft screen

Logged by: J. Sminchak

Completion Date: 12/12/00

Construction Notes:

Battelle . . . Putting Technology To Work

LC34 IDC Coring Logsheet

Boring ID PA-19S

Date 2/28/01

Location LC34

Boring Diameter	4 in	Total Depth	23 ft
Casing Outer Diameter	2 1/2 in	Sand Pack	---
Casing Inner Diameter	2 in	Sand Pack Depth	from --- to --- ft
Casing Material	stainless steel	Grout Material	cement
Screen Type	stainless steel, slotted	Grout Depth	from 0 to 5 ft
Screen Slot	0.010	Surface Completion	flush vault
Screen Length	3 ft	Drilling Method	Direct Push
Screen Depth	from 20 to 23 ft	Driller	Precision

Lithologic Description	Depth	Sample	USCS	Well	Other
loose tan sand	0-6	---	SP		
Direct push	6-23	---	---		
				3 ft screen

Logged by: J. Sminchak

Completion Date: 2/28/01

Construction Notes:

Battelle
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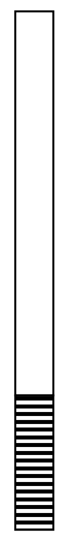
LC34 IDC Coring Logsheet

Boring ID **PA-19I**

Date 2/28/01

Location LC34

Boring Diameter	4 in	Total Depth	28 ft
Casing Outer Diameter	2 1/2 in	Sand Pack	---
Casing Inner Diameter	2 in	Sand Pack Depth	from --- to --- ft
Casing Material	stainless steel	Grout Material	cement
Screen Type	stainless steel, slotted	Grout Depth	from 0 to 5 ft
Screen Slot	0.010	Surface Completion	flush vault
Screen Length	3 ft	Drilling Method	Direct Push
Screen Depth	from 25 to 28 ft	Driller	Precision

Lithologic Description	Depth	Sample	USCS	Well	Other
loose tan sand	0-6	---	SP		
Direct push	6-28	---	---		
					3 ft screen

Logged by: J. Sminchak

Completion Date: 2/28/01

Construction Notes:

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LC34 IDC Coring Logsheet

Boring ID PA-19D

Date 2/28/01

Location LC34

Boring Diameter	4 in	Total Depth	45 ft
Casing Outer Diameter	2 1/2 in	Sand Pack	---
Casing Inner Diameter	2 in	Sand Pack Depth	from --- to --- ft
Casing Material	stainless steel	Grout Material	cement
Screen Type	stainless steel, slotted	Grout Depth	from 0 to 45 ft
Screen Slot	0.010	Surface Completion	flush vault
Screen Length	3 ft	Drilling Method	Direct Push
Screen Depth	from 42 to 45 ft	Driller	Precision

Lithologic Description	Depth	Sample	USCS	Well	Other
loose tan sand	0-6	---	SP		
Direct push	6-45	---	---		
					3 ft screen

Logged by: J. Sminchak

Completion Date: 2/28/01

Construction Notes:

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LC34 IDC Coring Logsheet

Boring ID PA-20

Date 4/9/01

Location Roadway

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Boring Diameter	10 & 5 7/8 in	Total Depth	61 ft
Casing Outer Diameter	6 & 2 in	Sand Pack	20/30
Casing Inner Diameter	in	Sand Pack Depth	from 53 to 61 ft
Casing Material	304 SCH 10 Stainless	Grout Material	type G & silica flour
Screen Type	wirewound 304 Sch 10	Grout Depth	from GS to 51 ft
Screen Slot	0.10	Surface Completion	flush mount vault
Screen Length	5 ft	Drilling Method	mud rotary
Screen Depth	from 55 to 60 ft	Driller	R. Hutchinson

Lithologic Description	Depth	Sample	USCS	Well	Other
sand, med gray, silty, rec 1.1 ft, PID 0.0, 12/14/12/13	41-43	SB50-43	SP		Flush Mount
silt, clayey, med gray, rec 1.0 ft, PID 0.0, 3/2/2/3	43-45	SB50-45	ML		
clay, med plasticity, med. gray, rec. 6", PID 0.0, 3/3	45-46	SB50-46	CL		46'
clay, plastic, med. gray, wet, rec. 1', PID 15, 8/9/5/5	47.5-48	SB50-48	CH		
sand,some silt and clay, fine grained, rec. 1.5', PID 2.0, 10/12/11/12	48.5-48.9		SM		
sand, med grained with some shells, PID 0.0	48.9-50	SB50-50	SP		
sand, fine-med grained with shell frags, rec 2.0, PID 0.0, 10/13/13/15	50-50.5		SW		
clay, soft, wet, plastic, med. gray , PID 0.0	50.5-51	SB50-52	CH		51' bent. seal (2')
sand, fine-med grained, shelly zones, med. gray, PID 0.0	51-52	SB50-52B	SP		
sand, w coarse shell fragments, PID 0.0, rec 1.7 or 2.0	52-52.3		Sp		53 sand pack (20/30)
abrupt contact w med grained sand, no shells, silty	52.3-53 53-54	SB50-54	SM SM		

Logged by: C.J. Perry

Completion Date: 4/5/01

Construction Notes: 6-in surface casing set to 46', 2-in casing screen set at 60'

LC34 IDC Coring Logsheet

Date 4/9/01

Boring ID PA-20

Location Roadway

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Lithologic Description	Depth	Sample	USCS	Well	Other
sand, shelly cs fragments, med gray, rec 1.4 or 2.0, PID 0.0, 6/7/7/4	54.6-55.2		SP		55 2-" SS Screen 61' TD
clay, shelly, some silt, soft, wet, med. gray	55.2-56	SB 50-56	CL		
sand, very shelly, med. gray, trace silt and clay, Rec 1.9 of 2.0, PID 0.0, 6/7/7/7	56-58	SB 56-58	SM/SC		
sand, shelly, no fines, med gray, rec. 2.0 of 2.0, PID 0.0, 13/13/15/17	58-60	SB 50-60	SP		
Total Depth (sampled): 60'					
Total Dept (drilled): 61'					
5' x 2" diameter well screen 55-60'					

LC34 IDC Coring Logsheet

Boring ID PA-21

Date 4/9/01

Location ISCO Plot

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Boring Diameter	10 & 5 7/8 in	Total Depth	61 ft
Casing Outer Diameter	6 & 2 in	Sand Pack	20/30
Casing Inner Diameter	in	Sand Pack Depth	from 53 to 61 ft
Casing Material	304 SCH 10 Stainless	Grout Material	type G & silica flour
Screen Type	wirewound 304 Sch 10	Grout Depth	from GS to 51 ft
Screen Slot	0.10	Surface Completion	flush mount vault
Screen Length	5 ft	Drilling Method	mud rotary
Screen Depth	from 55 to 60 ft	Driller	R. Hutchinson

Lithologic Description	Depth	Sample	USCS	Well	Other
sand, brn-gray, some silt, med grnd, rec 1.15 of 2, PID 0.0, 11/13/15/20	40-42	SB51-41	SM		Flush Mount
sand, brn-gray, silty,fine grnd., rec 1.3 of 2', PID 2.0, 6/7/8/6	42-44	SB51 .44	SM		
sand, brn, med grnd, grading to silty clay/clay, rec. 2 of 2', PID 2000+, 8/7/4/3	44-44.5	SB51-44B	SM		
silty clay, med. brn gray, wet	44.5-44.75	SB51-45	ML		
clay, med gray, wet, soft	44.75-46	SB51-46	CH		46'
clay, med gray, wet, soft, rec. 1.1 of 2.0, PID 29, 6/7/9/5	47-47.5		CH		
sand, med grained, med gray, massive, shells, PID 2000+	47.5-48	SB-51-48.8	SP		
sand, clayey, mucky, w/ cs shell frags, rec. 2.0 of 2.0, PID 46, 7/8/8/12	48-48.2	SB51-48B	SC		
clay, soft, plastic, wet, med gray, PID 323	48.2-49		CH		
sand, fine-med grnd, massive, med. gray, PID 96	49-50		SP		
sand, med-cs grnd, some silt, rec 1.9 of 2.0, PID 2.0, 7/7/6/6	50-50.3	SB51-50	SM		

Logged by: C.J. Perry

Completion Date: 4/4/01

Construction Notes: 6-in surface casing set to 46', 2-in casing screen set at 60'

LC34 IDC Coring Logsheet

Boring ID PA-21

Date 4/9/01

Location ISCO Plot

Lithologic Description	Depth	Sample	USCS	Well	Other
sand, silty and clayey, shell frags, med gray	50.3-50.6		SC		Type G Cement
sand, fine grnd, massive, med. gray, PID 2.0	50.6-52	SB 51-52	SP		51 Bentonite Seal
sand, silty and clayey, med. gray, shelly, Rec 2.0 of 2.0', PID 34, 7/8/9/10	52-52.8		SM		53
sand, med grnd, fining downward, some shells	52.8-54	SB 51-54	SP		55
sand, w silt and clay, shelly, med gray, rec 2.0 of 2.0', PID 8.0, 5/5/4/6	54-56	SB51-56	SM		2-in Screen 0.0010
sand, fn-med grnd, massive, med gray, rec 2.0 of 2.0, PID =0.0, 4/4/3/5	56-56.6		SP		
sand, w silt and clay, mucky, shelly	56.6-57.6		SM		
sand, fn grnd, tr. silt and clay	57.6-58	SB51-58	SM		
sand, med grnd, slightly silty, shells, rec 2.0 of 2.0', PID 0.0, 6/8/12/16	59-60		SP		60
clayey interval from 59.1-59.5, PID 0.0		SB51-60	SC		TD 61'
Total Dept (Sampled): 60'					
Total Depth (reamed): 61'					
5' x 2" diameter well screen 55-60'					

LC34 IDC Coring Logsheet

Boring ID PA-22

Date 4/9/01

Location Resistive Heating Plot

Battelle ... Putting Technology To Work

Boring Diameter	10 & 5 7/8 in	Total Depth	61 ft
Casing Outer Diameter	6 & 2 in	Sand Pack	20/30
Casing Inner Diameter	in	Sand Pack Depth	from 53 to 61 ft
Casing Material	304 SCH 10 Stainless	Grout Material	type G & silica flour
Screen Type	wirewound 304 Sch 10	Grout Depth	from GS to 51 ft
Screen Slot	0.10	Surface Completion	flush mount vault
Screen Length	5 ft	Drilling Method	mud rotary
Screen Depth	from 55 to 60 ft	Driller	R. Hutchinson

Lithologic Description	Depth	Sample	USCS	Well	Other
sand, med grnd, shell frags, gray, rec 1.3 of 2, PID 155, 8/10/13/16	40-42	SB52-42	SP		Flush Mount
sand, med-grnd, med. gray, rec 0.75 of 2', PID 44, 6/7/7/8	42-44	SB52 44	SP		
silt, massive, med gray, grading to clay, rec. 1.4 of 2', PID 102, 8/7/6/5	44.6-45.7	SB52-45	ML		
clay, plastic, med. gray, 3" thick, PID 234	45.7-46	SB52-45	CH		
clay, med gray, plastic, 3/3, PID 381	46-46.9	SB52-47	CH		46'
sand, fine-grnd, med gray, PID 725	46.9-47.2	SB52-47B	SP		
sand, fine grained, silty, shelly, med gray	47.2-.5		SM		
clay, stiff, wet, med gray	47.5-47.7	SB52-47.5	CL		
sand, med-grnd, massive, few shells, med gray	47.7-48	SB52-48	SP		
clay, stiff, mod. wet, shell frags, Rec. 2.0 of 2.0, 6/6/7/8	48-48.9	SB52-49/49B	CL		
sand, fn-med grnd, massive, few shells 1.9 of 2.0	48.9-50	SB52-50	SP		

Logged by: C.J. Perry

Completion Date: 4/5/01

Construction Notes: 6-in surface casing set to 46', 2-in casing screen set at 60'

LC34 IDC Coring Logsheet Boring ID PA-22

Date 4/9/01 Location Resistive Heating Plot

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Lithologic Description	Depth	Sample	USCS	Well	Other
sand, med. grnd, med. gray, some shells, Rec 0.75 of 2.0, PID 20, 7/8/8/9	50-50.75	SB52-51	SP		Type G Cement
sand, med grnd, very shelly, Rec 2.0 of 2.0, PID 20, 6/7/5/8	52-52.9		SP		51 Bentonite Seal
sand, fn-med grnd, silty	52.9-54		SP		53
sand, med grnd, very shelly, loose, wet, PID 80, 7/5/9/9	54-54.2	SB 52-54	SP		55
sand, med. grnd, v. shelly but sandier, PID 1530	54.2-56	SB52-56/56B	SP		2-in Screen 0.0010
sand, med grnd, w/ clay and silt, muckey, shells, 1.7 of 2.0, PID 1200+, 7/7/4/3	56.3-58	SB52-58	SM		
sand, cs grnd, trc silt, v. shelly, loose, rec 2.0 of 2.0, PID 50+, 11/12/14/17	558-58.5		SP		
sand, med grnd, mucky, wet	58.5-59		SP		
sand, med grnd, massive, decreasing shell fragments wit depth	59-60		SP		60
					TD 61'
Total Dept (Sampled): 60'					
Total Depth (reamed): 61'					
5' x 2" diameter well screen 55-60'					

Appendix C. CVOC Measurements

C.1 TCE Results of Ground-Water Samples
C.2 Other CVOC Results of Ground-Water Samples
C.3 Resistive Heating Pre-Demonstration Soil Sample Results
C.4 Resistive Heating Post-Demonstration Soil Sample Results
Figure C-1. TCE Concentrations and Observed Soil Color Results at the Resistive Heating Plot

Table C-1. TCE Results of Groundwater Samples

Well ID	TCE (µg/L) Pre-Demo Results	Week 3-4 Results	Week 3-4 % Change in Conc.	Week 5 Results	Week 5 % Change in Conc.	Week 7-8 Results	Week 7-8 % Change in Conc.	Jan 10-14, 2000 Results	Jan 10-14, 2000 % Change in Conc.
Resistive Heating Plot Wells									
PA-13S	1,030,000	1,220,000	18%	476,000	-54%	NA	NA	NA	NA
PA-13S-DUP	1,100,000	1,240,000	13%	NA	NA	NA	NA	NA	NA
PA-13I	1,070,000	1,250,000	17%	268,000	-75%	NA	NA	NA	NA
PA-13D	892,000	1,160,000	30%	380,000	-57%	NA	NA	NA	NA
PA-13D-DUP	730,000	NA	NA	NA	NA	NA	NA	NA	NA
PA-14S	935,000	106,000	-89%	556	>-99%	NA	NA	NA	NA
PA-14I	960,000	75,500	-92%	NA	NA	NA	NA	NA	NA
PA-14D	868,000	482,000	-44%	NA	NA	NA	NA	NA	NA
Resistive Heating Perimeter Wells									
PA-2S	22,900	1,110	-95%	82.6	>-99%	NA	NA	17,400	-24%
PA-2I	1,140,000	720,000	-37%	425,000	-63%	NA	NA	1,100,000	-4%
PA-2I-DUP	NA	NA	NA	475,000	-58%	NA	NA	NA	NA
PA-2D	1,150,000	1,080,000	-6%	1,120,000	-3%	NA	NA	1,250,000	9%
PA-7S	118,000	92,000	-22%	55,000	-53%	NA	NA	39,600	-66%
PA-7I	365,000	486,000	33%	438,000	20%	NA	NA	112,000	-69%
PA-7D	309	19,000	6,049%	23,100	7,376%	NA	NA	160,000	51,680%
PA-10S	162,000	299,000	85%	182,000	12%	NA	NA	182,000	12%
PA-10I	1,100,000	860,000	-22%	458,000	-58%	NA	NA	280,000	-75%
PA-10I-DUP	NA	NA	NA	451,000	-59%	NA	NA	NA	NA
PA-10D	1,120,000	180,000	-84%	825,000	-26%	NA	NA	1,060,000	-5%
PA-10D-DUP	NA	NA	NA	NA	NA	NA	NA	1,120,000	0%
IW-17S	397	468,000	117,784%	494,000	124,333%	NA	NA	77,500	19,421%
IW-17I	15,000	17,400	16%	31,000	107%	NA	NA	152,000	913%
IW-17D	154,000	7,410	-95%	1,180	-99%	NA	NA	630J	>-99%
PA-15	NA	NA	NA	NA	NA	NA	NA	180,000	NA
Distant Wells									
PA-1S	984	2,550	159%	9,690	885%	19,400	1,872%	16,200	1,546%
PA-1I	2,920	4,420	51%	2,310	-21%	288	-90%	140J	-95%
PA-1I-DUP	NA	NA	NA	NA	NA	NA	NA	NA	NA
PA-1D	172	845	391%	24.1	-86%	24.6	-86%	2.58	>-99%
PA-8S	5,730	15,300	167%	25,800	350%	115,000	1,907%	**79,300**	1,284%
PA-8S-DUP	NA	NA	NA	NA	NA	113,000	1,872%	84,400	1,373%
PA-8I	988,000	1,040,000	5%	1,390,000	41%	1,000,000	1%	805,000	-19%
PA-8D	478,000	625,000	31%	635,000	33%	900,000	88%	960,000	101%
PA-8D-DUP	NA	555,000	16%	NA	NA	NA	NA	NA	NA
PA-11S	865,000	800,000	-8%	790,000	-9%	810,000	-6%	1,090,000	26%
PA-11I	1,060,000	1,280,000	21%	1,200,000	13%	1,190,000	12%	1,200,000	13%
PA-11D	1,010,000	1,240,000	23%	1,030,000	2%	1,250,000	24%	1,180,000	17%

Table C-1. TCE Results of Groundwater Samples (Continued)

Well ID	TCE (µg/L) Apr 10-14, 2000 Results	Apr 10-14, 2000 % Change in Conc.	ISCO Post-Demo Results	ISCO Post-Demo % Change in Conc.	Resistive Heating Post-Demo Results	Resistive Heating Post-Demo % Change in Conc.	June 12, 2001 Results	June 12, 2001 % Change in Conc.
Resistive Heating Plot Wells								
PA-13S	180,000 *	-83%	NA	NA	820,000 D	-20%	758,000	-20%
PA-13S-DUP	170,000 *	-85%	NA	NA	NA	NA	NA	NA
PA-13I	1,300,000 D*	21%	NA	NA	NA	NA	60,200	-94%
PA-13D	3,300 *	>-99%	NA	NA	920,000	3%	794,000	-11%
PA-13D-DUP	NA	NA	NA	NA	910,000	25%	647,000	-11%
PA-14S	9,400 *	>-99%	NA	NA	710,000	-24%	601,000	-36%
PA-14I	46,000 *	-95%	NA	NA	NA	NA	174,000	-82%
PA-14D	68,000 *	-92%	NA	NA	4,200	>-99%	2,730	>-99%
Resistive Heating Perimeter Wells								
PA-2S	6,400	-72%	19,000	-17%	330 J	-99%	NA	NA
PA-2I	1,800,000D	58%	980,000	-14%	970,000	-15%	NA	NA
PA-2I-DUP	1,400,000D	23%	NA	NA	NA	NA	NA	NA
PA-2D	1,300,000D	13%	990,000D	-14%	1,300,000	13%	NA	NA
PA-7S	64,000	-46%	NA	NA	150,000	27%	NA	NA
PA-7I	36,000	-90%	NA	NA	62,000	-83%	NA	NA
PA-7D	33,000	10,580%	NA	NA	<2,500	NA	NA	NA
PA-10S	760,000D	369%	NA	NA	24,000	-85%	NA	NA
PA-10I	740,000D	-33%	NA	NA	750,000	-32%	NA	NA
PA-10I-DUP	NA	NA	NA	NA	870,000	-21%	NA	NA
PA-10D	1,000,000D	-11%	NA	NA	1,100,000	-2%	NA	NA
PA-10D-DUP	NA	NA	NA	NA	NA	NA	NA	NA
IW-17S	Dry	NA	NA	NA	NA	NA	NA	NA
IW-17I	680,000	4,433%	NA	NA	190,000	1,167%	NA	NA
IW-17D	1,600J	>-99%	NA	NA	1,500	-99%	NA	NA
PA-15	270,000D	NA	NA	NA	30,000	NA	NA	NA
Distant Wells								
PA-1S	3,700	276%	4,500	357%	8,000	713%	NA	NA
PA-1I	510J	-83%	<2000	>-99%	<250	-96%	NA	NA
PA-1I-DUP	NA	NA	<2000	>-99%	NA	NA	NA	NA
PA-1D	0.67J	>-99%	2.80	>-99%	<4	-98%	NA	NA
PA-8S	740,000	12,814%	630,000	10,895%	7,600	33%	NA	NA
PA-8S-DUP	NA	NA	NA	NA	NA	NA	NA	NA
PA-8I	190,000	-81%	330,000	-67%	870,000	-12%	NA	NA
PA-8D	1,300,000D	172%	1,800,000D	277%	1,100,000	130%	NA	NA
PA-8D-DUP	NA	NA	NA	NA	NA	NA	NA	NA
PA-11S	970,000	12%	**<5**	>-99%	390,000	-55%	NA	NA
PA-11I	1,200,000D	13%	1,200,000D	13%	790,000	-25%	NA	NA
PA-11D	1,300,000D	29%	1,400,000D	39%	1,300,000	29%	NA	NA

Notes:
Pre-Demo: Sep 3 to 10, 1999.
Week 3-4: Sep 24 to 20, 1999.
Week 5: Oct 6 to 8, 1999.
Week 7-8: Oct 19 to 28, 1999.
ISCO Post-Demo: May 8 to 14, 2000.
Resistive Heating Post-Demo: Nov 27 to Dec 2, 2000.
All units are in µg/L.
NA: Not available.
<: The compound was analyzed but not detected at or above the specified reporting limit.
J: Result was estimated but below the reporting limit.
D: Result was quanitified after dilution.
*: Resisitve Heating Plot wells sampled in Apr, 2000 may not be representative because most of well screens were appeared to be submerged under sediments.
Red indicates that TCE concentration has increased compared to Pre-demo conditions.
Blue indicates that TCE concentration has decreased compared to Pre-demo conditions.
Purple bold face indicates that water sample was purple when collected.

Table C-2. Other CVOC Results of Groundwater Samples

Well ID	*cis*-1,2-DCE (µg/L) Pre-Demo	Week 3-4	Week 5	Week 7-8	Jan 2000	Apr 2000	ISCO Post-Demo	Res Heating Post-Demo	June 2001	*trans*-1,2-DCE (µg/L) Pre-Demo	Week 3-4	Week 5	Week 7-8	Jan 2000	Apr 2000	ISCO Post-Demo	Res Heating Post-Demo	June 2001
Resistive Heating Plot Wells																		
PA-13S	4,400	17,400	350,000	NA	NA	8,900	NA	21,000 J	14,000	<5,000	<10,000	3,000J	NA	NA	<5,000	NA	<25,000	<100
PA-13S-DUP	4,900	16,000	NA	NA	NA	8,200	NA	NA	NA	<5,000	<10,000	NA	NA	NA	<5,000	NA	NA	NA
PA-13I	4,900	<10,000	3,900J	NA	NA	17,000J	NA	NA	9,370	<5,000	<10,000	<5,000	NA	NA	6,200J	NA	NA	16
PA-13D	2,200	5,900J	3,000J	NA	NA	230	NA	18,000 J	52,000	<5,000	<10,000	<5,000	NA	NA	26J	NA	<25,000	<1,000
PA-13D-DUP	<62,000	NA	NA	NA	NA	NA	NA	18,000 J	NA	<42,000	NA	NA	NA	NA	NA	NA	<33,000	NA
PA-14S	5,880	2,090	19J	NA	NA	140J	NA	95,000	73,800	<5,000	<200	<20	NA	NA	<560	NA	<20,000	<1,000
PA-14I	26,000	349	NA	NA	NA	1,700J	NA	NA	80,000	<5,000	<200	NA	NA	NA	<5,000	NA	NA	1,150
PA-14I-DUP	25,500	NA	NA	NA	NA	NA	NA	NA	NA	<5,000	NA	NA	NA	NA	NA	NA	NA	NA
PA-14D	21,900	11,600	NA	NA	NA	1,300J	NA	1,100	2,660	<5,000	<10,000	NA	NA	NA	<4,200	NA	<200	33
PA-14D-DUP	23,200	NA	NA	NA	NA	NA	NA	NA	NA	<5,000	NA	NA	NA	NA	NA	NA	NA	NA
Resistive Heating Perimeter Wells																		
PA-2S	3,020	3,520	2,170	NA	32,800	28,000	19,000	6,000	NA	<500	<20	<20	NA	<1,000	<2,500	<620	<500	NA
PA-2I	5,480	33,600	2,900J	NA	<10,000	7,200J	20,000J	11,000 J	NA	<5,000	<10,000	<5,000	NA	<10,000	<25,000	<25,000	<25,000	NA
PA-2I-DUP	NA	NA	3,600J	NA	NA	12,000J	NA	NA	NA	NA	NA	<5,000	NA	NA	<25,000	NA	NA	NA
PA-2D	2,700	7,400J	3,600J	NA	8,500J	<25,000	<25,000	<33,000	NA	<5,000	<10,000	<5,000	NA	<10,000	<25,000	<25,000	<33,000	NA
PA-7S	22,100	19,200	7,430	NA	8,900	100,000	NA	130,000	NA	<5,000	<10,000	<5,000	NA	<400	<3,300	NA	<12,000	NA
PA-7I	160,000	109,000	73,200	NA	21,400	21,000	NA	170,000	NA	<5,000	<10,000	<5,000	NA	<1,000	290J	NA	<17,000	NA
PA-7D	21	38,000	41,800	NA	54,500	96,000	NA	30,000	NA	2.78	633	<10,000	NA	<10,000	<5,000	NA	<2,500	NA
PA-10S	8,880	5,300J	1,900J	NA	81,000	42,000	NA	19,000	NA	<5,000	<10,000	<2,000	NA	<10,000	<20,000	NA	<1,900	NA
PA-10I	4,700J	6,900J	4,900J	NA	<10,000	50,000	NA	12,000 J	NA	<5,000	<10,000	<10,000	NA	<10,000	<20,000	NA	<42,000	NA
PA-10I-DUP	NA	NA	<10,000	NA	NA	NA	NA	15,000 J	NA	NA	NA	<10,000	NA	NA	NA	NA	<42,000	NA
PA-10D	2,400J	<10,000	<10,000	NA	9,800J	14,000J	NA	23,000 J	NA	<5,000	<10,000	<10,000	NA	<10,000	<25,000	NA	<42,000	NA
PA-10D-DUP	NA	NA	NA	NA	12,300	NA	NA	NA	NA	NA	NA	NA	NA	<10,000	NA	NA	NA	NA
IW-17S	593	15,700	4,640	NA	4,180	Dry	NA	Dry	NA	<20	225	140J	NA	<1,000	Dry	NA	Dry	NA
IW-17I	123,000	7,150	7,950	NA	14,600	50,000	NA	30,000	NA	<5,000	<1,000	<5,000	NA	<1,000	<20,000	NA	<8,300	NA
IW-17D	39,200	18,100	18,600	NA	70,000	65,000	NA	16,000 D	NA	<5,000	150J	251	NA	2,060	1,800J	NA	390	NA
PA-15	NA	NA	NA	NA	39,300	39,000	NA	170,000	NA	NA	NA	NA	NA	<10,000	<5,600	NA	<17,000	NA
Distant Wells																		
PA-1S	1,190	945	5,030	12,800	20,000	29,000	27,000	22,000	NA	38.4	50J	220	484	714	1,400J	1,100J	570 J	NA
PA-1I	32,800	22,100	10,800	8,400	43,900	53,000	48,000	2,400	NA	1,540	1,220	530J	431	1,670	1,500J	1,400J	300	NA
PA-1I-DUP	NA	NA	NA	NA	NA	NA	47,000	NA	NA	NA	NA	NA	NA	NA	NA	1,400J	NA	NA
PA-1D	299	1,100	689	589	1.4J	6.2J	2.9	<4	NA	22.9	64J	32.4	21.9	1.2J	0.46J	0.46J	2.8 J	NA
PA-8S	10,000	9,930	12,000	18,200	<2,000	23,000	32,000	36,000	NA	140J	220	220	352	<2,000	<20,000	<17,000	<2,900	NA
PA-8S-DUP	NA	NA	NA	18,000	<2,000	NA	NA	NA	NA	NA	NA	NA	368	<2,000	NA	NA	NA	NA
PA-8I	36,800	51,000	64,000	104,000	128,000	220,000	210,000	100,000	NA	<5,000	<10,000	<1,000	<10,000	<10,000	<17,000	<10,000	<33,000	NA
PA-8D	36,500	38,600	31,100	20,800	6,600J	11,000J	10,000J	19,000 J	NA	<5,000	<10,000	<2,000	<10,000	<10,000	<20,000	<25,000	<42,000	NA
PA-8D-DUP	NA	32,600	NA	NA	NA	NA	NA	NA	NA	NA	<10,000	NA	NA	NA	NA	NA	NA	NA
PA-11S	4,900J	8,000J	5,400J	5,600J	<10,000	<25,000	<5	8,500 J	NA	<5,000	<10,000	<10,000	<10,000	<10,000	<25,000	<5	<25,000	NA
PA-11I	4,900J	6,900J	5,200J	5,400J	<10,000	5,700J	<25,000	<42,000	NA	<5,000	<10,000	<10,000	<10,000	<10,000	<25,000	<25,000	<42,000	NA
PA-11D	6,180	<10,000	6,700J	<10,000	<10,000	<17,000	<25,000	<42,000	NA	<5,000	<10,000	<10,000	<10,000	<10,000	<17,000	<25,000	<42,000	NA

Table C-2. Other CVOC Results of Groundwater Samples (Continued)

Well ID	Vinyl chloride (µg/L)								
	Pre-Demo	Week 3-4	Week 5	Week 7-8	Jan 2000	Apr 2000	ISCO Post-Demo	Res Heating Post-Demo	June 2001
Resistive Heating Plot Wells									
PA-13S	<5,000	<10,000	<5,000	NA	NA	<10,000	NA	<50,000	700
PA-13S-DUP	<5,000	<10,000	NA	NA	NA	<10,000	NA	NA	NA
PA-13I	<5,000	<10,000	<5,000	NA	NA	<50,000	NA	NA	<100
PA-13D	<5,000	<10,000	<5,000	NA	NA	21J	NA	<50,000	<1,000
PA-13D	<83,000	NA	NA	NA	NA	NA	NA	<67,000	NA
PA-14S	<5,000	170J	NA	NA	NA	<1,100	NA	10,000 J	6,280
PA-14I	<5,000	100J	NA	NA	NA	<10,000	NA	NA	1,710
PA-14I-DUP	<5,000	NA	NA	NA	NA	NA	NA	NA	NA
PA-14D	<5,000	<10,000	NA	NA	NA	<8,300	NA	32 J	48.7
PA-14D-DUP	<5,000	NA	NA	NA	NA	NA	NA	NA	NA
Resistive Heating Perimeter Wells									
PA-2S	<500	<20	<20	NA	<1,000	2,800J	4,100	650 J	NA
PA-2I	<5,000	<10,000	<5,000	NA	<10,000	<50,000	<50,000	<50,000	NA
PA-2I-DUP	NA	NA	<5,000	NA	NA	<50,000	NA	NA	NA
PA-2D	<5,000	<10,000	<5,000	NA	<10,000	<50,000	<50,000	<67,000	NA
PA-7S	<5,000	<10,000	<5,000	NA	<400	1,200J	NA	13,000 J	NA
PA-7I	<5,000	<10,000	<5,000	NA	<1,000	<3,300	NA	12,000 J	NA
PA-7D	3.3	764	<10,000	NA	<10,000	6,400J	NA	15,000	NA
PA-10S	<5,000	<10,000	<2,000	NA	<10,000	2,500J	NA	4,300	NA
PA-10I	<5,000	<10,000	<10,000	NA	<10,000	<40,000	NA	<83,000	NA
PA-10I-DUP	NA	NA	<10,000	NA	NA	NA	NA	<83,000	NA
PA-10D	<5,000	<10,000	<10,000	NA	<10,000	<50,000	NA	<83,000	NA
PA-10D-DUP	NA	NA	NA	NA	<10,000	NA	NA	NA	NA
IW-17S	<20	292	<200	NA	<1,000	Dry	NA	Dry	NA
IW-17I	<5,000	<1,000	<5,000	NA	<1,000	<40,000	NA	<17,000	NA
IW-17D	<5,000	428	<200	NA	<1,000	3,800J	NA	330	NA
PA-15	NA	NA	NA	NA	<10,000	590J	NA	2,800 J	NA
Distant Wells									
PA-1S	<20	<100	30.3	152	<200	2,400J	2,300J	560 J	NA
PA-1I	1,910	1,700	1,260	1,250	6,260	7,200	6,500	5,100	NA
PA-1I-DUP	NA	NA	NA	NA	NA	NA	6,300	NA	NA
PA-1D	171	338	332	195	12.1	5.1	4.5	76	NA
PA-8S	<200	<200	<20	<200	<2,000	<40,000	<33,000	670 J	NA
PA-8S-DUP	NA	NA	NA	<200	<2,000	NA	NA	NA	NA
PA-8I	<5,000	<10,000	<1,000	<10,000	<10,000	<33,000	<20,000	<67,000	NA
PA-8D	<5,000	<10,000	<2,000	<10,000	<10,000	<40,000	<50,000	<83,000	NA
PA-8D-DUP	NA	<10,000	NA	NA	NA	NA	NA	NA	NA
PA-11S	<5,000	<10,000	<10,000	<10,000	<10,000	<50,000	<10	<50,000	NA
PA-11I	<5,000	<10,000	<10,000	<10,000	<10,000	<50,000	<50,000	<83,000	NA
PA-11D	<5,000	<10,000	<10,000	<10,000	<10,000	<33,000	<50,000	<83,000	NA

Table C-2. Other CVOC Results of Groundwater Samples (Continued)

Notes:

Pre-Demo: Sep 3 to 10, 1999.
Week 3-4: Sep 24 to 20, 1999.
Week 5: Oct 6 to 8, 1999.
Week 7-8: Oct 19 to 28, 1999.
ISCO Post-Demo: May 8 to 14, 2000.
Res Heating Post-Demo: Nov 27 to Dec 2, 2000.
June 2001: June 12, 2001
NA: Not available.
<: The compound was analyzed but not detected at or above the specified reporting limit.
J: Result was estimated but below the reporting limit.
D: Result was quanitified after dilution.

	Yellow indicates that a measurable concentration was obtained for this sample.
	Orange indicates that concentration in this well increased compared to pre-treatment levels.
	Blue indicates that concentration in this well decreased comnpared to pre-treatment levels.

Table C-3. Resistive Heating Predemonstration Soil Sample Results (mg/Kg)

Analytical Sample ID	Sample ID	Sample Depth (ft) Top Depth	Bottom Depth	MeOH (g)	Wet Soil Weight (g)	Dry Soil Weight (g)	TCE Result in MeOH (µg/L)	TCE Result in Dry Soil (mg/kg)	*cis*-1,2-DCE Result in MeOH (µg/L)	*cis*-1,2-DCE Result in Dry Soil (mg/kg)	*trans*-1,2-DCE Result in MeOH (µg/L)	*trans*-1,2-DCE Result in Dry Soil (mg/kg)	Vinyl Chloride Result in MeOH (µg/L)	Vinyl Chloride Result in Dry Soil (mg/kg)
SB-1-593	SB-1-2	0	2	213	182	163	6,400	7.8	<410	ND	<410	ND		ND
SB-1-594	SB-1-4	2	4	214	192	180	4,700	5.3	<380	ND	<380	ND		ND
SB-1-595	SB-1-6	4	6	213	244	225	270	0.3	<270	ND	<270	ND		ND
SB-1-596	SB-1-8	6	8	214	192	169	2,200	2.8	<400	ND	<400	ND		ND
SB-1-597	SB-1-10	8	10	193	152	123	7,400	10.5	<500	ND	<500	ND		ND
SB-1-598	SB-1-12	10	12	214	189	151	6,000	8.8	<450	ND	<450	ND		ND
SB-1-599	SB-1-14	12	14	192	215	169	7,900	12.5	<320	ND	<320	ND		ND
SB-1-600	SB-1-18	16	18	193	266	212	2,500	4.0	<310	ND	<310	ND		ND
SB-1-601	SB-1-20	18	20	193	209	157	72,000	121.7	<3,300	ND	<3,300	ND		ND
SB-1-602	SB-1-22	20	22	213	229	174	190,000	314.6	<11,000	ND	<11,000	ND		ND
SB-1-603	SB-1-24	22	24	192	254	201	1,200,000	1,935.0	<79,000	ND	<79,000	ND		ND
SB-1-604	SB-1-26	24	26	214	254	187	460,000	820.4	<17,000	ND	<17,000	ND		ND
SB-1-605	SB-1-28	26	28	193	239	164	260,000	526.1	<12,000	ND	<12,000	ND		ND
SB-1-606	SB-1-30	28	30	213	162	111	520,000	940.6	<20,000	ND	<20,000	ND		ND
SB-1-607	SB-1-32	30	32	192	160	121	12,000,000	19,090.9	<1,000,000	ND	<1,000,000	ND		ND
SB-1-608	SB-1-32B	30	32	192	198	158	11,000,000	16,656.6	<630,000	ND	<630,000	ND		ND
SB-1-609	SB-1-34	32	34	213	233	177	210,000	349.1	<8,200	ND	<8,200	ND		ND
SB-1-610	SB-1-36	34	36	214	334	235	300,000	623.6	<18,000	ND	<18,000	ND		ND
SB-1-611	SB-1-38	36	38	193	220	155	540,000	1,024.6	<24,000	ND	<24,000	ND		ND
SB-1-612	SB-1-40	38	40	213	229	160	3,100,000	5,874.2	<180,000	ND	<180,000	ND		ND
SB-1-613	SB-1-42	40	42	214	216	162	3,400,000	5,677.3	<140,000	ND	<140,000	ND		ND
SB-1-614	SB-1-44	42	44	214	241	183	220,000	368.3	<11,000	ND	<11,000	ND		ND
SB-1-615	SB-1-46	44	46	193	232	168	18,000,000	33,099.9	<1,700,000	ND	<1,700,000	ND		ND
SB-1-616	SB-1-48	46	48	214	203	140	20,000,000	37,537.4	<800,000	ND	<800,000	ND		ND
SB-1-617	SB-1-BLANK	MeOH Blank Sample		154	0	0	<250	ND	<250	ND	<250	ND		ND
SB-2-510	SB-2-6	4	6	192	141	134	1,600	1.7	660	0.7	<450	ND		ND
SB-2-511	SB-2-8	6	8	189	221	199	580	0.7	310	0.4	<280	ND		ND
SB-2-512	SB-2-10	8	10	212	203	168	300 J	0.4	300 J	0.4	<400	ND		ND
SB-2-513	SB-2-12	10	12	192	216	183	510	0.7	<300	ND	<300	ND		ND
SB-2-514	SB-2-14	12	14	187	335	279	<300	ND	<300	ND	<300	ND		ND
SB-2-515	SB-2-16	14	16	192	191	157	770	1.1	290 J	0.4	<390	ND		ND
SB-2-516	SB-2-18	16	18	189	214	269	1,300	0.7	380	0.2	<310	ND		ND
SB-2-517	SB-2-20	18	20	188	195	150	1,200	1.9	260 J	0.4	<330	ND		ND
SB-2-518	SB-2-20B	18	20	213	238	188	1,600	2.5	250 J	0.4	<320	ND		ND
SB-2-519	SB-2-22	20	22	192	281	226	1,000	1.6	560	0.9	<310	ND		ND
SB-2-520	SB-2-24	22	24	189	295	229	29,000	50.4	<1,600	ND	<1,600	ND		ND
SB-2-521	SB-2-26	24	26	190	296	213	54,000	107.8	<3,500	ND	<3,500	ND		ND
SB-2-522	SB-2-28	26	28	192	277	207	160,000	292.2	<8,400	ND	<8,400	ND		ND
SB-2-523	SB-2-30	28	30	189	286	205	230,000	458.4	<12,000	ND	<12,000	ND		ND
SB-2-524	SB-2-32	30	32	191	332	254	160,000	294.5	<11,000	ND	<11,000	ND		ND
SB-2-525	SB-2-34	32	34	190	221	174	110,000	174.3	<4,500	ND	<4,500	ND		ND
SB-2-526	SB-2-36	34	36	189	277	223	110,000	175.7	<4,400	ND	<4,400	ND		ND
SB-2-527	SB-2-38	36	38	186	263	186	220,000	439.9	<8,800	ND	<8,800	ND		ND
SB-2-528	SB-2-40	38	40	191	176	116	280,000	558.3	<10,000	ND	<10,000	ND		ND
SB-2-529	SB-2-42	40	42	192	264	224	3,500	5.0	<290	ND	<290	ND		ND

Table C-3. Resistive Heating Predemonstration Soil Sample Results (mg/Kg) (Continued)

