

Field Methods and Procedures

C.1 Field Sampling Procedures

C.1.1 Depth-Discrete Groundwater Sampling and Cone Penetrometer Testing

Depth-discrete groundwater samples were collected using a combination of Waterloo Profiler[®] and Hydropunch[®] techniques (within the same boring) from temporary borings advanced with a Vibra-Push[™] rig. Prior to groundwater sample collection, a stratigraphic interpretation was obtained from an adjacent borehole at each location to adjust sample depths as necessary to target water-bearing zones.

C.1.1.1 Stratigraphic Logging

A CPT rig was used to collect data for stratigraphic interpretation at all locations, unless access was prevented by site conditions. A CPT generates a stratigraphic interpretation by advancing a CPT “cone” at a constant 2 centimeters per second (cm/s) (Figure C-1). The CPT cone measures cone bearing stress (Q_t), sleeve friction (F_s), and porewater pressure (U) generated during advancement of the cone. A stratigraphic interpretation is made based on cone-bearing stress and the friction ratio (R_f)¹ between the cone-bearing stress and the sleeve friction (Figure C-2). Generally, cohesive soils (clays) have higher friction ratios (R_f), lower cone bearing (Q_t), and generate large excess porewater pressures during advancement of the CPT cone. Cohesionless soils (sands) tend to have lower friction ratios (R_f), higher cone bearing (Q_t), and generate little excess porewater pressure during advancement of the cone.

Continuous core was collected at three locations that the CPT rig could not access due either overhead clearance restrictions (RGW-14 and RGW-15) or problems penetrating soil at the former facility yard (RGW-12). Continuous core was collected in three foot sections with the same Vibra-Push[™] rig. Soil cores were logged as detailed in Section C.1.2.4.

C.1.1.2 Grab Groundwater Sampling – Waterloo Profiler[®]

The Waterloo Profiler[®], which is designed to collect depth-discrete groundwater samples in a single direct-push hole with one probe entry, was originally proposed to collect all depth-discrete groundwater samples. However, shallow, low-yield groundwater zones were identified for sampling through interpretation of the CPT and lithologic logs, and failed attempts to use the Waterloo Profiler[®]. Therefore, all potential groundwater sampling intervals identified shallower than approximately 20 feet below ground surface (bgs) were completed, as possible, with a Hydropunch[®] and in one case with a temporary well.

Under ideal conditions the Waterloo Profiler[®] is designed to increase the speed of sampling and increase precision at which depth grab groundwater samples are collected. The

¹ The friction ratio (R_f) is sleeve friction (F_s) divided by the cone-bearing stress (Q_t).

Waterloo Profiler[®] tip was equipped with sample intake ports arranged radially around the cone-tip direct-push rod. Each of the six intake ports are constructed with an outer coarse and inner fine screen and are 0.5 cm in diameter, giving a total inlet area of approximately 1.2 square centimeters (cm²) (0.19 square inches [in.²]).

The Profiler tip was attached to 4-foot lengths of hollow, heavy-duty threaded steel pipe that extended to the ground surface. The sample ports in the profiler head are connected to the surface with disposable Teflon[®] tubing threaded through the drive rods. The Waterloo Profiler[®] was advanced using the large direct push rig (equipped with Vibra-Push[®] and hydraulic hammer capability), which was also used for the continuous coring at RGW-12, RGW-14, and RGW-15. Four-foot lengths of pipe were continually added as the tool was advanced deeper into the ground to the sampling depth. To prevent the sample ports from clogging as the tool was advanced through the soil, distilled water was slowly pumped through the tubing and out of the sampling ports. A very small amount of water was injected (approximately 10 mL per minute). In addition to keeping the ports open, injecting distilled water while advancing the tool purges the tubing of the water leftover from the previous sampling, preventing cross contamination of the subsequent groundwater sample.

Once the tool had been advanced to the desired sampling depth, the direction flow of the pump was reversed, and groundwater from the aquifer was extracted. Purging of the system was required, since the tubing and ports contained distilled water that had been pumped down the system. The electric conductivity, pH, temperature, dissolved oxygen, and salinity were monitored using the in-line sensors mounted in a flow-cell at the end of the sampling line. However, the groundwater yield at many sample intervals was too low to be continuously measured in the flow cell; the normal flow cell requires approximately 500 milliliters (mL) of water before it is full and the sensors are submerged. In many of the sample intervals, visually obvious when formation water was being extracted due to the dramatic increase in turbidity and periodic measurements of parameters were made if possible. At a few intervals yields were so low determination of formation water was based on turbidity alone (typically above 1000 nephelometric turbidity units [NTU] versus 0 NTU for distilled water), and there was barely sufficient groundwater volume to fill the full number of sample containers (three 40 mL VOA). The amount of groundwater purged prior to sampling always exceeded the amount of distilled water used during tool advancement.