Analytical Sample ID	Sample ID	Sample Depth (ft) Top Depth	Bottom Depth	MeOH (g)	Wet Soil Weight (g)	Dry Soil Weight (g)	TCE Result in MeOH (µg/L)	TCE Result in Dry Soil (mg/kg)	*cis*-1,2-DCE Result in MeOH (µg/L)	*cis*-1,2-DCE Result in Dry Soil (mg/kg)	*trans*-1,2-DCE Result in MeOH (µg/L)	*trans*-1,2-DCE Result in Dry Soil (mg/kg)	Vinyl Chloride Result in MeOH (µg/L)	Vinyl Chloride Result in Dry Soil (mg/kg)
SB-2-530	SB-2-44	42	44	190	297	236	150,000	249.4	<4,500	ND	<4,500	ND		ND
SB-2-531	SB-2-46	44	46	190	312	240	140,000	251.0	<6,500	ND	<6,500	ND		ND
SB-2-532	SB-2-47	45.5	47	190	294	202	19,000,000	41,043.6	<730,000	ND	<730,000	ND		ND
SB-2-533	SB-2-47B	45.5	47	190	352	239	5,200,000	12,213.4	<250,000	ND	<250,000	ND		ND
SB-2-534	SB-2-BLANK	MeOH Blank Sample		190	0	0	<250	ND	<250	ND	<250	ND		ND
SB-3-487	SB-3-2	0	2	189	190	174	7,800	9.2	720	0.9	<310	ND		ND
SB-3-488	SB-3-4	2	4	186	193	175	720	0.9	270	0.3	<250	ND		ND
SB-3-489	SB-3-6	4	6	189	160	145	120 J	0.1	<370	ND	<370	ND		ND
SB-3-490	SB-3-8	6	8	190	133	115	200 J	0.3	<450	ND	<450	ND		ND
SB-3-491	SB-3-10	8	10	194	174	142	240 J	0.3	<350	ND	<350	ND		ND
SB-3-492	SB-3-12	10	12	192	224	176	210 J	0.3	<250	ND	<250	ND		ND
SB-3-493	SB-3-14	12	14	190	207	164	210 J	0.3	<250	ND	<250	ND		ND
SB-3-494	SB-3-16	14	16	188	238	197	410	0.6	180 J	0.3	<250	ND		ND
SB-3-495	SB-3-18	16	18	192	188	149	870	1.3	270 J	0.4	<320	ND		ND
SB-3-496	SB-3-20	18	20	188	186	150	670	1.0	160 J	0.2	<320	ND		ND
SB-3-497	SB-3-22	20	22	191	203	158	5,600	8.9	410	0.7	<250	ND		ND
SB-3-498	SB-3-26	24	26	190	243	178	100,000	183.2	9,200	16.9	<5,000	ND		ND
SB-3-499	SB-3-28	26	28	186	205	150	57,000	100.9	27,000	47.8	<3,100	ND		ND
SB-3-500	SB-3-28B	26	28	188	239	176	60,000	108.8	27,000	49.0	<3,100	ND		ND
SB-3-501	SB-3-30	28	30	188	243	189	21,000	34.8	27,000	44.7	<1,800	ND		ND
SB-3-502	SB-3-32	30	32	192	207	164	3,100	4.8	21,000	32.4	<1,000	ND		ND
SB-3-503	SB-3-34	32	34	191	209	166	11,000	17.0	22,000	33.9	<1,000	ND		ND
SB-3-504	SB-3-36	34	36	188	185	133	16,000 E	28.4	45,000 E	79.9	240 J	0.42 J		ND
SB-3-504	SB-3-36	34	36	188	185	133	20,000 D	35.5	51,000 D	90.6	<320	ND		ND
SB-3-505	SB-3-38	36	38	193	213	152	760 J	1.4	32,000	59.0	<1,000	ND		ND
SB-3-506	SB-3-42	40	42	190	186	147	18,000	27.5	22,000	33.6	<1,300	ND		ND
SB-3-507	SB-3-44	42	44	190	204	150	66,000	115.3	22,000	38.4	<2,500	ND		ND
SB-3-508	SB-3-46	44	46	191	228	181	130,000	204.1	6,200	9.7	<6,200	ND		ND
SB-3-508	SB-3-46	44	46	191	228	181	140,000	219.7	5,400	8.5	<5,000	ND		ND
SB-3-509	SB-3-BLANK	MeOH Blank Sample			0	0	<250	ND	<250	ND	<250	ND		ND
SB-4-124	SB-4-2	0	2	188	131	116	<450	ND	<450	ND	<450	ND		ND
SB-4-125	SB-4-4	2	4	193	126	115	4,000	4.6	960	1.1	<480	ND		ND
SB-4-126	SB-4-6	4	6	192	153	140	4,400	5.1	<400	ND	<400	ND		ND
SB-4-127	SB-4-8	6	8	189	110	95	39,000	48.7	<1,600	ND	<1,600	ND		ND
SB-4-128	SB-4-10	8	10	190	176	146	170 J	0.2	<340	ND	<340	ND		ND
SB-4-129	SB-4-12	10	12	192	135	108	3,200	4.6	140 J	0.2	<450	ND		ND
SB-4-130	SB-4-14	12	14	190	190	156	NA	NA	NA	NA	NA	NA		NA
SB-4-131	SB-4-16	14	16	190	114	NA	5,300 1	8.3	360 J,1	0.6	<530	ND		ND
SB-4-132	SB-4-18	16	18	192	133	109	4,700	6.5	1,100	1.5	<460	ND		ND
SB-4-133	SB-4-20	18	20	197	108	89	4,500	6.0	320 J	0.4	<580	ND		ND
SB-4-134	SB-4-22	20	22	195	203	166	30,000	43.6	<1,000	ND	<1,000	ND		ND
SB-4-135	SB-4-22B	20	22	187	145	119	39,000	54.1	<1,600	ND	<1,600	ND		ND
SB-4-136	SB-4-24	22	24	191	178	141	40,000	60.3	<1,700	ND	<1,700	ND		ND
SB-4-137	SB-4-26	24	26	191	165	131	6,100,000	9,050.9	<18,000	ND	<18,000	ND		ND

Table C-3. Resistive Heating Predemonstration Soil Sample Results (mg/Kg) (Continued)

		Sample Depth (ft)			Wet Soil	Dry Soil	TCE		*cis*-1,2-DCE		*trans*-1,2-DCE		Vinyl Chloride	
Analytical Sample ID	Sample ID	Top Depth	Bottom Depth	MeOH (g)	Weight (g)	Weight (g)	Result in MeOH (µg/L)	Result in Dry Soil (mg/kg)	Result in MeOH (µg/L)	Result in Dry Soil (mg/kg)	Result in MeOH (µg/L)	Result in Dry Soil (mg/kg)	Result in MeOH (µg/L)	Result in Dry Soil (mg/kg)
SB-4-138	SB-4-28	26	28	194	169	124	110,000	184.7	<5,200	ND	<5,200	ND		ND
SB-4-139	SB-4-30	28	30	187	109	82	110,000	167.3	<3,900	ND	<3,900	ND		ND
SB-4-140	SB-4-32	30	32	189	283	217	7,200,000 E	12,668.9	<120,000	ND	<120,000	ND		ND
SB-4-140	SB-4-32	30	32	189	283	217	6,300,000 D	11,085.3	<120,000	ND	<120,000	ND		ND
SB-4-141	SB-4-34	32	34	195	151	120	77,000	112.3	<2,000	ND	<2,000	ND		ND
SB-4-142	SB-4-36	34	36	190	141	113	70,000	100.2	<2,100	ND	<2,100	ND		ND
SB-4-143	SB-4-38	36	38	190	168	118	160,000	287.7	<7,100	ND	<7,100	ND		ND
SB-4-144	SB-4-40	38	40	195	197	150	520,000	847.5	<16,000	ND	<16,000	ND		ND
SB-4-145	SB-4-42	40	42	193	238	179	92,000	159.7	<31,000	ND	<31,000	ND		ND
SB-4-146	SB-4-44	42	44	195	291	229	100,000	167.5	<4,200	ND	<4,200	ND		ND
SB-4-147	SB-4-46	44	46	188	210	159	18,000,000	30,222.8	<1,200,000	ND	<1,200,000	ND		ND
SB-4-148	SB-4-BLANK	MeOH Blank Sample			0	0	<250	ND	<250	ND	<250	ND		ND
SB-5-415	SB-5-2	0	2	196	113	101	<550	ND	<550	ND	<550	ND		ND
SB-5-416	SB-5-4	2	4	187	146	127	<400	ND	<400	ND	<400	ND		ND
SB-5-417	SB-5-6	4	6	190	222	195	<250	ND	<250	ND	<250	ND		ND
SB-5-418	SB-5-8	6	8	187	131	110	<450	ND	<450	ND	<450	ND		ND
SB-5-419	SB-5-10	8	10	187	170	138	<350	ND	<350	ND	<350	ND		ND
SB-5-420	SB-5-12	10	12	190	158	128	210 J	0.3	<380	ND	<380	ND		ND
SB-5-421	SB-5-14	12	14	193	175	145	<350	ND	<350	ND	<350	ND		ND
SB-5-422	SB-5-16	14	16	190	197	163	<250	ND	<250	ND	<250	ND		ND
SB-5-423	SB-5-18	16	18	194	135	108	<450	ND	<450	ND	<450	ND		ND
SB-5-424	SB-5-20	18	20	192	189	143	3,200 R	5.2	910	1.5	<320	ND		ND
SB-5-425	SB-5-20B	18	20	189	151	120	2,700 R	4.0	650	1.0	<400	ND		ND
SB-5-426	SB-5-22	20	22	189	178	144	19,000 R	27.7	360 J	0.5	<670	ND		ND
SB-5-427	SB-5-24	22	24	188	168	138	1,300,000	1,835.2	<44,000	ND	<44,000	ND		ND
SB-5-428	SB-5-26	24	26	192	227	170	150,000	259.8	<12,000	ND	<12,000	ND		ND
SB-5-429	SB-5-28	26	28	191	228	165	15,000,000 E	27,564.0	<120,000	ND	<120,000	ND		ND
SB-5-429	SB-5-28	26	28	191	228	165	3,200,000 D	5,880.3	<120,000	ND	<120,000	ND		ND
SB-5-430	SB-5-30	28	30	191	169	121	310,000	541.8	<12,000	ND	<12,000	ND		ND
SB-5-431	SB-5-32	30	32	193	246	186	520,000	901.5	<17,000	ND	<17,000	ND		ND
SB-5-432	SB-5-34	32	34	192	196	150	3,300,000	5,345.1	<100,000	ND	<100,000	ND		ND
SB-5-433	SB-5-36	34	36	189	173	134	15,000,000	23,361.8	<340,000	ND	<340,000	ND		ND
SB-5-433	SB-5-36	34	36	189	173	134	13,000,000	20,246.9	<340,000	ND	<340,000	ND		ND
SB-5-434	SB-5-38	36	38	193	189	127	4,100,000	8,061.7	<130,000	ND	<130,000	ND		ND
SB-5-435	SB-5-40	38	40	188	207	146	15,000,000	28,167.6	<360,000	ND	<360,000	ND		ND
SB-5-436	SB-5-42	40	42	192	209	145	3,400,000	6,534.3	<100,000	ND	<100,000	ND		ND
SB-5-437	SB-5-45	43	45	190	222	164	24,000,000 E	42,405.1	<250,000	ND	<250,000	ND		ND
SB-5-437	SB-5-45	43	45	190	222	164	21,000,000 D	37,104.5	<250,000	ND	<250,000	ND		ND
SB-5-438	SB-5-BLANK	MeOH Blank Sample			0	0	4,400 1	6.9	<250	ND	<250	ND		ND
SB-6-197	SB-6-2	0	2	189	136	128	<250	ND	<250	ND	<250	ND		ND
SB-6-198	SB-6-4	2	4	189	118	106	<250	ND	<250	ND	<250	ND		ND
SB-6-199	SB-6-6	4	6	190	115	102	<250	ND	<250	ND	<250	ND		ND
SB-6-200	SB-6-8	6	8	190	113	95	<250	ND	<250	ND	<250	ND		ND
SB-6-201	SB-6-10	8	10	189	132	107	<250	ND	<250	ND	<250	ND		ND

Table C-3. Resistive Heating Predemonstration Soil Sample Results (mg/Kg) (Continued)

Analytical Sample ID	Sample ID	Sample Depth (ft) Top Depth	Bottom Depth	MeOH (g)	Wet Soil Weight (g)	Dry Soil Weight (g)	TCE Result in MeOH (µg/L)	TCE Result in Dry Soil (mg/kg)	*cis*-1,2-DCE Result in MeOH (µg/L)	*cis*-1,2-DCE Result in Dry Soil (mg/kg)	*trans*-1,2-DCE Result in MeOH (µg/L)	*trans*-1,2-DCE Result in Dry Soil (mg/kg)	Vinyl Chloride Result in MeOH (µg/L)	Vinyl Chloride Result in Dry Soil (mg/kg)
SB-6-202	SB-6-12	10	12	189	196	161	<250	ND	<250	ND	<250	ND		ND
SB-6-203	SB-6-14	12	14	191	128	103	<250	ND	<250	ND	<250	ND		ND
SB-6-204	SB-6-16	14	16	192	151	127	<250	ND	<250	ND	<250	ND		ND
SB-6-205	SB-6-18	16	18	187	176	148	1,400	1.9	<250	ND	<250	ND		ND
SB-6-206	SB-6-20	18	20	191	155	120	<250	ND	<250	ND	<250	ND		ND
SB-6-207	SB-6-22	20	22	190	170	140	2,800	3.9	<250	ND	<250	ND		ND
SB-6-208	SB-6-24	22	24	188	228	230	19,000	18.6	<2,000	ND	<2,000	ND		ND
SB-6-209	SB-6-26	24	26	192	181	149	7,600	10.8	<620	ND	<620	ND		ND
SB-6-210	SB-6-28	26	28	189	218	163	40,000	69.1	<5,000	ND	<5,000	ND		ND
SB-6-211	SB-6-30	28	30	189	188	136	31,000	54.6	6,900	12.2	<2,500	ND		ND
SB-6-212	SB-6-32	30	32	189	150	115	11,000	17.0	9,500	14.7	<620	ND		ND
SB-6-213	SB-6-32B	30	32	188	163	124	11,000	17.5	8,700	13.8	<620	ND		ND
SB-6-214	SB-6-36	34	36	185	207	169	7,700	11.4	7,800	11.5	<620	ND		ND
SB-6-215	SB-6-38	36	38	189	228	164	11,000	20.5	17,000	31.6	<2,000	ND		ND
SB-6-216	SB-6-40	38	40	188	176	112	5,300	11.2	19,000	40.0	<2,000	ND		ND
SB-6-217	SB-6-42	40	42	191	215	161	11,000	18.8	21,000	36.0	<2,000	ND		ND
SB-6-218	SB-6-44	42	44	186	123	99	4,100	5.8	11,000	15.4	<620	ND		ND
SB-6-219	SB-6-46	44	46	188	135	105	210,000	313.1	<12,000	ND	<12,000	ND		ND
SB-6-220	SB-6-BLANK	MeOH Blank Sample			0	0	<250	ND	<250	ND	<250	ND		ND
SB-7-100	SB-7-2	0	2	192	149	132	500	0.6	<410	ND	<410	ND		ND
SB-7-101	SB-7-4	2	4	190	164	149	120 J	0.1	<370	ND	<370	ND		ND
SB-7-102	SB-7-6	4	6	189	162	134	<370	ND	<370	ND	<370	ND		ND
SB-7-103	SB-7-8	6	8	191	195	150.2	<250	ND	<250	ND	<250	ND		ND
SB-7-104	SB-7-10	8	10	189	146	117	690	1.0	<410	ND	<410	ND		ND
SB-7-105	SB-7-12	10	12	190	198	106.4	0	0.0	<250	ND	<250	ND		ND
SB-7-106	SB-7-14	12	14	189	135	106.2	<440	ND	<440	ND	<440	ND		ND
SB-7-107	SB-7-16	14	16	190	151	124	150 J	0.2	<400	ND	<400	ND		ND
SB-7-108	SB-7-18	16	18	190	116	95	0	0.0	<520	ND	<520	ND		ND
SB-7-109	SB-7-20	18	20	191	131	46.8	2,400	9.7	520	2.1	<460	ND		ND
SB-7-110	SB-7-22	20	22	188	152	120	21,000	31.1	560 J	0.8	<780	ND		ND
SB-7-111	SB-7-26	24	26	190	127	93.8	90,000	143.1	1,500 J	2.4	<2,400	ND		ND
SB-7-112	SB-7-28	26	28	192	159	96	150,000	330.0	2,000 J	4.4	<3,800	ND		ND
SB-7-113	SB-7-30	28	30	190	140	98	80,000	139.5	18,000	31.4	<2,100	ND		ND
SB-7-114	SB-7-32	30	32	190	134	97	76,000	125.4	5,400	8.9	<2,200	ND		ND
SB-7-115	SB-7-34	32	34	189	140	108.1	60,000	90.8	11,000	16.7	<2,100	ND		ND
SB-7-116	SB-7-36	34	36	189	148	111.6	88,000	139.2	10,000	15.8	<3,400	ND		ND
SB-7-117	SB-7-38	36	38	187	75	40.9	120,000	260.2	11,000	23.8	<5,300	ND		ND
SB-7-118	SB-7-40	38	40	183	68	50.9	48,000	70.1	2,200	3.2	<1,700	ND		ND
SB-7-119	SB-7-40B	38	40	189	325	251.8	63,000	112.8	2,800 J	5.0	<3,600	ND		ND
SB-7-120	SB-7-43	41	43	189	115	81.3	130,000	216.7	<5,200	ND	<5,200	ND		ND
SB-7-121	SB-7-45	43	45	189	187	138.7	5,200,000	8,802.5	<110,000	ND	<110,000	ND		ND
SB-7-122	SB-7-BLANK	MeOH Blank Sample			0	0	<250	ND	<250	ND	<250	ND		ND
SB-8-342	SB-8-2	0	2	193	84	78	290 J	0.3	<730	ND	<730	ND		ND
SB-8-343	SB-8-4	2	4	191	81	73	170 J	0.2	<740	ND	<740	ND		ND

Table C-3. Resistive Heating Predemonstration Soil Sample Results (mg/Kg) (Continued)

		Sample Depth (ft)			Wet Soil	Dry Soil	TCE		*cis*-1,2-DCE		*trans*-1,2-DCE		Vinyl Chloride	
Analytical Sample ID	Sample ID	Top Depth	Bottom Depth	MeOH (g)	Weight (g)	Weight (g)	Result in MeOH (µg/L)	Result in Dry Soil (mg/kg)	Result in MeOH (µg/L)	Result in Dry Soil (mg/kg)	Result in MeOH (µg/L)	Result in Dry Soil (mg/kg)	Result in MeOH (µg/L)	Result in Dry Soil (mg/kg)
SB-8-344	SB-8-6	4	6	190	186	169	<320	ND	<320	ND	<320	ND		ND
SB-8-345	SB-8-8	6	8	196	128	104	830 R	1.1	<480	ND	<480	ND		ND
SB-8-346	SB-8-10	8	10	191	139	106	330 J	0.5	<430	ND	<430	ND		ND
SB-8-347	SB-8-12	10	12	194	134	111	600 R	0.8	<460	ND	<460	ND		ND
SB-8-348	SB-8-14	12	14	191	53	45	940 J	1.2	<1,100	ND	<1,100	ND		ND
SB-8-349	SB-8-16	14	16	189	119	91	430 J	0.6	190 J	0.3	<500	ND		ND
SB-8-350	SB-8-16B	14	16	189	105	80	130,000 E	193.2	650	1.0	<570	ND		ND
SB-8-350	SB-8-16B	14	16	189	105	80	230,000 D	341.8	650	1.0	<570	ND		ND
SB-8-351	SB-8-18	16	18	188	122	90	310 J	0.5	<490	ND	<490	ND		ND
SB-8-352	SB-8-20	18	20	191	133	111	1,300 R	1.7	190 J	0.3	<450	ND		ND
SB-8-353	SB-8-22	20	22	189	175	136	140,000	217.3	<5,700	ND	<5,700	ND		ND
SB-8-354	SB-8-24	22	24	192	167	120	190,000	329.1	<9,100	ND	<9,100	ND		ND
SB-8-355	SB-8-26	24	26	191	201	143	180,000	329.8	<5,000	ND	<5,000	ND		ND
SB-8-356	SB-8-28	26	28	190	80	62	130,000	183.6	1,900 J	2.7	<5,000	ND		ND
SB-8-357	SB-8-30	28	30	188	148	115	120,000	181.5	2,600 J	3.9	<5,000	ND		ND
SB-8-358	SB-8-32	30	32	190	173	133	100,000	157.5	5,200	8.2	<5,000	ND	<9,900	ND
SB-8-359	SB-8-34	32	34	191	159	109	160,000	294.5	19,000	35.0	<7,600	ND	<15,000	ND
SB-8-360	SB-8-36	34	36	188	176	121	60,000	112.8	36,000	67.7	<3,400	ND	<6,800	ND
SB-8-361	SB-8-38	36	38	189	164	125	89,000	140.9	15,000	23.7	<3,600	ND	<7,300	ND
SB-8-362	SB-8-42	40	42	189	227	170	120,000	208.6	5,500 J	9.6	<6,200	ND	<12,000	ND
SB-8-363	SB-8-44	42	44	190	183	154	4,900,000	6,711.5	<220,000	ND	<220,000	ND	<440,000	ND
SB-8-364	SB-8-BLANK	MeOH Blank Sample			0	0	280 1	0.4	<250	ND	<250	ND	<500	ND
SB-9-221	SB-9-2	0	2	189	94	86	<250	ND	<250	ND	<250	ND	<500	ND
SB-9-222	SB-9-4	2	4	189	111	98	710	0.9	1,900	2.3	<250	ND	<500	ND
SB-9-223	SB-9-6	4	6	188	173	143	<250	ND	440	0.6	<250	ND	<500	ND
SB-9-224	SB-9-8	6	8	187	220.7	187	<250	ND	610	0.8	<250	ND	<500	ND
SB-9-225	SB-9-9.5	7.5	9.5	188	212.9	170	4,200	6.5	<500	ND	<500	ND	<1,000	ND
SB-9-226	SB-9-11.5	9.5	11.5	189	126.6	104	370	0.5	<250	ND	<250	ND	<500	ND
SB-9-227	SB-9-13.5	11.5	13.5	191	126.3	102	<250	ND	<250	ND	<250	ND	<500	ND
SB-9-228	SB-9-15.5	13.5	15.5	191	133.3	98	490	0.8	2,000	3.2	<250	ND	<500	ND
SB-9-229	SB-9-17.5	15.5	17.5	189	170.7	140	270	0.4	390	0.6	<250	ND	<500	ND
SB-9-230	SB-9-19.5	17.5	19.5	188	221.1	171	3,200	5.2	<500	ND	<500	ND	<1,000	ND
SB-9-231	SB-9-21.5	19.5	21.5	190	204.6	165	8,500	12.7	<1,000	ND	<1,000	ND	<2,000	ND
SB-9-232	SB-9-21.5B	19.5	21.5	190	232.2	165	7,500	14.3	<1,000	ND	<1,000	ND	<2,000	ND
SB-9-233	SB-9-23.5	21.5	23.5	187	198	147	17,000	29.1	2,000	3.4	<2,000	ND	<4,000	ND
SB-9-234	SB-9-25.5	23.5	25.5	189	188.4	148	17,000	26.3	5,200	8.0	<2,000	ND	<4,000	ND
SB-9-235	SB-9-27.5	25.5	27.5	188	186.3	135	48,000	84.3	14,000	24.6	<3,100	ND	<6,200	ND
SB-9-236	SB-9-29.5	27.5	29.5	188	233.8	181	18,000	29.8	12,000	19.9	<2,000	ND	<7,500	ND
SB-9-237	SB-9-31.5	29.5	31.5	188	199.4	157	1,600	2.5	7,700	12.0	<1,000	ND	<2,000	ND
SB-9-238	SB-9-33.5	31.5	33.5	190	207	163	<500	ND	4,500	7.0	<500	ND	<1,000	ND
SB-9-239	SB-9-35.5	33.5	35.5	185	116	83	850	1.4	250	0.4	<250	ND	<500	ND
SB-9-240	SB-9-37.5	35.5	37.5	188	166.2	119	<250	ND	670	1.2	<250	ND	<500	ND
SB-9-241	SB-9-39.5	37.5	39.5	189	134.2	99	2,100	3.4	2,200	3.5	<250	ND	<500	ND
SB-9-242	SB-9-42	40	42	188	170.1	132	33,000	51.1	<3,100	ND	<3,100	ND	<6,200	ND
SB-9-243	SB-9-44	42	44	187	195	135	35,000	66.8	<3,800	ND	<3,800	ND	<7,500	ND

Table C-3. Resistive Heating Predemonstration Soil Sample Results (mg/Kg) (Continued)

		Sample Depth (ft)			Wet Soil	Dry Soil	TCE		*cis*-1,2-DCE		*trans*-1,2-DCE		Vinyl Chloride	
Analytical Sample ID	Sample ID	Top Depth	Bottom Depth	MeOH (g)	Weight (g)	Weight (g)	Result in MeOH (µg/L)	Result in Dry Soil (mg/kg)	Result in MeOH (µg/L)	Result in Dry Soil (mg/kg)	Result in MeOH (µg/L)	Result in Dry Soil (mg/kg)	Result in MeOH (µg/L)	Result in Dry Soil (mg/kg)
SB-9-244	SB-9-BLANK	MeOH Blank Sample			0	0	<250	ND	<250	ND	<250	ND	<500	ND
SB-10-004	SB-10-2	0	2	191	244.2	225.9	<250	ND	<250	ND	<250	ND	<500	ND
SB-10-005	SB-10-4	2	4	190	204.2	193	<250	ND	<250	ND	<250	ND	<500	ND
SB-10-006	SB-10-6	4	6	191	330.2	279.8	<250	ND	<250	ND	<250	ND	<500	ND
SB-10-007	SB-10-7.5	6	7.5	191	134.2	117	3,100	3.9	<250	ND	<250	ND	<500	ND
SB-10-008	SB-10-9.5	7.5	9.5	191	174.2	151.8	2,200	2.8	<250	ND	<250	ND	<500	ND
SB-10-009	SB-10-11.5	9.5	11.5	190	154.2	111.8	<250	ND	<250	ND	<250	ND	<500	ND
SB-10-010	SB-10-13.5	11.5	13.5	186	341.2	271.8	1,100	1.9	<250	ND	<250	ND	<500	ND
SB-10-036	SB-10-15.5	13.5	15.5	189	256.2	205	<250	ND	<250	ND	<250	ND	<500	ND
SB-10-037	SB-10-17.5	15.5	17.5	188	313.1	241	<250	ND	<250	ND	<250	ND	<500	ND
SB-10-038	SB-10-19.5	17.5	19.5	188	227.2	190	480	0.7	<250	ND	<250	ND	<500	ND
SB-10-039	SB-10-21.5	19.5	21.5	188	278.2	222	19,000 E	30.9	<250	ND	<250	ND	<500	ND
SB-10-039	SB-10-21.5	19.5	21.5	188	278.2	222	19,000 D	30.9	<250	ND	<250	ND	<500	ND
SB-10-040	SB-10-23.5	21.5	23.5	189	222.2	178	62,000 E	95.5	<250	ND	<250	ND	<500	ND
SB-10-040	SB-10-23.5	21.5	23.5	189	222.2	178	60,000 D	92.4	<250	ND	<250	ND	<500	ND
SB-10-041	SB-10-25.5	23.5	25.5	188	179.2	142	69,000 E	104.3	<250	ND	<250	ND	<500	ND
SB-10-041	SB-10-25.5	23.5	25.5	188	179.2	142	70,000 D	105.8	<250	ND	<250	ND	<500	ND
SB-10-042	SB-10-27.5	25.5	27.5	188	204.2	147	54,000	97.8	11,000	19.9	<250	ND	<500	ND
SB-10-043	SB-10-29.5	27.5	29.5	189	182.2	152	29,000	40.3	16,000	22.2	<250	ND	<500	ND
SB-10-044	SB-10-29.5B	27.5	29.5	189	239.2	203	25,000	35.1	15,000	21.1	<250	ND	<500	ND
SB-10-045	SB-10-31.5	29.5	31.5	192	157.2	126	3,300	4.8	9,100 E	13.2	<250	ND	<500	ND
SB-10-045	SB-10-31.5	29.5	31.5	192	157.2	126	<250	ND	9,500	13.8	<250	ND	<500	ND
SB-10-046	SB-10-33.5	31.5	33.5	195	316	216	<250	ND	2,600	5.8	<250	ND	<500	ND
SB-10-047	SB-10-35.5	33.5	35.5	191	236	174	<250	ND	250	0.4	<250	ND	<500	ND
SB-10-049	SB-10-37.5	35.5	37.5	189	190.2	142	<250	ND	1,800	3.0	<250	ND	<500	ND
SB-10-050	SB-10-39.5	37.5	39.5	194	249	198.3	8,800	13.9	14,000	22.2	<250	ND	<500	ND
SB-10-051	SB-10-41.5	39.5	41.5	192	208.2	155.5	7,400	12.6	3,200	5.5	<250	ND	<500	ND
SB-10-052	SB-10-43.75	41.75	43.75	192	221	167.1	15,000	25.4	<250	ND	<250	ND	<500	ND
SB-10-053	SB-10-44.75	42.75	44.75	192	201	146.8	5,600 E	9.8	1,200	2.1	<250	ND	<500	ND
SB-10-053	SB-10-44.75	42.75	44.75	192	201	146.8	6,700 E	11.8	<250	ND	<250	ND	<500	ND
SB-10-054	SB-10-BLANK	MeOH Blank Sample			0	0	<250	ND	<250	ND	<250	ND	<500	ND
SB-11-174	SB-11-2	0	2	188	111	98	3,400	4.1	<250	ND	<250	ND	<500	ND
SB-11-175	SB-11-4	2	4	191	150	143	2,600	2.8	<250	ND	<250	ND	<500	ND
SB-11-176	SB-11-6	4	6	192	161	142	1,700	2.1	<250	ND	<250	ND	<500	ND
SB-11-177	SB-11-8	6	8	189	145	120	2,000	2.7	<250	ND	<250	ND	<500	ND
SB-11-178	SB-11-9.5	7.5	9.5	185	93	74	540	0.7	<250	ND	<250	ND	<500	ND
SB-11-179	SB-11-11.5	9.5	11.5	188	166	136	790	1.1	<250	ND	<250	ND	<500	ND
SB-11-180	SB-11-13.5	11.5	13.5	196	197	146	<250	ND	<250	ND	<250	ND	<500	ND
SB-11-181	SB-11-15.5	13.5	15.5	194	139	107	770	1.2	<250	ND	<250	ND	<500	ND
SB-11-182	SB-11-17.5	15.5	17.5	194	229	177	1,000	1.6	<250	ND	<250	ND	<500	ND
SB-11-183	SB-11-19.5	17.5	19.5	188	150	112	<250	ND	<250	ND	<250	ND	<500	ND
SB-11-184	SB-11-21.5	19.5	21.5	191	281	223	5,600	9.2	<1,000	ND	<1,000	ND	<2,000	ND
SB-11-185	SB-11-25.5	23.5	25.5	189	161	109	50,000	94.2	3,300	6.2	<3,100	ND	<6,200	ND
SB-11-186	SB-11-25.5B	23.5	25.5	188	126	122	25,000	26.4	<2,000	ND	<2,000	ND	<4,000	ND

Table C-3. Resistive Heating Predemonstration Soil Sample Results (mg/Kg) (Continued)

Analytical Sample ID	Sample ID	Sample Depth (ft) Top Depth	Bottom Depth	MeOH (g)	Wet Soil Weight (g)	Dry Soil Weight (g)	TCE Result in MeOH (µg/L)	TCE Result in Dry Soil (mg/kg)	*cis*-1,2-DCE Result in MeOH (µg/L)	*cis*-1,2-DCE Result in Dry Soil (mg/kg)	*trans*-1,2-DCE Result in MeOH (µg/L)	*trans*-1,2-DCE Result in Dry Soil (mg/kg)	Vinyl Chloride Result in MeOH (µg/L)	Vinyl Chloride Result in Dry Soil (mg/kg)
SB-11-187	SB-11-27.5	25.5	27.5	189	255	100	36,000	167.1	8,900	41.3	<5,000	ND	<10,000	ND
SB-11-188	SB-11-29.5	27.5	29.5	188	127	NA	31,000 1	48.8	13,000 1	20.5	<2,000	ND	<4,000	ND
SB-11-189	SB-11-31.5	29.5	31.5	188	224	171	26,000	43.7	22,000	36.9	<2,000	ND	<4,000	ND
SB-11-190	SB-11-33.5	31.5	33.5	191	223	172	13,000	21.4	19,000	31.2	<2,000	ND	<4,000	ND
SB-11-191	SB-11-35.5	33.5	35.5	190	164	113	1,100	2.0	15,000	27.6	<1,000	ND	<2,000	ND
SB-11-192	SB-11-37.5	35.5	37.5	189	150	109	0	0.0	2,800	4.7	<250	ND	<500	ND
SB-11-193	SB-11-39.5	37.5	39.5	189	216	161	250	0.4	3,600	6.2	<250	ND	<500	ND
SB-11-194	SB-11-42.5	40.5	42.5	179	152	113	22,000	36.0	2,300	3.8	<2,000	ND	<4,000	ND
SB-11-195	SB-11-44.5	42.5	44.5	187	129	81	23,000	46.0	1,800	3.6	<1,200	ND	<2,500	ND
SB-11-196	SB-11-BLANK	MeOH Blank Sample			0	0	<250	ND	<250	ND	<250	ND	<500	ND
SB-12-077	SB-12-2	0	2	193	166	148	<370	ND	<370	ND	<370	ND	<730	ND
SB-12-078	SB-12-4	2	4	191	118	92	<510	ND	<510	ND	<510	ND	<1,000	ND
SB-12-079	SB-12-6	4	6	189	206	157	<250	ND	<250	ND	<250	ND	<500	ND
SB-12-080	SB-12-9.5	7.5	9.5	192	266	211	<250	ND	<250	ND	<250	ND	<500	ND
SB-12-081	SB-12-11.5	9.5	11.5	194	196	157	1,600	2.4	<310	ND	<310	ND	<630	ND
SB-12-082	SB-12-13.5	11.5	13.5	193	133	NA	230 J, 1	0.4	<460	ND	<460	ND	<920	ND
SB-12-083	SB-12-15.5	13.5	15.5	190	163	127.2	<370	ND	160 J	0.2	<370	ND	<740	ND
SB-12-084	SB-12-19.5	17.5	19.5	195	91	69.2	<680	ND	510 J	0.7	<680	ND	<1,400	ND
SB-12-085	SB-12-21.5	19.5	21.5	193	181	141	9,900	15.3	1,600	2.5	<340	ND	<670	ND
SB-12-086	SB-12-23.5	21.5	23.5	195	107	77	25,000	40.1	4,200	6.7	<1,200	ND	<2,300	ND
SB-12-087	SB-12-25.5	23.5	25.5	192	160	109.8	61,000	112.1	13,000	23.9	<1,900	ND	<3,800	ND
SB-12-088	SB-12-27.5	25.5	27.5	195	214	155	47,000	84.5	20,000	36.0	<1,700	ND	<3,300	ND
SB-12-089	SB-12-27.5B	25.5	27.5	192	127	80	130,000	256.9	10,000	19.8	<4,800	ND	<9,600	ND
SB-12-090	SB-12-29.5	27.5	29.5	192	182	136.9	18,000 D	29.6	23,000 D	37.8	470	0.8	<670	ND
SB-12-090	SB-12-29.5	27.5	29.5	192	182	136.9	17,000 E	27.9	22,000 E	36.1	<330	ND	<670	ND
SB-12-091	SB-12-31.5	29.5	31.5	191	146	114	1,500	2.2	12,000	17.9	170 J	0.3 J	<830	ND
SB-12-092	SB-12-33.5	31.5	33.5	189	216	179.9	270	0.4	7,200	10.3	<250	ND	<500	ND
SB-12-093	SB-12-35.5	33.5	35.5	193	130	91	120 J	0.2	910	1.6	<470	ND	<940	ND
SB-12-094	SB-12-37.5	35.5	37.5	190	230	158.6	340	0.7	460	0.9	<250	ND	<500	ND
SB-12-095	SB-12-39.5	37.5	39.5	193	150	119.5	360 J	0.5	280 J	0.4	<410	ND	<810	ND
SB-12-096	SB-12-41.5	39.5	41.5	187	223	165.9	9,200	16.1	3,000	5.3	<330	ND	<660	ND
SB-12-098	SB-12-43.5	41.5	43.5	194	184	124.9	19,000	36.5	3,700	7.1	<670	ND	<1,300	ND
SB-12-099	SB-12-45.5	43.5	45.5	191	185	119.4	700	1.5	360	0.7	<320	ND	<650	ND
SB-12-123	SB-12-BLANK	MeOH Blank Sample			0	0	<250	ND	<250	ND	<250	ND	<500	ND

Notes:

NA: Not available.

ND: Not detected.

<: Result was not detected at or above the stated reporting limit.

1. Dry soil concentration is calculated as 1.57 times of wet soil concentration to account for average moisture content.

D: Result was obtained from the analysis of a dilution.

E: Estimated result. Result concentration exceeds the calibration range.

J: Result was estimated but below the reporting limit.

R: Corresponding rinsate blank contained more than 10 % of this sample result.

Table C-4. Resistive Heating Postdemonstration Soil Sample Results (mg/Kg)

	Sample Depth (ft)				Wet Soil	Dry Soil	TCE		*cis* -1,2-DCE		*trans* -1,2-DCE		Vinyl Chloride	
Sample ID	Top Depth	Bottom Depth	Sample Date	MeOH (g)	Weight (g)	Weight (g)	Results in MeOH (µg/L)	Results in Dry Soil (mg/Kg)	Results in MeOH (µg/L)	Results in Dry Soil (mg/Kg)	Results in MeOH (µg/L)	Results in Dry Soil (mg/Kg)	Results in MeOH (µg/L)	Results in Dry Soil (mg/Kg)
SB-201-2	0	2	12/8/2000	198	153	131	370	1	<250	ND	<250	ND	<500	ND
SB-201-4	2	4	12/8/2000	197	198	196	1,400	2	<250	ND	<250	ND	<500	ND
SB-201-6	4	6	12/8/2000	194	151	148	1,700	3	<250	ND	<250	ND	<500	ND
SB-201-8	6	8	12/8/2000	208	168	165	880	1	<250	ND	<250	ND	<500	ND
SB-201-10	8	10	12/9/2000	190	204	177	12,000	18	730	1	<500	ND	<1,000	ND
SB-201-12	10	12	12/9/2000	199	266	218	9,500	13	15,000	21	<1,000	ND	<2,000	ND
SB-201-14	12	14	12/9/2000	196	151	128	<830	ND	12,000	25	<830	ND	<1,700	ND
SB-201-16	14	16	12/9/2000	196	165	141	<830	ND	11,000	21	<830	ND	<1,700	ND
SB-201-18	16	18	12/9/2000	NA	NR	NR	NA	NA	NA	NA	NA	NA	NA	NA
SB-201-20	18	20	12/11/2000	199	281	234	<500	ND	7,400	9	<500	ND	<1,000	ND
SB-201-22	20	22	12/11/2000	195	238	204	20,000	28	1,600	2	<1,000	ND	<2,000	ND
SB-201-24	22	24	12/11/2000	198	216	183	39,000	60	<1,800	ND	<1,800	ND	<3,600	ND
SB-201-26	24	26	12/11/2000	201	195	166	2,300,000	3,927	<100,000	ND	<100,000	ND	<200,000	ND
SB-201-28	26	28	12/11/2000	198	205	166	230,000	401	<12,000	ND	<12,000	ND	<25,000	ND
SB-201-30	28	30	12/11/2000	201	218	169	260,000	467	<17,000	ND	<17,000	ND	<33,000	ND
SB-201-32	30	32	12/11/2000	203	179	166	200,000	325	<10,000	ND	<10,000	ND	<20,000	ND
SB-201-32-DUP	30	32	12/11/2000	203	179	144	190,000	385	<8,300	ND	<8,300	ND	<17,000	ND
SB-201-34	32	34	12/11/2000	202	197	164	120,000	211	<8,300	ND	<8,300	ND	<17,000	ND
SB-201-36	34	36	12/11/2000	198	199	167	150,000	254	<8,300	ND	<8,300	ND	<17,000	ND
SB-201-38	36	38	12/11/2000	195	169	137	130,000	265	<10,000	ND	<10,000	ND	<20,000	ND
SB-201-40	38	40	12/11/2000	204	187	155	170,000	318	<3,300	ND	<3,300	ND	<6,700	ND
SB-201-42	40	42	12/11/2000	193	142	119	83,000	186	<3,600	ND	<3,600	ND	<7,100	ND
SB-201-44	42	44	12/11/2000	190	141	125	71,000	146	<3,600	ND	<3,600	ND	<7,100	ND
SB-201-46	44	46	12/11/2000	194	235	186	230,000	364	<8,300	ND	<8,300	ND	17,000	27
SB-201-48	46	48	12/11/2000	199	197	167	160,000	270	<6,200	ND	<6,200	ND	<12,000	ND
SB-201-76	Lab Blank		12/9/2000	NA	NA	NA	<250	ND	<250	ND	<250	ND	<500	ND
SB-201-80	Lab Blank		12/12/2000	NA	NA	NA	<250	ND	<250	ND	<250	ND	<500	ND
SB-201-81	Lab Blank		12/12/2000	NA	NA	NA	<250	ND	<250	ND	<250	ND	<500	ND
SB-202-2	0	2	12/8/2000	196	122	122	<250	ND	<250	ND	<250	ND	<500	ND
SB-202-4	2	4	12/8/2000	196	122	123	<250	ND	<250	ND	<250	ND	<500	ND
SB-202-6	4	6	12/8/2000	188	178	170	2,000	3	<250	ND	<250	ND	<500	ND
SB-202-8	6	8	12/8/2000	191	155	146	3,900	7	<250	ND	<250	ND	<500	ND
SB-202-10	8	10	12/9/2000	202	234	201	28,000	40	<2,000	ND	<2,000	ND	<4,000	ND
SB-202-12	10	12	12/9/2000	205	257	222	22,000 D	29	5,800	8	<250	ND	<500	ND
SB-202-14	12	14	12/9/2000	185	206	173	6,100	9	5,600	9	<250	ND	<500	ND
SB-202-16	14	16	12/9/2000	189	206	173	1,200	2	5,500	9	<500	ND	<1,000	ND
SB-202-18	16	18	12/9/2000	201	235	195	35,000	53	4,900	7	<1,000	ND	<2,000	ND
SB-202-18-DUP	16	18	12/9/2000	205	249	206	19,000	28	3,600	5	<720	ND	<1,400	ND
SB-202-20	18	20	12/9/2000	202	190	160	62,000	111	3,700	7	<2,000	ND	<4,000	ND
SB-202-22	20	22	12/9/2000	199	191	167	2,600,000	4,295	<210,000	ND	<210,000	ND	<420,000	ND
SB-202-24	22	24	12/9/2000	196	221	186	820,000	1,248	<50,000	ND	<50,000	ND	<100,000	ND
SB-202-26	24	26	12/9/2000	202	268	230	80,000	102	<5,000	ND	<5,000	ND	<10,000	ND
SB-202-28	26	28	12/9/2000	198	213	178	220,000	353	<12,000	ND	<12,000	ND	<25,000	ND

Table C-4. Resistive Heating Postdemonstration Soil Sample Results (mg/Kg) (Continued)

	Sample Depth (ft)				Wet Soil	Dry Soil	TCE		*cis* -1,2-DCE		*trans* -1,2-DCE		Vinyl Chloride	
Sample ID	Top Depth	Bottom Depth	Sample Date	MeOH (g)	Weight (g)	Weight (g)	Results in MeOH (µg/L)	Results in Dry Soil (mg/Kg)	Results in MeOH (µg/L)	Results in Dry Soil (mg/Kg)	Results in MeOH (µg/L)	Results in Dry Soil (mg/Kg)	Results in MeOH (µg/L)	Results in Dry Soil (mg/Kg)
SB-202-30	28	30	12/9/2000	197	227	174	3,200,000	5,561	<210,000	ND	<210,000	ND	<420,000	ND
SB-202-32	30	32	12/9/2000	194	214	175	240,000	390	<12,000	ND	<12,000	ND	<25,000	ND
SB-202-34	32	34	12/9/2000	186	214	169	280,000	465	<12,000	ND	<12,000	ND	<25,000	ND
SB-202-36	34	36	12/9/2000	192	264	233	87,000	102	<5,000	ND	<5,000	ND	<10,000	ND
SB-202-38	36	38	12/9/2000	189	284	211	290,000	429	<16,000	ND	<16,000	ND	<31,000	ND
SB-202-40	38	40	12/9/2000	187	212	***181***	320,000	474	<17,000	ND	<17,000	ND	<33,000	ND
SB-202-42	40	42	12/9/2000	195	227	192	170,000	250	12,000	18	<10,000	ND	<20,000	ND
SB-202-44	42	44	12/9/2000	204	195	164	190,000	335	<10,000	ND	<10,000	ND	<20,000	ND
SB-202-46	44	46	12/9/2000	201	216	189	5,300	8	<250	ND	<250	ND	<500	ND
SB-202-75	Lab Blank		12/9/2000	NA	NA	NA	<250	ND	<250	ND	<250	ND	<500	ND
SB-202-77	Lab Blank		12/11/2000	NA	NA	NA	<250	ND	<250	ND	<250	ND	<500	ND
RINSATE-13	EQ		12/9/2000	NA	NA	NA	<1	ND	<1	ND	<1	ND	<2	ND
SB-203-2	0	2	11/17/2000	203	95	91	430	1	<250	ND	<250	ND	<500	ND
SB-203-4	2	4	11/17/2000	204	127	120	<250	ND	<250	ND	<250	ND	<500	ND
SB-203-6	4	6	11/17/2000	194	143	131	390	1	<250	ND	<250	ND	<500	ND
SB-203-8	6	8	11/17/2000	196	139	125	1,300	3	<250	ND	<250	ND	<500	ND
SB-203-10	8	10	11/17/2000	197	189	157	50,000	90	2,300	4	<2,000	ND	<4,000	ND
SB-203-12	10	12	11/17/2000	204	205	178	71,000	114	<3,000	ND	<3,000	ND	<5,900	ND
SB-203-14	12	14	11/17/2000	187	145	142	36,000	61	5,300	9	<1,500	ND	<3,000	ND
SB-203-16	14	16	11/17/2000	187	165	116	51,000	126	11,000	27	<2,000	ND	<4,000	ND
SB-203-18	16	18	11/17/2000	195	183	148	51,000	97	16,000	30	<2,500	ND	<5,000	ND
SB-203-20	18	20	11/17/2000	195	175	142	36,000	71	17,000	34	<1,200	ND	<2,500	ND
SB-203-22	20	22	11/17/2000	NA	NR	NR	NA	NA	NA	NA	NA	NA	NA	NA
SB-203-24	22	24	11/17/2000	NA	NR	NR	NA	NA	NA	NA	NA	NA	NA	NA
SB-203-26	24	26	11/17/2000	193	226	180	160,000	258	22,000	35	<8,300	ND	<17,000	ND
SB-203-28	26	28	11/17/2000	193	212	165	140,000	247	27,000	48	<5,000	ND	<10,000	ND
SB-203-30	28	30	11/17/2000	192	206	164	700,000	1,217	25,000	43	<25,000	ND	<50,000	ND
SB-203-32	30	32	11/17/2000	192	206	140	130,000	287	19,000	42	<5,000	ND	<10,000	ND
SB-203-34	32	34	11/17/2000	200	171	145	29,000	56	5,900	11	<1,000	ND	<2,000	ND
SB-203-36	34	36	11/17/2000	196	179	155	44,000	77	3,300	6	<1,800	ND	<3,600	ND
SB-203-38	36	38	11/17/2000	199	188	144	150,000	308	18,000	37	<6,200	ND	<12,000	ND
SB-203-38-DUP	36	38	11/17/2000	194	170	125	130,000	302	17,000	40	<4,200	ND	<8,300	ND
SB-203-40	38	40	11/17/2000	201	187	134	81,000	186	14,000	32	<3,600	ND	<7,100	ND
SB-203-44	42	44	11/17/2000	201	276	225	25,000	34	1,000	1	<1,000	ND	<2,000	ND
SB-203-46	44	46	11/17/2000	191	227	191	28,000 D	41	<500	ND	<500	ND	<1,000	ND
SB-203-056	Lab Blank		11/20/2000	NA	NA	NA	<250	ND	<250	ND	<250	ND	<500	ND
SB-203-EB	EQ		11/20/2000	NA	NA	NA	1		<1	ND	<1	ND	<2	ND
SB-204-2	0	2	11/16/2000	194	117	100	510	1	<250	ND	<250	ND	<500	ND
SB-204-4	2	4	11/16/2000	193	145	143	1,500	3	<250	ND	<250	ND	<500	ND
SB-204-6	4	6	11/16/2000	194	148	144	<250	ND	<250	ND	<250	ND	<500	ND
SB-204-8	6	8	11/16/2000	194	120	113	2,100	5	<250	ND	<250	ND	<500	ND
SB-204-10	8	10	11/17/2000	193	220	184	3,800	6	2,700	4	<250	ND	<500	ND
SB-204-12	10	12	11/17/2000	193	224	185	21,000	32	1,200	2	<720	ND	<1,400	ND

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Table C-4. Resistive Heating Postdemonstration Soil Sample Results (mg/Kg) (Continued)

	Sample Depth (ft)				Wet Soil	Dry Soil	TCE		*cis*-1,2-DCE		*trans*-1,2-DCE		Vinyl Chloride	
Sample ID	Top Depth	Bottom Depth	Sample Date	MeOH (g)	Weight (g)	Weight (g)	Results in MeOH (µg/L)	Results in Dry Soil (mg/Kg)	Results in MeOH (µg/L)	Results in Dry Soil (mg/Kg)	Results in MeOH (µg/L)	Results in Dry Soil (mg/Kg)	Results in MeOH (µg/L)	Results in Dry Soil (mg/Kg)
SB-204-14	12	14	11/17/2000	NA	NR	NR	NA	NA	NA	NA	NA	NA	NA	NA
SB-204-16	14	16	11/17/2000	NA	NR	NR	NA	NA	NA	NA	NA	NA	NA	NA
SB-204-18	16	18	11/17/2000	193	212	174	12,000	19	380	1	<250	ND	<500	ND
SB-204-20	18	20	11/17/2000	194	234	194	1,500	2	760	1	<250	ND	<500	ND
SB-204-22	20	22	11/17/2000	194	247	208	61,000	83	<2,000	ND	<2,000	ND	<4,000	ND
SB-204-24	22	24	11/17/2000	201	164	135	50,000	105	<1,500	ND	<1,500	ND	<2,900	ND
SB-204-24-DUP	22	24	11/17/2000	202	149	128	47,000	102	<1,500	ND	<1,500	ND	<3,000	ND
SB-204-26	24	26	11/17/2000	197	218	172	140,000	240	5,500	9	<5,000	ND	<10,000	ND
SB-204-28	26	28	11/17/2000	192	216	175	120,000	195	4,900	8	<4,600	ND	<9,100	ND
SB-204-30	28	30	11/17/2000	201	252	194	250,000	403	<10,000	ND	<10,000	ND	<20,000	ND
SB-204-32	30	32	11/17/2000	199	288	242	160,000	197	<6,200	ND	<6,200	ND	<12,000	ND
SB-204-34	32	34	11/17/2000	194	237	196	180,000	263	<6,200	ND	<6,200	ND	<12,000	ND
SB-204-36	34	36	11/17/2000	192	231	181	110,000	178	<4,600	ND	<4,600	ND	<9,100	ND
SB-204-38	36	38	11/17/2000	193	231	176	250,000	425	<10,000	ND	<10,000	ND	<20,000	ND
SB-204-40	38	40	11/17/2000	193	192	162	82,000	139	<3,300	ND	<3,300	ND	<6,600	ND
SB-204-43	41	43	11/17/2000	195	264	214	280,000	388	<10,000	ND	<10,000	ND	<20,000	ND
SB-204-45	43	45	11/17/2000	194	304	229	260,000	364	<10,000	ND	<10,000	ND	<20,000	ND
SB-204-055	Lab Blank		11/17/2000	NA	NA	NA	<250	ND	<250	ND	<250	ND	<12,000	ND
SB-204-EB	EQ		11/17/2000	NA	NA	NA	1		<1	ND	<1	ND	<2	ND
SB-205-2	0	2	11/17/2000	193	81	79	1,900	6	<250	ND	<250	ND	<500	ND
SB-205-4	2	4	11/17/2000	195	168	161	820	1	<250	ND	<250	ND	<500	ND
SB-205-6	4	6	11/17/2000	192	137	135	6,400	12	<250	ND	<250	ND	<500	ND
SB-205-8	6	8	11/17/2000	192	93	88	1,600	5	<250	ND	<250	ND	<500	ND
SB-205-10	8	10	11/20/2000	193	106	88	3,300	10	1,700	5	<250	ND	<500	ND
SB-205-12	10	12	11/20/2000	193	113	97	3,800	10	550	1	<250	ND	<500	ND
SB-205-14	12	14	11/20/2000	192	164	140	9,000	17	2,400	5	<250	ND	<500	ND
SB-205-16	14	16	11/20/2000	193	143	119	54,000	122	<1,200	ND	<1,200	ND	<2,500	ND
SB-205-18	16	18	11/20/2000	198	165	138	98,000	197	<2,000	ND	<2,000	ND	<4,000	ND
SB-205-20	18	20	11/20/2000	203	129	100	31,000	89	<830	ND	<830	ND	<1,700	ND
SB-205-22	20	22	11/20/2000	194	149	121	27,000	61	<830	ND	<830	ND	<1,700	ND
SB-205-24	22	24	11/20/2000	NA	NR	NR	NA	NA	NA	NA	NA	NA	NA	NA
SB-205-26	24	26	11/20/2000	194	149	143	100,000	176	2,800	5	<2,500	ND	<5,000	ND
SB-205-26B	24	26	11/20/2000	194	169	127	78,000	177	<2,500	ND	<2,500	ND	<5,000	ND
SB-205-28	26	28	11/20/2000	193	270	181	96,000	177	3,000	6	<2,000	ND	<4,000	ND
SB-205-30	28	30	11/20/2000	199	270	233	82,000	102	2,500	3	<2,500	ND	<5,000	ND
SB-205-32	30	32	11/20/2000	202	195	159	82,000	150	2,500	5	<2,000	ND	<4,000	ND
SB-205-34	32	34	11/20/2000	200	198	165	81,000	140	2,100	4	<1,800	ND	<3,600	ND
SB-205-36	34	36	11/20/2000	207	184	160	36,000	64	1,000	2	<1,000	ND	<2,000	ND
SB-205-38	36	38	11/20/2000	205	185	148	73,000	146	<2,500	ND	<2,500	ND	<5,000	ND
SB-205-40	38	40	11/20/2000	195	174	142	120,000	236	2,700	5	<2,500	ND	<5,000	ND
SB-205-42	40	42	11/20/2000	194	210	176	61,000	97	2,100	3	<1,200	ND	<2,500	ND
SB-205-45	43	45	11/20/2000	193	214	181	84,000	129	<2,000	ND	<2,000	ND	<4,000	ND
SB-205-057	Lab Blank		11/20/2000	NA	NA	NA	<250	ND	<250	ND	<250	ND	<500	ND

Table C-4. Resistive Heating Postdemonstration Soil Sample Results (mg/Kg) (Continued)

Sample ID	Sample Depth (ft) Top Depth	Bottom Depth	Sample Date	MeOH (g)	Wet Soil Weight (g)	Dry Soil Weight (g)	TCE Results in MeOH (µg/L)	TCE Results in Dry Soil (mg/Kg)	cis-1,2-DCE Results in MeOH (µg/L)	cis-1,2-DCE Results in Dry Soil (mg/Kg)	trans-1,2-DCE Results in MeOH (µg/L)	trans-1,2-DCE Results in Dry Soil (mg/Kg)	Vinyl Chloride Results in MeOH (µg/L)	Vinyl Chloride Results in Dry Soil (mg/Kg)
SB-205-058	Lab Blank		11/20/2000	NA	NA	NA	<250	ND	<250	ND	<250	ND	<500	ND
SB-205-EB	EQ		11/20/2000	NA	NA	NA	1		<1	ND	<1	ND	<2	ND
SB-206-2	0	2	11/20/2000	193	56	57	1,300	6	<250	ND	<250	ND	<500	ND
SB-206-4	2	4	11/20/2000	196	133	129	<250	ND	<250	ND	<250	ND	<500	ND
SB-206-6	4	6	11/20/2000	204	142	135	2,900	6	<250	ND	<250	ND	<500	ND
SB-206-8	6	8	11/20/2000	202	149	137	1,700	3	<250	ND	<250	ND	<500	ND
SB-206-10	8	10	11/21/2000	193	158	139	29,000	55	<1,200	ND	<1,200	ND	<2,500	ND
SB-206-12	10	12	11/21/2000	194	164	140	36,000	69	<1,800	ND	<1,800	ND	<3,600	ND
SB-206-14	12	14	11/21/2000	207	162	135	33,000	71	2,000	4	<1,800	ND	<3,600	ND
SB-206-16	14	16	11/21/2000	204	215	181	47,000	76	2,900	5	<2,000	ND	<4,000	ND
SB-206-18	16	18	11/21/2000	199	165	133	77,000	164	5,300	11	<3,600	ND	<7,100	ND
SB-206-20	18	20	11/21/2000	199	213	190	82,000	119	5,700	8	<4,200	ND	<8,300	ND
SB-206-22	20	22	11/21/2000	203	333	278	200,000	224	17,000	19	<8,300	ND	<17,000	ND
SB-206-24	22	24	11/21/2000	194	177	167	88,000	135	8,500	13	<3,100	ND	<6,200	ND
SB-206-26	24	26	11/21/2000	195	124	102	81,000	213	5,600	15	<4,200	ND	<8,300	ND
SB-206-26-DUP	24	26	11/21/2000	195	121	99	65,000	177	4,700	13	<3,600	ND	<7,100	ND
SB-206-28	26	28	11/21/2000	195	170	141	120,000	235	7,100	14	<6,200	ND	<12,000	ND
SB-206-30	28	30	11/21/2000	195	177	147	56,000	105	<3,600	ND	<3,600	ND	<7,100	ND
SB-206-32	30	32	11/21/2000	201	153	134	42,000	86	<2,500	ND	<2,500	ND	<5,000	ND
SB-206-34	32	34	11/21/2000	207	193	163	35,000	63	9,100	16	<1,800	ND	<3,600	ND
SB-206-36	34	36	11/21/2000	195	210	182	23,000	35	5,800	9	<1,500	ND	<2,900	ND
SB-206-38	36	38	11/21/2000	197	222	182	62,000	99	6,100	10	<2,500	ND	<5,000	ND
SB-206-40	38	40	11/21/2000	193	171	145	48,000	89	7,400	14	<1,800	ND	<3,600	ND
SB-206-43	41	43	11/21/2000	203	179	150	78,000	149	3,700	7	<3,600	ND	<7,100	ND
SB-206-45	43	45	11/21/2000	202	246	210	91,000	126	4,900	7	<4,200	ND	<8,300	ND
SB-206-059	Lab Blank		11/20/2000	NA	NA	NA	<250	ND	<250	ND	<250	ND	<500	ND
SB-206-060	Lab Blank		11/21/2000	NA	NA	NA	<250	ND	<250	ND	<250	ND	<500	ND
SB-206-EB	EQ		11/21/2000	NA	NA	NA	1		<1	ND	<1	ND	<2	ND
SB-207-2	0	2	11/16/2000	204	97	94	<250	ND	<250	ND	<250	ND	<500	ND
SB-207-4	2	4	11/16/2000	200	160	155	290	0.48	<250	ND	<250	ND	<500	ND
SB-207-6	4	6	11/16/2000	192	146	130	2,900	6	<250	ND	<250	ND	<500	ND
SB-207-8	6	8	11/16/2000	203	253	213	44,000	61	<1,800	ND	<1,800	ND	<3,600	ND
SB-207-10	8	10	11/16/2000	206	202	173	<500	ND	7,900	13	<500	ND	<1,000	ND
SB-207-10-DUP	8	10	11/16/2000	202	143	122	<250	ND	3,400	8	<250	ND	<500	ND
SB-207-12	10	12	11/16/2000	204	194	154	<720	ND	16,000	31	<720	ND	<1,400	ND
SB-207-14	12	14	11/16/2000	194	202	168	<250	ND	710	1	<250	ND	<500	ND
SB-207-16	14	16	11/16/2000	199	136	119	660	1	650	1	<250	ND	<500	ND
SB-207-18	16	18	11/16/2000	193	232	195	570	1	530	1	<250	ND	<500	ND
SB-207-20	18	20	11/16/2000	195	246	208	<250	ND	1,600	2	<250	ND	<500	ND
SB-207-22	20	22	11/16/2000	193	188	156	33,000	58	<1,200	ND	<1,200	ND	<2,500	ND
SB-207-24	22	24	11/16/2000	193	207	173	53,000	85	<1,800	ND	<1,800	ND	<3,600	ND
SB-207-26	24	26	11/16/2000	192	246	172	280,000	516	<12,000	ND	<12,000	ND	<25,000	ND
SB-207-28	26	28	11/16/2000	210	283	217	240,000	367	<10,000	ND	<10,000	ND	<20,000	ND

Table C-4. Resistive Heating Postdemonstration Soil Sample Results (mg/Kg) (Continued)

	Sample Depth (ft)				Wet Soil	Dry Soil	TCE		*cis* -1,2-DCE		*trans* -1,2-DCE		Vinyl Chloride	
Sample ID	Top Depth	Bottom Depth	Sample Date	MeOH (g)	Weight (g)	Weight (g)	Results in MeOH (µg/L)	Results in Dry Soil (mg/Kg)	Results in MeOH (µg/L)	Results in Dry Soil (mg/Kg)	Results in MeOH (µg/L)	Results in Dry Soil (mg/Kg)	Results in MeOH (µg/L)	Results in Dry Soil (mg/Kg)
SB-207-30	28	30	11/16/2000	193	196	152	98,000	186	<4,600	ND	<4,600	ND	<9,100	ND
SB-207-32	30	32	11/16/2000	202	205	175	120,000	196	<4,600	ND	<4,600	ND	<9,100	ND
SB-207-34	32	34	11/16/2000	156	223	152	220,000	389	<10,000	ND	<10,000	ND	<20,000	ND
SB-207-36	34	36	11/16/2000	240	185	145	170,000	403	<6,200	ND	<6,200	ND	<12,000	ND
SB-207-38	36	38	11/16/2000	193	222	177	97,000	159	<4,200	ND	<4,200	ND	<8,400	ND
SB-207-40	38	40	11/16/2000	193	213	183	55,000	82	<2,500	ND	<2,500	ND	<5,000	ND
SB-207-42	40	42	11/16/2000	199	293	193	280,000	511	<12,000	ND	<12,000	ND	<25,000	ND
SB-207-44	42	44	11/16/2000	204	275	219	190,000	273	<6,200	ND	<6,200	ND	<12,000	ND
SB-207-054	Lab Blank		11/16/2000	NA	NA	NA	<250	ND	<250	ND	<250	ND	<500	ND
SB-207-EB	EQ		11/16/2000	NA	NA	NA	1		<1	ND	<1	ND	<2	ND
SB-208-2	0	2	11/15/2000	192	134	130	820	2	370	1	<250	ND	<500	ND
SB-208-4	2	4	11/15/2000	196	181	177	1,000	1	<250	ND	<250	ND	<500	ND
SB-208-6	4	6	11/15/2000	194	170	156	2,900	5	530	1	<250	ND	<500	ND
SB-208-8	6	8	11/15/2000	187	156	133	37,000	72	<2,500	ND	<2,500	ND	<5,000	ND
SB-208-10	8	10	11/15/2000	191	176	154	<250	ND	1,100	2	<250	ND	<500	ND
SB-208-12	10	12	11/15/2000	206	188	164	<250	ND	470	1	<250	ND	<500	ND
SB-208-14	12	14	11/15/2000	193	154	125	11,000	24	830	2	<500	ND	<1,000	ND
SB-208-16	14	16	11/15/2000	197	188	163	3,700	6	380	1	<250	ND	<500	ND
SB-208-18	16	18	11/15/2000	196	252	215	20,000	27	1,700	2	<720	ND	<1,400	ND
SB-208-20	18	20	11/15/2000	NA	NR	NR	NA	NA	NA	NA	NA	NA	NA	NA
SB-208-22	20	22	11/15/2000	198	240	192	21,000	33	3,500	5	<1,000	ND	<2,000	ND
SB-208-24	22	24	11/15/2000	197	227	186	7,700	12	1,500	2	<380	ND	<770	ND
SB-208-26	24	26	11/15/2000	196	289	204	18,000	29	4,100	7	<720	ND	<1,400	ND
SB-208-28	26	28	11/15/2000	191	212	153	16,000	31	3,800	7	<720	ND	<1,400	ND
SB-208-30	28	30	11/16/2000	192	150	74	8,000	34	1,500	6	<250	ND	<500	ND
SB-208-32	30	32	11/16/2000	NA	NR	NR	NA	NA	NA	NA	NA	NA	NA	NA
SB-208-34	32	34	11/16/2000	197	228	179	31,000	52	4,000	7	<1,000	ND	<2,000	ND
SB-208-36	34	36	11/16/2000	196	199	151	32,000	63	4,000	8	<1,000	ND	<2,000	ND
SB-208-38	36	38	11/16/2000	203	310	248	1,400	2	490	1	<250	ND	<500	ND
SB-208-40	38	40	11/16/2000	204	235	201	7,600	11	770	1	<250	ND	<500	ND
SB-208-40-DUP	38	40	11/16/2000	195	247	214	8,600	11	890	1	<250	ND	<500	ND
SB-208-42	40	42	11/16/2000	199	265	220	3,100	4	420	1	<250	ND	<500	ND
SB-208-44	42	44	11/16/2000	204	277	232	40,000	52	2,800	4	<1,800	ND	<3,600	ND
SB-208-45	43	45	11/16/2000	191	254	202	110,000	160	6,000	9	<4,600	ND	<9,100	ND
SB-208-052	Lab Blank		11/15/2000	NA	NA	NA	<250	ND	<250	ND	<250	ND	<500	ND
SB-208-EB	EQ		11/16/2000	NA	NA	NA	1		<1	ND	<1	ND	<2	ND
SB-209-2	0	2	11/15/2000	202	115	110	<250	ND	290	1	<250	ND	<500	ND
SB-209-4	2	4	11/15/2000	194	75	71	<250	ND	<250	ND	<250	ND	<500	ND
SB-209-6	4	6	11/15/2000	203	171	147	2,000	4	600	1	<250	ND	<500	ND
SB-209-8	6	8	11/15/2000	190	191	173	3,600	5	1,600	2	<250	ND	<500	ND
SB-209-10	8	10	11/15/2000	203	223	193	550	1	2,400	4	<250	ND	<500	ND
SB-209-12	10	12	11/15/2000	194	166	145	540	1	1,300	2	<250	ND	<500	ND
SB-209-14	12	14	11/15/2000	195	188	154	2,500	5	9,600	18	<250	ND	<500	ND

Table C-4. Resistive Heating Postdemonstration Soil Sample Results (mg/Kg) (Continued)

	Sample Depth (ft)				Wet Soil	Dry Soil	TCE		*cis* -1,2-DCE		*trans* -1,2-DCE		Vinyl Chloride	
Sample ID	Top Depth	Bottom Depth	Sample Date	MeOH (g)	Weight (g)	Weight (g)	Results in MeOH (µg/L)	Results in Dry Soil (mg/Kg)	Results in MeOH (µg/L)	Results in Dry Soil (mg/Kg)	Results in MeOH (µg/L)	Results in Dry Soil (mg/Kg)	Results in MeOH (µg/L)	Results in Dry Soil (mg/Kg)
SB-209-16	14	16	11/15/2000	200	172	139	1,800	4	5,800	12	<500	ND	<1,000	ND
SB-209-18	16	18	11/15/2000	199	232	191	8,600	13	16,000	25	<1,200	ND	<2,500	ND
SB-209-18B	16	18	11/15/2000	189	163	138	3,000	6	5,900	11	<500	ND	<1,000	ND
SB-209-20	18	20	11/15/2000	199	178	149	1,700	3	12,000	23	<1,000	ND	<2,000	ND
SB-209-22	20	22	11/15/2000	195	172	133	13,000	28	7,400	16	<500	ND	<1,000	ND
SB-209-24	22	24	11/15/2000	193	222	182	22,000	34	9,500	15	<720	ND	<1,400	ND
SB-209-26	24	26	11/15/2000	201	249	191	39,000	64	36,000	59	<1,200	ND	<2,500	ND
SB-209-28	26	28	11/15/2000	193	230	190	24,000	36	20,000	30	<1,200	ND	<2,500	ND
SB-209-30	28	30	11/15/2000	193	240	197	19,000	28	19,000	28	<1,000	ND	<2,000	ND
SB-209-32	30	32	11/15/2000	192	263	233	9,400	11	9,700	11	<720	ND	<1,400	ND
SB-209-34	32	34	11/15/2000	193	236	197	13,000	19	5,300	8	<500	ND	<1,000	ND
SB-209-36	34	36	11/15/2000	193	224	171	3,100	5	10,000	17	<720	ND	<1,400	ND
SB-209-38	36	38	11/15/2000	193	224	194	52,000	74	2,300	3	<1,800	ND	<3,600	ND
SB-209-40	38	40	11/15/2000	193	236	172	30,000	54	<1,200	ND	<1,200	ND	<2,500	ND
SB-209-42	40	42	11/15/2000	192	272	206	51,000	77	<1,800	ND	<1,800	ND	<3,600	ND
SB-209-44	42	44	11/15/2000	200	295	232	38,000	52	<1,200	ND	<1,200	ND	<2,500	ND
SB-209-EB	EQ		11/15/2000	NA	NA	NA	1		<1	ND	<1	ND	<2	ND
SB-210-2	0	2	11/13/2000	192	113	109	<250	ND	<250	ND	<250	ND	<500	ND
SB-210-4	2	4	11/13/2000	198	127	125	<250	ND	<250	ND	<250	ND	<500	ND
SB-210-6	4	6	11/13/2000	191	107	95	1,200	3	<250	ND	<250	ND	<500	ND
SB-210-8	6	8	11/13/2000	193	135	114	11,000	26	910	2	<250	ND	<500	ND
SB-210-10	8	10	11/13/2000	NA	NR	NR	NA	NA	NA	NA	NA	NA	NA	NA
SB-210-12	10	12	11/13/2000	NA	NR	NR	NA	NA	NA	NA	NA	NA	NA	NA
SB-210-14	12	14	11/13/2000	199	287	241	<250	ND	420	1	<250	ND	<500	ND
SB-210-16	14	16	11/13/2000	191	117	101	2,200	6	<250	ND	<250	ND	<500	ND
SB-210-18	16	18	11/13/2000	190	131	111	NA	NA	NA	NA	NA	NA	NA	NA
SB-210-20	18	20	11/13/2000	198	314	263	8,700	10	340	0	<250	ND	<500	ND
SB-210-22	20	22	11/13/2000	194	201	164	52,000	90	<1,800	ND	<1,800	ND	<3,600	ND
SB-210-24	22	24	11/13/2000	194	253	202	31,000	46	1,000	1	<1,000	ND	<2,000	ND
SB-210-26	24	26	11/13/2000	191	243	196	180,000	265	<6,200	ND	<6,200	ND	<12,000	ND
SB-210-26B	24	26	11/13/2000	198	224	183	120,000	191	<5,000	ND	<5,000	ND	<10,000	ND
SB-210-28	26	28	11/13/2000	200	357	281	100,000	117	3,400	4	<2,500	ND	<5,000	ND
SB-210-30	28	30	11/13/2000	195	317	255	140,000	170	13,000	16	<3,600	ND	<7,200	ND
SB-210-32	30	32	11/14/2000	190	215	163	160,000	287	5,000	9	<5,000	ND	<10,000	ND
SB-210-34	32	34	11/14/2000	202	281	224	150,000	209	<6,200	ND	<6,200	ND	<12,000	ND
SB-210-36	34	36	11/14/2000	199	240	167	220,000	428	<10,000	ND	<10,000	ND	<20,000	ND
SB-210-38	36	38	11/14/2000	194	187	150	140,000	264	<5,000	ND	<5,000	ND	<10,000	ND
SB-210-40	38	40	11/14/2000	198	287	222	170,000	242	<7,200	ND	<7,200	ND	<14,000	ND
SB-210-42	40	42	11/14/2000	200	264	206	170,000	257	<7,200	ND	<7,200	ND	<14,000	ND
SB-210-44	42	44	11/14/2000	182	192	140	50,000	101	4,600	9	<2,500	ND	<5,000	ND
SB-210-46	44	46	11/14/2000	194	163	129	27,000	59	2,100	5	<1,200	ND	<2,500	ND
SB-210-EB	EQ		11/14/2000	NA	NA	NA	1		<1	ND	<1	ND	<2	ND
SB-210B-2	0	2	11/27/2000	193	144	139	1,600	3	<250	ND	<250	ND	<500	ND

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Table C-4. Resistive Heating Postdemonstration Soil Sample Results (mg/Kg) (Continued)

Sample ID	Sample Depth (ft) Top Depth	Sample Depth (ft) Bottom Depth	Sample Date	MeOH (g)	Wet Soil Weight (g)	Dry Soil Weight (g)	TCE Results in MeOH (µg/L)	TCE Results in Dry Soil (mg/Kg)	*cis* -1,2-DCE Results in MeOH (µg/L)	*cis* -1,2-DCE Results in Dry Soil (mg/Kg)	*trans* -1,2-DCE Results in MeOH (µg/L)	*trans* -1,2-DCE Results in Dry Soil (mg/Kg)	Vinyl Chloride Results in MeOH (µg/L)	Vinyl Chloride Results in Dry Soil (mg/Kg)
SB-210B-4	2	4	11/27/2000	198	122	114	1,000	2	<250	ND	<250	ND	<500	ND
SB-210B-6	4	6	11/27/2000	199	160	134	11,000	23	1,600	3	<460	ND	<910	ND
SB-210B-8	6	8	11/27/2000	200	193	159	11,000	20	3,700	7	<500	ND	<1,000	ND
SB-210B-10	8	10	11/27/2000	NA	NR	NR	NA	NA	NA	NA	NA	NA	NA	NA
SB-210B-12	10	12	11/27/2000	NA	NR	NR	NA	NA	NA	NA	NA	NA	NA	NA
SB-210B-14	12	14	11/27/2000	203	174	149	<250	ND	<250	ND	<250	ND	<500	ND
SB-210B-16	14	16	11/27/2000	208	165	139	<250	ND	<250	ND	<250	ND	<500	ND
SB-210B-18	16	18	11/27/2000	193	208	176	700	1	<250	ND	<250	ND	<500	ND
SB-210B-20	18	20	11/27/2000	208	184	153	2,900	6	310	1	<250	ND	<500	ND
SB-210B-22	20	22	11/27/2000	192	161	137	8,200	16	250	0	<250	ND	<500	ND
SB-210B-24	22	24	11/27/2000	205	216	177	29,000	49	<1,200	ND	<1,200	ND	<2,500	ND
SB-210B-26	24	26	11/27/2000	194	224	169	320,000	569	<12,000	ND	<12,000	ND	<25,000	ND
SB-210B-28	26	28	11/27/2000	192	237	194	210,000	310	<8,300	ND	<8,300	ND	<17,000	ND
SB-210B-30	28	30	11/27/2000	191	195	163	46,000	77	4,600	8	<1,800	ND	<3,600	ND
SB-210B-32	30	32	11/27/2000	190	192	168	17,000	27	3,200	5	<830	ND	<1,700	ND
SB-210B-32B	30	32	11/27/2000	190	171	151	12,000	21	2,400	4	<500	ND	<1,000	ND
SB-210B-34	32	34	11/27/2000	187	200	150	180,000	344	<8,300	ND	<8,300	ND	<17,000	ND
SB-210B-36	34	36	11/27/2000	192	169	133	150,000	315	<8,300	ND	<8,300	ND	<17,000	ND
SB-210B-38	36	38	11/27/2000	194	205	177	80,000	124	<4,200	ND	<4,200	ND	<8,300	ND
SB-210B-40	38	40	11/27/2000	194	195	164	130,000	219	<8,300	ND	<8,300	ND	<17,000	ND
SB-210B-42	40	42	11/27/2000	191	193	162	140,000	236	<6,200	ND	<6,200	ND	<12,000	ND
SB-210B-44	42	44	11/27/2000	191	190	145	150,000	297	<8,300	ND	<8,300	ND	<17,000	ND
SB-061-A	Lab Blank		11/28/2000	NA	NA	NA	<250	ND	<250	ND	<250	ND	<500	ND
RINSATE-1	EQ		11/27/2000	NA	NA	NA	1		<1	ND	<1	ND	<2	ND
SB-211-2	0	2	11/14/2000	192	66	66	1,600	6	<250	ND	<250	ND	<500	ND
SB-211-4	2	4	11/14/2000	195	67	60	410	2	<250	ND	<250	ND	<500	ND
SB-211-6	4	6	11/14/2000	194	119	107	1,300	3	<250	ND	<250	ND	<500	ND
SB-211-8	6	8	11/14/2000	194	233	94	12,000	49	1,300	5	<500	ND	<1,000	ND
SB-211-10	8	10	11/14/2000	194	233	197	470	1	3,700	5	<250	ND	<500	ND
SB-211-12	10	12	11/14/2000	NA	NR	NR	NA	NA	NA	NA	NA	NA	NA	NA
SB-211-14	12	14	11/14/2000	197	210	177	<830	ND	9,500	15	<830	ND	<1,700	ND
SB-211-16	14	16	11/14/2000	NA	NR	NR	NA	NA	NA	NA	NA	NA	NA	NA
SB-211-18	16	18	11/14/2000	199	249	209	1,600	2	4,500	6	<250	ND	<500	ND
SB-211-20	18	20	11/14/2000	202	193	169	1,800	3	1,400	2	<250	ND	<500	ND
SB-211-22	20	22	11/14/2000	200	226	190	9,000	14	8,800	13	<830	ND	<1,700	ND
SB-211-24	22	24	11/14/2000	200	181	151	4,400	8	5,700	11	<500	ND	<1,000	ND
SB-211-26	24	26	11/14/2000	197	207	177	2,300	4	2,400	4	<250	ND	<500	ND
SB-211-28	26	28	11/14/2000	197	219	186	8,300	13	8,700	13	<250	ND	<500	ND
SB-211-30	28	30	11/14/2000	205	190	137	140,000	319	9,500	22	<5,000	ND	<10,000	ND
SB-211-32	30	32	11/14/2000	195	201	178	67,000	102	3,200	5	<2,500	ND	<5,000	ND
SB-211-32B	30	32	11/14/2000	195	163	144	50,000	92	<2,500	ND	<2,500	ND	<5,000	ND
SB-211-34	32	34	11/14/2000	195	163	161	51,000	79	10,000	15	<1,800	ND	<3,600	ND
SB-211-36	34	36	11/14/2000	207	196	163	39,000	71	6,700	12	<1,200	ND	<2,500	ND

Table C-4. Resistive Heating Postdemonstration Soil Sample Results (mg/Kg) (Continued)

	Sample Depth (ft)				Wet Soil	Dry Soil	TCE		*cis*-1,2-DCE		*trans*-1,2-DCE		Vinyl Chloride	
Sample ID	Top Depth	Bottom Depth	Sample Date	MeOH (g)	Weight (g)	Weight (g)	Results in MeOH (µg/L)	Results in Dry Soil (mg/Kg)	Results in MeOH (µg/L)	Results in Dry Soil (mg/Kg)	Results in MeOH (µg/L)	Results in Dry Soil (mg/Kg)	Results in MeOH (µg/L)	Results in Dry Soil (mg/Kg)
SB-211-38	36	38	11/14/2000	199	265	238	12,000	14	4,200	5	<250	ND	<500	ND
SB-211-40	38	40	11/14/2000	202	197	182	5,800	9	1,400	2	<250	ND	<500	ND
SB-211-42	40	42	11/14/2000	202	317	255	1,300	2	3,000	4	<250	ND	<500	ND
SB-211-44	42	44	11/14/2000	196	218	189	<250	ND	530	1	<250	ND	<500	ND
SB-211-50	Lab Blank		1/14/2000	NA	NA	NA	<250	ND	<250	ND	<250	ND	<500	ND
SB-211-EB	EQ		11/14/2000	NA	NA	NA	1		<1	ND	<1	ND	<2	ND
SB-212-2	0	2	11/14/2000	163	131	126	<250	ND	<250	ND	<250	ND	<500	ND
SB-212-4	2	4	11/14/2000	191	142	121	1,600	3	<250	ND	<250	ND	<500	ND
SB-212-6	4	6	11/14/2000	197	140	135	5,300	10	640	1	<250	ND	<500	ND
SB-212-8	6	8	11/14/2000	194	161	132	5,600	12	2,300	5	<250	ND	<500	ND
SB-212-10	8	10	11/14/2000	198	138	117	7,100	16	2,500	6	<250	ND	<500	ND
SB-212-12	10	12	11/14/2000	191	257	220	<250	ND	3,900	5	<250	ND	<500	ND
SB-212-14	12	14	11/14/2000	197	150	129	660	1	1,400	3	<250	ND	<500	ND
SB-212-16	14	16	11/14/2000	196	178	152	790	1	8,000	14	<500	ND	<1,000	ND
SB-212-18	16	18	11/14/2000	200	195	164	<380	ND	5,100	9	<380	ND	<770	ND
SB-212-20	18	20	11/14/2000	193	193	153	2,600	5	22,000	41	<1,800	ND	<3,600	ND
SB-212-22	20	22	11/14/2000	195	199	169	2,200	4	14,000	23	<1,000	ND	<2,000	ND
SB-212-24	22	24	11/14/2000	191	237	182	3,400	6	45,000	73	<3,100	ND	<6,200	ND
SB-212-26	24	26	11/14/2000	193	211	163	11,000	20	44,000	79	<3,100	ND	<6,200	ND
SB-212-28	26	28	11/14/2000	191	325	263	8,600	10	54,000	62	<3,600	ND	<7,200	ND
SB-212-30	28	30	11/14/2000	193	244	206	5,400	7	33,000	45	<2,500	ND	<5,000	ND
SB-212-32	30	32	11/15/2000	192	188	157	1,900	3	22,000	38	<1,800	ND	<3,600	ND
SB-212-34	32	34	11/15/2000	193	224	190	16,000	23	25,000	37	<1,800	ND	<3,600	ND
SB-212-36	34	36	11/15/2000	199	159	132	290	1	950	2	<250	ND	<500	ND
SB-212-36-DUP	34	36	11/15/2000	194	164	134	630	1	1,500	3	<250	ND	<500	ND
SB-212-38	36	38	11/15/2000	193	201	165	1,600	3	5,200	9	<380	ND	<770	ND
SB-212-40	38	40	11/15/2000	199	263	223	<250	ND	<250	ND	<250	ND	<500	ND
SB-212-42	40	42	11/15/2000	190	300	221	520	1	260	0	<250	ND	<500	ND
SB-212-44	42	44	11/15/2000	195	216	162	1,000	2	390	1	<250	ND	<500	ND
SB-212-45	43	45	11/15/2000	199	216	159	4,300	8	670	1	<250	ND	<500	ND
SB-212-051	Lab Blank		11/15/2000	NA	NA	NA	<250	ND	<250	ND	<250	ND	<500	ND
SB-212-EB	EQ		11/15/2000	NA	NA	NA	1		<1	ND	<1	ND	<2	ND

NA: Not available.
ND: Not detected.
NR: No recovery.
EQ: Equipment rinsate blank.
J: Result was estimated but below the reporting limit.
D: Result was quanitified after dilution.

Figure C-1. TCE Concentrations in Soil and Observed Soil Color Results at Resistive Heating Plot (mg/kg)

Top Depth	Bottom Depth	Pre-Demo SB1	Post-Demo SB201	Pre-Demo SB2	Post-Demo SB202	Pre-Demo SB3	Post-Demo SB203	Pre-Demo SB4	Post-Demo SB204
0	2	8	0.8	NA	ND	9.2	1	ND	1
2	4	5	1.8	NA	ND	0.9	ND	4.6	3
4	6	0.3	2.9	1.7	2.9	0.1 J	1	5.1	ND
6	8	3	1.4	0.7	6.7	0.3 J	3	48.7	5
8	10	11	18	0.4 J	40.2	0.3 J	90	0.2 J	6
10	12	9	13	0.7	29.2	0.3 J	114	4.6	32
12	14	12	ND	ND	9.4	0.3 J	61	NA	NA
14	16	NA	ND	1.1	1.9	0.6	126	8.3	NA
16	18	4	NA	0.7	53	1.3	97	6.5	19
18	20	122	ND	2.5	111	1.0	71	6.0	2
20	22	315	28	2	4,295	8.9	NA	54.1	83
22	24	1,935	60	50	1,248	NA	NA	60	105
24	26	820	3,927	108	102	183	258	9,051	240
26	28	526	401	292	353	109	247	185	195
28	30	941	467	458	5,561	35	1,217	167	403
30	32	19,091	385	295	390	5	287	12,669	197
32	34	349	211	174	465	17	56	112	263
34	36	624	254	176	102	35.5 D	77	100	178
36	38	1,025	265	440	429	1.4 J	308	288	425
38	40	5,874	318	558	474	27	302	848	139
40	42	5,677	186	5	250	115	186	160	388
42	44	368	146	249	335	204	34	167	364
44	46	33,100	364	251	8	220	41	30,223	NA
46	48	37,537	270	41,044	NA	NA	NA	NA	NA

Top Depth	Bottom Depth	Pre-Demo SB5	Post-Demo SB205	Pre-Demo SB6	Post-Demo SB206	Post-Demo SB7	Post-Demo SB207	Pre-Demo SB8	Post-Demo SB208
0	2	ND	6	ND	6	0.6	ND	0.3 J	2
2	4	ND	1	ND	ND	0.1	0	0.2 J	1
4	6	ND	12	ND	6	ND	6	ND	5
6	8	ND	5	ND	3	ND	61	1.1	72
8	10	ND	10	ND	55	1.0	ND	0.5 J	ND
10	12	0.3 J	10	ND	69	0.0	ND	0.8	ND
12	14	ND	17	ND	71	ND	ND	1.2 J	24
14	16	ND	122	ND	76	0.2	1	342	6
16	18	ND	197	1.9	164	0.0	1	0.5 J	27
18	20	5.2	89	ND	119	10	ND	1.7	NA
20	22	27.7	61	3.9	224	31	58	217	33
22	24	1,835	NA	18.6	135	NA	85	329	12
24	26	260	177	10.8	213	143	516	330	29
26	28	5,880	177	69.1	235	330	367	184	31
28	30	542	102	54.6	105	140	186	182	34
30	32	902	150	17.0	86	125	196	157	NA
32	34	5,345	140	17.5	63	91	389	294	52
34	36	23,362	64	11.4	35	139	403	113	63
36	38	8,062	146	20.5	99	260	159	141	2
38	40	28,168	236	11.2	89	113	82	NA	11
40	42	6,534	97	18.8	149	217	511	209	4
42	44	37,104	129	5.8	126	8,802	273	6,711	52
44	46	NA	NA	313.1	NA	NA	NA	NA	160

Figure C-1. TCE Concentrations in Soil and Observed Soil Color Results at Resistive Heating Plot (mg/kg) (Continued)

Top Depth	Bottom Depth	Pre-Demo SB9	Post-Demo SB209	Pre-Demo SB10	Post-Demo SB210	Pre-Demo SB10B	Post-Demo SB210B	Pre-Demo SB11	Post-Demo SB211
0	2	ND	ND	ND	ND	SB10B	3	4.1	6
2	4	0.9	ND	ND	ND	Duplicate	2	2.8	2
4	6	ND	4	ND	3		23	2.1	3
6	8	ND	5	3.9	26		20	2.7	49
8	10	6.5	1	2.8	NA		NA	0.7	1
10	12	0.5	1	ND	NA		NA	1.1	NA
12	14	ND	5	1.9	ND		ND	ND	ND
14	16	0.8	4	ND	6		ND	1.2	NA
16	18	0.4	13	ND	NA		1	1.6	2
18	20	5	3	0.7	10		6	ND	3
20	22	14	28	30.9	90		16	9.2	14
22	24	29	34	92.4	46		49	NA	8
24	26	26	64	106	265		569	94	4
26	28	84	36	98	117		310	167	13
28	30	30	28	40.3	170		77	49	319
30	32	2.5	11	4.8	287		27	43.7	102
32	34	ND	NA	ND	209		344	21.4	79
34	36	1.4	5	ND	428		315	2.0	71
36	38	ND	74	ND	264		124	0.0	14
38	40	3.4	54	13.9	242		219	0.4	9
40	42	51	77	12.6	257		236	36.0	2
42	44	67	52	25.4	101		297	46.0	ND
44	46	NA	NA	11.8	59		NA	NA	NA

Top Depth	Bottom Depth	Pre-Demo SB12	Post-Demo SB212
0	2	ND	ND
2	4	ND	3
4	6	ND	10
6	8	NA	12
8	10	ND	16
10	12	2.4	ND
12	14	0.4 J	1
14	16	ND	1
16	18	NA	ND
18	20	ND	5
20	22	15.3	4
22	24	40.1	6
24	26	112.1	20
26	28	256.9	10
28	30	29.6	7
30	32	2.2	3
32	34	0.4	23
34	36	0.2 J	1
36	38	0.7	3
38	40	0.5 J	ND
40	42	16.1	1
42	44	36.5	2
44	46	1.5	8

NA: Not available.
ND: Not detected.
Solid horizontal lines demarcate MFGU. Tan and gray colors are the observed colors from soil samples.