Groundwater samples were conveyed to the surface via small-diameter Teflon[®] tubing that was attached to a fitting inside of the Profiler tip and passed up through the inside of the threaded steel pipes. A common Waterloo Profiler[®] sampling system configuration includes the use of a peristaltic pump with in-line sample containers. Standard 40-milliliter (mL) glass volatile organic ampoules (VOA) sample bottles are held in stainless-steel bottle holders used to collect the sample directly from the suction side of the pump so the sample does not contact the pump head tubing or the atmosphere. However, high suspended solids content and gas in the sampling line prevented the system from working properly. Gas in the sample line is likely the result of suction-induced degassing of dissolved gasses (e.g., carbon dioxide, oxygen, methane, ethane, etc.) The stainless-steel tubes repeatedly plugged with sediment and gas generated in the sampling line continuously bubbled through the water in the sample vials, potentially adversely impacting the quality of the sample. For these reasons, the sample manifold was not and the samples were collected on the effluent side of the pump head using standard procedures for filling of VOAs.

C.1.1.3 Hydropunch® and Temporary Well Grab Groundwater Sampling

From the depth at which groundwater was first encountered to approximately 20 feet bgs, yields were so low that the Waterloo Profiler®, with a very small sample intake area, was unable to function. For this reason a Hydropunch® tool was used to sample groundwater zones shallower than 20 feet bgs due to low groundwater yields. A Hydropunch® tool with a Hydropunch® screen 1 foot in length has an approximate screen area of 183 cm² (28 in.²) When this method was used, the Hydropunch® was driven on the end of the same rods used to advance the Waterloo Profiler® tool. Once the target depth was reached, the rods retracted exposing a 1-foot stainless-steel screen, and allowing groundwater to flow into the tool.

Teflon® tubing was lowered to screen interval of the Hydropunch® sampler, and groundwater samples were conveyed to the surface and collected using the same procedures detailed for the Waterloo Profiler®. Once the sample was collected, rods were retracted from the boring. If a second interval was to be sampled using Hydropunch®, then the rods were decontaminated and driven to the lower depth in the same boring.

At one sample interval (RGW-11 at 10 feet bgs), a temporary ¾-inch PVC well was used in place of the Waterloo Profiler® or the Hydropunch® tool. Groundwater yields at this location were so low that the PVC well was left in overnight to allow accumulation of sufficient volume to allow collection of samples. At all depths, often fewer than a full number of VOAs required were collected because of limited yields.

C.1.1.4 CPT and Grab Groundwater Sampling Borehole Abandonment

Once sampling was completed at each CPT and grab groundwater sampling borehole was grouted from the bottom up. A rod with a disposable tip was advanced to the total depth of the borehole. A PVC pipe was placed in the rod, and the rod was then retracted. Each hole was sealed by the emplacement of cement grout through a PVC tremie pipe, displacing borehole water as the grout was injected and the pipe was removed. The surface of the hole was restored to the original condition.

C.1.2 Monitoring Well Drilling and Construction

C.1.2.1 Drilling

Rotosonic drilling was used at most locations for well construction, including all locations within the facility where the highest levels of contamination are present. In the initial phase, at locations with limited-access, a limited-access hollow-stem-auger rig was used for well installation. After the initial rounds of groundwater sampling, it was determined that additional wells were needed. At the time these newer wells were installed (in September 2005), a recently constructed limited-access rotosonic rig was now available and used to install these newer wells.

During drilling, soil samples were collected continuously for lithologic interpretation (Section C.1.1.1). At a minimum of 5-foot intervals, a portion of the sample was placed into a sealable plastic bag and screened in the field for total organic vapors using a photoionization detector (PID).

C.1.2.2 Rotosonic Drilling

Rotosonic drilling is a technologically advanced method using a combination of tool rotation, hydraulic direct-push, and mechanically-generated oscillations to advance a dual walled of drill casing. Advantages of the rotosonic drilling method over other methods are that it:

- Drills through most type of alluvial soils.
- Yields continuous, relatively undisturbed cores.
- Uses no fluid (mud or air) to return drill cuttings.
- Flush-cases the borehole during drilling to minimize the risk of cross-contamination within the borehole, which is particularly import in areas of highest contamination.
- Typically yields significantly fewer cuttings than conventional methods.