Appendix D. Inorganic and Other Aquifer Parameters

Tables D-1 to D-7

Table D-1. Groundwater Field Parameters

Well ID	pH								ORP (mV)							
	Pre-Demo	Week 3-4	Week 7-8	Jan. 2000	Apr 2000	ISCO Post-Demo	Rest Heat Post-Demo	Jul 2001	Pre-Demo	Week 3-4	Week 7-8	Jan. 2000	Apr 2000	ISCO Post-Demo	Rest Heat Post-Demo	Jul 2001
Resistive Heating Plot Wells																
PA-13S	6.87	6.29	NA	NA	7.04	NA	6.31	6.77	-107.9	-83.7	NA	NA	-286.1	NA	-106.80	-17.10
PA-13I	7.38	7.81	NA	NA	8.41	NA	NA	7.44	-73.9	-146.8	NA	NA	-82.5	NA	NA	-68.40
PA-13D	7.24	7.98	NA	NA	8.50	NA	6.54	6.29	-105.8	-71.4	NA	NA	-111.6	NA	-97.00	-237.50
PA-14S	7.13	9.15	NA	NA	6.72	NA	7.59	6.73	-129.6	-196.3	NA	NA	-208.0	NA	-43.80	-17.70
PA-14I	7.51	8.89	NA	NA	6.62	NA	NA	7.06	-118.3	-151.9	NA	NA	-260.1	NA	NA	-88.50
PA-14D	7.45	7.57	NA	NA	NA	NA	6.76	6.31	-141.7	-58.5	NA	NA	-231.0	NA	-249.90	-221.30
Resistive Heating Plot Perimeter Wells																
PA-2S	6.94	7.37	NA	7.50	6.90	6.62	6.98	NA	-58.3	-138.5	NA	-97.6	-277.7	-153.1	-114.20	NA
PA-2I	7.30	6.50	NA	7.50	6.77	6.75	6.85	NA	-31.9	-68.9	NA	-127.0	-102.6	-134.7	-102.50	NA
PA-2D	7.27	6.99	NA	7.46	4.10?	7.00	6.80	NA	-89.8	-163.6	NA	-132.0	-75.7	-112.6	-77.10	NA
PA-7S	6.86	6.59	NA	7.14	6.60	NA	6.59	NA	-82.5	-111.2	NA	-121.6	-157.0	NA	-110.00	NA
PA-7I	7.31	7.26	NA	7.51	6.85	NA	6.77	NA	-33.9	-80.3	NA	-120.4	-89.4	NA	-73.60	NA
PA-7D	7.49	7.00	NA	7.14	7.81	NA	6.78	NA	-56.1	-144.0	NA	-127.9	-58.3	NA	-163.20	NA
PA-10S	6.78	6.72	NA	6.98	6.63	NA	7.16	NA	-119.5	-99.2	NA	-142.8	-121.9	NA	-149.00	NA
PA-10I	6.86	6.72	NA	6.81	6.63	NA	7.05	NA	-129.7	-99.8	NA	-132.4	-125.2	NA	-122.40	NA
PA-10D	7.37	6.48	NA	6.87	7.04	NA	7.74	NA	-131.1	46.2	NA	-125.4	-89.4	NA	-104.50	NA
IW-17S	6.79	5.93	NA	7.85	Dry	NA	Dry	NA	-12.4	-29.5	NA	-122.3	Dry	NA	Dry	NA
IW-17I	7.41	6.92	NA	6.83	6.20	NA	6.61	NA	-12.3	-96.6	NA	-132.5	-76.9	NA	-106.90	NA
IW-17D	7.39	NA	NA	8.43	7.56	NA	7.41	NA	-115.8	-242.3	NA	-144.5	-85.7	NA	-156.60	NA
PA-15	NA	NA	NA	6.86	6.37	NA	6.30	NA	NA	NA	NA	-154.1	-190.4	NA	-76.40	NA
Distant Wells																
PA-1S	7.58	7.79	7.65	8.15	7.54	7.29	7.35	NA	-57.4	1.6	148.2	43.4	-55.0	-117.1	-128.20	NA
PA-1I	7.72	8.39	NM	8.27	7.64	7.60	7.32	NA	-13.3	-19.5	54.8	-94.6	3.1	-65.3	-234.90	NA
PA-1D	7.57	7.88	7.90	7.97	7.52	7.50	6.94	NA	-112.2	-13.4	-762.4	-124.8	-66.8	-90.1	-213.00	NA
PA-8S	6.93	7.08	7.22	6.87	6.66	6.54	6.95	NA	-96.2	-61.8	-115.9	209.6	-33.4	-58.4	-134.90	NA
PA-8I	7.27	7.41	7.52	7.43	7.21	7.16	6.53	NA	-6.6	4.3	-31.8	109.5	-99.2	-114.8	-76.20	NA
PA-8D	7.45	7.66	7.73	7.85	6.86	6.78	6.80	NA	-19.0	9.0	-50.7	87.0	-123.8	-52.8	-110.90	NA
PA-11S	7.02	6.95	6.75	7.45	6.37	NM	8.14	NA	-124.8	-77.8	-76.0	-152.1	-71.3	NM	14.20	NA
PA-11I	7.11	7.25	7.07	7.24	7.01	6.22	7.23	NA	-136.4	-93.9	-133.5	-127.2	-86.0	-75.9	-145.00	NA
PA-11D	7.55	7.69	7.41	7.71	7.45	7.46	7.77	NA	-136.3	-73.2	-96.7	-156.4	-143.9	-133.3	-123.40	NA

Table D-1. Groundwater Field Parameters (Continued)

Well ID	DO (mg/L)								Temperature (°C)							
	Pre-Demo	Week 3-4	Week 7-8	Jan. 2000	Apr 2000	ISCO Post-Demo	Rest Heat Post-Demo	Jul 2001	Pre-Demo	Week 3-4	Week 7-8	Jan. 2000	Apr 2000	ISCO Post-Demo	Rest Heat Post-Demo	Jul 2001
Resistive Heating Plot Wells																
PA-13S	0.28	0.86	NA	NA	0.22	NA	0.63	0.84	26.12	43.74	NA	NA	43.71	NA	36.35	36.06
PA-13I	0.27	0.91	NA	NA	0.07	NA	NA	1.11	27.36	30.93	NA	NA	31.12	NA	NA	35.51
PA-13D	0.62	2.21	NA	NA	0.02	NA	0.81	0.30	27.26	44.51	NA	NA	40.86	NA	51.66	41.34
PA-14S	0.31	0.10	NA	NA	0.34	NA	0.60	0.55	26.94	30.29	NA	NA	53.97	NA	41.19	36.23
PA-14I	0.40	0.77	NA	NA	0.15	NA	NA	0.99	27.70	39.99	NA	NA	38.29	NA	NA	37.25
PA-14D	0.10	1.13	NA	NA	0.24	NA	NA	0.35	27.29	43.32	NA	NA	37.70	NA	31.59	41.36
Resistive Heating Plot Perimeter Wells																
PA-2S	0.84	0.42	NA	NA	0.46	0.34	0.41	NA	27.00	27.45	NA	21.57	42.07	34.61	35.19	NA
PA-2I	0.48	0.79	NA	NA	0.39	0.45	0.55	NA	27.03	27.43	NA	24.66	26.68	32.22	36.42	NA
PA-2D	0.80	0.29	NA	NA	0.36	0.68	0.96	NA	26.36	27.80	NA	23.15	30.91	33.29	36.88	NA
PA-7S	0.52	0.41	NA	NA	1.02	NA	0.84	NA	28.84	28.60	NA	29.42	49.21	NA	33.10	NA
PA-7I	0.43	0.58	NA	NA	1.46	NA	0.64	NA	28.53	28.74	NA	26.77	36.14	NA	31.35	NA
PA-7D	0.43	0.73	NA	NA	NA	NA	0.41	NA	28.08	28.33	NA	28.29	39.63	NA	32.42	NA
PA-10S	0.54	0.96	NA	NA	1.24	NA	1.57	NA	23.67	36.77	NA	29.95	45.76	NA	39.87	NA
PA-10I	0.54	0.76	NA	NA	0.85	NA	2.57	NA	23.71	30.73	NA	32.16	32.95	NA	42.08	NA
PA-10D	0.89	0.46	NA	NA	1.47	NA	NA	NA	23.76	29.88	NA	32.10	33.60	NA	39.80	NA
IW-17S	0.46	2.46	NA	NA	Dry	NA	Dry	NA	28.39	40.76	NA	44.32	Dry	NA	Dry	NA
IW-17I	0.47	0.79	NA	NA	0.73	NA	0.47	NA	27.01	29.37	NA	37.25	39.02	NA	28.87	NA
IW-17D	0.34	0.81	NA	NA	0.34	NA	0.42	NA	26.85	28.05	NA	30.45	40.30	NA	47.62	NA
PA-15	NA	NA	NA	NA	0.27	NA	0.52	NA	NA	NA	NA	36.75	32.57	NA	35.15	NA
Distant Wells																
PA-1S	0.43	0.58	1.11	0.18	0.42	0.37	0.51	NA	26.96	27.25	27.62	26.03	24.46	24.96	25.91	NA
PA-1I	0.49	0.41	0.33	1.23	0.64	0.41	0.41	NA	27.60	30.42	27.49	26.10	25.27	25.73	25.92	NA
PA-1D	0.23	0.51	0.39	1.43	0.48	0.48	0.50	NA	27.09	27.43	27.38	25.94	25.64	26.39	25.64	NA
PA-8S	0.69	0.40	0.30	NA	0.47	0.38	1.03	NA	28.91	28.74	27.97	25.55	24.96	26.32	27.53	NA
PA-8I	0.68	0.87	0.51	NA	0.48	0.36	0.94	NA	28.65	28.51	27.58	25.28	25.60	26.40	27.54	NA
PA-8D	0.73	0.56	0.84	NA	0.55	0.68	0.68	NA	27.67	27.78	27.43	25.15	25.76	26.13	26.46	NA
PA-11S	0.47	0.54	0.67	NA	0.50	NM	2.15	NA	24.82	25.58	26.15	25.45	24.83	NM	27.66	NA
PA-11I	0.21	0.66	1.20	NA	0.52	0.56	NA	NA	25.29	25.87	26.01	25.14	24.75	25.80	27.26	NA
PA-11D	0.54	1.09	2.38	NA	0.60	0.66	NA	NA	24.64	25.43	25.51	24.83	24.53	25.12	26.04	NA

Table D-1. Groundwater Field Parameters (Continued)

Well ID	Eh (mV)								Conductivity (mS/cm)							
	Pre-Demo	Week 3-4	Week 7-8	Jan 2000	Apr 2000	ISCO Post-Demo	Rest Heating Post-Demo	Jul 2001	Pre-Demo	Week 3-4	Week 7-8	Jan 2000	Apr 2000	ISCO Post-Demo	Rest Heating Post-Demo	Jul 2001
Resistive Heating Plot Wells																
PA-13S	89.1	113.3	NA	NA	10.9	NA	190.2	255.9	0.884	1.013	NA	NA	125.90	NA	4.78	1.51
PA-13I	123.1	50.2	NA	NA	214.5	NA	NA	204.6	0.926	0.991	NA	NA	146.40	NA	NA	1.50
PA-13D	91.2	125.6	NA	NA	185.4	NA	200.0	35.5	3.384	2.663	NA	NA	377.80	NA	29.05	0.47
PA-14S	67.4	0.7	NA	NA	89.0	NA	253.2	255.3	0.776	1.187	NA	NA	251.60	NA	4.03	1.35
PA-14I	78.7	45.1	NA	NA	36.9	NA	NA	184.5	1.171	4.457	NA	NA	272.50	NA	NA	1.49
PA-14D	55.3	138.5	NA	NA	66.0	NA	47.1	51.7	2.836	2.771	NA	NA	224.40	NA	18.18	0.75
Resistive Heating Plot Perimeter Wells																
PA-2S	138.7	58.5	NA	199.4	19.3	143.9	182.8	NA	0.669	0.579	NA	2.762	84.69	3.33	2.93	NA
PA-2I	165.1	128.1	NA	170.0	194.4	162.3	194.5	NA	0.900	1.439	NA	1.723	93.10	3.09	3.10	NA
PA-2D	107.2	33.4	NA	165.0	221.3	184.4	219.9	NA	3.108	0.663	NA	4.294	146.60	5.48	7.67	NA
PA-7S	114.5	85.8	NA	175.4	140.0	NA	187.0	NA	0.854	0.932	NA	1.678	48.07	NA	2.14	NA
PA-7I	163.1	116.7	NA	176.6	207.6	NA	223.4	NA	1.704	1.335	NA	1.887	60.81	NA	2.21	NA
PA-7D	140.9	53.0	NA	169.1	238.7	NA	133.8	NA	2.562	1.840	NA	3.060	39.63	NA	3.93	NA
PA-10S	77.5	97.8	NA	154.2	175.1	NA	148.0	NA	0.804	0.817	NA	3.245	66.59	NA	3.24	NA
PA-10I	67.3	97.2	NA	164.6	171.8	NA	174.6	NA	0.953	0.893	NA	1.980	48.10	NA	2.26	NA
PA-10D	65.9	243.2	NA	171.6	207.6	NA	192.5	NA	3.125	1.414	NA	6.474	121.90	NA	5.19	NA
IW-17S	184.6	167.5	NA	174.7	NA	NA	Dry	NA	0.783	1.333	NA	2.475	Dry	NA	NA	NA
IW-17I	184.7	100.4	NA	164.5	220.1	NA	190.1	NA	2.202	0.835	NA	2.160	111.90	NA	2.01	NA
IW-17D	81.2	-45.3	NA	152.5	211.3	NA	140.4	NA	2.607	2.197	NA	5.720	116.30	NA	4.81	NA
PA-15	NA	NA	NA	142.9	106.6	NA	220.6	NA	NA	NA	NA	4.041	76.05	NA	3.14	NA
Distant Wells																
PA-1S	139.6	198.6	345.2	340.4	242.0	NA	168.8	NA	0.355	0.389	1.221	1.375	1.26	1.39	1.57	NA
PA-1I	183.7	177.5	251.8	202.4	300.1	231.7	62.10	NA	0.676	0.450	0.860	1.861	1.93	1.73	1.30	NA
PA-1D	84.8	183.6	-565.4	172.2	230.2	206.9	84.00	NA	2.225	1.347	4.449	5.392	4.76	4.79	2.32	NA
PA-8S	100.8	135.2	81.1	506.6	263.6	238.6	162.10	NA	0.746	0.666	1.373	5.615	4.92	5.11	4.42	NA
PA-8I	190.4	201.3	165.2	406.5	197.8	182.2	220.80	NA	1.043	1.029	2.688	3.572	3.92	3.81	6.29	NA
PA-8D	178	206.0	146.3	384.0	173.2	244.2	186.10	NA	2.600	2.328	5.216	5.752	7.53	7.22	5.61	NA
PA-11S	72.2	119.2	121.0	144.9	225.7	NA	311.2	NA	0.829	0.737	1.534	1.517	187.20	NM	7.12	NA
PA-11I	60.6	103.1	63.5	169.8	211.0	221.1	152.00	NA	0.878	0.750	1.773	1.848	67.76	11.92	10.73	NA
PA-11D	60.7	123.8	100.3	140.6	153.1	163.7	173.60	NA	2.881	2.474	5.635	6.103	121.60	5.52	5.23	NA

Pre-Demo: Sep 3 to 10, 1999.
Week 3-4: Sep 24 to 20, 1999.
Week 7-8: Oct 19 to 28, 1999.
ISCO Post-Demo: May 8 to 14, 2000.
Resistive Heating Post-Demo: Nov 27 to Dec 2, 2000.
NA: Not available.

Table D-2. Iron, Manganese, and Postassium Results of Groundwater Samples

Compound	Iron (mg/L)								Manganese (mg/L)								Potassium (mg/L)				
SMCL	0.3 mg/L								0.05 mg/L								NA				
Well ID	Pre-Demo	Week 3-4	Week 7-8	Jan 2000	Apr 2000	ISCO Post-Demo	Restv Heating Post-Demo	Jul 2001	Pre-Demo	Week 3-4	Week 7-8	Jan 2000	Apr 2000	ISCO Post-Demo	Restv Heating Post-Demo	Jul 2001	Pre-Demo	Apr 2000	ISCO Post-Demo	Restv Heating Post-Demo	Jul 2001
Resistive Heating Plot Wells																					
PA-13S	2.6	NA	NA	NA	0.24	NA	0.52	0.15	0.963	NA	NA	NA	0.038	NA	0.079	0.071	<5.0	29.1	NA	126	174
PA-13I	0.33	NA	NA	NA	0.4	NA	NA	0.45	0.023	NA	NA	NA	0.065	NA	NA	0.11	12.5	29.7	NA	NA	48.5
PA-13D	<0.05	NA	NA	NA	0.49	NA	<0.25	0.13	<0.015	NA	NA	NA	<0.015	NA	0.13	0.16	20.2	46.4	NA	136	85.5
PA-14S	0.78	NA	NA	NA	0.43	NA	<0.25	<0.05	0.022	NA	NA	NA	0.015	NA	<0.015	<0.015	NA	18.6	NA	9.8	42.6
PA-14I	11.4	NA	NA	NA	8.9	NA	NA	<0.05	1.1	NA	NA	NA	0.17	NA	NA	<0.015	NA	34.1	NA	NA	14.2
PA-14D	0.31	NA	NA	NA	0.38	NA	<0.25	<0.05	0.02	NA	NA	NA	0.028	NA	<0.075	0.021	NA	34.4	NA	143	93.9
Resistive Heating Plot Perimeter Wells																					
PA-2S	1.4	7.00	NA	2.5	0.82	2.7	0.96	NA	0.067	0.072	NA	0.06	0.072	0.071	0.054	NA	NA	99.3	145	NA	NA
PA-2I	0.28	0.62	NA	3.6	2.2	1.6	1.4	NA	0.03	0.066	NA	0.12	0.098	0.048	0.1	NA	NA	19.4	79.5	NA	NA
PA-2I-DUP	NA	NA	NA	NA	2.5	NA	NA	NA	NA	NA	NA	NA	0.096	NA	NA	NA	NA	19.3	NA	NA	NA
PA-2D	9.72	4.20	NA	0.96	4.6	1.1	0.27	NA	1	0.093	NA	0.033	0.098	0.036	0.039	NA	NA	69	40.6	NA	NA
PA-7S	1.2	2.40	NA	4.2	9.8	NA	7.2	NA	0.037	0.068	NA	0.068	0.15	NA	0.074	NA	NA	6.5	NA	NA	NA
PA-7I	<0.05	<0.05	NA	0.26	0.52	NA	0.73	NA	0.03	0.026	NA	0.02	0.043	NA	0.077	NA	NA	13.6	NA	NA	NA
PA-7D	<0.05	1.70	NA	1.6	0.24	NA	0.53	NA	0.028	0.039	NA	0.03	0.054	NA	0.11	NA	NA	29.4	NA	NA	NA
PA-7D-Dup	NA	NA	NA	NA	NA	NA	0.64	NA	NA	NA	NA	NA	NA	NA	0.11	NA	NA	NA	NA	NA	NA
PA-10S	4.8	3.50	NA	4.5	4.5	NA	1.3	NA	0.11	0.039	NA	0.044	0.047	NA	0.029	NA	NA	61.6	NA	NA	NA
PA-10I	12.6	9.50	NA	8.3	3.8	NA	3.5	NA	0.13	0.120	NA	0.12	0.059	NA	0.062	NA	NA	<5	NA	NA	NA
PA-10I-Dup	NA	NA	NA	NA	NA	NA	3.7	NA	NA	NA	NA	NA	NA	NA	0.063	NA	NA	NA	NA	NA	NA
PA-10D	1.2	0.69	NA	0.69	0.3	NA	<0.05	NA	0.029	0.063	NA	0.044	0.021	NA	<0.015	NA	NA	19.2	NA	NA	NA
PA-10D-DUP	NA	NA	NA	0.68	NA	NA	NA	NA	NA	NA	NA	0.044	NA	NA	NA	NA	NA	NA	NA	NA	NA
IW-17S	0.16	3.20	NA	0.099	NS[2]	NA	NS[2]	NA	0.035	0.088	NA	<0.015	NS[2]	NA	NS[2]	NA	NA	NS[2]	NA	NA	NA
IW-17I	<0.05	1.30	NA	3.2	18.7	NA	2.5	NA	0.068	0.068	NA	0.066	0.16	NA	0.047	NA	NA	8.9	NA	NA	NA
IW-17D	0.24	NA	NA	<0.050	<0.05	NA	0.39	NA	0.053	NA	NA	<0.015	0.024	NA	0.025	NA	NA	24.7	NA	NA	NA
PA-15	NA	NA	NA	<0.050	2.5	NA	5.1	NA	NA	NA	NA	<0.015	0.084	NA	0.11	NA	NA	22.9	NA	NA	NA
Distant Wells																					
PA-1S	0.12	<0.05	<0.05	3.3	0.2	0.45	0.86	NA	<0.015	<0.015	<0.015	0.039	0.015	0.019	0.052	NA	NA	7.3	24.4	NA	NA
PA-1I	<0.05	<0.05	<0.05	0.082	<0.05	<0.05	0.7	NA	<0.015	<0.015	<0.015	<0.015	0.018	0.017	0.13	NA	NA	20.7	22.4	NA	NA
PA-1I-DUP	NA	NA	NA	NA	NA	<0.05	NA	NA	NA	NA	NA	NA	NA	0.019	NA	NA	NA	NA	24	NA	NA
PA-1D	0.11	0.12	0.16	0.15	<0.05	<0.05	0.48	NA	0.037	0.040	0.037	0.026	0.021	0.021	0.12	NA	NA	12.8	13.2	NA	NA
PA-1D-Dup	NA	NA	NA	NA	NA	NA	0.54	NA	NA	NA	NA	NA	NA	NA	0.12	NA	NA	NA	NA	NA	NA
PA-8S	1.9	1.60	2.1	0.16	2.7	4.1	5.6	NA	0.092	0.099	0.095	77.6	4	3.8	1.2	NA	NA	253	277	NA	NA
PA-8S-DUP	NA	NA	2	0.46	NA	NA	NA	NA	NA	NA	0.095	80.7	NA	NA	NA	NA	NA	NA	NA	NA	NA
PA-8I	0.23	0.14	<0.05	0.57	0.7	4	4	NA	0.028	0.027	0.028	0.19	0.13	0.43	0.34	NA	NA	16.3	17.8	NA	NA

Table D-2. Iron, Manganese, and Postassium Results of Groundwater Samples (Continued)

Compound	Iron (mg/L)								Manganese (mg/L)								Potassium (mg/L)				
SMCL	0.3 mg/L								0.05 mg/L								NA				
Well ID	Pre-Demo	Week 3-4	Week 7-8	Jan 2000	Apr 2000	ISCO Post-Demo	Restv Heating Post-Demo	Jul 2001	Pre-Demo	Week 3-4	Week 7-8	Jan 2000	Apr 2000	ISCO Post-Demo	Restv Heating Post-Demo	Jul 2001	Pre-Demo	Apr 2000	ISCO Post-Demo	Restv Heating Post-Demo	Jul 2001
PA-8D	<0.05	<0.05	<0.05	0.46	0.31	0.46	2.1	NA	0.029	0.022	<0.015	0.045	0.054	0.11	0.36	NA	NA	21.4	24.5	NA	NA
PA-8D-DUP	NA	<0.05	NA	NA	NA	NA	NA	NA	NA	0.026	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PA-11S	4.8	3.70	3.3	3.1	22.6	<0.1	<0.05	NA	0.075	0.061	0.053	0.046	0.22	342	0.81	NA	NA	524	1,590	NA	NA
PA-11I	0.9	3.10	1.9	2.2	1.3	38.8	7.4	NA	0.028	0.034	0.043	0.028	0.062	0.27	0.048	NA	NA	10.4	511	NA	NA
PA-11D	2.4	0.60	0.92	0.57	0.9	0.46	0.45	NA	0.026	0.019	0.023	0.019	0.022	0.019	<0.015	NA	NA	19.7	22.6	NA	NA

NA: Not available.
NS: Not sampled.
<: The compound was analyzed but not detected at or above the specified reporting limit.
SMCL: Secondary Maximum Contaminant Level.
Shading denotes that the concentration has increased by more than 25 % and exceeded the SMCL.
Shading denotes that the concentration has increased at least doubled over pre-demonstration range in LC34 wells.
1. Sample was not collected due to excess amount of KMnO4 in the flush mount.
2. Sample was not collected because the well was dry.

Table D-3. Chloride and Total Dissolved Solids Results of Groundwater Samples

SMCL	Chloride (mg/L) 250 mg/L						TDS (mg/L) 500 mg/L					
Well ID	Pre-Demo	Jan 2000	Apr 2000	ISCO Post-Demo	Rest Heat Post-Demo	Jul 2001	Pre-Demo	Jan 2000	Apr 2000	ISCO Post-Demo	Rest Heat Post-Demo	Jul 2001
Resistive Heating Plot Wells												
PA-13S	38	NA	NA	NA	383	277	583	NA	NA	NA	1,750	1,190
PA-13S-DUP	NA	NA	NA	NA	NA	291	587	NA	NA	NA	NA	1,180
PA-13I	66.2	NA	NA	NA	NA	233	NA	NA	NA	NA	NA	925
PA-13D	10.6	NA	NA	NA	4,800	3,610	NA	NA	NA	NA	10,600	8,360
PA-14S	37.4	NA	NA	NA	141	101	548	NA	NA	NA	1,330	772
PA-14I	123	NA	NA	NA	NA	156	724	NA	NA	NA	NA	870
PA-14I-DUP	NA	NA	NA	NA	NA	NA	712	NA	NA	NA	NA	NA
PA-14D	774	NA	NA	NA	3,520	4,790	1,980	NA	NA	NA	7,220	10,700
PA-14D DUP	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Resistive Heating Plot Perimeter Wells												
PA-2S	NA	NA	NA	247	243	NA	NA	NA	NA	NA	915	NA
PA-2I	NA	NA	NA	234	191	NA	NA	NA	NA	NA	1,050	NA
PA-2D	NA	NA	NA	695	960	NA	NA	NA	NA	NA	2,720	NA
PA-7S	NA	NA	NA	NA	119	NA	NA	NA	NA	NA	657	NA
PA-7I	NA	NA	NA	NA	143	NA	NA	NA	NA	NA	752	NA
PA-7D	NA	NA	NA	NA	531	NA	NA	NA	NA	NA	1,260	NA
PA-7D-DUP	NA	NA	NA	NA	522	NA	NA	NA	NA	NA	1,270	NA
PA-10S	NA	NA	NA	NA	342	NA	NA	NA	NA	NA	1,040	NA
PA-10I	NA	NA	NA	NA	130	NA	NA	NA	NA	NA	789	NA
PA-10I-DUP	NA	NA	NA	NA	128	NA	NA	NA	NA	NA	777	NA
PA-10D	NA	NA	NA	NA	701	NA	NA	NA	NA	NA	1,580	NA
IW-17S	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
IW-17I	NA	NA	NA	NA	73.7	NA	NA	NA	NA	NA	663	NA
IW-17D	NA	NA	NA	NA	640	NA	NA	NA	NA	NA	1,350	NA
PA-15	NA	NA	NA	NA	190	NA	NA	NA	NA	NA	975	NA
Distant Wells												
PA-1S	9.8	33.9	51.6	60.3	56.8	NA	205	326	413	470	583	NA
PA-1I	66.2	92.6	122	105	66.6	NA	424	442	550	513	496	NA
PA-1I-DUP	NA	NA	NA	111	NA	NA	NA	NA	NA	542	NA	NA
PA-1D	627	588	639	639	327	NA	1,380	1,400	1,410	1,490	1,200	NA
PA-1D-Dup	NA	NA	NA	NA	313	NA	NA	NA	NA	NA	1,180	NA
PA-8S	24.2	265	266	273	101	NA	445	1,960	1,710	1,800	1,600	NA
PA-8S-DUP	NA	279	NA	NA	NA	NA	NA	2,050	NA	NA	NA	NA
PA-8I	119	284	418	439	504	NA	706	977	1,210	1,240	2,200	NA
PA-8D	774	822	819	788	640	NA	1,410	1,490	2,550	2,520	1,910	NA
PA-8D-DUP	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PA-11S	36.7	34.1	678	397	357	NA	531	403	2,760	4,710	2,900	NA
PA-11I	49	48.5	248	1230	635	NA	549	557	1,140	4,500	3,790	NA
PA-11D	819	749	771	756	737	NA	1,540	1,510	1,820	1,750	1,670	NA
PA-11D-DUP	NA	NA	NA	NA	NA	NA	NA	NA	NA	1,760	NA	NA

Pre-Demo: Sep 3 to 10, 1999.
Week 3-4: Sep 24 to 20, 1999.
Week 7-8: Oct 19 to 28, 1999.
ISCO Post-Demo: May 8 to 14, 2000.
Resistive Heating Post-Demo: Nov 27 to Dec 2, 2000.
NA: Not available.
NS: Not sampled.
SMCL: Secondary Maximum Contaminant Level.
J: Estimated but below the detection limit.
Shading denotes that the concentration exceeds the SMCL Level.

Table D-4. Other Parameter Results of Groundwater Samples

	Cations (mg/L)									Anions (mg/L)								
	Calcium			Magnesium			Sodium			NO_3-NO_2			Sulfate			Alk as $CaCO_3$		
Well ID	**Pre-Demo**	**Post-Demo**	**Jul 2001**	**Pre-Demo**	**Post-Demo**	**July 2001**	**Pre-Demo**	**Post-Demo**	**Jul 2001**	**Pre-Demo**	**Post-Demo**	**July 2001**	**Pre-Demo**	**Post-Demo**	**July 2001**	**Pre-Demo**	**Post-Demo**	**Jul 2001**
Resistive Heating Plot Wells																		
PA-13S	143	233	97.4	23.4	54.4	40	23.9	161	113	<0.1	<0.1	<0.1	74	169	123	479	588	424
PA-13I	70.1	NA	153	54	NA	76.5	33.1	NA	96.7	<0.1	NA	<0.1	64.8	NA	150	351	NA	243
PA-13D	113	819	647	113	51.4	75	369	2,070	1,530	<0.1	<0.1	0.21	78.3	166	139	410	231	268
PA-14S	97.4	6.6	55.3	37.4	<1	10.6	17.4	467	138	<0.1	<0.1	<0.1	39	37.1	18.6	337	898	388
PA-14I	60.3	NA	13.6	73.7	NA	1.2	120	NA	258	<0.1	NA	<0.1	104	NA	30	465	NA	434
PA-14D	93.1	1,060	662	90.3	30	30.2	325	3,130	2,490	<0.1	<0.1	<0.1	68.3	117	163	343	421	394
Resistive Heating Plot Perimeter Wells																		
PA-2S	NA	77.7	NA	NA	2.6	NA	NA	NA	NA	NA	<0.1	NA	NA	57.7	NA	NA	323	NA
PA-2I	NA	205	NA	NA	18.8	NA	NA	NA	NA	NA	0.11	NA	NA	149	NA	NA	467	NA
PA-2D	113	186	NA	NA	229	NA	NA	NA	NA	NA	0.75	NA	NA	146	NA	NA	663	NA
PA-7S	NA	184	NA	NA	5.9	NA	NA	NA	NA	NA	<0.1	NA	NA	<5	NA	NA	420	NA
PA-7I	NA	166	NA	NA	26.7	NA	NA	NA	NA	NA	<0.1	NA	NA	<10	NA	NA	439	NA
PA-7D	NA	104	NA	NA	38.1	NA	NA	NA	NA	NA	<0.1	NA	NA	36.7	NA	NA	272	NA
PA-7D-DUP	NA	103	NA	NA	31.7	NA	NA	NA	NA	NA	<0.1	NA	NA	36.6	NA	NA	273	NA
PA-10S	NA	138	NA	NA	11	NA	NA	NA	NA	NA	<0.1	NA	NA	<10	NA	NA	335	NA
PA-10I	NA	186	NA	NA	11.8	NA	NA	NA	NA	NA	<0.1	NA	NA	85.4	NA	NA	356	NA
PA-10I-DUP	NA	193	NA	NA	12.2	NA	NA	NA	NA	NA	<0.1	NA	NA	86.2	NA	NA	355	NA
PA-10D	NA	71.7	NA	NA	71.6	NA	NA	NA	NA	NA	<0.1	NA	NA	68.4	NA	NA	293	NA
IW-17S	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
IW-17I	NA	144	NA	NA	17.6	NA	NA	NA	NA	NA	<0.1	NA	NA	33.7	NA	NA	475	NA
IW-17D	NA	72.2	NA	NA	64.2	NA	NA	NA	NA	NA	<0.1	NA	NA	57.3	NA	NA	212	NA
PA-15	NA	202	NA	NA	10.7	NA	NA	NA	NA	NA	<0.1	NA	NA	62.4	NA	NA	520	NA
Distant Wells																		
PA-1S	NA	128	NA	NA	8.8	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	310	NA
PA-1I	NA	83.2	NA	NA	19.8	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	255	NA
PA-1D	NA	119	NA	NA	29.9	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	230	NA
PA-1D-DUP	NA	117	NA	NA	28.5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	234	NA
PA-8S	NA	51	NA	NA	11.4	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	840	NA
PA-8I	NA	202	NA	NA	190	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	933	NA
PA-8D	NA	151	NA	NA	152	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	632	NA
PA-11S	NA	38	NA	NA	32.4	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	811	NA
PA-11I	NA	126	NA	NA	40.4	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	923	NA
PA-11D	NA	92.8	NA	NA	100	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	306	NA

Table D-4. Other Parameter Results of Groundwater Samples (Continued)

Well ID	Chromium (mg/L)			Nickel (mg/L)			BOD (mg/L)			TOC (mg/L)		
	Pre-Demo	Post-Demo	Jul 2001	Pre-Demo	Post-Demo	Jul 2001	Pre-Demo	Post-Demo	Jul 2001	Pre-Demo	Post-Demo	Jul 2001
Resistive Heating Plot Wells												
PA-13S	NA	NA	NA	NA	NA	NA	20	32.4	25.8	5.6	44.8	39.6
PA-13I	NA	NA	NA	NA	NA	NA	<3	NA	3.3	7.1	NA	14.9
PA-13D	NA	NA	NA	NA	NA	NA	13.2	360	360	39.6	300	273
PA-14S	NA	NA	<0.010	NA	NA	<0.040	<3	42	22.2	5.7	34.7	18.7
PA-14I	NA	NA	<0.010	NA	NA	<0.040	8.9	NA	3.7	23.4	NA	8.9
PA-14D	NA	NA	<0.010	NA	NA	<0.040	6	288	560	9	270	326
Resistive Heating Plot Perimeter Wells												
PA-2S	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PA-2I	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PA-2D	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PA-7S	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PA-7I	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PA-7D	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PA-7D-DUP	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PA-10S	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PA-10I	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PA-10I-DUP	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PA-10D	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
IW-17S	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
IW-17I	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
IW-17D	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PA-15	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Distant Wells												
PA-1S	NA	NA	<0.010	NA	NA	<0.040	NA	NA	NA	NA	NA	NA
PA-1I	NA	NA	<0.010	NA	NA	<0.040	NA	NA	NA	NA	NA	NA
PA-1D	NA	NA	<0.010	NA	NA	<0.040	NA	NA	NA	NA	NA	NA
PA-8S	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PA-8I	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PA-8D	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PA-11S	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PA-11I	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PA-11D	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:

Pre-Demo: Sep 3 to 10, 1999.

Post-Demo: Nov 27 to Dec 2, 2000.

NA: Not available.

<: The compound was analyzed but not detected at or above the specified reporting limit.

Table D-5. Surface Emission Test Results

Sample ID	Sample Date	TCE ppb (v/v)	Sample ID	Sample Date	TCE ppb (v/v)
ISCO Plot			***Resistive Heating Plot***		
OX-SE-1	9/30/1999	1.6	SPH-SE-1	10/8/1999	2.1
OX-SE-2	9/30/1999	2.4	SPH-SE-2	10/8/1999	3.6
OX-SE-3	10/1/1999	3.4	SPH-SE-3	10/8/1999	2
OX-SE-4	10/25/1999	0.68	SPH-SE-4	10/22/1999	13,000
OX-SE-5	10/25/1999	1.1	SPH-SE-5	10/22/1999	12,000
OX-SE-6	10/25/1999	1.4	SPH-SE-6	10/22/1999	13,000
OX-SE-7	1/17/2000	11	SPH-SE-7	1/18/2000	23
OX-SE-8	1/17/2000	7.6	SPH-SE-8	1/18/2000	78
OX-SE-9	1/17/2000	5.8	SPH-SE-9	1/18/2000	35
OX-SE-10	4/11/2000	2.6	SPH-SE-10	4/11/2000	0.93
OX-SE-11	4/11/2000	0.69	SPH-SE-11	4/11/2000	0.67
OX-SE-12	4/11/2000	1.7	SPH-SE-12	4/11/2000	<0.37
OX-SE-21	8/29/2000	16	SPH-SE-13	4/11/2000	1,300
OX-SE-22	8/29/2000	130	SPH-SE-21	8/30/2000	<0.42
OX-SE-23	8/30/2000	180	SPH-SE-22	8/30/2000	1
Steam Injection Plot			SPH-SE-23	8/30/2000	<870
CP-SE-1	11/17/1999	< 0.39	SPH-SE-24	8/31/2000	500
CP-SE-2	11/17/1999	< 0.39	SPH-SE-25	9/1/2000	59.00
CP-SE-3	11/17/1999	< 0.41	SPH-SE-26	9/1/2000	17
SI-SE-4	1/18/2000	12	SPH-SE-27	11/30/2000	3,100
SI-SE-5	1/18/2000	13	SPH-SE-28	11/30/2000	10,000
SI-SE-6	1/18/2000	13	SPH-SE-29	12/1/2000	11,000
SI-SE-7	4/11/2000	2.2	SPH-SE-30	12/2/2000	9
SI-SE-8	4/11/2000	11	SPH-SE-31	12/2/2000	1
SI-SE-9	4/11/2000	2.7	SPH-SE-32	12/4/2000	<0.40
SI-SE-33	12/4/2000	1.2	***Background***		
SI-SE-34	12/5/2000	1.1	DW-SE-1	10/1/1999	< 0.42
SI-SE-35	12/5/2000	<0.40	DW-SE-2	10/8/1999	< 0.44
Ambient Air at Shoulder Level			DW-SE-3	10/25/1999	0.44
SPH-SE-14	5/9/2000	<0.39[a]	DW-SE-4	10/22/1999	6,000[b]
SPH-SE-15	5/9/2000	<0.39[a]	DW-SE-5	1/17/2000	< 0.38
SPH-SE-C27	9/1/2000	<0.88	DW-SE-6	4/11/2000	0.43
DW-C1	4/11/2000	2.1[c]	DW-SE-7	4/11/2000	0.86
DW-C2	5/9/2000	<0.39	DW-SE-8	4/11/2000	0.79
DW-C3	5/9/2000	<0.39	DW-SE-36	12/6/2000	<0.40
DW-C21	8/31/2000	0.86[c]	DW-SE-37	12/6/2000	0.49
DW-C22	9/1/2000	<0.58[c]	DW-SE-38	12/7/2000	<0.40

ppb (v/v): parts per billion by volume.

a. SPH-SE-14/15 samples were collected at an ambient elevation east and west edge of the resistive heating plot w/o using an air collection box.

b. Background sample (10/22/99) was taken immediately after SPH-SE-6 sample (the last sample for this event), which had an unexpectedly high concentration of 13,000 ppbv. This may indicate condensation of TCE in the emissions collection box at levels that could not be removed by the standard decontamination procedure of purging the box with air for two hours. In subsequent events (1/17/2000 background), special additional decontamination steps were taken to minimize carryover.

c. This sample was collected by holding a Summa canister at shoulder level collecting an ambient air sample to evaluate local background air.

Table D-6. TOC Results of Soil Samples

Pre-Demo			Post-Demo		
Sample ID	SW9060 (mg/kg)	Walkley-Black (mg/kg)	Sample ID	SW9060 (mg/kg)	Walkley-Black (mg/kg)
Resisitve Heating Plot					
SB-5-28TOC	NA	<0.20	SB-204-18TOC	10,500	<100
SB-5-38TOC	NA	<0.20	SB-204-30TOC	16,800	686
SB-5-45TOC	NA	<0.20	SB-204-40TOC	12,200	202
SB-5-45TOCB	NA	<0.20	SB-211-22TOC	7,740	<167
SB-8-24TOC	NA	0.20	SB-211-30TOC	11,100	603
SB-8-32TOC	NA	<0.20	SB-211-40TOC	18,000	986
SB-8-38TOC	NA	0.29	NA	NA	NA

<: Result was not detected at or above the stated reporting limit.
NA: Not available.

Table D-7. CVOC Results of Perimeter Soil Cores

Analytical Sample ID	Sample Depth (ft)		Sample Date	MeOH (g)	Wet Soil Weight (g)	Dry Soil Weight (g)	TCE		*cis* -1,2-DCE		*trans* -1,2-DCE		Vinyl Chloride	
	Top Depth	Bottom Depth					Result in MeOH (µg/L)	Result in Dry Soil (mg/kg)	Result in MeOH (µg/L)	Result in Dry Soil (mg/kg)	Result in MeOH (µg/L)	Result in Dry Soil (mg/kg)	Result in MeOH (µg/L)	Result in Dry Soil (mg/kg)
DB-1-266	0	2	8/30/2000	193	165	153	<250	ND	<250	ND	<250	ND	<500	ND
DB-1-267	2	4	8/30/2000	192	139	121	<250	ND	<250	ND	<250	ND	<500	ND
DB-1-268	4	6	8/30/2000	192	181	150	<250	ND	<250	ND	<250	ND	<500	ND
DB-1-269	6	8	8/30/2000	193	285	236	<250	ND	1,600	2.36	<250	ND	<500	ND
DB-1-270	10	12	8/30/2000	192	225	186	930	1.41	1,200	1.77	<250	ND	<500	ND
DB-1-271	12	14	8/30/2000	192	309	260	460	0.52	430	0.63	<250	ND	<500	ND
DB-1-272	14	16	8/30/2000	193	160	137	<250	ND	<250	ND	<250	ND	<500	ND
DB-1-273	16	18	8/30/2000	194	140	119	<250	ND	<250	ND	<250	ND	<500	ND
DB-1-274	16	18	8/30/2000	192	150	128	<250	ND	<250	ND	<250	ND	<500	ND
DB-1-275	18	20	8/30/2000	193	216	174	<250	ND	<250	ND	<250	ND	<500	ND
DB-1-276	20	22	8/30/2000	190	216	168	<250	ND	<250	ND	<250	ND	520	0.81
DB-1-277	22	24	8/30/2000	193	311	232	<250	ND	<250	ND	<250	ND	1,600	2.57
DB-1-278	24	26	8/30/2000	191	256	196	<250	ND	<250	ND	<250	ND	1,200	1.89
DB-1-279	26	28	8/30/2000	191	296	233	<250	ND	<250	ND	<250	ND	1,500	2.30
DB-1-280	28	30	8/30/2000	192	231	186	<250	ND	<250	ND	<250	ND	750	1.13
DB-1-281	30	32	8/30/2000	191	315	230	<250	ND	<250	ND	<250	ND	<500	ND
DB-1-282	32	34	8/30/2000	189	249	174	<250	ND	<250	ND	<250	ND	<500	ND
DB-1-283	34	36	8/30/2000	192	236	178	1,200	2.03	<250	ND	<250	ND	<500	ND
DB-1-284	36	38	8/30/2000	194	255	204	460	0.67	<250	ND	<250	ND	<500	ND
DB-1-285	38	40	8/30/2000	193	294	239	<250	ND	<250	ND	<250	ND	<500	ND
DB-1-286	Blank		8/30/2000	NA	NA	NA	<250	ND	<250	ND	<250	ND	<500	ND
DB-1-287	Blank		8/31/2000	NA	NA	NA	<250	ND	<250	ND	<250	ND	<500	ND
DB-1-288	Blank		8/31/2000	NA	NA	NA	<250	ND	<250	ND	<250	ND	<500	ND
PA-201-1	0	2	8/14/2000	198	184	185	6,400	8.6	<250	ND	<250	ND	<500	ND
PA-201-2	2	4	8/14/2000	185	195	189	<250	ND	<250	ND	<250	ND	<500	ND
PA-201-3	4	6	8/14/2000	184	220	209	560	0.7	<250	ND	<250	ND	<500	ND
PA-201-103	6	8	8/21/2000	194	230	205	920	1.2	<250	ND	<250	ND	<500	ND
PA-201-104	8	10	8/21/2000	193	334	285	<250	ND	<250	ND	<250	ND	<500	ND
PA-201-105	10	12	8/21/2000	195	257	222	<250	ND	<250	ND	<250	ND	<500	ND
PA-201-106	12	14	8/21/2000	193	239	205	1,100	1.5	290	0.42	<250	ND	<500	ND
PA-201-107	14	16	8/21/2000	187	260	218	3,600	4.6	1,900	2.77	<250	ND	<500	ND
PA-201-108	16	18	8/21/2000	192	301	254	820	0.9	1,300	1.89	<250	ND	<500	ND
PA-201-109	18	20	8/21/2000	193	251	205	1,800	2.5	2,500	3.73	<250	ND	<500	ND
PA-201-110	20	22	8/21/2000	195	213	177	1,300	2.1	2,300	3.38	<250	ND	<500	ND
PA-201-111	20	22	8/21/2000	194	243	199	4,500	6.5	3,800	5.65	<250	ND	<500	ND
PA-201-112	22	24	8/21/2000	196	293	237	10,000	12.8	7,800	11.72	<500	ND	<1,000	ND

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Table D-7. CVOC Results of Perimeter Soil Cores (Continued)

Analytical Sample ID	Sample Depth (ft) Top Depth	Sample Depth (ft) Bottom Depth	Sample Date	MeOH (g)	Wet Soil Weight (g)	Dry Soil Weight (g)	TCE Result in MeOH (µg/L)	TCE Result in Dry Soil (mg/kg)	*cis* -1,2-DCE Result in MeOH (µg/L)	*cis* -1,2-DCE Result in Dry Soil (mg/kg)	*trans* -1,2-DCE Result in MeOH (µg/L)	*trans* -1,2-DCE Result in Dry Soil (mg/kg)	Vinyl Chloride Result in MeOH (µg/L)	Vinyl Chloride Result in Dry Soil (mg/kg)
PA-201-113	24	26	8/21/2000	192	358	280	<1,000	ND	16,000	24.71	<1,000	ND	<2,000	ND
PA-201-114	26	28	8/21/2000	194	334	258	<1,200	ND	20,000	31.21	<1,200	ND	<2,500	ND
PA-201-115	28	30	8/21/2000	194	351	291	<500	ND	16,000	23.55	<500	ND	1,400	2.06
PA-201-116	30	32	8/21/2000	195	363	301	<250	ND	7,600	11.19	<250	ND	1,000	1.47
PA-201-117	32	34	8/21/2000	195	347	271	<360	ND	5,600	8.66	<360	ND	760	1.18
PA-201-118	34	36	8/21/2000	193	264	196	<250	ND	1,500	2.42	<250	ND	<500	ND
PA-201-119	36	38	8/21/2000	194	284	200	<250	ND	550	0.93	<250	ND	<500	ND
PA-201-120	38	40	8/21/2000	193	290	214	<250	ND	<250	ND	<250	ND	<500	ND
PA-201-121	40	42	8/21/2000	190	313	246	<250	ND	<250	ND	<250	ND	<500	ND
PA-201-122	42	44	8/21/2000	192	381	293	<250	ND	<250	ND	<250	ND	<500	ND
PA-201-123	44	46	8/21/2000	192	248	184	<250	ND	<250	ND	<250	ND	<500	ND
PA-201-320	Blank		9/1/2000	NA	NA	NA	<250	ND	<250	ND	<250	ND	<500	ND
PA-202-2	0	2	12/12/2000	199	121	121	990	2	<250	ND	<250	ND	<500	ND
PA-202-4	2	4	12/12/2000	195	163	160	480	1	<250	ND	<250	ND	<500	ND
PA-202-6	4	6	12/12/2000	197	125	112	<250	ND	<250	ND	<250	ND	<500	ND
PA-202-8	6	8	12/12/2000	193	126	110	660	2	<250	ND	<250	ND	<500	ND
PA-202-10	8	10	12/12/2000	203	141	121	<250	ND	<250	ND	<250	ND	<500	ND
PA-202-12	10	12	12/12/2000	199	173	148	880	2	<250	ND	<250	ND	<500	ND
PA-202-14	12	14	12/12/2000	193	177	154	520	1	<250	ND	<250	ND	<500	ND
PA-202-16	14	16	12/12/2000	203	184	152	250	0	420	1	<250	ND	<500	ND
PA-202-18	16	18	12/12/2000	195	188	159	400,000	694	<25,000	ND	<25,000	ND	<50,000	ND
PA-202-20	18	20	12/12/2000	199	191	161	12,000	21	<500	ND	<500	ND	<1,000	ND
PA-202-22	20	22	12/12/2000	197	163	136	77,000	156	<5,000	ND	<5,000	ND	<10,000	ND
PA-202-24	22	24	12/12/2000	202	141	117	250,000	598	<12,000	ND	<12,000	ND	<25,000	ND
PA-202-26	24	26	12/12/2000	189	186	142	400,000	798	<25,000	ND	<25,000	ND	<50,000	ND
PA-202-28	26	28	12/12/2000	198	185	149	180,000	346	<10,000	ND	<10,000	ND	<20,000	ND
PA-202-28-DUP	26	28	12/12/2000	200	192	156	170,000	315	<10,000	ND	<10,000	ND	<20,000	ND
PA-202-30	28	30	12/12/2000	194	230	187	2,500,000 D	3,858	<25,000	ND	<25,000	ND	<50,000	ND
PA-202-32	30	32	12/12/2000	198	210	176	8,100,000 D	13,100	<120,000	ND	<120,000	ND	<250,000	ND
PA-202-34	32	34	12/12/2000	197	258	188	1,200,000	2,039	<62,000	ND	<62,000	ND	<120,000	ND
PA-202-36	34	36	12/12/2000	192	185	141	2,400,000 D	4,886	<17,000	ND	<17,000	ND	<33,000	ND
PA-202-38	36	38	12/12/2000	192	223	164	370,000	681	<21,000	ND	<21,000	ND	<42,000	ND
PA-202-40	38	40	12/12/2000	195	222	176	250,000	416	<12,000	ND	<12,000	ND	<25,000	ND
PA-202-43	41	43	12/12/2000	197	254	207	310,000	444	<17,000	ND	<17,000	ND	<33,000	ND
PA-202-45	43	45	12/12/2000	198	198	147	230,000	472	<12,000	ND	<12,000	ND	<25,000	ND
PA-202-EB	EQ		12/12/2000	NA	NA	NA	20		<1	ND	<1	ND	<2	ND

Table D-7. CVOC Results of Perimeter Soil Cores (Continued)

Analytical Sample ID	Sample Depth (ft) Top Depth	Sample Depth (ft) Bottom Depth	Sample Date	MeOH (g)	Wet Soil Weight (g)	Dry Soil Weight (g)	TCE Result in MeOH (µg/L)	TCE Result in Dry Soil (mg/kg)	*cis*-1,2-DCE Result in MeOH (µg/L)	*cis*-1,2-DCE Result in Dry Soil (mg/kg)	*trans*-1,2-DCE Result in MeOH (µg/L)	*trans*-1,2-DCE Result in Dry Soil (mg/kg)	Vinyl Chloride Result in MeOH (µg/L)	Vinyl Chloride Result in Dry Soil (mg/kg)
PA-202-11	0	2	8/14/2000	193	240	223	<250	ND	<250	ND	<250	ND	<500	ND
PA-202-12	2	4	8/14/2000	191	173	169	620	0.90	<250	ND	<250	ND	<500	ND
PA-202-13	4	6	8/14/2000	186	200	191	<250	ND	<250	ND	<250	ND	<500	ND
PA-202-180	6	8	8/24/2000	193	230	195	<250	ND	<250	ND	<250	ND	<500	ND
PA-202-181	8	10	8/24/2000	193	347	295	2,600	2.6	870	1.25	<250	ND	<500	ND
PA-202-182	12	14	8/24/2000	194	276	228	640	0.8	540	0.80	<250	ND	<500	ND
PA-202-183	16	18	8/24/2000	192	292	240	6,600	8.1	2,000	2.96	<250	ND	<500	ND
PA-202-184	18	20	8/24/2000	192	197	72	9,400	48.0	940	2.82	<250	ND	<500	ND
PA-202-185	20	22	8/24/2000	193	338	295	150,000	146.1	<4,200	ND	<4,200	ND	<8,400	ND
PA-202-186	22	24	8/24/2000	193	357	238	74,000	113.0	<2,500	ND	<2,500	ND	<5,000	ND
PA-202-325	Blank		9/1/2000	NA	NA	NA	<250	ND	<250	ND	<250	ND	<500	ND
PA-207-94	0	2	8/19/2000	193	185	181	980	1.3	600	0.77	<250	ND	<500	ND
PA-207-95	2	4	8/19/2000	193	174	147	2,200	4.1	<250	ND	<250	ND	<500	ND
PA-207-96	4	6	8/19/2000	193	183	168	710	1.1	<250	ND	<250	ND	<500	ND
PA-207-145	6	8	8/22/2000	196	176	153	540	1.0	<250	ND	<250	ND	<500	ND
PA-207-146	8	10	8/22/2000	196	229	199	2,700	3.8	590	0.84	<250	ND	<500	ND
PA-207-147	10	12	8/22/2000	199	261	223	6,600	8.6	1,200	1.72	<250	ND	<500	ND
PA-207-148	12	14	8/22/2000	193	172	152	5,800	10.1	2,400	3.35	<250	ND	<500	ND
PA-207-149	14	16	8/22/2000	192	210	179	58,000	88.8	8,400	12.09	<2,100	ND	<4,200	ND
PA-207-150	16	18	8/22/2000	193	253	214	67,000	88.7	7,800	11.29	<3,600	ND	<7,200	ND
PA-207-151	18	20	8/22/2000	193	272	235	4,100	4.9	15,000	21.35	<1,000	ND	<2,000	ND
PA-207-152	20	22	8/22/2000	195	271	230	9,900	12.4	16,000	23.11	<1,200	ND	<2,500	ND
PA-207-153	22	24	8/22/2000	194	251	197	1,700	2.6	8,700	13.40	<620	ND	1,700	2.62
PA-207-154	24	26	8/22/2000	195	306	239	<620	ND	8,200	12.68	<620	ND	2,700	4.17
PA-207-155	26	28	8/22/2000	193	219	169	900	1.6	3,700	5.78	<250	ND	<500	ND
PA-207-156	28	30	8/22/2000	195	245	198	760	1.1	2,200	3.31	<250	ND	<500	ND
PA-207-157	30	32	8/22/2000	193	240	203	21,000	29.1	6,100	8.83	<1,000	ND	<2,000	ND
PA-207-158	32	34	8/22/2000	194	249	222	15,000 D	18.4	3,200	4.44	<250	ND	<500	ND
PA-207-159	34	36	8/22/2000	194	178	133	<1,000	ND	15,000	24.06	<1,000	ND	<2,000	ND
PA-207-160	34	36	8/22/2000	193	162	121	<830	ND	13,000	20.86	<830	ND	<1,700	ND
PA-207-161	36	38	8/22/2000	194	199	157	4,300	7.9	7,800	11.96	<500	ND	<1,000	ND
PA-207-162	38	40	8/22/2000	192	303	242	<250	ND	570	0.87	<250	ND	<500	ND
PA-207-163	40	42	8/22/2000	192	245	197	<250	ND	<250	ND	<250	ND	<500	ND
PA-207-164	41.5	43.5	8/22/2000	192	256	194	<250	ND	<250	ND	<250	ND	<500	ND
PA-207-165	43	45	8/22/2000	193	214	157	410	0.8	<250	ND	<250	ND	<500	ND
PA-207-318	Blank		9/1/2000	NA	NA	NA	<250	ND	<250	ND	<250	ND	<500	ND

Table D-7. CVOC Results of Perimeter Soil Cores (Continued)

Analytical Sample ID	Sample Depth (ft) Top Depth	Sample Depth (ft) Bottom Depth	Sample Date	MeOH (g)	Wet Soil Weight (g)	Dry Soil Weight (g)	TCE Result in MeOH (µg/L)	TCE Result in Dry Soil (mg/kg)	*cis*-1,2-DCE Result in MeOH (µg/L)	*cis*-1,2-DCE Result in Dry Soil (mg/kg)	*trans*-1,2-DCE Result in MeOH (µg/L)	*trans*-1,2-DCE Result in Dry Soil (mg/kg)	Vinyl Chloride Result in MeOH (µg/L)	Vinyl Chloride Result in Dry Soil (mg/kg)
PA-208-97	0	2	8/19/2000	194	211	203	2,800	3.5	<250	ND	<250	ND	<500	ND
PA-208-98	2	4	8/19/2000	194	214	210	970	1.2	<250	ND	<250	ND	<500	ND
PA-208-99	4	6	8/19/2000	194	187	180	630	0.9	<250	ND	<250	ND	<500	ND
PA-208-124	6	8	8/21/2000	195	313	274	<250	ND	<250	ND	<250	ND	<500	ND
PA-208-125	8	10	8/21/2000	193	312	265	<250	ND	<250	ND	<250	ND	<500	ND
PA-208-126	10	12	8/21/2000	197	326	253	270	0.3	350	0.54	<250	ND	<500	ND
PA-208-127	12	14	8/21/2000	196	297	271	<250	ND	<250	ND	<250	ND	<500	ND
PA-208-128	14	16	8/21/2000	192	248	207	<380	ND	6,000	8.78	<380	ND	<770	ND
PA-208-129	16	18	8/21/2000	193	195	169	<250	ND	1,900	2.70	<250	ND	<500	ND
PA-208-130	18	20	8/21/2000	193	302	255	27,000	30.8	4,900	7.11	<1,000	ND	<2,000	ND
PA-208-131	20	22	8/21/2000	195	232	200	23,000	32.1	4,200	5.99	<1,000	ND	<2,000	ND
PA-208-132	22	24	8/21/2000	193	301	243	82,000	102.0	14,000	21.06	<4,200	ND	<8,300	ND
PA-208-133	24	26	8/21/2000	193	301	233	190,000	254.7	29,000	45.17	<6,200	ND	<12,000	ND
PA-208-134	24	26	8/21/2000	191	267	205	110,000	163.0	19,000	29.80	<4,200	ND	<8,300	ND
PA-208-135	26	28	8/21/2000	191	293	221	76,000	107.9	56,000	89.13	<3,100	ND	<6,200	ND
PA-208-136	28	30	8/21/2000	192	383	298	29,000	31.9	55,000	85.31	<4,200	ND	<8,300	ND
PA-208-137	30	32	8/21/2000	192	239	196	63,000	91.9	12,000	17.82	<2,100	ND	<4,200	ND
PA-208-138	32	34	8/21/2000	194	338	285	55,000	57.6	13,000	18.87	<2,500	ND	<5,000	ND
PA-208-139	34	36	8/21/2000	194	337	245	25,000	34.4	39,000	64.01	<2,500	ND	<5,000	ND
PA-208-140	36	38	8/21/2000	195	276	190	25,000	43.8	23,000	39.52	<1,200	ND	<2,500	ND
PA-208-141	38	40	8/21/2000	193	260	191	84,000	137.8	16,000	26.03	<2,500	ND	<5,000	ND
PA-208-142	40	42	8/21/2000	194	275	203	94,000	147.1	7,600	12.32	<4,200	ND	<8,300	ND
PA-208-143	41.5	43.5	8/21/2000	192	305	216	170,000	261.3	<8,300	ND	<8,300	ND	<17,000	ND
PA-208-144	43	45	8/21/2000	194	239	173	130,000	234.1	<6,200	ND	<6,200	ND	<12,000	ND
PA-208-319	Blank		9/1/2000	NA	NA	NA	<250	ND	<250	ND	<250	ND	<500	ND
PA-211-207	0	2	8/25/2000	194	232	228	3,000	3.3	<250	ND	<250	ND	<500	ND
PA-211-208	2	4	8/25/2000	194	257	248	NA	0.0	NA	NA	NA	NA	NA	NA
PA-211-209	4	6	8/25/2000	194	241	233	2,300	2.5	<250	ND	<250	ND	<500	ND
PA-211-210	6	8	8/25/2000	195	217	205	2,800	3.5	<250	ND	<250	ND	<500	ND
PA-211-211	8	10	8/25/2000	190	171	152	290	0.5	<250	ND	<250	ND	<500	ND
PA-211-212	10	12	8/25/2000	195	166	143	530	1.0	340	0.49	<250	ND	<500	ND
PA-211-213	12	14	8/25/2000	195	253	217	11,000	14.3	2,300	3.29	<420	ND	<850	ND
PA-211-214	14	16	8/25/2000	194	226	190	18,000	26.7	1,400	2.04	<620	ND	<1,200	ND
PA-211-215	16	18	8/25/2000	192	188	155	18,000	32.1	770	1.14	<620	ND	<1,200	ND
PA-211-216	18	20	8/25/2000	193	221	178	2,000	3.2	<250	ND	<250	ND	<500	ND
PA-211-217	20	22	8/25/2000	193	268	231	2,800	3.4	<250	ND	<250	ND	<500	ND

Table D-7. CVOC Results of Perimeter Soil Cores (Continued)

Analytical Sample ID	Sample Depth (ft) Top Depth	Bottom Depth	Sample Date	MeOH (g)	Wet Soil Weight (g)	Dry Soil Weight (g)	TCE Result in MeOH (µg/L)	TCE Result in Dry Soil (mg/kg)	*cis*-1,2-DCE Result in MeOH (µg/L)	*cis*-1,2-DCE Result in Dry Soil (mg/kg)	*trans*-1,2-DCE Result in MeOH (µg/L)	*trans*-1,2-DCE Result in Dry Soil (mg/kg)	Vinyl Chloride Result in MeOH (µg/L)	Vinyl Chloride Result in Dry Soil (mg/kg)
PA-211-218	22	24	8/25/2000	197	264	225	2,600,000	3,332.2	<120,000	ND	<120,000	ND	<250,000	ND
PA-211-219	24	26	8/25/2000	191	218	180	79,000	122.8	<4,200	ND	<4,200	ND	<8,400	ND
PA-211-220	26	28	8/25/2000	191	219	188	660,000	957.6	<25,000	ND	<25,000	ND	<50,000	ND
PA-211-221	28	30	8/28/2000	193	148	127	89,000	185.9	<3,100	ND	<3,100	ND	<6,200	ND
PA-211-222	30	32	8/28/2000	193	201	163	270,000	467.6	<12,000	ND	<12,000	ND	<25,000	ND
PA-211-223	32	34	8/28/2000	251	261	251	230,000	300.3	<12,000	ND	<12,000	ND	<25,000	ND
PA-211-224	34	36	8/28/2000	195	209	167	120,000	207.5	<5,000	ND	<5,000	ND	<10,000	ND
PA-211-225	36	38	8/28/2000	196	201	174	130,000	205.5	<6,200	ND	<6,200	ND	<12,000	ND
PA-211-226	38	40	8/28/2000	192	317	252	750,000	916.8	<42,000	ND	<42,000	ND	<83,000	ND
PA-211-227	38	40	8/28/2000	194	401	318	930,000	960.9	<50,000	ND	<50,000	ND	<100,000	ND
PA-211-228	40	42	8/28/2000	195	270	209	1,600,000	2,356.6	<72,000	ND	<72,000	ND	<140,000	ND
PA-211-229	42	44	8/28/2000	193	300	240	190,000	240.9	<10,000	ND	<10,000	ND	<20,000	ND
PA-211-314	Blank		9/1/2000	NA	NA	NA	370	0.5	<250	ND	<250	ND	<500	ND
LC34B214-2	0	2	12/13/2000	191	106	104	<250	ND	<250	ND	<250	ND	<500	ND
LC34B214-4	2	4	12/13/2000	198	156	145	<250	ND	<250	ND	<250	ND	<500	ND
LC34B214-6	4	6	12/13/2000	191	135	121	<250	ND	260	1	<250	ND	<500	ND
LC34B214-8	6	8	12/13/2000	196	162	141	<250	ND	1,100	2	<250	ND	<500	ND
LC34B214-10	8	10	12/13/2000	201	122	108	<250	ND	12,000	30	<250	ND	<500	ND
LC34B214-12	10	12	12/13/2000	198	111	92	<250	ND	11,000 D	32	<250	ND	<500	ND
LC34B214-14	12	14	12/13/2000	202	190	161	<250	ND	17,000 D	30	<250	ND	<500	ND
LC34B214-16	14	16	12/13/2000	200	190	160	6,200	11	15,000 D	27	<250	ND	<500	ND
LC34B214-18	16	18	12/13/2000	192	245	205	2,600	4	150,000 D	207	<250	ND	<500	ND
LC34B214-20	18	20	12/13/2000	198	109	96	540	1	6,500	18	<250	ND	<500	ND
LC34B214-20-DUP	18	20	12/13/2000	200	120	103	560	1	7,300	19	<250	ND	<500	ND
LC34B214-22	20	22	12/13/2000	195	166	133	4,700	10	12,000	25	<250	ND	<500	ND
LC34B214-24	22	24	12/13/2000	194	209	160	1,500	3	3,800	7	<250	ND	<500	ND
LC34B214-26	24	26	12/13/2000	194	219	171	<500	ND	6,600	11	<500	ND	<1,000	ND
LC34B214-28	26	28	12/13/2000	203	191	153	<380	ND	7,000	13	<380	ND	<770	ND
LC34B214-30	28	30	12/13/2000	198	247	209	<380	ND	6,600	9	<380	ND	<770	ND
LC34B214-32	30	32	12/13/2000	193	147	121	<250	ND	3,500	8	<250	ND	<500	ND
LC34B214-34	32	34	12/13/2000	191	151	120	<250	ND	1,400	3	<250	ND	<500	ND
LC34B214-36	34	36	12/13/2000	194	231	175	<250	ND	1,200	2	<250	ND	<500	ND
LC34B214-39	37	39	12/13/2000	197	199	155	<250	ND	<250	ND	<250	ND	<500	ND
LC34B214-41	39	41	12/13/2000	189	270	216	<250	ND	<250	ND	<250	ND	<500	ND
LC34B214-87	Lab Blank		12/13/2000	NA	NA	NA	<250	ND	<250	ND	<250	ND	<500	ND
LC34B214-88	Lab Blank		12/13/2000	NA	NA	NA	<250	ND	<250	ND	<250	ND	<500	ND

Table D-7. CVOC Results of Perimeter Soil Cores (Continued)

Analytical Sample ID	Sample Depth (ft) Top Depth	Bottom Depth	Sample Date	MeOH (g)	Wet Soil Weight (g)	Dry Soil Weight (g)	TCE Result in MeOH (µg/L)	TCE Result in Dry Soil (mg/kg)	*cis*-1,2-DCE Result in MeOH (µg/L)	*cis*-1,2-DCE Result in Dry Soil (mg/kg)	*trans*-1,2-DCE Result in MeOH (µg/L)	*trans*-1,2-DCE Result in Dry Soil (mg/kg)	Vinyl Chloride Result in MeOH (µg/L)	Vinyl Chloride Result in Dry Soil (mg/kg)
LC34B214-EB	EQ		12/13/2000	NA	NA	NA	<1	ND	<1	ND	<1	ND	<2	ND
LC34B314-2	0	2	12/14/2000	194	124	122	<250	ND	<250	ND	<250	ND	<500	ND
LC34B314-4	2	4	12/14/2000	199	147	138	<250	ND	820	2	<250	ND	<500	ND
LC34B314-6	4	6	12/14/2000	199	112	104	<250	ND	<250	ND	<250	ND	<500	ND
LC34B314-8	6	8	12/14/2000	197	183	169	<250	ND	350	1	<250	ND	<500	ND
LC34B314-10	8	10	12/14/2000	189	194	166	3,100	5	12,000	19	<830	ND	<1,700	ND
LC34B314-12	10	12	12/14/2000	195	149	126	1,900	4	7,200	15	<250	ND	<500	ND
LC34B314-12-DUP	10	12	12/14/2000	204	172	145	2,500	5	9,200	18	<250	ND	<500	ND
LC34B314-14	12	14	12/14/2000	199	170	141	2,900	6	14,000 D	28	<250	ND	<500	ND
LC34B314-16	14	16	12/14/2000	198	217	182	7,500	12	20,000 D	31	<250	ND	<500	ND
LC34B314-18	16	18	12/14/2000	199	227	186	10,000	16	15,000	24	<380	ND	<770	ND
LC34B314-20	18	20	12/14/2000	193	150	126	1,300	3	3,800	8	<250	ND	<500	ND
LC34B314-22	20	22	12/15/2000	192	137	110	<250	ND	2,700	7	<250	ND	<500	ND
LC34B314-24	22	24	12/15/2000	190	220	178	<250	ND	4,300	7	<250	ND	<500	ND
LC34B314-26	24	26	12/15/2000	197	281	226	<250	ND	6,700	9	<250	ND	<500	ND
LC34B314-28	26	28	12/15/2000	197	282	155	<250	ND	7,300	18	<250	ND	<500	ND
LC34B314-30	28	30	12/15/2000	196	200	152	<250	ND	2,900	6	<250	ND	<500	ND
LC34B314-32	30	32	12/15/2000	183	216	171	<250	ND	1,300	2	<250	ND	<500	ND
LC34B314-34	32	34	12/15/2000	195	222	145	<250	ND	1,200	3	<250	ND	<500	ND
LC34B314-36	34	36	12/15/2000	201	132	107	<250	ND	<250	ND	<250	ND	<500	ND
LC34B314-38	36	38	12/15/2000	200	234	165	380	1	<250	ND	<250	ND	<500	ND
LC34B314-40	38	40	12/15/2000	203	230	183	<250	ND	<250	ND	<250	ND	<500	ND
LC34B314-42	40	42	12/15/2000	199	252	196	<250	ND	<250	ND	<250	ND	<500	ND
LC34B314-44	42	44	12/15/2000	207	205	164	4,400	8	<250	ND	<250	ND	<500	ND
LC34B314-91[1)]	Lab Blank		12/15/2000	NA	NA	NA	<250	ND	<250	ND	<250	ND	<500	ND
LC34B314-92	Lab Blank		12/15/2000	NA	NA	NA	<250	ND	<250	ND	<250	ND	<500	ND
LC34B314-EB	EQ		12/15/2000	NA	NA	NA	0.82 J	NA	<1	ND	<1	ND	<2	ND
LC34B214-14	0	2	8/14/2000	192	194	187	<250	ND	<250	ND	<250	ND	<500	ND
LC34B214-15	2	4	8/14/2000	190	172	163	<250	ND	<250	ND	<250	ND	<500	ND
LC34B214-16	4	6	8/14/2000	188	202	189	<250	ND	<250	ND	<250	ND	<500	ND
LC34B214-170	6	8	8/23/2000	193	198	171	7,300	11.6	1,700	2.42	<250	ND	<500	ND
LC34B214-171	8	10	8/23/2000	195	215	185	13,000	19.5	1,400	2.00	<500	ND	<1,000	ND
LC34B214-172	10	12	8/23/2000	195	260	221	16,000	20.7	4,400	6.35	<830	ND	<1,700	ND
LC34B214-173	12	14	8/23/2000	193	237	203	12,000	16.5	3,300	4.73	<500	ND	<1,000	ND
LC34B214-174	12	14	8/23/2000	196	223	191	9,800	14.4	2,500	3.58	<360	ND	<720	ND
LC34B214-175	14	16	8/23/2000	193	189	149	<1,000	ND	12,000	18.41	<1,000	ND	<2,000	ND

Table D-7. CVOC Results of Perimeter Soil Cores (Continued)

Analytical Sample ID	Sample Depth (ft) Top Depth	Sample Depth (ft) Bottom Depth	Sample Date	MeOH (g)	Wet Soil Weight (g)	Dry Soil Weight (g)	TCE Result in MeOH (µg/L)	TCE Result in Dry Soil (mg/kg)	*cis*-1,2-DCE Result in MeOH (µg/L)	*cis*-1,2-DCE Result in Dry Soil (mg/kg)	*trans*-1,2-DCE Result in MeOH (µg/L)	*trans*-1,2-DCE Result in Dry Soil (mg/kg)	Vinyl Chloride Result in MeOH (µg/L)	Vinyl Chloride Result in Dry Soil (mg/kg)
LC34B214-176	16	18	8/23/2000	193	239	206	590	0.8	9,300	13.26	<500	ND	<1,000	ND
LC34B214-324	Blank		9/1/2000	NA	NA	NA	<250	ND	<250	ND	<250	ND	<500	ND
LC34B217-2	0	2	12/14/2000	199	192	187	<250	ND	<250	ND	<250	ND	<500	ND
LC34B217-4	2	4	12/14/2000	195	176	171	<250	ND	<250	ND	<250	ND	<500	ND
LC34B217-6	4	6	12/14/2000	193	192	189	910	1	270	0	<250	ND	<500	ND
LC34B217-8	6	8	12/14/2000	194	142	137	670	1	250	0	<250	ND	<500	ND
LC34B217-10	8	10	12/14/2000	196	142	121	5,700	13	3,300	7	<250	ND	<500	ND
LC34B217-12	10	12	12/14/2000	193	129	110	4,700	11	3,800	9	<250	ND	<500	ND
LC34B217-14	12	14	12/14/2000	195	160	135	7,000	14	4,300	9	<380	ND	<770	ND
LC34B217-16	14	16	12/14/2000	202	118	99	2,300	6	5,100	14	<500	ND	<1,000	ND
LC34B217-18	16	18	12/14/2000	193	184	156	<500	ND	19,000	33	<500	ND	<1,000	ND
LC34B217-20 1)	18	20	12/14/2000	195	154	125	<250	ND	17,000 D	38	<250	ND	<500	ND
LC34B217-22	20	22	12/14/2000	193	207	171	4,700	8	31,000	51	<1,800	ND	<3,600	ND
LC34B217-24	22	24	12/14/2000	193	188	146	49,000	96	8,600	17	<1,800	ND	<3,600	ND
LC34B217-26	24	26	12/14/2000	198	198	157	86,000	160	<3,600	ND	<3,600	ND	<7,100	ND
LC34B217-28	26	28	12/14/2000	188	208	156	120,000	223	7,100	13	<4,200	ND	<8,300	ND
LC34B217-30	28	30	12/14/2000	192	197	154	36,000	67	18,000	33	<1,200	ND	<2,500	ND
LC34B217-32	30	32	12/14/2000	191	129	104	10,000	26	12,000	31	<830	ND	<1,700	ND
LC34B217-32-DUP	30	32	12/14/2000	198	163	135	13,000	27	16,000	33	<830	ND	<1,700	ND
LC34B217-34	32	34	12/14/2000	NA	NR	NR	NA	NA	NA	NA	NA	NA	NA	NA
LC34B217-36	34	36	12/14/2000	187	275	203	<250	ND	3,900	6	<250	ND	<500	ND
LC34B217-38	36	38	12/14/2000	189	246	146	<250	ND	650	2	<250	ND	<500	ND
LC34B217-40	38	40	12/14/2000	NA	NR	NR	NA	NA	NA	NA	NA	NA	NA	NA
LC34B217-42	40	42	12/14/2000	194	196	156	<250	ND	<250	ND	<250	ND	<500	ND
LC34B217-44	42	44	12/14/2000	190	191	156	<250	ND	<250	ND	<250	ND	<500	ND
LC34B217-90	Lab Blank		12/14/2000	NA	NA	NA	<250	ND	<250	ND	<250	ND	<500	ND
LC34B217-93	Lab Blank		12/14/2000	NA	NA	NA	<250	ND	<250	ND	<250	ND	<500	ND
LC34B217-EB	EQ		12/14/2000	NA	NA	NA	<1	ND	<1	ND	<1	ND	<2	ND
LC34B217-100	0	2	8/19/2000	194	175	173	3,400	5	<250	ND	<250	ND	<500	ND
LC34B217-101	2	4	8/19/2000	195	203	201	<250	ND	<250	ND	<250	ND	<500	ND
LC34B217-102	4	6	8/19/2000	193	221	211	<250	ND	<250	ND	<250	ND	<500	ND
LC34B217-166	6	8	8/23/2000	196	193	165	250	0.4	<250	ND	<250	ND	<500	ND
LC34B217-167	8	10	8/23/2000	193	241	201	620	1	340	0.50	<250	ND	<500	ND
LC34B217-168	10	12	8/23/2000	194	255	223	12,000	15	1,400	1.97	<360	ND	<720	ND
LC34B217-169	12	14	8/23/2000	192	236	202	9,500	13	760	1.09	<250	ND	<500	ND
LC34B217-316	Blank		9/1/2000	NA	NA	NA	<250	ND	<250	ND	<250	ND	<500	ND

Table D-7. CVOC Results of Perimeter Soil Cores (Continued)

Analytical Sample ID	Sample Depth (ft) Top Depth	Sample Depth (ft) Bottom Depth	Sample Date	MeOH (g)	Wet Soil Weight (g)	Dry Soil Weight (g)	TCE Result in MeOH (µg/L)	TCE Result in Dry Soil (mg/kg)	*cis* -1,2-DCE Result in MeOH (µg/L)	*cis* -1,2-DCE Result in Dry Soil (mg/kg)	*trans* -1,2-DCE Result in MeOH (µg/L)	*trans* -1,2-DCE Result in Dry Soil (mg/kg)	Vinyl Chloride Result in MeOH (µg/L)	Vinyl Chloride Result in Dry Soil (mg/kg)
LC34B239-230	0	2	8/28/2000	196	158	157	480	1	<250	ND	<250	ND	<500	ND
LC34B239-231	2	4	8/28/2000	192	201	198	320	0.4	<250	ND	<250	ND	<500	ND
LC34B239-232	4	6	8/28/2000	191	288	281	330	0.3	<250	ND	<250	ND	<500	ND
LC34B239-233	6	8	8/28/2000	193	159	154	800	1	<250	ND	<250	ND	<500	ND
LC34B239-234	8	10	8/28/2000	194	206	177	4,000	6	2,500	3.57	<250	ND	<500	ND
LC34B239-235	10	12	8/28/2000	194	256	219	9,200	12	10,000	14.35	<500	ND	<1,000	ND
LC34B239-236	12	14	8/28/2000	193	197	171	5,400	9	11,000	15.60	<500	ND	<1,000	ND
LC34B239-237	14	16	8/28/2000	191	234	200	2,900	4	5,900	8.47	<500	ND	<1,000	ND
LC34B239-238	16	18	8/28/2000	193	176	147	4,900	9	7,300	10.68	<250	ND	<500	ND
LC34B239-239	18	20	8/28/2000	192	261	206	11,000	16	880	1.35	<500	ND	<1,000	ND
LC34B239-240	20	22	8/29/2000	196	232	197	3,300	5	880	1.27	<250	ND	<500	ND
LC34B239-241	22	24	8/29/2000	239	187	185	210,000	346	<6,200	ND	<6,200	ND	<12,000	ND
LC34B239-242	22	24	8/29/2000	193	202	161	150,000	266	<5,000	ND	<5,000	ND	<10,000	ND
LC34B239-243	24	26	8/29/2000	192	184	150	120,000	222	<3,600	ND	<3,600	ND	<7,100	ND
LC34B239-244	26	28	8/29/2000	193	285	225	220,000	298	<6,200	ND	<6,200	ND	<12,000	ND
LC34B239-245	28	30	8/29/2000	193	323	249	280,000	358	<8,300	ND	<8,300	ND	<17,000	ND
LC34B239-246	30	32	8/29/2000	193	325	264	250,000	289	<8,300	ND	<8,300	ND	<17,000	ND
LC34B239-247	32	34	8/29/2000	193	332	261	260,000	314	<10,000	ND	<10,000	ND	<20,000	ND
LC34B239-248	34	36	8/29/2000	192	240	197	170,000	247	<5,000	ND	<5,000	ND	<10,000	ND
LC34B239-249	36	38	8/29/2000	197	312	245	220,000	284	6,600	10.16	<6,200	ND	<12,000	ND
LC34B239-250	38	40	8/29/2000	195	272	234	130,000	158	<4,200	ND	<4,200	ND	<8,300	ND
LC34B239-251	42	44	8/29/2000	192	363	287	240,000	267	<6,200	ND	<6,200	ND	<12,000	ND
LC34B239-252	44	46	8/29/2000	195	290	231	200,000	265	<6,200	ND	<6,200	ND	<12,000	ND
LC34B239-253	Blank		8/29/2000	NA	NA	NA	<250	ND	<250	ND	<250	ND	<500	ND
SB-28-254	0	2	8/29/2000	194	188	185	930	1	<250	ND	<250	ND	<500	ND
SB-28-255	2	4	8/29/2000	192	201	196	710	0.9	<250	ND	<250	ND	<500	ND
SB-28-256	4	6	8/29/2000	195	307	300	640	0.5	<250	ND	<250	ND	<500	ND
SB-28-257	6	8	8/29/2000	194	190	179	<250	ND	<250	ND	<250	ND	<500	ND
SB-28-258	8	10	8/29/2000	193	169	164	<250	ND	<250	ND	<250	ND	<500	ND
SB-28-259	8	10	8/29/2000	194	160	147	<250	ND	<250	ND	<250	ND	<500	ND
SB-28-260	10	12	8/29/2000	193	217	183	<250	ND	410	0.60	<250	ND	<500	ND
SB-28-261	12	14	8/29/2000	191	269	229	290	0.4	900	1.30	<250	ND	<500	ND
SB-28-262	14	16	8/29/2000	193	248	170	630	1	270	0.47	<250	ND	<500	ND
SB-28-263	16	18	8/29/2000	193	176	149	<250	ND	270	0.39	<250	ND	<500	ND
SB-28-264	18	20	8/29/2000	192	229	190	4,500	7	3,600	5.30	<250	ND	<500	ND
SB-28-265	20	22	8/29/2000	193	243	204	47,000	65	3,000	4.37	<1,200	ND	<2,500	ND

Table D-7. CVOC Results of Perimeter Soil Cores (Continued)

Analytical Sample ID	Sample Depth (ft) Top Depth	Sample Depth (ft) Bottom Depth	Sample Date	MeOH (g)	Wet Soil Weight (g)	Dry Soil Weight (g)	TCE Result in MeOH (µg/L)	TCE Result in Dry Soil (mg/kg)	*cis*-1,2-DCE Result in MeOH (µg/L)	*cis*-1,2-DCE Result in Dry Soil (mg/kg)	*trans*-1,2-DCE Result in MeOH (µg/L)	*trans*-1,2-DCE Result in Dry Soil (mg/kg)	Vinyl Chloride Result in MeOH (µg/L)	Vinyl Chloride Result in Dry Soil (mg/kg)
SB-28-317	Blank		9/1/2000	NA	NA	NA	<250	ND	<250	ND	<250	ND	<500	ND
SB-28B-289	0	2	8/31/2000	195	99	101	<250	ND	<250	ND	<250	ND	<500	ND
SB-28B-290	2	4	8/31/2000	192	125	121	<250	ND	<250	ND	<250	ND	<500	ND
SB-28B-291	4	6	8/31/2000	193	128	127	<250	ND	<250	ND	<250	ND	<500	ND
SB-28B-292	6	8	8/31/2000	196	126	121	<250	ND	<250	ND	<250	ND	<500	ND
SB-28B-293	8	10	8/31/2000	197	167	146	<250	ND	<250	ND	<250	ND	<500	ND
SB-28B-294	10	12	8/31/2000	196	191	163	17,000	29	1,800	2.59	<1,000	ND	<2,000	ND
SB-28B-295	12	14	8/31/2000	195	113	104	15,000	37	<1,000	ND	<1,000	ND	<2,000	ND
SB-28B-296	14	16	8/31/2000	192	200	167	36,000	60	<1,700	ND	<1,700	ND	<3,400	ND
SB-28B-297	16	18	8/31/2000	192	298	252	3,900,000	4,473	<100,000	ND	<100,000	ND	<200,000	ND
SB-28B-298	18	20	8/31/2000	193	100	86	240,000	721	<12,000	ND	<12,000	ND	<25,000	ND
SB-28B-299	20	22	8/31/2000	191	261	220	3,400,000	4,370	<100,000	ND	<100,000	ND	<200,000	ND
SB-28B-300	22	24	8/31/2000	195	197	159	130,000	233	<6,200	ND	<6,200	ND	<12,000	ND
SB-28B-301	24	26	8/31/2000	196	305	236	180,000	242	<6,200	ND	<6,200	ND	<12,000	ND
SB-28B-302	26	28	8/31/2000	196	189	149	150,000	290	<6,200	ND	<6,200	ND	<12,000	ND
SB-28B-303	28	30	8/31/2000	196	216	167	230,000	409	<12,000	ND	<12,000	ND	<25,000	ND
SB-28B-304	30	32	8/31/2000	195	197	155	370,000	689	<25,000	ND	<25,000	ND	<50,000	ND
SB-28B-305	32	34	8/31/2000	190	188	155	140,000	247	<5,000	ND	<5,000	ND	<10,000	ND
SB-28B-306	34	36	8/31/2000	194	120	105	1,300,000	3,226	<42,000	ND	<42,000	ND	<84,000	ND
SB-28B-307	36	38	8/31/2000	195	107	92	500,000	1,423	<17,000	ND	<17,000	ND	<33,000	ND
SB-28B-308	36	38	8/31/2000	192	163	129	580,000	1,246	<25,000	ND	<25,000	ND	<50,000	ND
SB-28B-309	38	40	8/31/2000	199	256	196	190,000	302	<6,200	ND	<6,200	ND	<12,000	ND
SB-28B-310	40	42	8/31/2000	91	429	276	210,000	204	<8,300	ND	<8,300	ND	<17,000	ND
SB-28B-311	42	44	8/31/2000	191	208	167	110,000	186	<5,000	ND	<5,000	ND	<10,000	ND
SB-28B-312	44	46	8/31/2000	195	174	142	93,000	183	<6,200	ND	<6,200	ND	<12,000	ND
SB-28B-313	Blank		8/31/2000	NA	NA	NA	440	0.8	<250	ND	<250	ND	<500	ND
LC34B209-2	0	2	12/12/2000	196	117	114	<250	ND	<250	ND	<250	ND	<500	ND
LC34B209-4	2	4	12/12/2000	195	101	93	<250	ND	<250	ND	<250	ND	<500	ND
LC34B209-6	4	6	12/12/2000	200	151	126	550	1	<250	ND	<250	ND	<500	ND
LC34B209-8	6	8	12/12/2000	192	158	129	1,200	3	300	1	<250	ND	<500	ND
LC34B209-10	8	10	12/12/2000	195	211	176	11,000	18	18,000	29	<500	ND	<1,000	ND
LC34B209-12	10	12	12/12/2000	195	183	151	15,000	28	12,000	22	<1,000	ND	<2,000	ND
LC34B209-14	12	14	12/12/2000	205	142	***115***	20,000	50	13,000	32	<1,000	ND	<2,000	ND
LC34B209-16	14	16	12/12/2000	196	166	137	14,000	28	13,000	26	<830	ND	<1,700	ND
LC34B209-18	16	18	12/12/2000	200	134	115	1,300	3	1,400 D	3	<250	ND	<500	ND
LC34B209-20	18	20	12/12/2000	204	136	110	8,800	23	13,000 D	34	<250	ND	<500	ND

Table D-7. CVOC Results of Perimeter Soil Cores (Continued)

Analytical Sample ID	Sample Depth (ft) Top Depth	Sample Depth (ft) Bottom Depth	Sample Date	MeOH (g)	Wet Soil Weight (g)	Dry Soil Weight (g)	TCE Result in MeOH (µg/L)	TCE Result in Dry Soil (mg/kg)	*cis* -1,2-DCE Result in MeOH (µg/L)	*cis* -1,2-DCE Result in Dry Soil (mg/kg)	*trans* -1,2-DCE Result in MeOH (µg/L)	*trans* -1,2-DCE Result in Dry Soil (mg/kg)	Vinyl Chloride Result in MeOH (µg/L)	Vinyl Chloride Result in Dry Soil (mg/kg)
LC34B209-22	20	22	12/12/2000	190	258	202	36,000	53	14,000	21	<2,000	ND	<4,000	ND
LC34B209-24	22	24	12/12/2000	198	269	211	28,000	41	9,900	14	<1,500	ND	<2,900	ND
LC34B209-26	24	26	12/13/2000	197	233	182	3,400	6	3,600	6	<250	ND	<500	ND
LC34B209-28	26	28	12/13/2000	199	137	118	350	1	1,300	3	<250	ND	<500	ND
LC34B209-30	28	30	12/13/2000	199	284	226	2,300	3	12,000	16	<250	ND	710	1.0
LC34B209-32	30	32	12/13/2000	198	241	202	1,000	1	8,200	12	<250	ND	720	1.0
LC34B209-34	32	34	12/13/2000	199	159	121	1,200	3	5,600	13	<250	ND	<500	ND
LC34B209-36	34	36	12/13/2000	199	179	120	<250	ND	8,600	22	<250	ND	1,000	2.6
LC34B209-38	36	38	12/13/2000	198	235	187	2,500	4	<250	ND	<250	ND	<500	ND
LC34B209-38B	36	38	12/13/2000	192	246	192	1,900	3	<250	ND	<250	ND	<500	ND
LC34B209-40	38	40	12/13/2000	190	232	189	<250	ND	<250	ND	<250	ND	<500	ND
LC34B209-43	41	43	12/13/2000	194	244	180	<250	ND	<250	ND	<250	ND	<500	ND
LC34B209-45	43	45	12/13/2000	202	165	120	920	2	<250	ND	<250	ND	<500	ND
LC34B209-85	Lab Blank		12/12/2000	NA	NA	NA	<250	ND	<250	ND	<250	ND	<500	ND
LC34B209-86	Lab Blank		12/13/2000	NA	NA	NA	870		<250	ND	<250	ND	<500	ND
LC34B209-EB	EQ		12/12/2000	NA	NA	NA	<1	ND	<1	ND	<1	ND	<2	ND
LC34B309-2	0	2	12/13/2000	197	127	123	<250	ND	<250	ND	<250	ND	<500	ND
LC34B309-4	2	4	12/13/2000	200	134	129	<250	ND	<250	ND	<250	ND	<500	ND
LC34B309-6	4	6	12/13/2000	191	157	147	<250	ND	<250	ND	<250	ND	<500	ND
LC34B309-8	6	8	12/13/2000	188	142	119	<250	ND	2,900	6	<250	ND	<500	ND
LC34B309-10	8	10	12/13/2000	201	165	133	<500	ND	8,700	19	<500	ND	<1,000	ND
LC34B309-12	10	12	12/13/2000	196	139	113	<830	ND	12,000	29	<830	ND	<1,700	ND
LC34B309-14	12	14	12/13/2000	192	137	111	1,100	3	13,000	32	<830	ND	<1,700	ND
LC34B309-16	14	16	12/13/2000	199	161	133	<500	ND	9,800	21	<500	ND	<1,000	ND
LC34B309-18	16	18	12/13/2000	196	138	117	<830	ND	15,000	35	<830	ND	<1,700	ND
LC34B309-20	18	20	12/13/2000	205	125	100	<830	ND	12,000	34	<830	ND	<1,700	ND
LC34B309-22	20	22	12/13/2000	194	183	153	<250	ND	2,700	5	<250	ND	<500	ND
LC34B309-24	22	24	12/13/2000	206	204	168	<250	ND	3,700	7	<250	ND	<500	ND
LC34B309-26	24	26	12/13/2000	203	295	230	<500	ND	7,900	11	<500	ND	<1,000	ND
LC34B309-28	26	28	12/13/2000	198	220	176	<500	ND	8,500	14	<500	ND	<1,000	ND
LC34B309-30	28	30	12/13/2000	183	246	193	<250	ND	6,300	9	<250	ND	<500	ND
LC34B309-32	30	32	12/13/2000	180	160	137	<250	ND	1,100	2	<250	ND	<500	ND
LC34B309-34	32	34	12/13/2000	215	214	163	<250	ND	350	1	<250	ND	<500	ND
LC34B309-36	34	36	12/13/2000	201	180	139	<250	ND	<250	ND	<250	ND	<500	ND
LC34B309-36-DUP	34	36	12/13/2000	191	119	96	<250	ND	<250	ND	<250	ND	<500	ND
LC34B309-38	36	38	12/13/2000	191	155	108	<250	ND	<250	ND	<250	ND	<500	ND

Table D-7. CVOC Results of Perimeter Soil Cores (Continued)

Analytical Sample ID	Sample Depth (ft) Top Depth	Sample Depth (ft) Bottom Depth	Sample Date	MeOH (g)	Wet Soil Weight (g)	Dry Soil Weight (g)	TCE Result in MeOH (µg/L)	TCE Result in Dry Soil (mg/kg)	*cis* -1,2-DCE Result in MeOH (µg/L)	*cis* -1,2-DCE Result in Dry Soil (mg/kg)	*trans* -1,2-DCE Result in MeOH (µg/L)	*trans* -1,2-DCE Result in Dry Soil (mg/kg)	Vinyl Chloride Result in MeOH (µg/L)	Vinyl Chloride Result in Dry Soil (mg/kg)
LC34B309-40	38	40	12/13/2000	199	198	147	<250	ND	<250	ND	<250	ND	<500	ND
LC34B309-42	40	42	12/13/2000	190	243	189	<250	ND	<250	ND	<250	ND	<500	ND
LC34B309-44	42	44	12/13/2000	193	232	181	<250	ND	<250	ND	<250	ND	<500	ND
LC34B309-89	Lab Blank		12/14/2000	NA	NA	NA	<250	ND	<250	ND	<250	ND	<500	ND
LC34B309-90	Lab Blank		12/14/2000	NA	NA	NA	<250	ND	<250	ND	<250	ND	<500	ND
LC34B309-EB	EQ		12/14/2000	NA	NA	NA	<1	ND	<1	ND	<1	ND	<2	ND

NA: Not available.

ND: Not detected.

NR: No recovery.

EQ: Equipment rinsate blank.

1) Sample LC34B217-20 was originally analyzed within holding time criteria but the results were not withing 20% of the calibration range. *cis* -1,2-DCE was reanalyzed and the result was from the new analysis.

J: Result was estimated but below the reporting limit.

D: Result was quanitified after dilution.

<: Result was not detected at or above the stated reporting limit.

Appendix E. Microbiological Assessment

E.1 Microbiological Evaluation Work Plan
E.2 Microbiological Evaluation Sampling Procedure
E.3 Microbiological Evaluation Results

E.1 Microbiological Evaluation Work Plan

Biological Sampling & Analysis Work Plan

The Effect of Source Remediation Methods on the Presence and Activity of Indigenous Subsurface Bacteria at Launch Complex 34, Cape Canaveral Air Station, Florida

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June 28, 1999

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1.0 Purpose and Objectives

Overall purpose is to evaluate effects of three DNAPL source remediation treatments on the indigenous bacterial population. The three treatments in three different plots at LC34 are resistive heating, in-situ chemical oxidation (ISCO), and steam injection (SI). The objectives of the biological sampling and analysis are:

1. To determine the immediate effect that each remediation technology has on the microbial community structure and specifically on TCE biodegraders.
2. To establish how quickly the microbial communities at the site recover and if any of the effects could be long-term.
3. To determine at what point that biodegradation could be used to complete remediation of the plume.
4. To establish if any of the technologies could cause and short-term effect on significant biogeochemical processes and the distribution and abundance of potential pathogens in the environment.

2.0 Background

Launch Pad 34 at Cape Canaveral Air Station has dense non-aqueous phase (DNAPL) concentrations of TCE over a wide aerial extent in relatively sandy soils with a shallow groundwater table (Resource Conservation and Recovery Act Facility Investigation Work Plan for Launch Complex 34, Cape Canaveral Air Station, Brevard County, Florida, 1996, Kennedy Space Center Report KSC-JJ-4277.). These conditions have made it an ideal site for side-by-side comparison of various DNAPL remediation technologies currently being conducted by the DNAPL Remediation Multi-agency Consortium. Initial sampling at the site revealed that there are also high concentrations of vinyl chloride and dichloroethylene indicating natural attenuation via biodegradation of the TCE plume has been occurring. Since these compounds are daughter products of the anaerobic reductive dechlorination of TCE by microbes (see discussion below) it is probable that these conditions could be greatly effected by the source remediation processes being tested. Since most of these processes will introduce air into the subsurface and are potentially toxic to many microbes they could have a variety of effects on the biological activity and biodegradation rates of contaminants in the source area and the surrounding plume. The effects could range from long-term disruption of the microbial community structure and biological activity at the site, to a significant stimulation of biodegradation of TCE. Whatever the effect, it needs to be monitored carefully since the long-term remediation of this or any similar site will be significantly effected not only by the technologies ability to remove the DNAPL source but also by the rate of biodegradation both natural and stimulated that can occur in the aquifer after the source is removed. The rate and extent of biodegradation will effect how low the technology must lower the source concentration before natural or stimulated bioremediation can complete the remediation to the ppb levels normally used as cleanup goals. It could also have a major effect on the life-cycle costs of remediation of these sites.

Secondarily, unlikely as this is, it is also important to verify that these source remediation technologies do not cause any gross changes biogeochemistry, and distribution and abundance of potential pathogens. The pathogens are a possibility at this site since there was long-term sewage discharge at the edge of test plots. Studies at other sites have suggested that stimulation of pathogens especially by thermal increases could be a possibility and thus should be considered in the overall risk scenario for these remediation technologies.

Reductive Dechlorination of Chlorinated Solvents

Microbial degradation of chlorinated solvents has been shown to occur under both anaerobic and aerobic conditions. Highly chlorinated solvents are in a relatively oxidized state and are hence more readily degraded under anaerobic conditions than under aerobic conditions (Vogel et al., 1987). In subsurface environments where oxygen is not always available, reductive dechlorination is one of most important naturally occurring biotransformation reactions for chlorinated solvents. Microbial reductive dechlorination is a redox reaction that requires the presence of a suitable electron donor to provide electrons for dechlorination of chlorinated organic (Freedman and Gossett, 1989).

Highly chlorinated solvents, such as tetrachloroethylene (PCE) and trichloroethylene (TCE), are commonly detected in the subsurface. Under anaerobic conditions, PCE is reductively dechlorinated to TCE, which in turn may be dechlorinated to 1,2-dichloroethylene (cis-1,2-DCE, or trans-1,2-DCE), followed sequentially by vinyl chloride (VC) and finally ethylene (Freedman and Gossett, 1989) or ethane (Debruin et al. 1992). Further reductive dechlorination of DCE and VC to CO_2 and complete dechlorination of PCE to CO_2 are possible under anaerobic conditions (Bradley and Chapelle, 1996; Bradley and Chapelle, 1997; Bradley et al., 1998; Cabirol et al., 1998). However, complete dechlorination of PCE is often not achieved due to slow dechlorination process of its reduced intermediates, cis-1,2-DCE and VC, resulting the accumulation of these unfavorable intermediates in anaerobic environments. The accumulation of cis-1,2-DCE and VC is of great concern because they are known carcinogens. Such incomplete dechlorination is commonly observed in fields where reductive dechlorination of PCE and TCE is taking place (McCarty, 1996).

Reductive dechlorination reactions can be carried out by anaerobic microorganisms via either energy yielding or cometabolic processes. The energy-yielding process involves the use of chlorinated solvents as terminal electron acceptors (sometimes referred to as dehalorespiration). Anaerobic cultures that are capable of using PCE or TCE as terminal electron acceptors include the obligate anaerobes *Dehalospirillum multivorans* (Scholz-Muramatsu et al., 1995), *Dehalococcoides ethenogenes* (Maymo-Gattel et al., 1997), *Desulfitobacterium sp*. strain PCE1 (Gerritse et al ., 1996), *Desulfitobacterium sp*. strain PCE-S (Miller et al., 1997; Miller et al., 1998), *Desulfomonile tiedjei* (Fathepure et al., 1987; DeWeerd et al., 1990), *Dehalobacter restrictus* (Holliger and Schumacher, 1994; Holliger et al., 1998), strain TT4B (Krumholz et al., 1996), and the facultative organism strain MS-1 (Sharma and McCarty, 1996). With the exception of *Dehalococcoides ethenogenes* which dechlorinates PCE to ethene, and *Desulfitobacterium sp*. strain PCE1 which dechlorinates PCE to TCE, the end product of PCE dechlorination for all described pure cultures is cis-1,2, DCE. The end products of reductive dechlorination reactions vary depending on the physiological groups of bacteria involved. In acetogens, methanogens, and some other anaerobic bacteria, reductive dechlorination is believed to be mediated by metallocoenzymes like the cobalt containing vitamin B12 and related corrinoids, and by the nickel containing cofactor F430. These metallocoenzymes are present as components of enzymes that catalyze normal physiological pathways in several anaerobic bacteria, and fortuitously are able to reductively dechlorinate several chlorinated compounds. Acetogenic and methanogenic bacteria contain high levels of these metallocoenzymes, the concentrations of which can be strongly dependent on growth substrates (Deikert et al., 1981; Krzycki and Zeikus, 1980).

The presence of a suitable electron donor, such as hydrogen or reduced organic compounds including hydrocarbons, natural organic matter, glucose, sucrose, propionate, benzoate, lactate, butyrate, ethanol, methanol, and acetate have been reported serve as electron donors for reductive dechlorination (Bouwer and McCarty, 1983; Carr and Hughes, 1998; DiStefano et al., 1992; Fennell and Gossett, 1997; Freedman and Gossett, 1989; Gibson and Sewell, 1992; Holliger et al., 1993; Lee et al., 1997; Tandoi et al., 1994). However, since the microbial populations differ from site to site and their responses to substrates vary greatly, the addition of certain types of electron donors may or may not effectively enhance reductive dechlorination processes. Both laboratory studies and field observations suggest that the addition of electron donors for the enhancement of dechlorination can induce complex scenarios that are a function of the subsurface conditions (Carr and Hughes, 1998; Fennell and Gossett, 1997) and the indigenous microbial population (Gibson and Sewell, 1992). Although it is known that hydrogen serves as the specific electron donor for reductive dechlorination (Holliger et al., 1993; Holliger and Schumacher, 1994; Maymo-Gatell et al., 1995), different concentrations of hydrogen stimulate different groups of anaerobic microbial populations which may or may not be responsible for dechlorination, and may out compete the halorespirers, making the direct addition of hydrogen problematic. In fact, recent research has indicated that dechlorinating bacteria possess lower half-velocity coefficients for H_2 utilization than methanogens, suggesting that dechlorinating bacteria should out compete methanogens at low H_2 concentrations (Ballapragada et al., 1997; Smatlak et al., 1996). In short-term microcosm studies, the addition of slow-release H_2 donors butyrate and propionate was found to support complete dechlorination as well as to enrich PCE-degrading bacteria (Fennell and Gossett, 1997). In contrast, the addition of fast-release H_2 donors ethanol, lactate, and acetate did not result in complete dechlorination. However, both ethanol and lactate did support sustained dechlorination during long-term tests. In some cases, the addition of acetate and methanol to laboratory microcosms with PCE contaminated soil did not enhance dechlorination (Gibson and Sewell, 1992). Complex substrates such as molasses and yeast extract have been shown to result in higher dechlorination levels than simple substrates (Lee et al, 1997; Odem et al., 1995; Rasmussen et al., 1994). Apparently, the fate of amended electron donors and the dynamic changes of microbial populations responsible for reductive dechlorination within soils are still not well understood.

Aerobic Degradation of Chlorinated Solvents

Under aerobic conditions, microbial degradation of chlorinated solvents to non-toxic products can occur by metabolic or cometabolic transformation reactions. DCE and VC have both been shown to be aerobically degraded in energy-yielding reactions. Recently, several aerobic strains that are capable of using VC as primary carbon and energy source have been isolated. These aerobic microorganisms include Mycobacterium sp.(Hartmans and De Bont, 1992), *Rhodococcus sp*.(Malachowsky et al., 1994), *Actinomycetales sp*.(Phelps et al., 1991), and *Nitrosomonas sp*. (Vanelli et al., 1990). It is suggested that these VC-utilizers may not play significant roles in contaminated site remediation due to their long doubling time.

While there have been no reports of aerobic cultures that can oxidize TCE for growth, methanotrophs are one group of bacteria that can cometabolically oxidize chlorinated solvents such as TCE, DCE, and VC to carbon dioxide and chloride ions. These organisms utilize methane as their primary carbon and energy source and produce methane monooxygenase, a key enzyme that is involved in the oxidation of methane. The same enzyme can also cometabolically oxidize chlorinated solvents. Typically, the chloroethenes are initially oxidized to chloroethene epoxides, which in turn decompose into various readily degradable chlorinated and non-chlorinated acids, alcohols or aldehydes, and carbon monoxide (Oldenhuis et al., 1989; Strandberg et al., 1989; Tsien et al., 1989; Little et al., 1988; Alvarez-Cohen and McCarty, 1991; Neuman and Wackett, 1991; Fox et al., 1990; Chang and Alvarez-Cohen, 1996). Anaerobic reductive dechlorination has also been shown to occur under bulk aerobic conditions dominated by aerobic co-metabolic biodegradation both in the field and in soil columns (Enzien et al., 1994)

3.0 Scope

Launch Complex 34 at Cape Canaveral Air Station in Florida is the test site for the remediation technology evaluation study. Separate testing plots will be established for each of the following three remediation technologies:

1. Resistive Heating by Six-Phase Heating™
2. In-Situ Oxidation (ISCO)
3. Steam Injection (SI)

Soil core samples and groundwater samples at different depths (subsurface layers) from each plot will be collected and analyzed by microbiology and molecular biology methods before and after remediation treatment in order to determine the effect of the treatments on the indigenous microbial population.

4.0 Analytical Approach and Justification

Several different microbiology and molecular analysis will be conducted to evaluate the effect of the remediation technologies used on the microbial community. The following analyses will be conducted:

- Total Heterotrophic Counts
- Viability Analysis
- Coliform and *Legionella* Analysis
- PLFA Analysis
- DNA Analysis

At this time, there are no fool-proof, broadly applicable methods for functionally characterizing microbial communities. The combination of assays we propose will provide a broadly based characterization of the microbial community by utilizing a crude phylogenetic characterization (PLFA), DNA-based characterization of community components, and microscopic counts of viable (aerobic and anaerobic) bacteria and total bacteria. We anticipate that this array of methods that we will help avoid some of the common pitfalls of environmental microbiology studies generally (Madsen, 1998).

Heterotrophic Counts Analysis. The concentration of culturable bacteria in a subset of samples collected from each plot at each event will be done using very low carbon availability media such as 0.1% PTYG or dilute soil-extract media amended with citrate and formate. This has been found to give the best overall recovery of subsurface bacteria (Balkwill, 1989). These viable counts can be done using either MPN or plating techniques for both soil and water. These analyses can be done both under aerobic or anaerobic conditions (Gas-Pak) to provide an estimate of changes in culturable bacteria. This analysis should be used more as a check to verify changes in viable biomass changes, community shifts from anaerobic to aerobic, and direct effects that these remediation technologies may have on the culturability of indigenous bacteria. These data will help determine if these more conventional microbiological analyses can be used to monitor the effects of the remediation technologies in future applications.

Viability Analysis. In addition, the proportion of live and dead bacteria in these samples will be determined using a fluorescence-based assay (Molecular Probes, LIVE/DEAD® *Bac*Light™ Viability Kit). Since these technologies, especially the thermal ones, may kill bacteria it is important to determine the proportion of the total bacteria observed are dead and how this proportion is changed by the remediation technology being tested. Note: dead bacteria will still be visible by direct count, and thus you could have a total count of 10 billion cells/ml and yet no biological activity because they are all dead.

Coliform and Legionella Analysis. Water samples, collected near the sewage outfall and a few, will be analyzed for total coliforms. One-two liter samples will be collected specifically for this analysis. Samples will be shipped to BMI on ice for inventory and sample management. Coliforms are the primary indicator of human fecal contamination and thus the potential for presence of human pathogens. Since the site has a long-term sewage outfall at the edge of the test beds and since this environment is generally warm and contains high levels of nutrients it is possible that human pathogens may have survived and may be stimulated by the remediation technologies being tested. The coliform analyses of groundwater samples will verify it pathogens could be present. If initial screening indicates no coliforms than this sampling can be dropped; however, if coliforms are present it may be necessary to expand this analysis to determine the extent of their influence and the effect of that the remediation technology is having on them. *Legionella pneumophila* is a frank human pathogen that causes legionnaires disease (an often fatal pneumonia) that is found widely in the environment. It can become a problem in areas that are thermally altered, eg. nuclear reactor cooling reservoirs, pools, cooling towers, air conditioners, etc. A preliminary study done at SRS during a demonstration of radio frequency heating suggested that thermal alteration of the vadose zone could increase the density of legionella in the sediment. Since there is a sewage outfall nearby, since two of the remediation technologies are thermal, and since the remediation technologies are extracting VOC from the subsurface it would be prudent to test the subsurface for changes in *Legionella pneumophila.* This can be done by using commercially available DNA probes for *Legionella pneumophila* and testing both the soil and groundwater samples being analyzed for nucleic acid probes. This adds very little expense and can be done as part of that analyses, see below.

PLFA/FAME Analysis. Phospholipid ester-linked fatty acids (PLFA) and Fatty Acid Methyl Ester (FAME) analysis can measure viable biomass, characterize the types of organisms, and determine the physiological status of the microbial community. Aliquots of each sample (100 g soil and 1-2 L water) will be shipped to frozen to EPA for analysis. The PLFA method is based on extraction and GC/MS analysis of "signature" lipid biomarkers from the cell membranes and walls of microorganisms. A profile of the fatty acids and other lipids is used to determine the characteristics of the microbial community. Water will be filtered with organic free filters in the field and shipped to EPA frozen. The filter can be used to extract both nucleic acids for probe analyses and lipids for PLFA/FAME analyses. Depending on the biomass in the water 1-10 liters will need to be filtered for each sample.

DNA Analysis. DNA probe analysis allow examination of sediment and water samples directly for community structure, and functional components by determining the frequency and abundance to certain enzyme systems critical to biogeochemistry and biodegradation potential of that environment. Sediment samples will be collected aseptically in sleeves and shipped frozen to EPA. These sediment samples will than be extracted and the DNA analyzed for presence of certain probes for specific genetically elements. Water samples will be filtered in the field to remove the microbiota and shipped frozen to EPA for subsequent extraction and probing. The Universal probe 1390 and Bacterial domain probe 338 will help quantify the DNA extracted from the samples. This information will be useful to determine the portion of DNA that is of bacterial origin and the amount of DNA to be used in the analysis of specific bacterial groups. Transformation of chlorinated ethenes by aerobic methylotrophic bacteria that use the methane monooxygenase enzyme has been reported (Little et al., 1988). Methanotrophs can be separated into coherent phylogenetic clusters that share common physiological characteristics (Murrell, 1998) making the use of 16S rRNA probe technology useful for studying their ecology. Therefore, this study will use 16S rRNA-targeted probes, Ser-987 and RuMP-998, to detect Type II and Type I methanotrophs, respectively. Together, these probes will be used to monitor shifts in methanotroph population numbers that may result from the application of the chemical oxidation technology. Reductive dechlorination of chlorinated ethenes has also been reported under anaerobic conditions. Therefore, we propose the use of archaea domain (Arch-915) and sulfate-reducing specific probes (Dsv-689) to assess microbial communities involved in reductive dechlorination. The characterization of enzymes capable of reductive dehalogenation such as the dehalogenase of *Dehalospirillum multivorans* (Neumann et al., 1995) or the PCE reductive-dehalogenase of *Dehalococcoides ethenogenes* (Maymo-Gatell et al., 1999) provides promise for future gene probe design. As these gene probes become available, they will be utilized for this study. The detection of *Legionella* has been improved using a combined approach of PCR primers and oligonucleotide probe that target the 16S rRNA gene has been reported (Miyamoto et al., 1997; Maiwald et al., 1998). These PCR primers and probes will be used in this study to assess the effects of steam injection on members of this species. The following table provides the list of 16S rRNA-targeted probes that we propose to use in this study.

Target	Probe/Primer Name	Target site[a]	Probe/Primer Sequence 5'--3'	Reference
Universal	S-*-Univ-1390-a-A-18	1407-1390	GACGGGCGGTGTGTACAA	Zheng et al., 1996
Bacteria domain	S-D-Bact-0338-a-A-18	338-355	GCTGCCTCCCGTAGGAGT	Amann et al., 1990a
Archeae domain	S-D-Arch-0915-a-A-20	915-934	GTGCTCCCCCGCCAATTCCT	Amann et al., 1990b
Desulfovibrio spp.	S-F-Dsv-0687-a-A-16	687-702	TACGGATTTCACTCCT	Devereux et al., 1992
Type II Methanotrophs	S-*-M.Ser-0987-a-A-22	987-1008	CCATACCGGACATGTCAAAAGC	Brusseau et al., 1994
Type I Methanotrophs	S-*-M.RuMP-0998-a-A-20	988-1007	GATTCTCTGGATGTCAAGGG	Brusseau et al., 1994
Legionella spp.	*Legionella* CP2 Probe	649-630	CAACCAGTATTATCTGACCG	Jonas et al., 1995
Legionella spp.	Primer LEG 225	225-244	AAGATTAGCCTGCGTCCGAT	Miyamoto et al., 1997
Legionella spp.	Primer LEG 858	880-859	GTCAACTTATCGCGTTTGCT	Miyamoto et al., 1997

[a] *Escherichia coli* numbering

In addition to hybridization of 16S rRNA gene probes hybridization to DNA extracted by a direct method, we will also utilize the denaturing gradient gel electrophoresis (DGGE) described in Muyzer et al., 1996. The DGGE method has been used to detect overall shifts in reductively dechlorinating microbial communities (Flynn et al., 2000). If significant shifts are observed, the DNA bands will be sequenced to analyzed the genetic diversity of the communities.

5.0 Sample Collection, Transport, and Storage

In each test plot, soil samples of approximately 500-g each (250 g frozen for DNA/PLFA analysis; 250 g ambient for microbial counts) will be collected using sterile brass core cylinders. Each clinder holds approximately 250 g of soil. Sterilization of soil sample containers will involve detergent wash, water wash, heating (100 C), and alcohol wash. Polyethylene caps will not be heated, just sterilized with alcohol. Sterilization of drilling equipment will involve steam cleaning between samples.

Five borings per test plot will be used to collect aquifer samples at four depths (capillary fringe, upper sand unit [USU], middle fine grained unit [MFGU], and lower sand unit [LSU]). In addition, groundwater samples will be collected from two well clusters at three depths per plot (USU, MFGU, and LSU). Control samples from an unaffected control area will be collected under the same sampling regime. Soil controls will be collected from five locations, four depths each for consistency with treatment plot samples. Similarly, groundwater controls will be collected from 2 well clusters, at 3 depths each, if available.

Samples will be collected at four events for each technology/plot within two phases:

<u>Phase 1 (June ’99 – Sep ’00)</u>
T<0 month (pretreatment for SPH and OX)
T= 0 months (post treatment; SPH and OX)
T<0 month (pretreatment; SI)

<u>Phase 2 (Sep ‘00 – Sep ’01)</u>
T= 6 months (post-treatment; SPH, OX, and SI)
T= 12 months (post-treatment; SPH)

Tables 1 and 2 show the number of soil and groundwater samples involved. Table 3 shows the sampling requirements for this evaluation. Immediately after soil samples are retrieved from the borings, the collection cylinders will be tightly capped and sealed to minimize changes in environmental conditions, primarily oxygen content, of the samples. This will subsequently minimize adverse effects to the microbial population during sample transport. Samples for DNA/PLFA analysis will be frozen under nitrogen and shipped via express mail. Samples for microbial counts will be shipped at ambient temperature to an off-site lab designated by the IDC. Microbiology analysis will be conducted within 24 hours of sample collection. Approximately 5-10 g aliquots from each sample will be stored at $<-60^{o}C$ for molecular analysis. The study will be conducted over the course of 1.5 years in which two of the three remediation treatment methods will be demonstrated simultaneously.

Soil and groundwater sample from the region near the historical sewage outfall will be collected and analyzed as shown in Table 3.

As shown in Table 3, groundwater samples will include unfiltered groundwater (for microbial counts) and filters (for DNA/PLFA analysis) from filtration of 1 to 4 L of groundwater. Anodisc™ filters will be used and filtration apparatus will be autoclaved for 20 minutes between samples.

Table 1. Overall Soil Sample Collection Requirement

Plot (Remediation Treatment)	"Event" or Time Points (<0, 0, 6, 12 mo.)	Depths (5, 15, 30, 45 ft.)	Sampling Locations per Plot	Total # Soil Samples Collected Per Plot	Total # of Soil Samples Collected
Resistive Heating[a]	3	4	5	80	344
ISCO[b]	3	4	5	80	
Steam Injection	4	4	5	80	
Control	4	4	5	80	
Baseline (T<0 for SPH and OX)	1	4	3[c]	12	
Sewage Outfall	1	4	3	12	

a Fresh samples to be collected as baseline or T<0; shown in last row
b Fresh samples to be collected as baseline or T<0; shown in last row
c From undisturbed DNAPL area inside ESB

Table 2. Overall Groundwater Sample Collection Requirement

Plot (Remediation Treatment)	"Event" or Time Points (<0, 0, 6, 12 mo.	Depths (5, 30, 45 ft.)	Sampling Well Clusters per Plot	Total # of groundwater Samples Collected Per Plot	Total # of Groundwater Samples Collected
Resistive Heating[a]	3	3	2	18	87
ISCO[b]	3	3	2	18	
Steam Injection	4	3	2	24	
None (control)	3	3	2	18	
Sewage Outfall	3	3	1	9	

Table 3. Summary of Soil and Groundwater Sampling Requirements

		Native Microbes Analysis				Pathogens Analysis		
Medium	**Plot**	**PLFA/DNA**[1]	***Microbial***[2]	**Locations**	**Sample**	***Coliform/ Legionella***	***Locations***	**Sample**
Soil[3]	Resisitive Heating	Freeze, store	***Ambient, 24 hrs***	5 cores per plot, 4 depths	2x250 g	*NA*		
		Freeze, store	***Ambient, 24 hrs***		2x250 g	*NA*		
	Steam Injection	Freeze, store	***Ambient, 24 hrs***		2x250 g	*NA*		
ISCO		Freeze, store	***Ambient, 24 hrs***		2x250 g	*NA*		
Control	*Baseline*	Freeze, store	*Ambient, 24 hrs*	*Inside ESB; 3 cores 4 depths*	*2x250 g*	*NA*		
	Sewage Outfall	*NA*				*3 cores near sewage outfall at 4 depths each*		*2x250 g*
Ground -water[4]	*Resistive Heating*	*Filters from 1-4 L filtering, Freeze*	*500 mL unfiltered in Whirl-Pak, ambient*	*PA-13S/D and PA-14S/D*		*NA*		
	ISCO	*Filters from 1-4 L filtering, Freeze*	*500 mL unfiltered in Whirl-Pak, ambient*	*BAT-2S/I/D and BAT-5S/I/D*		*NA*		
	Steam Injection	*Filters from 1-4 L filtering, Freeze*	*500 mL unfiltered in Whirl-Pak, ambient*	*PA-16S/I/D and PA-17S/I/D*		*NA*		
	Control	*Filters from 1-4 L filtering, Freeze*	*500 mL unfiltered in Whirl-Pak, ambient*	*IW-1I/D and PA-1S/I/D*		*NA*		
	Sewage Outfall	*NA*	*NA*	*NA*		*1 L unfiltered in Whirl-Pak*	*IW-17I/D and PA-15*	

Shaded and italicized text indicates new sampling and analysis scope that needs to be funded. Bold and italics indicates that the sampling is funded but the analysis is not funded.

NA: Not applicable

[1] DNA/PLFA: DNA/PLFA Analysis. Sleeves are frozen in Nitrogen before shipping.

[2] Microbial: Total Heterotrophic Counts/Viability Analysis. Sleeves are shipped at ambient temperature for analysis within 24 hrs.

[3] Soil samples will be collected in 6"-long 1.5"-dia brass sleeves, then capped. Brass sleeves need to be autoclaved and wiped with ethanol just before use. Caps need to be wiped with ethanol prior to use.

[4] 3 to 4 liters of groundwater will be filtered and filters will be shipped for analysis. Filters for DNA analysis will be frozen under N_2 before shipping. Groundwater for microbial analysis will be shipped at ambient temperature for analysis within 24 hrs. Between samples, filtration apparatus needs to be autoclaved for 20 minutes.

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E.2 Microbiological Evaluation Sampling Procedures

Work Plan for Biological Soil and Groundwater Sampling and Procedure

Battelle
January 4, 2001

Soil Sampling

Soil samples are collected at four discrete depths in the subsurface with a 2-inch diameter sample barrel containing sample sleeves. Once the sample is retrieved, the sleeves are removed from the sample barrel, capped at both ends, and preserved accordingly. The sleeves are then transported to off-site analytical laboratories for analyses. Field personnel should change their gloves after each sample to prevent cross-contamination. The details of the sampling are provided below:

Sampler*s*: The Mostap™ is 20-inch long with a 1.5-inch diameter and the Macro-core™ sampler is about 33-inch long with a 2-inch diameter. Sleeves (brass or stainless steel) are placed in a sample sampler (Macro-core™ or Mostap™). Brass sleeves with 1.5-inch diameter and 6-inch long are used for a Cone-Penetrometer (CPT) rig from U.S. EPA. Stainless steel sleeves with 2-inch diameter and 6-inch long are used with a rig from a contracted drilling company rig.

For Mostap™, three of these brass sleeves and one spacer will be placed in the sampler. For the Macro- Core™ sampler, five 6-inch long stainless sleeves and one spacer are required. All sleeves and spacers need to be sterilized and the procedure is as follows.

Procedures: sampling preparation procedures are as follows:

1. Preparation for sterilization:

    - Dip sleeves in an isopropyl alcohol bath to clean surface inside and outside
    - Air-dry the sleeves at ambient temperature until they are dried
    - Wrap up the sleeves with aluminum foil
    - Place the aluminum foil-wrapped sleeves in an autoclavable bag and keep the bag in a heat-resistant plastic container
    - Place the container in an autoclave for 30 minutes at about 140 °C
    - Once the autoclaving is completed, let the sleeves sit until the materials are cool, and then pack and ship to the field site.

2. In the field, drive the sample barrel down to four different depths: approximately 8 (capillary fringe), 15 (USU below water table), 23 (MFGU), and 45 (LSU) ft below ground surface (bgs). Once the sample barrel is withdrawn, the sleeves are extruded from the sample barrel. Each sleeve immediately capped with plastic end caps that have been previously wiped with isopropyl alcohol. After capping, clear labeling of the sleeve is required including sample site, sample ID, actual depth of the sample, collection date and time, percentage of recovery in each sleeve, and markings for top and bottom of the sample sleeves.

Sample Preservation: one of the sleeves is kept at ambient temperature. At least, two of the sleeves need to be frozen in liquid nitrogen immediately then stored in a freezer at temperature below freezing point.

Off-site Laboratories: The sample sleeve at ambient temperature is to be shipped off to Florida State University for analyses of ***live/dead stain test*** and ***aerobic and anaerobic heterotrophic counting***. The frozen samples are shipped off to EPA Ada Laboratory, an off-site laboratory for ***DNA*** and ***Phospholipids Fatty Acid Analyses (PLFA)***.

3. Decontamination Procedure: after the samples are extruded, the sample barrel used to collect the soil samples needs to be disassembled and cleaned in Alconox® detergent mixed water. The sample barrel is then rinsed with tap water, followed by de-ionized (DI) water. The sample barrel is air-dried and rinsed with isopropyl alcohol before the next sampling.

Groundwater Sampling

Groundwater sampling involves collection of groundwater from performance monitoring wells using a peristaltic pump and Teflon® tubing. During the groundwater sampling, unfiltered water samples will be collected. Large volume of groundwater will be filtered through in-line filtration unit and the filter will be retrieved and this filter will be preserved necessarily.

1. Preparation for Sterlization
   - Dip in-line filter holders in an alcohol bath and air-dry
   - Wrap each filter unit up in aluminum foil
   - Place them in an autoclavable bag and keep the bag in a heat resistant container
   - Autoclave the container with filters for 30 minutes at 140°C

- Once the autoclaving is completed, let the sleeves sit until the materials are cool, and then pack and ship to the field site.

2. Materials and Equipments: Non-carbon Anodisc® 0.2 µm pore size supported filters, filtration equipment, a low-flow pump, Teflon tubing and Viton® tubing and a vacuum (or pressure) pump.

The dimensions of the Anodisc® filters are 0.2 micron pore size and 47-mm diameter. The filters are pre-sterilized by the manufacturer. Each filter is carefully placed inside a filter holder case. A forcep is used to place a filter in either an in-line polycarbon filter holder or in an off-line filter holder. The filter is very brittle and should be handled delicately.

3. Filter samples by using an in-line filter holder: An Anodisc® filter is wetted with D.I. water and placed on the influent end of the filter holder. A rubber o-ring is gently placed on the filter holder. The filter holder is connected to the effluent end of the peristaltic pump with Teflon® tubing and approximately one liter of groundwater is filtered through it. The filter is retrieved from the filter holder carefully with forceps and placed in a Whirl-Pak®. The filter, along with the bag, is deep frozen under liquid nitrogen and stored in a freezer until shipping.

4. Filter Samples by using an filtration unit: To use this filtration device, a vacuum or pressure pump is required to pull or push the water through. Influent water from a low-flow peristaltic pump goes into a funnel-shaped water container. The filter will be retrieved after water

filtration and the filtrated water can be disposed. The filter is frozen immediately in liquid nitrogen and stored then kept in a freezer.

5. Unfiltered Groundwater Samples: unfiltered groundwater samples are collected into each 500-mLWhirl-Pak® bag. This water sample is kept at ambient temperature.

6. Labeling includes sample ID, same date and time, and site ID on the Whirl-Pak® after the sample is placed with a permanent marker.

7. Sterilization of the filter holders may be done as follows:

- Clean forceps and filter holder in warm detergent mixed water, then rinse with isopropyl alcohol and air-dry at room temperature.
- The cleaned forceps and filter holders are wrapped in aluminum foil and taped with a piece of autoclave tape that indicates when the autoclaving is completed.
- These items are then placed in an autoclavable bag and the bag is placed in an autoclave for about 30 minutes at 140 °C. After taking them out of the autoclave, the items sit until cool.

8. Off-site laboratories: The unfiltered water samples are shipped off to Florida State University for ***aerobic and anaerobic heterotrophic count tests and viability analysis*** at ambient temperature within 24 hours**.** The filter samples are shipped off in dry-ice condition to EPA Ada Lab for ***DNA, PLFA, and Legionella analyses***.

Sample Locations

Soil Sampling

Five biological sampling locations will be located in each of three plots in January 2001. One duplicate samples will be collected from one of the five boring locations in each plot (Figure 1). At each location, soil samples will be collected at four depths (Capillary fringe, USU, MFGU and LSU). Soil sampling procedures are described in previous sections. Summary of the biological soil sampling is shown in Table 1.

Table 1. Biological Soil Sampling in January-February 2001

Plot	Event	Number of Coring	Total Number of Samples
Steam Injection	Pre-Demo (T<0)	5	20 + 1 (Dup)
ISCO	6 Months After (T=6)	5	20 + 1 (Dup)
Control	-	5	20
SPH*	Post-Demo (T=0)	5	20 + 1 (Dup)

* In February along with chemical coring in ISCO plot.

Groundwater Sampling

Biological groundwater samples will be collected from wells within the Steam Injection plot, the ISCO plot, and the resistive heating plot in January 2001 in conjunction with the biological soil sampling. Groundwater sampling will be completed as described previously. One QA groundwater sample will be completed at a random well location. Table 2 summarizes the performance monitoring wells (Figure 1) to be sampled.

Table 2. Biological Groundwater Sampling in January-February 2001

Plot	Event	Well ID	Total Number of Samples
Steam Injection	Pre-Demo (T<0)	PA-16S/I/D PA-17S/I/D	6
ISCO	6 Months After (T=6)	BAT-2S/I/D BAT-5S/I/D	6
Resistive Heating	Post-Demo (T=0)	PA-13S/D PA-14S/D	4
Control	-	PA-18S/I/D	3
QA	-	random	1

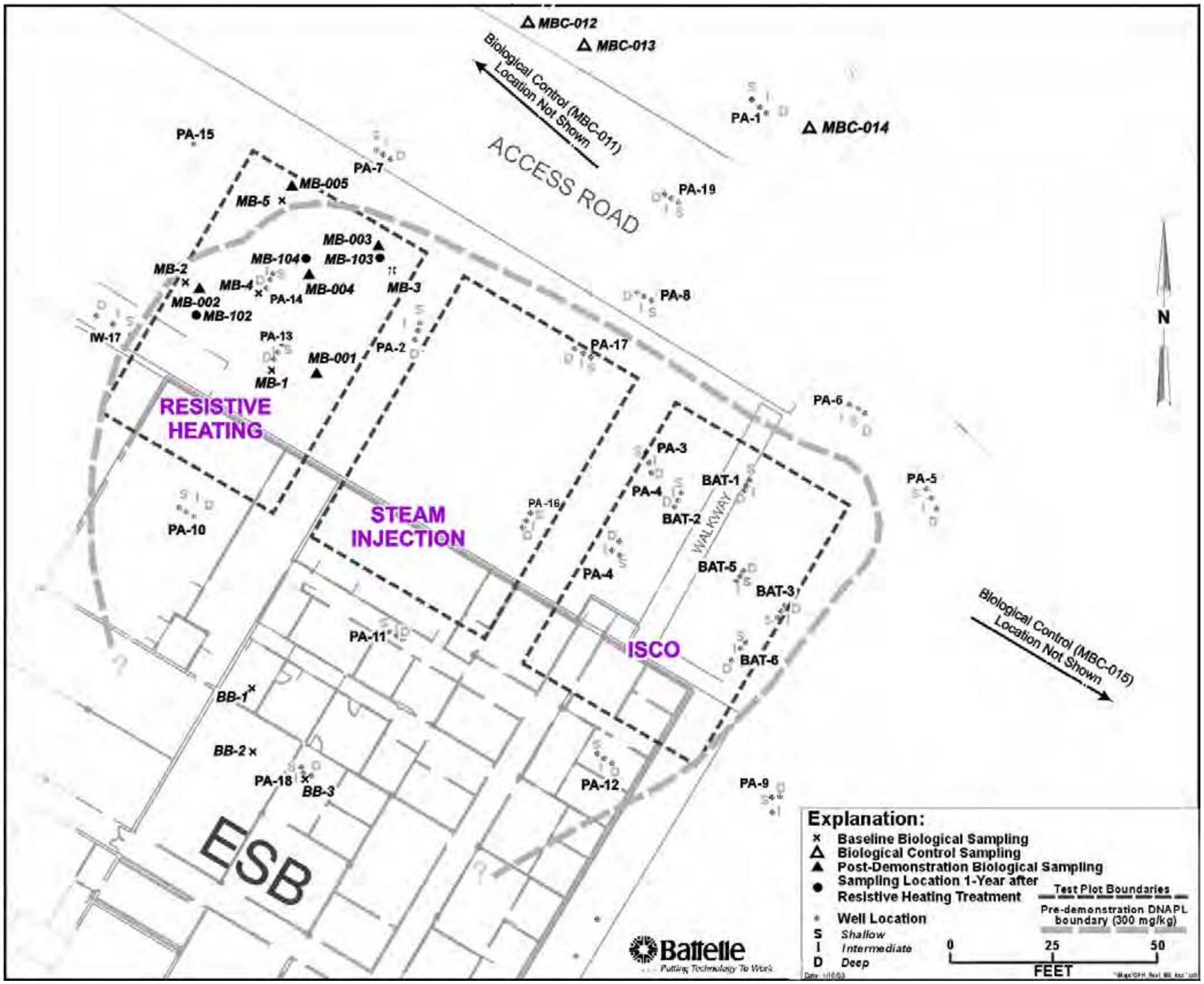

Figure 2. Map of Biological Sampling Location at LC34

E.3 Microbiological Evaluation Results

Some results of the microbiological evaluation described in Appendix E.1 are contained in Tables E-1 and E-2. Only the soil and groundwater samples collected for microbial counts analysis have been analyzed. The samples collected for DNA probes analysis were frozen under nitrogen and shipped to the U.S. EPA's R.S. Kerr Environmental Research Center and are awaiting analysis.

Table E-1 describes the microbial counts analysis of soil samples that represent predemonstration (baseline or T<0) and postdemonstration (Treated, T=0) conditions in the ISCO and resistive heating plots. The predemonstration baseline results were taken from the sampling conducted in the Steam Plot. The results of an extended monitoring event (Treated, T=6) conducted 6 months after the end of oxidation treatment in the plot are also listed. The control samples (control, untreated) are samples collected from an unaffected (TCE contaminated, but not in the oxidation zone) portion of the Launch Complex 34 aquifer; these control samples were collected at the same time as the postdemonstration (T=0) sampling event. Table E-2 lists similar results for groundwater samples. Because of the large variability in the data, only a few general trends were identified. As seen in Table E-1, both aerobic and anaerobic plate counts in the soil were lower in the treated soil (T=0) compared to the untreated (baseline) soil or control samples. In some regions, microbial populations appear to have been eliminated completely. This indicates that oxidation diminishes the microbial populations in the short term. The differences in surviving population numbers in different parts of the plot are probably indicative of the differential distribution of the oxidant. However, six months later, the microbial populations reappeared strongly in both aerobic and anaerobic conditions.

As seen in Table E-2, the groundwater analysis shows similar trends. Aerobic and anaerobic counts in the groundwater were diminished by the oxidation treatment, but rebounded within six months. This indicates that the chemical oxidation application reduces microbial populations in the short-term, but the populations rebound within a six-month period. Rebound in microbial populations is important because of the reliance on natural attenuation to address any residual contamination in the aquifer, following chemical oxidation treatment.

Microbiological analysis of soil and groundwater samples was conducted to evaluate the effect of resistive heating treatment on the microbial community. Samples were collected before and after (8 months after) the resistive heating treatment demonstration. For each monitoring event, soil samples were collected from five locations in the plot and five locations in a control (unaffected) area. At each location, four depths were sampled – capillary fringe, Upper Sand Unit, Middle Fine-Grained Unit, and Lower Sand Unit. The results are presented in Tables E-1 and E-2.

Table 5-20 (see Section 5) summarizes the soil analysis results. The geometric mean typically is the mean of the five samples collected in each stratigraphic unit in the plot. The 8 months of time that elapsed since the end of resistive heating treatment application and collection of the microbial samples may have given time for microbial populations to re-establish. The Middle Fine-Grained Unit experienced some reduction in microbial populations that persisted until the sampling after the of resistive heating treatment application. It could be that microbial populations were reduced immediately after the demonstration, however, if this phenomenon did occur the populations were re-established in the following 8 months. In the capillary fringe and in the Upper Sand Unit, microbial populations appeared to have increased by an order of magnitude. The persistence of these microorganisms despite the autoclave-like conditions in the of resistive heating plot may have positive implications for biodegradation of any TCE residuals following the of resistive heating treatment.

Table E-1. Results of Microbial Counts of Soil Samples

Sample ID	Top Depth ft bgs	Bottom Depth ft bgs	Aerobic Plate Counts CFU/g or MPN/g	Anaerobic Viable Counts Cells/g or MPN/g	BacLight Counts %live/%dead
Baseline Samples (August 2000)					
BB1-A	7	9	15,849	7,943	59/41
BB1-A	15.5	17	<316.23	158	25/75
BB2-A	7	9	19,953	31,623	70/30
BB3-A	9	11	12,589	3,162	39/61
BB3-A	15	17	<316.23	<1.78	28/72
BB-1-7.0	6.5	7.0	79,432.8	1,584,893.2	40/60
BB-1-14.0	13.5	14.0	<316.2	631.0	32/68
BB-1-24.0	23.5	24.0	199.5	1,584.9	28/72
BB-1-44.0	43.5	44.0	<316.2	316.2	82/18
BB-2'-7.0	6.5	7.0	19,952.6	19,952.6	43/57
BB-2-7.0	6.5	7.0	31,622.8	10,000.0	27/73
BB-2-16.5	16.0	16.5	2,511.9	3,162.3	15/85
BB-2-23.0	22.5	23.0	1,584,893.2	1,258,925.4	24/76
BB-2-24.0	23.5	24.0	<316.2	No Growth	10/90
BB-2-44.0	43.5	44.0	<316.2	251.2	92/08
BB-3-7.0	6.5	7.0	199,526.2	158,489.3	99/01
BB-3-14.0	13.5	14.0	6,309.6	50,118.7	84/16
BB-3-24.0	23.5	24.0	631.0	501.2	100/0
BB-3-44.0	43.5	44.0	25,118.9	63,095.7	56/44
Control Samples, Untreated (June 2000 except MBC014 in January 2001)					
MBC011-A-1	6	7.5	1,584,893	1,584,893	77/23
MBC011-A-2	15	16.5	501,187	794,328	79/26
MBC011-A-3	30	31.5	15,849	7,943	75/25
MBC011-A-4	40	41.5	316,228	63,096	26/74
MBC012-A-1	6	7.5	25,119	50,119	43/57
MBC012-A-3	30	31.5	125,893	6,310	48/52
MBC012-A-4	40	41.5	1,585	794	59/41
MBC013-A-1	6	7.5	125,893	19,953	50/50
MBC013-A-2	15	16.5	1,259	2,512	61/39
MBC013-A-3	30	31.5	501	794	44/56
MBC013-A-4	40	41.5	7,943	5,012	18/82
MBC014	7	7.5	63,095.73	79,432.82	47/53
MBC014	16	16.5	100,000.00	316,227.77	43/57
MBC014	31	31.5	39,810.72	79,432.82	55/45
MBC014	41	41.5	7,943.28	25,118.86	50/50
MBC015-A-1	6	7.5	3,981	5,012	53/47
MBC015-A-3	35	36.5	316	251	41/59
Control Samples, Untreated (April 2001)					
MBC-011	7	7.5	15,848,932	7,943,282	94/06
MBC-011	20	20.5	25,119	10,000	86/14
MBC-011	24.5	25	3,981	2,512	88/12
MBC-011	41.5	41.75	25,119	79,433	89/11
MBC-011	41.75	42	25,119	10,000	80/20

Table E-1. Results of Microbial Counts of Soil Samples (Continued)

Sample ID	Top Depth ft bgs	Bottom Depth ft bgs	Aerobic Plate Counts CFU/g or MPN/g	Anaerobic Viable Counts Cells/g or MPN/g	BacLight Counts %live/%dead
MBC-012	20.5	21	1,995	794	95/05
MBC-012	24.5	25	19,953	31,623	91/09
MBC-012	41	41.5	126	158	98/02
MBC-013	6.5	7	1,000,000	316,228	47/53
MBC-013	10	10.5	15,849	25,119	80/20
MBC-013	20.5	21	6,310	1,585	100/0
MBC-013	24	24.5	631	1,259	76/24
MBC-013	41.5	42	2,512	2,512	73/27
MBC-214	32	32.5	501,187	316,228	90/10
MBC-214	40	40.5	79,433	10,000	96/04
MBC-015	6.5	7	316,228	1,584,893	100/0
MBC-015	20.5	21	39,811	5,012	82/18
MBC-015	24	24.5	794	1,585	85/15
MBC-015	41.5	42	6,310	12,589	94/06
Resistive Heating Plot, Treated T=8 months after (April 2001)					
MB-001	7.5	8	6,309,573	12,589,254	52/48
MB-001	20.5	21	1,258,925	15,848,932	68/32
MB-001	29.5	30	<316.2	251	72/28
MB-001	39	39.5	25,119	50,119	76/24
MB-002	7.5	8	63,096	79,433	27/73
MB-002	19.5	20	100	126	30/70
MB-002	25	25.5	<316.2	251	57/43
MB-002	41.5	42	2,512	501	29/71
MB-003	5.5	6	7,943,282	6,309,573	44/56
MB-003	6	6.5	10,000,000	15,848,932	25/75
MB-003	21.5	22	1,258,925	794,328	32/68
MB-003	24	24.5	125,893	1,995,262	49/51
MB-003	41	41.5	158	251	95/05
MB-004	6	6.5	630,957	501,187	27/73
MB-004	21.5	22	100	1,259	09/91
MB-004	25	25.5	10,000	5,012	44/56
MB-004	41	41.5	158	31,623	46/54
MB-005	6.5	7	63,095,734	10,000,000	43/57
MB-005	20.5	21	794	316	56/44
MB-005	24.5	25	1,585	3,162	95/05
MB-005	41.5	42	<316.2	251	100/0
Resistive Heating Plot, Treated, T=18 months after (June 2002)					
MB-102	6	6.5	8,500	480	54/46
MB-102	15	15.5	4,800	4,800	72/28
MB-102	32	32.5	480	48,000	57/43
MB-102	40	40.5	85	48	54/46
MB-103	6.5	7	480	420	62/37
MB-103	15	15.5	19	48	52/48
MB-103	30	30.5	150	4,800	35/65
MB-103	40	40.5	190	480	22/78

Table E-1. Results of Microbial Counts of Soil Samples (Continued)

Sample ID	Top Depth ft bgs	Bottom Depth ft bgs	Aerobic Plate Counts CFU/g or MPN/g	Anaerobic Viable Counts Cells/g or MPN/g	BacLight Counts %live/%dead
MB-104	9	9.5	850	850	50/50
MB-104	15	15.5	48	5	67/33
MB-104	30	30.5	4.6	4.6	45/55
MB-104	40	40.5	190	19	45/55

bgs: Below ground surface.

CFU: Colony-forming units (roughly, number of culturable cells).

MPN: Most probable number.

Table E-2. Results of Microbial Counts Groundwater Samples

Sample ID	Aerobic Plate Counts CFU/mL or MPN/mL	Anaerobic Viable Counts Cells/mL or MPN/mL	BacLight Counts %live/%dead
Control Samples, Untreated, Distant Wells			
IW-1I	79,433	>1,584,893.19	31/69
IW-1D	5,012	15,849	35/65
PA-1S	15,849	158,489	50/50
PA-1I	501,187	>1,584,893.19	31/69
PA-1D	39,811	1,584,893	31/69
Resistive Heating Plot Wells, Treated, T=0 (January 2001)			
PA-13S	<31.62	31.62	48/52
PA-13D	<31.62	<1.78	66/34
PA-14S	<31.62	158.49	38/62
PA-14D	<31.62	<1.78	97/03
Resistive Heating Plot Perimeter Wells, T=0 (June 2000)			
PA-15	<31.62	25	18/82
PA-15-DUP	<31.62	<1.78	09/91
IW-17I	<31.62	316	46/54
IW-17D	<31.62	2	59/41
Resistive Heating Plot Wells, Treated, T=18 months after (June 2002)			
PA-13S	220,000	9	64/36
PA-13I	48,000	92	33/67
PA-13D	3,000	1	73/27
PA-14S	48,000	5	70/30
PA-14I	48,000	3	59/41
PA-14D	48	48	35/64

NA: Not available.

CFU: Colony-forming units (roughly, number of culturable cells).

MPN: most probable number.

Appendix F. Surface Emissions Testing Methods and Procedures

F.1 Surface Emissions Testing Methods and Procedures

One of the concerns about the technology as a means of soil and groundwater remediation was the possibility of transferring chlorinated volatile organic compounds (CVOCs) to the atmosphere through the ground surface or injection and monitoring wells. Emissions testing was performed to obtain a qualitative picture of VOC losses to the atmosphere from a mass balance perspective. Trying to quantify these discharges to the atmosphere went well beyond the resources of this study. The sampling and analytical methodologies for the emissions tests are presented in the following subsections.

F.1.1 Dynamic Surface Emissions Sampling Methodology

A dynamic surface emissions sampling method was used at the LC34 site. This method involves enclosing an area of soil under an inert box designed to allow the purging of the enclosure with high-purity air (Dupont, 1987). The box was purged with high-purity air for two hours to remove any ambient air from the region above the soil and to allow equilibrium to be established between the VOCs emitted from the soil and the organic-free air. The airstream was then sampled by drawing a known volume of the VOC/pure air mixture through a 1-L Summa canister. The Summa canister captured any organics associated with surface emissions from the test plot. The Summa canisters were then shipped to the off-site laboratory with a completed chain-of—custody form. The Summa canisters were then connected to an air sampler that was attached to a GC, which is where the concentrations of organics were quantified. These measured concentrations were used to calculate emission rates for the VOCs from the soil to the atmosphere.

A schematic diagram of the surface emissions sampling system is shown as Figure F-1. The system consists of a stainless steel box that covers a surface area of approximately 0.5 m^2. The box was fitted with inlet and outlet ports for the entry and exit of high-purity air, which is supplied via a gas cylinder. Inside the box was a manifold that delivered the air supply uniformly across the soil surface. The same type of manifold was also fitted to the exit port of the box. The configuration was designed to deliver an even flow of air across the entire soil surface under the box so that a representative sample was generated. To collect the sample, the air exiting the box was pulled by vacuum into the Summa canister.

In all testing cases, a totally inert system was employed. Teflon™ tubing and stainless steel fittings were used to ensure that there was no contribution to or removal of organics from the air stream. The Summa canister was located on the backside of the emissions box so that it would not be in a position to reverse the flow of air inside the box.

F.1.2 Sampling Schedule

Three surface emissions sampling locations were selected around the steam plot during the technology demonstration. The emissions box was placed strategically between two soil vapor extraction wells. The locations of the emissions sampling were chosen because this area had the highest probability of surface emissions during operations. The proposed testing occurred in the third, sixth, and ninth week of operations; these weeks were chosen because by then any vapor generated by the injection technology would be formed.

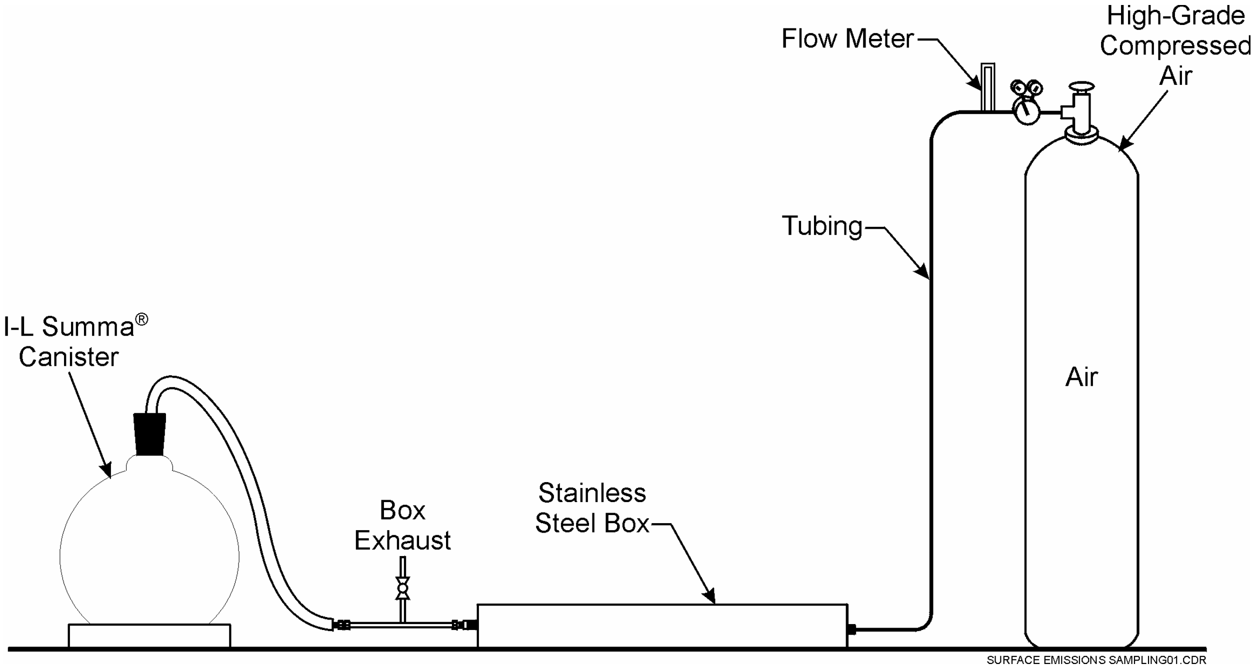

Figure F-1. Schematic Diagram of the Surface Emissions Sampling System

F.1.3 Analytical Calculations

The complete analytical results from the surface emissions sampling at LC34 are presented in this final report. The data is represented temporally, reflecting the three sampling events at the site. Flux values in µg of compound emitted into the atmosphere per unit of time were calculated. The results from the analysis of the Summa canisters and ambient air samples are presented in the final report. The ambient air samples were collected as reference concentrations of the emission levels to the existing air quality. GC calibration data is presented to verify the precision and accuracy of the sampling/analytical method.

To calculate actual emission rates of organic compounds from the soil surface into the atmosphere, the following equation for dynamic enclosure techniques was used (McVeety, 1991):

$$F = CV_r/S \tag{F-1}$$

where: F = flux in mass-area/time (µg m^2/min)
C = the concentration of gas in units of mass/volume (µg/m^3)
V_r = volumetric flowrate of sweep gas (m^3/min)
S = soil surface covered by the enclosure (m^2).

Table F-1. Suface Emissions Results from the Resisitve Heating Plot

Sample ID	Sample Date	TCE ppb (v/v)
Resistive Heating Plot		
Pre-Demonstration (Baseline Data)		
CP-SE-1	11/17/1999	<0.39
CP-SE-2	11/17/1999	<0.39
CP-SE-3	11/17/1999	<0.41
During Demonstration		
SPH-SE-1	10/8/1999	2.1
SPH-SE-2	10/8/1999	3.6
SPH-SE-3	10/8/1999	2
SPH-SE-4	10/22/1999	13,000
SPH-SE-5	10/22/1999	12,000
SPH-SE-6	10/22/1999	13,000
SPH-SE-7	1/18/2000	23
SPH-SE-8	1/18/2000	78
SPH-SE-9	1/18/2000	35
SPH-SE-10	4/11/2000	0.93
SPH-SE-11	4/11/2000	0.67
SPH-SE-12	4/11/2000	<0.37
SPH-SE-13	4/11/2000	1,300
Post-Demonstration		
SPH-SE-21	8/30/2000	<0.42
SPH-SE-22	8/30/2000	1
SPH-SE-23	8/30/2000	<870
SPH-SE-24	8/31/2000	500
SPH-SE-25	9/1/2000	59.00
SPH-SE-26	9/1/2000	17
SPH-SE-27	11/30/2000	3,100
SPH-SE-28	11/30/2000	10,000
SPH-SE-29	12/1/2000	11,000
SPH-SE-30	12/2/2000	9
SPH-SE-31	12/2/2000	1
SPH-SE-32	12/4/2000	<0.40
Ambient Air at Shoulder Level		
SPH-SE-14	5/9/2000	<0.39[a]
SPH-SE-15	5/9/2000	<0.39[a]
SPH-SE-C27	9/1/2000	<0.88
DW-C1	4/11/2000	2.1[b]
DW-C2	5/9/2000	<0.39
DW-C3	5/9/2000	<0.39
DW-11	8/31/2000	13
DW-12	9/1/2000	<27
DW-C21	8/31/2000	0.86[b]
DW-C22	9/1/2000	<0.58[b]

Table F-1. Suface Emissions Results from the Resisitve Heating Plot (Continued)

Sample ID	Sample Date	TCE ppb (v/v)
Background		
DW-SE-1	10/1/1999	< 0.42
DW-SE-2	10/8/1999	< 0.44
DW-SE-3	10/25/1999	0.44
DW-SE-4	10/22/1999	6,000[c]
DW-SE-5	1/17/2000	< 0.38
DW-SE-6	4/11/2000	0.43
DW-SE-7	4/11/2000	0.86
DW-SE-8	4/11/2000	0.79
DW-SE-36	12/6/2000	<0.40
DW-SE-37	12/6/2000	0.49
DW-SE-38	12/7/2000	<0.40

ppb (v/v): parts per billion by volume.

a. SPH-SE-14/15 samples were collected at an ambient elevation east and west edge of the resistive heating plot w/o using an air collection box.

b. This sample was collected by holding a Summa canister at shoulder level collecting an ambient air sample to evaluate local background air.

c. Background sample (10/22/99) was taken immediately after SPH-SE-6 sample (the last sample for this event), which had an unexpectedly high concentration of 13,000 ppbv. This may indicate condensation of TCE in the emissions collection box at levels that could not be removed by the standard decontamination procedure of purging the box with air for two hours. In subsequent events (1/17/2000 background), special additional decontamination steps were taken to minimize carryover.

Appendix G. Quality Assurance/ Quality Control Information

Tables G-1 to G-22

Appendix G.1 Investigating VOC Losses During Postdemonstration Soil Core Recovery and Soil Sampling

Field procedures for collecting soil cores and soil samples from the steam injection plot were modified in an effort to minimize VOC losses that can occur when sampling soil at elevated temperatures (Battelle, 2001). The primary modifications included: (1) additional personnel safety equipment, such as thermal-insulated gloves for core handling; (2) the addition of a cooling period to bring the soil cores to approximately 20ºC before collecting samples; and (3) capping the core ends while the cores were cooling. Concerns were raised about the possibility that increased handling times during soil coring, soil cooling, and sample collection may result in an increase in VOC losses. An experiment was conducted using soil samples spiked with a surrogate compound to investigate the effectiveness of the field procedures developed for LC34 in minimizing VOC losses.

Materials and Methods

Soil cores were collected in a 2-inch diameter, 4-foot long acetate sleeve that was placed tightly inside a 2-inch diameter stainless steel core barrel. The acetate sleeve was immediately capped on both ends with a protective polymer covering. The sleeve was placed in an ice bath to cool the heated core to below ambient groundwater temperatures (approximately 20ºC). The temperature of the soil core was monitored during the cooling process with a meat thermometer that was pushed into one end cap (see Figure G-1). Approximately 30 minutes was required to cool each 4-foot long, 2-inch diameter soil core from 50-95ºC to below 20ºC (see Figure G-2). Upon reaching ambient temperature, the core sleeve was then uncapped and cut open along its length to collect the soil sample for contaminant analysis (see Figure G-3).

FIGURE G-1. A soil core capped and cooling in an ice bath. The thermometer is visible in the end cap.

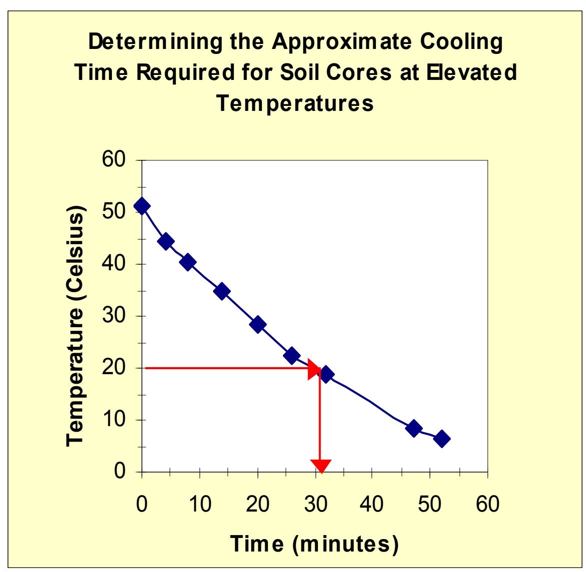

FIGURE G-2. Determining the length of time required to cool a soil core.

FIGURE G-3. A soil sample being collected from along the length of the core into a bottle 7containing methanol.

Soil samples were collected in relatively large quantities (approximately 200 g) along the entire length of the core rather than sampling small aliquots of the soil within the core, as required by the conventional method (EPA SW5035). This modification is advantageous because the resultant data provide an understanding of the continuous VOC distribution with depth. VOC losses during sampling were further minimized by placing the recovered soil samples directly into bottles containing methanol (approximately 250 mL) and extracting them on site. The extracted methanol was centrifuged and sent to an off-site laboratory for VOC analysis. The soil sampling and extraction strategy is described in more detail in Gavaskar et al. (2000).

To evaluate the efficiency of the sampling method in recovering VOCs, hot soil cores were extracted from 14 through 24 feet below ground surface and spiked with a surrogate compound, 1,1,1-trichloroethane (1,1,1-TCA). The surrogate was added to the intact soil core by using a 6" needle to inject 25 µL of surrogate into each end of the core for a total of 50 µL of 1,1,1-TCA. In order to evaluate the effect of the cooling period on VOC loss, three soil cores were spiked with TCA prior to cooling in the ice bath and three cores were spiked with TCA after cooling in the ice bath. In the pre-cooling test, the surrogate was injected as described above and the core barrels were subsequently capped and placed in the ice bath for the 30 minutes of cooling time required to bring the soil core to below 20°C. A thermometer was inserted through the cap to monitor the temperature of the soil core.

In the post-cooling test, the soil cores were injected with TCA after the soil core had been cooled in the ice bath to below 20°C. After cooling, the caps on the core barrel were removed and the surrogate compound was injected in the same manner, 25 µL per each end of the core barrel using a 6" syringe. The core was recapped and allowed to equilibrate for a few minutes before it was opened and samples were collected. Only for the purpose of the surrogate recovery tests, the entire contents of the sampling sleeve were collected and extracted on site with methanol. The soil:methanol ratio was kept approximately the same as during the regular soil sample collection and extraction. Several (four) aliquots of soil and several (four) bottles of methanol were required to extract the entire contents of the sample sleeve.

Two different capping methods were used during this experiment to evaluate the effectiveness of each cap type. Two of the soil cores were capped using flexible polymer sheets attached to the sleeve with rubber bands. The remaining four soil cores were capped with tight-fitting rigid polymer end caps. One reason that the polymer sheets were preferred over the rigid caps was that the flexible sheets were better positioned to handle any contraction of the sleeve during cooling.

Results

The results from the surrogate spiking experiment are shown in Table G-1. Soil cores 1, 3, and 5 received the surrogate spike prior to cooling in the ice bath. Soil cores 2, 4, and 6 received the surrogate spike after cooling in the ice bath. The results show that between 84 and 113% of the surrogate spike was recovered from the soil cores. Recovery comparison is not expected to be influenced significantly by soil type because all samples were collected from a fine grained to medium fine-grained sand unit. The results also indicate that the timing of the surrogate spike (i.e., pre- or post-cooling) appeared to have only a slight effect on the amount of surrogate recovered. Slightly less surrogate was recovered from the soil cores spiked prior to cooling. This implies that any losses of TCA in the soil samples spiked prior to cooling are minimal and acceptable, within the limitations of the field sampling protocol. The field sampling protocol was designed to process up to 300 soil samples that were collected over a 3-week period, during each monitoring event.

Table G-1. Recovery in Soil Cores Spiked with 1,1,1-TCA Surrogate

Soil Cores Spiked Prior to Cooling	Capping Method	1,1,1-TCA Recovery (%)	Soil Cores Spiked After Cooling	Capping Method	1,1,1-TCA Recovery (%)
Core 1	Flexible polymer sheet with rubber bands	96.3	Core 2	Flexible polymer sheet with rubber bands	98.7
Core 3	Rigid End Cap	101.0	Core 4	Rigid End Cap	112.6
Core 5	Rigid End Cap	84.3	Core 6	Rigid End Cap	109.6

The capping method (flexible versus rigid cap) did not show any clear differences in the surrogate recoveries. The flexible sheets are easier to use and appear to be sufficient to ensure good target compound recovery.

This experiment demonstrates that the soil core handling procedures developed for use at LC34 were successful in minimizing volatility losses associated with the extreme temperatures of the soil cores. It also shows that collecting and extracting larger aliquots of soil in the field is a good way of characterizing DNAPL source zones.

References

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Table G-2. 1,1,1-TCA Surrogate Spike Recovery Values for Soil Samples Collected During the Steam Postdemonstration Sampling

Steam Treatment Plot: Extraction Efficiency Test **QA/QC Target Level Recovery % = 70 – 130 %** **QA/QC Target Level RPD < 30.0 %**					**Total Number of Samples Collected = 312** **Total Number of Spiked Soil Samples Analyzed = 13** **Total Number of Spiked Methanol Blanks Analyzed = 13**				
Steam Demonstration: 1,1,1-TCA Spiked Samples									
Sample ID	**Sample Date**	**1,1,1-TCA Recovery (µg)**	**1,1,1-TCA Recovery (%)**	**RPD (%)**	**Sample ID**	**Sample Date**	**1,1,1-TCA Recovery (µg)**	**1,1,1-TCA Recovery (%)**	**RPD (%)**
SB-231-2(SS)	1/30/02	1,575	118	4.4	SB-238-2(SS)	2/14/02	1,254	94	4.6
SB-231-MB(SS)[(a)]		1,509	113		SB-238-MB(SS)		1,315	98	
SB-232-2(SS)	1/29/02	1,337	100	4.0	SB-239-2(SS)	2/06/02	1,300	97	14.3
SB-232-MB(SS)		1,286	96		SB-239-MB(SS)		1,518	113	
SB-233-2(SS)	1/28/02	1,308	98	13.1	SB-240-2(SS)	2/04/02	1,073	80	3.5
SB-233-MB(SS)		1,504	112		SB-240-MB(SS)		1,112	83	
SB-234-2(SS)	2/13/02	1,220	91	5.8	SB-241-2(SS)	2/01/02	780	58	38.1
SB-234-MB(SS)		1,153	86		SB-241-MB(SS)		1,261	94	
SB-235-2(SS)	2/14/02	1,244	93	5.2	SB-242-2(SS)	1/30/02	1,082	81	8.5
SB-235-MB(SS)		1,182	88		SB-242-MB(SS)		1,182	88	
SB-236-2(SS)	2/12/02	1,324	99	1.8	SB-339-2(SS)	2/08/02	1,382	103	17.9
SB-236-MB(SS)		1,300	97		SB-339-MB(SS)		1,173	88	
SB-237-2(SS)	2/7/02	1,148	86	4.1	Range of Recovery in Soil Samples: 58-118% Average: 92%				
SB-237-MB(SS)		1,103	82						

(a) Samples listed as –MB are methanol blanks spiked with 1,1,1-TCA for the purpose of comparing to the amount of 1,1,1-TCA recovered from the soil samples.

Table G-3. Results of the Extraction Procedure Performed on PA-4 Soil Samples

Extraction Procedure Conditions	Combined
Total Weight of Wet Soil (g) = 2,124.2	1,587.8 g dry soil from PA-4 boring
Concentration (mg TCE/g soil) = 3.3	529.3 g deionized water
Moisture Content of Soil (%) = 24.9	5 mL TCE

Laboratory Extraction Sample ID	TCE Concentration in MeOH (mg/L)	TCE Mass in MeOH (mg)	TCE Concentration in Spiked Soil (mg/kg)	Theoretical TCE Mass Expected in MeOH (mg)	Percentage Recovery of Spiked TCE (%)
1st Extraction procedure on same set of samples					
SEP-1-1	1800.0	547.1	3252.5	744.11	73.53
SEP-1-2	1650.0	501.8	3164.9	701.26	71.55
SEP-1-3	1950.0	592.2	3782.3	692.62	85.51
SEP-1-4	1840.0	558.1	3340.2	739.13	75.51
SEP-1-5	1860.0	564.0	3533.9	705.91	79.89
SEP-1-6 (Control)	78.3	19.4	-	25.00	77.65
				Average % Recovery =	77.20
2nd Extraction procedure on same set of samples					
SEP-2-1	568.0	172.7	861.1	887.28	19.47
SEP-2-2	315.0	95.5	500.5	843.77	11.31
SEP-2-3	170.0	51.3	268.2	846.42	6.06
SEP-2-4	329.0	99.8	498.4	885.29	11.27
SEP-2-5	312.0	94.8	476.3	880.31	10.77
SEP-2-6 (Control)	82.6	20.4	-	25.00	81.79
				Average % Recovery =	11.78
3rd Extraction procedure on same set of samples					
SEP-3-1	55.8	17.0	84.6	885.96	1.91
SEP-3-2	59.0	17.9	94.2	841.77	2.13
SEP-3-3	56.8	17.2	90.1	846.42	2.04
SEP-3-4	63.0	19.1	95.2	888.61	2.15
SEP-3-5	52.2	15.8	80.0	875.99	1.81
SEP-3-6 (Control)	84.3	20.9	-	25.00	83.55
				Average % Recovery =	2.01

Table G-4. Results and Precision of the Field Duplicate Samples Collected During the Pre- and Post-Demonstration Soil Sampling

Resistive Heating Treatment Plot Field Duplicate Soil Samples QA/QC Target Level < 30.0 %				**Total Number of Soil Samples Collected = 291 (Pre-) 309 (Post-) Total Number of Field Duplicate Samples Analyzed = 10 (Pre-) 13 (Post-)**			
Pre-Demonstration				**Post-Demonstration**			
Sample ID	**Sample Date**	**Result (mg/kg)**	**RPD (%)**	**Sample ID**	**Sample Date**	**Result (mg/kg)**	**RPD (%)**
SB-10-29.5	06/23/1999	40.3	12.90	SB-210-26	11/13/2000	265	27.92
SB-10-29.5 DUP		35.1		SB-210-26 DUP		191	
SB-11-25.5	06/25/1999	94.2	71.97[(b)]	SB-211-32	11/14/2000	102	9.80
SB-11-25.5 DUP		26.4		SB-211-32 DUP		92	
SB-7-40	06/25/1999	70.1	60.91[(b)]	SB-209-18	11/15/2000	13	53.85[(a)]
SB-7-40 DUP		112.8		SB-209-18 DUP		6	
SB-4-22	06/26/1999	43.6	24.08	SB-212-36	11/15/2000	1.0	0.0
SB-4-22 DUP		54.1		SB-212-36 DUP		1.0	
SB-9-21.5	06/27/1999	12.7	12.60	SB-208-40	11/16/2000	11	0.0
SB-9-21.5 DUP		14.3		SB-208-40 DUP		11	
SB-6-32	06/27/1999	17.0	2.94	SB-207-10	11/16/2000	0.0	0.0
SB-6-32 DUP		17.5		SB-207-10 DUP		0.0	
SB-5-20	06/29/1999	5.2	23.08	SB-203-38	11/17/2000	308	1.95
SB-5-20 DUP		4.0		SB-203-38 DUP		302	
SB-3-28	06/30/1999	100.9	7.83	SB-204-24	11/17/2000	105	2.86
SB-3-28 DUP		108.8		SB-204-24 DUP		102	
SB-2-20	06/30/1999	1.9	31.58[(a)]	SB-205-26	11/20/2000	176	0.57
SB-2-20 DUP		2.5		SB-205-26 DUP		177	
SB-1-32	07/01/1999	19,090.9	12.75	SB-206-26	11/21/2000	15	13.33
SB-1-32 DUP		16,656.6		SB-206-26 DUP		13	
				SB-210B-32	11/27/2000	27	22.22
				SB-210B-32 DUP		21	
				SB-202-18	12/09/2000	53	47.17[(c)]
				SB-202-18 DUP		28	
				SB-201-32	12/11/2000	325	18.46
				SB-201-32 DUP		385	

(a) Samples had high RPD values due to the effect of low (or below detect) concentrations of TCE drastically affected the RPD calculation.
(b) Samples had high RPD values due to this duplicate being used as a surrogate sample.
(c) Samples had high RPD values probably due to high levels of DNAPL distributed heterogeneously through the soil core sample.

Table G-5. Results of the Rinsate Blank Samples Collected During the Post-Demonstration Soil Sampling

Total Number of Samples Collected = 309 **Total Number of Field Samples Analyzed = 12**			
Post-Demonstration Rinsate Blank Samples			
Sample ID	**Sample Date**	**Result (ug/L)**	**Comments**
SB-210-EB	11/14/2000	<1.0	Met QA/QC Target Criteria
SB-211-EB	11/14/2000	<1.0	Met QA/QC Target Criteria
SB-212-EB	11/15/2000	<1.0	Met QA/QC Target Criteria
SB-209-EB	11/15/2000	<1.0	Met QA/QC Target Criteria
SB-207-EB	11/16/2000	<1.0	Met QA/QC Target Criteria
SB-208-EB	11/16/2000	<1.0	Met QA/QC Target Criteria
SB-204-EB	11/17/2000	<1.0	Met QA/QC Target Criteria
SB-210B-EB	11/27/2000	<1.0	Met QA/QC Target Criteria
SB-203-EB	11/20/2000	<1.0	Met QA/QC Target Criteria
SB-205-EB	11/20/2000	<1.0	Met QA/QC Target Criteria
SB-206-EB	11/21/2000	<1.0	Met QA/QC Target Criteria
SB-202-EB	12/09/2000	<1.0	Met QA/QC Target Criteria

(a) Pre-demonstration equipment blanks were not collected.

Table G-6. Results of the Methanol Blank Samples Collected During the Pre- and Post-Demonstration Soil Sampling

Resistive Heating Methanol Blank Soil Extraction QA/QC Samples QA/QC Target Level < 1.0 mg/kg				**Total Number of Soil Samples Collected = 291 (Pre-) 309 (Post-) Total Number of Field Samples Analyzed = 26**			
Pre-Demonstration Methanol Blank Samples				**Post-Demonstration Methanol Blank Samples**			
Sample ID	**Sample Date**	**Result (mg/kg)**	**Comments**	**Sample ID**	**Sample Date**	**Result (mg/kg)**	**Comments**
SB-10-Blank	06/23/1999	<0.250	Met QA/QC Target Criteria	SB-211-Blank	11/14/2000	<0.250	Met QA/QC Target Criteria
SB-12-Blank	06/24/1999	<0.250	Met QA/QC Target Criteria	SB-212-Blank	11/15/2000	<0.250	Met QA/QC Target Criteria
SB-11-Blank	06/25/1999	<0.250	Met QA/QC Target Criteria	SB-208-Blank	11/15/2000	<0.250	Met QA/QC Target Criteria
SB-7-Blank	06/25/1999	<0.250	Met QA/QC Target Criteria	SB-207-Blank	11/16/2000	<0.250	Met QA/QC Target Criteria
SB-4-Blank	06/26/1999	<0.250	Met QA/QC Target Criteria	SB-204-Blank	11/17/2000	<0.250	Met QA/QC Target Criteria
SB-6-Blank	06/27/1999	<0.250	Met QA/QC Target Criteria	SB-203-Blank	11/20/2000	<0.250	Met QA/QC Target Criteria
SB-9-Blank	06/27/1999	<0.250	Met QA/QC Target Criteria	SB-205-Blank	11/20/2000	<0.250	Met QA/QC Target Criteria
SB-8-Blank	06/28/1999	<0.250	Met QA/QC Target Criteria	SB-205-Blank	11/20/2000	<0.250	Met QA/QC Target Criteria
SB-5-Blank	06/29/1999	6.9[(a)]	See footnote.	SB-206-Blank	11/20/2000	<0.250	Met QA/QC Target Criteria
SB-2-Blank	06/30/1999	<0.250	Met QA/QC Target Criteria	SB-206-Blank	11/21/2000	<0.250	Met QA/QC Target Criteria
SB-3-Blank	06/30/1999	<0.250	Met QA/QC Target Criteria	SB-201-Blank	12/09/2000	<0.250	Met QA/QC Target Criteria
SB-1-Blank	07/01/1999	<0.250	Met QA/QC Target Criteria	SB-202-Blank	12/09/2000	<0.250	Met QA/QC Target Criteria
				SB-202-Blank	12/11/2000	<0.250	Met QA/QC Target Criteria
				SB-201-Blank	12/12/2000	<0.250	Met QA/QC Target Criteria
				SB-201-Blank	12/12/2000	<0.250	Met QA/QC Target Criteria

(a) Methanol Blank sample concentrations were below 10% of the TCE results for the samples in these batches. This batch included the following set of samples: SB-5-2 through SB-5-45

Table G-7. Results and Precision of the Field Duplicate Samples Collected During the Pre- and Post-Demonstration Groundwater Sampling

Resistive Heating Treatment Plot Field Duplicate Groundwater Samples QA/QC Target Level < 30.0 %				Total Number of Groundwater Samples Collected = 46 (Pre-) 42 (Post-) Total Number of Field Duplicate Samples Analyzed = 4			
Pre-Demonstration				**Post-Demonstration**			
Sample ID	**Sample Date**	**Result (ug/L)**	**RPD (%)**	**Sample ID**	**Sample Date**	**Result (ug/L)**	**RPD (%)**
PA-13S	09/03/1999	1,030,000	6.80	PA-13D	11/27/2000	920,000	1.09
PA-13S DUP		1,100,000		PA-13D DUP		910,000	
PA-13D	09/05/1999	892,000	18.16	PA-10I	11/29/2000	750,000	16.00
PA-13D DUP		730,000		PA-10I DUP		870,000	

Table G-8. Results and Precision of the Field Duplicate Samples Collected During Resistive Heating Demonstration Groundwater Sampling

Resistive Heating Treatment Plot Field Duplicate Groundwater Samples QA/QC Target Level < 30.0 %				Total Number of Groundwater Samples Collected = 154 Total Number of Field Duplicate Samples Analyzed = 10			
Demonstration							
Sample ID	**Sample Date**	**Result (ug/L)**	**RPD (%)**	**Sample ID**	**Sample Date**	**Result (ug/L)**	**RPD (%)**
PA-8D	09/29/1999	625,000	11.86	PA-10D	01/10/2000	1,060,000	5.66
PA-8D DUP		555,000		PA-10D DUP		1,120,000	
PA-2I	10/06/1999	425,000	11.76	PA-13S	04/10/2000	180,000	5.56
PA-2I DUP		475,000		PA-13S DUP		170,000	
PA-10I	10/08/1999	458,000	1.53	PA-2I	04/12/2000	1,800,000	22.22
PA-10I DUP		451,000		PA-2I DUP		1,400,000	
PA-8S	10/20/1999	115,000	1.75				
PA-8S DUP		113,000					

Table G-9. Rinsate Blank Results for Groundwater Samples Collected for the Resistive Heating Pre-and Post-Demonstration Groundwater Sampling

Resistive Heating Pre-Demonstration Groundwater QA/QC Samples QA/QC Target Level < 3.0 ug/L			**Total Number of Samples Collected = 46 (Pre-) 42 (Post-) Total Number of Rinsate Blank Samples Analyzed = 3**		
Pre-Demonstration Rinsate Blanks			**Post-Demonstration Rinsate Blanks**		
Analysis Date	**TCE Concentration (ug/L)**	**Comments**	**Analysis Date**	**TCE Concentration (ug/L)**	**Comments**
08/05/1999	3,236.0	Before switching to disposal tubing.	11/29/2000	8.5[(a)]	Met QA/QC Target Criteria
08/05/1999	227.0	Before switching to disposal tubing.	11/30/2000	<1.0	Met QA/QC Target Criteria
08/07/1999	58.3	Before switching to disposal tubing.	12/01/2000	0.46	Met QA/QC Target Criteria
08/10/1999	2,980.0	Before switching to disposal tubing.			
08/12/1999	140.0	Before switching to disposal tubing.			
08/12/1999	31.3	Before switching to disposal tubing.			
08/12/1999	339.0	Before switching to disposal tubing.			

a) Samples in this set included PA-13D and PA-13D DUP were collected prior to the field blank, PA-7S, PA-7I and PA-7D were collected after, but the field blank sample was less than 10% of the concentration results in these two samples.

Table G-10. Rinsate Blank Results for Groundwater Samples Collected for Resistive Heating Demonstration Groundwater Sampling

Resistive Heating Demonstration Groundwater QA/QC Samples QA/QC Target Level < 3.0 ug/L			**Total Number of Samples Collected = 154 Total Number of Rinsate Blank Samples Analyzed = 22**		
Demonstration					
Analysis Date	**TCE Concentration (ug/L)**	**Comments**	**Analysis Date**	**TCE Concentration (ug/L)**	**Comments**
09/27/1999	174.0	Before switching to disposal tubing.	10/22/1999	<2.0	Met QA/QC Target Criteria
09/27/1999	170.0	Before switching to disposal tubing.	10/26/1999	<2.0	Met QA/QC Target Criteria
09/27/1999	233.0	Before switching to disposal tubing.	10/26/1999	<2.0	Met QA/QC Target Criteria
09/28/1999	79.5	Before switching to disposal tubing.	11/16/1999	<2.0	Met QA/QC Target Criteria
09/28/1999	2,740.0	Before switching to disposal tubing.	01/11/2000	<2.0	Met QA/QC Target Criteria
09/28/1999	2,430.0	Before switching to disposal tubing.	01/12/2000	<2.0	Met QA/QC Target Criteria
09/30/1999	46.3	Before switching to disposal tubing.	01/13/2000	<3.0	Met QA/QC Target Criteria
09/28/1999	43.8	Before switching to disposal tubing.	01/14/2000	<2.0	Met QA/QC Target Criteria
09/28/1999	29.2	Before switching to disposal tubing.	04/11/2000	<1.0	Met QA/QC Target Criteria
10/06/1999	<2.0	Met QA/QC Target Criteria	04/12/2000	<1.0	Met QA/QC Target Criteria
10/07/1999	<2.0	Met QA/QC Target Criteria	04/13/2000	<1.0	Met QA/QC Target Criteria

Table G-11. Results of the Trip Blank Samples Analyzed During Resistive Heating Demonstration Soil and Groundwater Sampling

Total Number of Samples Collected = 600 (Soil) 242 (Groundwater) [(a)] Total Number of Field Samples Analyzed = 14							
Resistive Heating Demonstration Trip Blanks							
Sample ID	**Sample Date**	**Result (ug/L)**	**Comments**	**Sample ID**	**Sample Date**	**Result (ug/L)**	**Comments**
Trip Blank-1	08/03/1999	<1.0	Met QA/QC target criteria.	Trip Blank-10	05/23/2000	<5.0	Met QA/QC target criteria.
Trip Blank-2	01/05/2000	<1.0	Met QA/QC target criteria.	Trip Blank-11	05/24/2000	<5.0	Met QA/QC target criteria.
Trip Blank-3	04/13/2000	<1.0	Met QA/QC target criteria.	Trip Blank-12	05/25/2000	<5.0	Met QA/QC target criteria.
Trip Blank-4	04/13/2000	<1.0	Met QA/QC target criteria.	Trip Blank-13	05/26/2000	<5.0	Met QA/QC target criteria.
Trip Blank-5	04/13/2000	<1.0	Met QA/QC target criteria.	Trip Blank-14	06/01/2000	<5.0	Met QA/QC target criteria.
Trip Blank-6	05/09/2000	<1.0	Met QA/QC target criteria.	Trip Blank-15	06/01/2000	<5.0	Met QA/QC target criteria.
Trip Blank-7	05/11/2000	<2.0	Met QA/QC target criteria.	Trip Blank-16	06/02/2000	<5.0	Met QA/QC target criteria.
Trip Blank-8	05/19/2000	<5.0	Met QA/QC target criteria.	Trip Blank-17	12/01/2000	<5.0	Met QA/QC target criteria.
Trip Blank-9	05/22/2000	<5.0	Met QA/QC target criteria.				

(a) Groundwater samples that were analyzed by the on site mobile laboratory were not delivered with a trip blank sample for analysis.

Table G-12. Spike Recovery and Precision Values for Matrix Spike Samples Analyzed During Resistive Heating Pre-Demonstration Soil Sampling

Resistive Heating Treatment Plot MS/MSD Samples QA/QC Target Level Recovery % = 70 – 130 % QA/QC Target Level < 30.0 %			Total Number of Soil Samples Collected = 291 Total Number of MS/MSD Samples Analyzed = 12		
Pre-Demonstration					
Sample Date	**TCE Recovery (%)**	**RPD (%)**	**Sample Date**	**TCE Recovery (%)**	**RPD (%)**
06/28/1999	113	1.5	07/07/1999	118	1.5
	115			116	
06/30/1999	123	0.03	07/09/1999	112	0.4
	123			112	
07/02/1999	91	0.26	07/09/1999	106	0.19
	92			106	
07/02/1999	118	3.6	07/13/1999	119	0.02
	114			119	
07/05/1999	100	14.0	07/16/1999	117	2.8
	82			114	
07/06/1999	104	5.2	07/22/1999	111	0.32
	110			111	

Table G-13. Spike Recovery and Precision Values for Matrix Spike Samples Analyzed During Resistive Heating Post-Demonstration Soil Sampling

Resistive Heating Treatment Plot MS/MSD Samples QA/QC Target Level Recovery % = 70 – 130 % QA/QC Target Level < 30.0 %			Total Number of Soil Samples Collected = 309 Total Number of MS/MSD Samples Analyzed = 25		
Post-Demonstration					
Sample Date	**TCE Recovery (%)**	**RPD (%)**	**Sample Date**	**TCE Recovery (%)**	**RPD (%)**
11/18/2000	95 108	3.2	11/30/2000	85 87	0.64
11/19/2000	100 83	5.3	12/13/2000	111 109	0.68
11/20/2000	108 105	2.0	12/14/2000	93 93	0.34
11/21/2000	105 101	0.92	12/14/2000	86 95	2.9
11/21/2000	82 122	12.0	12/15/2000	80 91	4.2
11/22/2000	102 74	9.6	12/15/2000	121 101	7.3
11/24/2000	109 108	0.20	12/16/2000	109 105	1.3
11/24/2000	107 101	1.5	12/17/2000	91 89	0.99
11/27/2000	96 126	8.8	12/18/2000	103 96	2.6
11/27/2000	110 102	2.1	12/20/2000	110 102	7.0
11/28/2000	122 121	0.28	12/21/2000	100 105	5.3
11/29/2000	107 102	0.93	12/21/2000	91 93	3.0
11/29/2000	93 101	2.4			

Table G-14. Spike Recovery Values for Soil Laboratory Control Spike Samples Collected for Resistive Heating Pre-Demonstration

Resistive Heating Treatment Plot LCS/LCSD Samples QA/QC Target Level Recovery % = 70 – 130 % QA/QC Target Level < 30.0 %			Total Number of Soil Samples Collected = 291 Total Number of LCS/LCSD Samples Analyzed = 22		
Pre-Demonstration					
Sample Date	**TCE Recovery (%)**	**RPD (%)**	**Sample Date**	**TCE Recovery (%)**	**RPD (%)**
06/28/1999	110	4.6	07/06/1999	91	2.0
	105			93	
06/30/1999	121	2.4	07/06/1999	118	0.48
	124			117	
06/30/1999	109	0.46	07/07/1999	112	0.73
	108			113	
07/01/1999	122	1.9	07/08/1999	104	0.36
	120			104	
07/02/1999	94	1.6	07/09/1999	89	5.0
	95			94	
07/02/1999	92	0.91	07/09/1999	110	1.5
	93			111	
07/02/1999	107	2.5	07/12/1999	116	4.9
	110			111	
07/02/1999	118	3.6	07/13/1999	116	0.25
	114			116	
07/04/1999	92	3.9	07/14/1999	110	0.6
	96			110	
07/05/1999	110	0.88	07/21/1999	110	2.4
	109			112	
07/06/1999	117	0.76	07/24/1999	117	0.6
	118			117	

Table G-15. Spike Recovery Values for Soil Laboratory Control Spike Samples Collected for Resistive Heating Post-Demonstration

Resistive Heating Treatment Plot LCS/LCSD Samples QA/QC Target Level Recovery % = 70 – 130 % QA/QC Target Level < 30.0 %			Total Number of Soil Samples Collected = 309 Total Number of LCS/LCSD Samples Analyzed = 15		
Post-Demonstration					
Sample Date	**TCE Recovery (%)**	**RPD (%)**	**Sample Date**	**TCE Recovery (%)**	**RPD (%)**
11/18/2000	111	3.60	12/14/2000	91	2.20
	107			89	
11/20/2000	109	0.92	12/14/2000	93	0.34
	110			93	
11/21/2000	106	6.60	12/16/2000	94	9.57
	113			103	
11/24/2000	117	0.23	12/17/2000	105	10.48
	117			94	
11/27/2000	106	5.66	12/18/2000	94	1.06
	112			93	
11/28/2000	105	0.34	12/20/2000	104	13.46
	105			90	
11/29/2000	113	11.50	12/21/2000	88	2.27
	100			90	
12/12/2000	102	8.82			
	93				

Table G-16. Method Blank Samples Analyzed During Resistive Heating Pre-Demonstration Soil Sampling

Resistive Heating Pre-Demonstration Soil QA/QC Samples QA/QC Target Level < 1.0 mg/kg			Total Number of Samples Collected = 291 Total Number of Method Blank Samples Analyzed = 38		
Pre-Demonstration Method Blanks					
Analysis Date	**TCE Concentration (mg/kg)**	**Comments**	**Analysis Date**	**TCE Concentration (mg/kg)**	**Comments**
06/28/1999	<0.250	Met QA/QC Target Criteria	07/06/1999	<0.250	Met QA/QC Target Criteria
06/28/1999	<0.250	Met QA/QC Target Criteria	07/06/1999	<0.250	Met QA/QC Target Criteria
06/30/1999	<0.250	Met QA/QC Target Criteria	07/06/1999	<0.250	Met QA/QC Target Criteria
06/30/1999	<0.250	Met QA/QC Target Criteria	07/06/1999	<0.250	Met QA/QC Target Criteria
06/30/1999	<0.250	Met QA/QC Target Criteria	07/07/1999	<0.250	Met QA/QC Target Criteria
06/30/1999	<0.250	Met QA/QC Target Criteria	07/07/1999	<0.250	Met QA/QC Target Criteria
06/30/1999	<0.250	Met QA/QC Target Criteria	07/08/1999	<0.250	Met QA/QC Target Criteria
07/01/1999	<0.250	Met QA/QC Target Criteria	07/09/1999	<0.250	Met QA/QC Target Criteria
07/02/1999	<0.250	Met QA/QC Target Criteria	07/09/1999	<0.250	Met QA/QC Target Criteria
07/02/1999	<0.250	Met QA/QC Target Criteria	07/09/1999	<0.250	Met QA/QC Target Criteria
07/02/1999	<0.250	Met QA/QC Target Criteria	07/09/1999	<0.250	Met QA/QC Target Criteria
07/02/1999	<0.250	Met QA/QC Target Criteria	07/12/1999	<0.250	Met QA/QC Target Criteria
07/02/1999	<0.250	Met QA/QC Target Criteria	07/13/1999	<0.250	Met QA/QC Target Criteria
07/03/1999	<0.250	Met QA/QC Target Criteria	07/13/1999	<0.250	Met QA/QC Target Criteria
07/04/1999	<0.250	Met QA/QC Target Criteria	07/14/1999	<0.250	Met QA/QC Target Criteria
07/05/1999	<0.250	Met QA/QC Target Criteria	07/21/1999	<0.250	Met QA/QC Target Criteria
07/06/1999	<0.250	Met QA/QC Target Criteria	07/22/1999	<0.250	Met QA/QC Target Criteria
07/06/1999	<0.250	Met QA/QC Target Criteria	07/23/1999	<0.250	Met QA/QC Target Criteria
07/06/1999	<0.250	Met QA/QC Target Criteria	07/24/1999	<0.250	Met QA/QC Target Criteria
07/01/1999	<0.250	Met QA/QC Target Criteria	07/09/1999	<0.250	Met QA/QC Target Criteria
07/01/1999	<0.250	Met QA/QC Target Criteria	07/09/1999	<0.250	Met QA/QC Target Criteria
07/15/1999	<0.250	Met QA/QC Target Criteria	07/09/1999	<0.250	Met QA/QC Target Criteria
07/15/1999	<0.250	Met QA/QC Target Criteria	07/12/1999	<0.250	Met QA/QC Target Criteria

Table G-17. Method Blank Samples Analyzed During Resistive Heating Post-Demonstration Soil Sampling

Resistive Heating Pre-Demonstration Soil QA/QC Samples QA/QC Target Level < 1.0 mg/kg			Total Number of Samples Collected = 309 Total Number of Method Blank Samples Analyzed = 29		
Post-Demonstration Method Blanks					
Analysis Date	**TCE Concentration (mg/kg)**	**Comments**	**Analysis Date**	**TCE Concentration (mg/kg)**	**Comments**
11/18/2000	<0.250	Met QA/QC Target Criteria	12/13/2000	<0.250	Met QA/QC Target Criteria
11/18/2000	<0.250	Met QA/QC Target Criteria	12/14/2000	<0.250	Met QA/QC Target Criteria
11/20/2000	<0.250	Met QA/QC Target Criteria	12/14/2000	<0.250	Met QA/QC Target Criteria
11/20/2000	<0.250	Met QA/QC Target Criteria	12/14/2000	<0.250	Met QA/QC Target Criteria
11/21/2000	<0.250	Met QA/QC Target Criteria	12/15/2000	<0.250	Met QA/QC Target Criteria
11/21/2000	<0.250	Met QA/QC Target Criteria	12/15/2000	<0.250	Met QA/QC Target Criteria
11/23/2000	<0.250	Met QA/QC Target Criteria	12/16/2000	<0.250	Met QA/QC Target Criteria
11/24/2000	<0.250	Met QA/QC Target Criteria	12/16/2000	<0.250	Met QA/QC Target Criteria
11/27/2000	<0.250	Met QA/QC Target Criteria	12/17/2000	<0.250	Met QA/QC Target Criteria
11/27/2000	<0.250	Met QA/QC Target Criteria	12/18/2000	<0.250	Met QA/QC Target Criteria
11/28/2000	<0.250	Met QA/QC Target Criteria	12/20/2000	<0.250	Met QA/QC Target Criteria
11/28/2000	<0.250	Met QA/QC Target Criteria	12/20/2000	<0.250	Met QA/QC Target Criteria
11/29/2000	<0.250	Met QA/QC Target Criteria	12/21/2000	<0.250	Met QA/QC Target Criteria
11/30/2000	<0.250	Met QA/QC Target Criteria	12/21/2000	<0.250	Met QA/QC Target Criteria
12/12/2000	<0.250	Met QA/QC Target Criteria			

Table G-18. Spike Recovery and Precision Values for Matrix Spike Samples Analyzed During Resistive Heating Demonstration Groundwater Sampling

Resistive Heating Treatment Plot Groundwater QA/QC QA/QC Target Level Recovery % = 70 – 130 % QA/QC Target Level RPD < 30.0 %							
Resistive Heating Demonstration Matrix Spike Samples							
Sample ID	**Sample Date**	**TCE Recovery (%)**	**RPD (%)**	**Sample ID**	**Sample Date**	**TCE Recovery (%)**	**RPD (%)**
BAT-2S MS	08/03/1999	104	0.11	MP-2C MS	10/26/1999	109	0.4
BAT-2S MSD		103		MP-2C MSD		109	
BAT-5I MS	08/03/1999	51[a]	5.6	ML-2 MS	01/14/2000	181[a]	6.63
BAT-5I MSD		27[a]		ML-2 MSD		202[a]	
PA-7D MS	08/07/1999	92.0	0.6	PA-3D DUP MS	01/15/2000	130	0.874
PA-7D MSD		96.0		PA-3D DUP MSD		126	
MP-3A MS	09/30/1999	89	4.3	PA-1D MS	01/16/2000	94	3.56
MP-3A MSD		82		PA-1D MSD		98	
ML-2 MS	10/25/1999	116	0.9	PA-8S MS	06/15/2000	78	12.0
ML-2 MSD		115		PA-8S MSD		88	

(a) TCE recovery was affected by interference from excess potassium permanganate in these groundwater samples.

Table G-19. Spike Recovery and Precision Values for Laboratory Control Spike Samples Analyzed During the Pre- and Post-Demonstration Groundwater Sampling

Resistive Heating Treatment Plot Groundwater QA/QC QA/QC Target Level Recovery % = 70 – 130 % QA/QC Target Level RPD < 30.0 %				Total Number of Samples Collected = 46 (Pre-) 42 (Post-) Total Number of Matrix Spike Samples Analyzed = 12			
Pre-Demonstration LCS/LCSD Samples				**Post-Demonstration LCS/LCSD Samples**			
Sample ID	**Sample Date**	**TCE Recovery (%)**	**RPD (%)**	**Sample ID**	**Sample Date**	**TCE Recovery (%)**	**RPD (%)**
LCS-990805	08/05/1999	115	5.9	DQWR31AC-LCS	12/06/2000	96	2.8
LCSD-990805		122		DQWR31AD -LCSD		93	
LCS-990806	08/06/1999	107	3.1	DQTDH1AC-LCS	12/05/2000	93	1.7
LCSD-990806		111		DQTDH1AD -LCSD		95	
LCS-990807	08/07/1999	113	0.4	DQMKE1AC-LCS	12/01/2000	98	1.8
LCSD-990807		113		DQMKE1AD -LCSD		97	
LCS-990809	08/09/1999	109	2.0	DQQ031AC-LCS	12/04/2000	91	1.2
LCSD-990809		106		DQQ031ACD-LCSD		92	
LCS-990810	08/10/1999	111	2.5				
LCSD-990810		109					
LCS-990811	08/11/1999	112	3.8				
LCSD-990811		108					
LCS-990812	08/12/1999	106	0.6				
LCSD-990812		105					
LCS-990813	08/13/1999	98	4.0				
LCSD-990813		102					

Table G-20. Spike Recovery and Precision Values for Laboratory Control Spike Samples Analyzed During Resistive Heating Demonstration Groundwater Sampling

Resistive Heating Treatment Plot Groundwater QA/QC QA/QC Target Level Recovery % = 70 – 130 % QA/QC Target Level RPD < 30.0 %				Total Number of Samples Collected = 309 Total Number of Matrix Spike Samples Analyzed = 15			
Demonstration LCS/LCSD Spike Samples							
Sample ID	Sample Date	TCE Recovery (%)	RPD (%)	Sample ID	Sample Date	TCE Recovery (%)	RPD (%)
LCS-990927	09/27/1999	95	12.1	LCS-991025	10/25/1999	113	0.9
LCSD-990927		107		LCSD-991025		112	
LCS-990928	09/28/1999	113	5.1	LCS-991026	10/26/1999	112	4.6
LCSD-990928		107		LCSD-991026		107	
LCS-990929	09/29/1999	107	4.2	LCS-991118	11/18/1999	109	17.6
LCSD-990929		111		LCSD-991118		91	
LCS-991018	10/18/1999	114	1.4	LCS-00113	01/13/2000	101	-
LCSD-991018		115		LCSD-00113		-	
LCS-991019	10/19/1999	119	6.2	LCS-00114	01/14/2000	106	-
LCSD-991019		112		LCSD-00114		-	
LCS-991020	10/20/1999	109	9.8	LCS-00115	01/15/2000	113	1.16
LCSD-991020		99		LCSD-00115		103	
LCS-991021	10/21/1999	111	5.3	LCS-00116	01/16/2000	104	1.94
LCSD-991021		117		LCSD-00116		102	
LCS-991022	10/22/1999	108	3.3				
LCSD-991022		112					

Table G-21. Method Blank Samples Analyzed During Resistive Heating Pre-Demonstration Groundwater Sampling

Resistive Heating Pre- and Post-Demo Groundwater QA/QC Samples QA/QC Target Level < 3.0 ug/L			Total Number of Samples Collected = 46 (Pre-) 42 (Post-) Total Number of Method Blank Samples Analyzed = 13		
Pre-Demonstration Method Blanks			**Post-Demonstration Method Blanks**		
Analysis Date	**TCE Concentration (ug/L)**	**Comments**	**Analysis Date**	**TCE Concentration (ug/L)**	**Comments**
08/05/1999	<2.0	Met QA/QC Target Criteria	12/01/2000	<1.0	Met QA/QC Target Criteria
08/06/1999	<2.0	Met QA/QC Target Criteria	12/04/2000	<1.0	Met QA/QC Target Criteria
08/07/1999	<2.0	Met QA/QC Target Criteria	12/06/2000	<1.0	Met QA/QC Target Criteria
08/08/1999	<2.0	Met QA/QC Target Criteria	12/05/2000	<1.0	Met QA/QC Target Criteria
08/09/1999	<2.0	Met QA/QC Target Criteria			
08/10/1999	<2.0	Met QA/QC Target Criteria			
08/11/1999	<2.0	Met QA/QC Target Criteria			
08/12/1999	<2.0	Met QA/QC Target Criteria			
08/09/1999	<1.0	Met QA/QC Target Criteria			

Table G-22. Method Blank Samples Analyzed During Resistive Heating Demonstration Groundwater Sampling

Resistive Heating Demonstration Groundwater QA/QC Samples QA/QC Target Level < 3.0 ug/L			Total Number of Samples Collected = 154 Total Number of Method Blank Samples Analyzed = 21		
Demonstration					
Analysis Date	**TCE Concentration (ug/L)**	**Comments**	**Analysis Date**	**TCE Concentration (ug/L)**	**Comments**
09/27/1999	<2.0	Met QA/QC Target Criteria	11/16/1999	<2.0	Met QA/QC Target Criteria
09/28/1999	<2.0	Met QA/QC Target Criteria	01/13/2000	<2.0	Met QA/QC Target Criteria
09/29/1999	<2.0	Met QA/QC Target Criteria	01/14/2000	<2.0	Met QA/QC Target Criteria
09/30/1999	<2.0	Met QA/QC Target Criteria	01/15/2000	<2.0	Met QA/QC Target Criteria
10/06/1999	<2.0	Met QA/QC Target Criteria	01/16/2000	<2.0	Met QA/QC Target Criteria
10/07/1999	<2.0	Met QA/QC Target Criteria	01/17/2000	<2.0	Met QA/QC Target Criteria
10/20/1999	<2.0	Met QA/QC Target Criteria	04/11/2000	<1.0	Met QA/QC Target Criteria
10/21/1999	<2.0	Met QA/QC Target Criteria	04/13/2000	<1.0	Met QA/QC Target Criteria
10/22/1999	<2.0	Met QA/QC Target Criteria	04/18/2000	<1.0	Met QA/QC Target Criteria
10/25/1999	<2.0	Met QA/QC Target Criteria	04/21/2000	<1.0	Met QA/QC Target Criteria
10/26/1999	<2.0	Met QA/QC Target Criteria			

Appendix H. Economic Analysis Information

Appendix H

Economic Analysis Information

This appendix details the cost assessment for the application of the pump and treat (P&T) system for containment of a DNAPL source at Launch Complex 34, for a source zone that is the same size as the resistive heating plot. Because the groundwater flow in this area is generally to the northeast, the DNAPL source could be contained by installing one or more extraction wells on the northeast side of the resistive heating plot. The life cycle cost of a pump-and-treat system can be compared to the cost of DNAPL source removal using chemical oxidation, as described in Section 7 of the main report.

Experience at previous sites indicates that the most efficient long-term P&T system is one that is operated at the minimum rate necessary to contain a plume or source zone (Cherry et al., 1996). Table H-1 shows a preliminary size determination for the P&T system. The P&T system should be capable of capturing the groundwater flowing through a cross-section that is approximately 50 ft wide (width of the resistive heating plot) and 40 ft deep (thickness of surficial aquifer). Because capture with P&T systems is somewhat inefficient in that cleaner water from surrounding parts of the aquifer may also be drawn in, an additional safety factor of 100% was applied to ensure that any uncertainties in aquifer capture zone or DNAPL source characterization are accounted for. An extraction rate of 2 gallon per minute (gpm) is found to be sufficient to contain the source.

One advantage of low groundwater extraction rates is that the air effluent from stripping often does not have to be treated, as the rate of volatile organic compound (VOC) discharge to the ambient air is often within regulatory limits. The longer period of operation required (at a low withdrawal rate) is more than offset by higher efficiency (lower influx of clean water from outside the plume), lower initial capital investment (smaller treatment system), and lower annual operations and maintenance (O&M) requirements. Another advantage of a containment type P&T system is that, unlike source removal technologies, it does not require very extensive DNAPL zone characterization.

H.1 Capital Investment for the P&T System

The P&T system designed for this application consists of the components shown in Table H-2. Pneumatically driven pulse pumps, which are used in each well, are safer than electrical pumps in the presence of trichloroethylene (TCE) vapors in the wells. This type of pump can sustain low flowrates during continuous operation. Stainless steel and Teflon™ construction ensure compatibility with the high concentrations (up to 1,100 mg/L TCE) of dissolved solvent and any free-phase DNAPL that may be expected. Extraction wells are assumed to be 40 ft deep, 2 inches in diameter, and have stainless steel screens with polyvinyl chloride (PVC) risers.

The aboveground treatment system consists of a DNAPL separator and air stripper. Very little free-phase solvent is expected and the separator may be disconnected after the first year of operation, if desired. The air stripper used is a low-profile tray-type air stripper. As opposed to conventional packed towers, low-profile strippers have a smaller footprint, much smaller height, and can handle large air:water ratios (higher mass transfer rate of contaminants) without generating significant pressure losses. Because of their small size and easy installation, they are more often used in groundwater remediation. The capacity of the air stripper selected is much higher than 2 gpm, so that additional flow (or additional extraction wells) can be handled if required.

The high air:water ratio ensures that TCE (and other minor volatile components) are removed to the desired levels. The treated water effluent from the air stripper is discharged to the sewer. The air effluent is treated with a catalytic oxidation unit before discharge.

The piping from the wells to the air stripper is run through a 1-ft-deep covered trench. The air stripper and other associated equipment are housed on a 20-ft-x-20-ft concrete pad, covered by a basic shelter. The base will provide a power drop (through a pole transformer) and a licensed electrician will be used for the power hookups. Meters and control valves are strategically placed to control water and air flow through the system.

The existing monitoring system at the site will have to be supplemented with seven long-screen (10-foot screen) monitoring wells. The objective of these wells is to ensure that the desired containment is being achieved.

H.2 Annual Cost of the P&T System

The annual costs of P&T are shown in Table H-3 and include annual operation and maintenance (O&M) and monitoring. Annual O&M costs include the labor, materials, energy, and waste disposal cost of operating the system and routine maintenance (including scheduled replacement of seals, gaskets, and O-rings). Routine monitoring of the stripper influent and effluent is done through ports on the feed and effluent lines on a monthly basis. Groundwater monitoring is conducted on a quarterly basis through seven monitoring wells. All water samples are analyzed for PCE and other chlorinated volatile organic compound (CVOC) by-products.

H.3 Periodic Maintenance Cost

In addition to the routine maintenance described above, periodic maintenance will be required, as shown in Table H-3, to replace worn-out equipment. Based on manufacturers' recommendations for the respective equipment, replacement is done once in 5 or 10 years. In general, all equipment involving moving parts is assumed will be replaced once every 5 years, whereas other equipment is changed every 10 years.

H.4 Present Value (PV) Cost of P&T

Because a P&T system is operated for the long term, a 30-year period of operation is assumed for estimating cost. Because capital investment, annual costs, and periodic maintenance costs occur at different points in time, a life cycle analysis or present value analysis is conducted to estimate the long-term cost of P&T in today's dollars. This life cycle analysis approach is recommended for long-term remediation applications by the guidance provided in the Federal Technologies Roundtable's *Guide to Documenting and Managing Cost and Performance Information for Remediation Projects* (United States Environmental Protection Agency [U.S. EPA], 1998). The PV cost can then be compared with the cost of faster (DNAPL source reduction) remedies.

$$PV_{\text{P\&T costs}} = \sum \frac{\text{Annual Cost in Year t}}{(1 + r)^t} \qquad \text{Equation (H-1)}$$

$$PV_{\text{P\&T costs}} = \text{Capital Investment} + \frac{\text{Annual cost in Year 1}}{(1 + r)^1} + \ldots + \frac{\text{Annual cost in Year n}}{(1 + r)^n}$$

Equation (H-2)

Table H-3 shows the PV calculation for P&T based on Equation H-1. In Equation H-1, each year's cost is divided by a discount factor that reflects the rate of return that is foregone by incurring the cost. As seen in Equation H-2, at time t = 0, which is in the present, the cost incurred is the initial capital investment in equipment and labor to design, procure, and build the P&T system. Every year after that, a cost is incurred to operate and maintain the P&T system. A real rate of return (or discount rate), r, of 2.9% is used in the analysis as per recent U.S. EPA guidance on discount rates (U.S. EPA, 1999). The total PV cost of purchasing, installing, and operating a 1-gpm P&T source containment system for 30 years is estimated to be **$1,406,000** (rounded to the nearest thousand).

Long-term remediation costs are typically estimated for 30-year periods as mentioned above. Although the DNAPL source may persist for a much longer time, the contribution of costs incurred in later years to the PV cost of the P&T system is not very significant and the total 30-year cost is indicative of the total cost incurred for this application. This can be seen from the fact that in Years 28, 29, and 30, the differences in cumulative PV cost are not as significant as the difference in, say, Years 2, 3, and 4. The implication is that, due to the effect of discounting, costs that can be postponed to later years have a lower impact than costs that are incurred in the present.

As an illustration of a DNAPL source that may last much longer than the 30-year period of calculation, Figure H-1 shows a graphic representation of PV costs assuming that the same P&T system is operated for 100 years instead of 30 years. The PV cost curve flattens with each passing year. The total PV cost after 100 years is estimated at $2,188,000.

Table H-1. Pump & Treat (P&T) System Design Basis

Item	Value	Units	Item	Value	Units
Width of DNAPL zone, w	50	ft	Hyd. conductivity, K	40	ft/d
Depth of DNAPL zone, d	40	ft	Hyd. gradient, I	0.0007	ft/ft
Crossectional area of DNAPL zone, a	2000	sq ft	Porosity, n	0.3	
Capture zone required	187	cu ft/d	Gw velocity, v	0.093333	ft/d
Safety factor, 100%	2				
Required capture zone	373	cu ft/d	GPM =	1.9	gpm
Design pumping rate	2	gpm	Number of wells to achieve capture	1	
Pumping rate per well	2	gpm			
TCE conc. in water near DNAPL zone	100	mg/L	TCE allowed in discharge water	1	mg/L
Air stripper removal efficiency required	99.00%				
TCE in air effluent from stripper	2.4	lbs/day	TCE allowed in air effluent	6	lbs/day

Table H-2. Capital Investment for a P&T System at Launch Complex 34, Cape Canaveral

Item	# units		Unit Price	Cost	Basis
Design/Procurement					
Engineer	160	hrs	$85	$13,600	
Drafter	80	hrs	$40	$3,200	
Hydrologist	160	hrs	$85	$13,600	
Contingency	1	ea	$10,000	$10,000	10% of total capital
TOTAL				$30,400	
Pumping system					
Extraction wells	1	ea	$5,000	$5,000	2-inch, 40 ft deep, 30-foot SS screen; PVC; includes installation
Pulse pumps	1	ea	$595	$595	2.1 gpm max., 1.66"OD for 2-inch wells; handles solvent contact; pneumatic; with chec valves
Controllers	1	ea	$1,115	$1,115	Solar powered or 110 V; with pilot valve
Air compressor	1	ea	$645	$645	100 psi (125 psi max), 4.3 cfm continuous duty, oil-less; 1 hp
Miscellaneous fittings	1	ea	$5,000	$5,000	Estimate
Tubing	150	ft	$3	$509	1/2-inch OD, chemical resistant; well to surface manifold
TOTAL				$12,864	
Treatment System					
Piping	150	ft	$3	$509	chemical resistant
Trench	1	day	$320	$320	ground surface
DNAPL separarator tank	1	ea	$120	$120	125 gal; high grade steel with epoxy lining; conical bottom with discharge
Air stripper feed pump	1	ea	$460	$460	0.5 hp; up to 15 gpm
Piping	50	ft	$3	$170	0.5 inch, chemical resistant; feed pump to stripper
Water flow meter	1	ea	$160	$160	Low flow; with read out
Low-profile air stripper with control panel	1	ea	$9,400	$9,400	1-25 gpm, 4 tray; SS shell and trays
Pressure gauge	1	ea	50	$50	SS; 0-30 psi
Blower	1	ea	$1,650	$1,650	5 hp
Air flow meter	1	ea	$175	$175	Orifice type; 0-50 cfm
Stack	10	ft	$2	$20	2 inch, PVC, lead out of housing
Catalytic Oxidizer	1	ea	$65,000	$65,000	
Carbon	2	ea	$1,000	$2,000	
Stripper sump pump	1	ea	$130	$130	To sewer
Misc. fittings, switches	1	ea	$5,000	$5,000	Estimate (sample ports, valves, etc.)
TOTAL				$85,163	
Site Preparation					
Conctrete pad	400	sq ft	$3	$1,200	20 ft x 20 ft with berm; for air stripper and associated equipment
Berm	80	ft	$7	$539	
Power drop	1	ea	$5,838	$5,838	230 V, 50 Amps; pole transformer and licensed electrician
Monitoring wells	5	wells	$2,149	$10,745	Verify source containment; 2-inch PVC with SS screens
Sewer connection fee	1	ea	$2,150	$2,150	
Sewer pipe	300	ft	$10	$3,102	
Housing	1	ea	$2,280	$2,280	20 ft x 20 ft; shelter for air stripper and associated equipment
TOTAL				$25,854	
Installation/Start Up of Treatment System					
Engineer	60	hrs	$85	$5,100	Labor
Technician	200	hrs	$40	$8,000	Labor
TOTAL				$13,100	
TOTAL CAPITAL INVESTMENT				**$167,381**	

Table H-2. Capital Investment for a P&T System at Launch Complex 34, Cape Canaveral (Continued)

O&M Cost for P&T Sytem					
Annual Operation & Maintenance					
Engineer	80	hrs	$85	$6,800	Oversight
Technician	500	hrs	$40	$20,000	Routine operation; annual cleaning of air stripper trays, routine replacement of parts; any waste disposal
Replacement materials	1	ea	$2,000	$2,000	Seals, o-rings, tubing, etc.
Electricity	52,560	kW-hrs	$0.10	$5,256	8 hp (~6 kW) over 1 year of operation
Fuel (catalytic oxidizer	2,200	10E6 Btu	$6.00	$13,200	
Sewer disposal fee	525,600	gal/yr	$0.00152	$799	
Carbon disposal	2		$1,000	$2,000	
Waste disposal	1	drum	$80	$200	30 gal drum; DNAPL, if any; haul to incinerator
TOTAL				$50,255	
Annual Monitoring					
Air stripper influent	12	smpls	$120	$1,440	Verify air stripper loading; monthly
Air stripper effluent	14	smpls	$120	$1,680	Discharge quality confirmation; monthly; CVOC analysis; MS, MSD
Monitoring wells	34	smpls	$120	$4,080	5 wells; quarterly; MS, MSD
Sampling materials	1	ea	$500	$500	Miscellaneous
Technician	64	hrs	40	$2,560	Quarterly monitoring labor (from wells) only; weekly monitoring (from sample ports) included in O&M cost
Engineer	40	hrs	85	$3,400	Oversight; quarterly report
TOTAL				$7,200	
TOTAL ANNUAL COST				**$57,455**	
Periodic Maintenance, Every 5 years					
Pulse pumps	4	ea	$595	$2,380	As above
Air compressor	1	ea	$645	$645	As above
Air stripper feed pump	1	ea	$460	$460	As above
Blower	1	ea	$1,650	$1,650	As above
Catalyst replacement	1	ea	$5,000	$5,000	
Stripper sump pump	1	ea	$130	$130	As above
Miscellaneous materials	1	ea	$1,000	$1,000	Estimate
Technician	40	hrs	$40	$1,600	Labor
TOTAL				**$12,865**	
				$70,320	
Periodic Maintenance, Every 10 years					
Air stripper	1	ea	$9,400	$9,400	As above
Catalytic oxidizer	1	ea	$16,000	$16,000	Major overhaul
Water flow meters	1	ea	160	$160	As above
Air flow meter	1	ea	175	$175	As above
Technician	40	hrs	$40	$1,600	Labor
Miscellaneous materials	1	ea	$1,000	$1,000	Estimate
TOTAL				**$28,335**	
TOTAL PERIODIC MAINTENANCE COSTS				**$98,655**	

Table H-3. Present Value of P&T System Costs for 30-Year Operation

Year	P&T		
	Annual Cost *	PV of Annual Cost	Cumulative PV of Annual Cost
0	**$167,381**	$167,381	$167,381
1	$57,455	$55,836	$223,217
2	$57,455	$54,262	$277,479
3	$57,455	$52,733	$330,212
4	$57,455	$51,247	$381,459
5	**$70,320**	$60,954	$442,413
6	$57,455	$48,399	$490,811
7	$57,455	$47,035	$537,846
8	$57,455	$45,709	$583,556
9	$57,455	$44,421	$627,977
10	**$98,655**	$74,125	$702,102
11	$57,455	$41,953	$744,054
12	$57,455	$40,770	$784,825
13	$57,455	$39,621	$824,446
14	$57,455	$38,505	$862,951
15	**$70,320**	$45,798	$908,749
16	$57,455	$36,365	$945,114
17	$57,455	$35,340	$980,454
18	$57,455	$34,344	$1,014,798
19	$57,455	$33,376	$1,048,174
20	**$98,655**	$55,694	$1,103,868
21	$57,455	$31,521	$1,135,389
22	$57,455	$30,633	$1,166,022
23	$57,455	$29,770	$1,195,792
24	$57,455	$28,931	$1,224,723
25	**$70,320**	$34,411	$1,259,134
26	$57,455	$27,323	$1,286,457
27	$57,455	$26,553	$1,313,010
28	$57,455	$25,805	$1,338,814
29	$57,455	$25,077	$1,363,892
30	**$98,655**	$41,846	$1,405,738

* Annual cost in Year zero is equal to the capital investment.
Annual cost in other years is annual O&M cost plus annual monitoring cost
Annual costs in Years 10, 20, and 30 include annual
O&M, annual monitoring, and periodic maintenance

Figure H-1. P&T System Costs - 100 years