The inner drill pipe contains a core bit and acts as the core barrel sampler, while the outer pipe is used to prevent the collapse of the borehole during drilling and during the removal of core samples and construction of monitoring wells. The inner drill pipe is advanced in front of the outer drill pipe, collecting a continuous core sample. To recover the sample, the outer drill pipe is advanced down over the inner core barrel to hold the boring open, and the core barrel is lifted to the surface for sample recovery. The sample is vibrated out of the drill pipe into a plastic sheath for visual logging.

C.1.2.3 Hollow-Stem-Auger Drilling

A track-mounted CME 750, limited-access drill rig utilizing hollow-stem auger drilling methods was used for installation of monitoring wells which are located in areas difficult to access with the larger rotosonic rig (MW-04-15, RMW-05-15, RMW-08-15, RMW-08-35, RMW-09-15, RMW-09-35, RMW-10-15, and RMW-10-35).

Hollow-stem-auger rigs typical uses 5-foot sections of hollow drill pipe with auger flights welded to exterior (augers). These augers are rotated and downward pressure is applied to advance the borehole and remove soil cuttings. The hollow portion of the drill pipe allows insertion of a 5-foot core barrel to be advanced ahead of the drill bit allowing the collection of relatively undisturbed core for lithological logging. "Undisturbed" samples for soil samples for analytical or physical properties can also be collected through the auger.

C.1.2.4 Logging and Field Documentation

Logging of unconsolidated soil was performed by inspection of the continuous cores. Soil samples were visually classified in the field by a qualified geologist using the Unified Soil Classification System (USCS) (ASTM 2000a & b). In addition to the USCS classification, the boring logs include a description of color, consistency, grain-size distribution, changes in soil types, moisture content, and observations, such as debris. The logs also note approximate upper and lower limits of each distinct soil type encountered, signs of disturbance, and any problems encountered.

Additional information recorded on the boring logs includes:

- Sampler type, drilling method, and equipment used.
- Depth to water as first encountered during drilling.
- Date and time of start and completion of boring.
- Names of driller and onsite geologist.
- Observable contamination such as discoloration or odor.

General QC procedures applied during drilling activities included:

- Visually checking the ground surface in the vicinity of each boring to ensure that drill rig fluids (fuel or hydraulic fluid) did not leak and contaminate potential soil sample locations.
- Verifying that the drill pipes were decontaminated prior to use at each of the locations.
- Verifying that all sampling equipment was decontaminated between sampling intervals.

C.1.2.5 Monitoring Well Installation and Construction

All monitoring wells were constructed with new, decontaminated, 4-inch, flush-jointed and threaded, Schedule 40 PVC well casing and screen, with a threaded PVC bottom cap. The slot size for screened intervals was 0.02-inch. All but two wells were constructed with screens intervals 10-feet in length, Monitoring wells RMW-02-32 and RMW-12-32 were constructed with five-foot screen lengths to maximize the distance between the vertical distance between the screen interval of nearby wells screened shallow and deeper intervals at the same locations. The filter pack was constructed with RMC No. 3 Monterey Sand, which extended from the bottom of the screen interval to a minimum of one foot above the top of the screen. A one to two foot bentonite seal consisting of pure 1/4-inch to 3/8-inch sodium bentonite chips were placed above the filter pack. A sanitary seal consisting of Portland cement grout was placed above the bentonite seal to near ground surface. Wells were completed above ground with a protective steel casing and bollards or flush with the ground surface using a traffic-rated utility box. Depths, dimensions, and materials used in well installation was recorded and have been presented in a well construction diagrams (Appendix B).

The first installation of monitoring well RMW-12-32 was unsuccessful. Upon development of the originally constructed well, pieces of PVC well screen and filter pack sand were encountered removed from this well. It was determined that the well screen was broken and the well had to be replaced. Because of the very high density of underground utilities at this location, it was not possible to abandon the original well location and replace the well at a nearby location (the preferable option). Since no alternative location was possible, this well was reconstructed in the same borehole. The very high pH measurements since reconstruction of well RMW-12-32 indicate that Portland cement grout either from the original construction of this well or the reconstruction is likely mixed with or in direct contact with the filter pack.

C.1.2.6 Monitoring Well Development

Newly-installed monitoring wells were developed no sooner than 24 hours after completion. A development record were maintained for each monitoring well. Development records include:

- Monitoring well number.
- Date and time of development.
- Development method.
- Monitoring well depth.
- Volume of water produced.
- Description of water produced.
- Post-development water level and monitoring well depth.
- Field analytical measurements, including pH, temperature, electrical conductivity, and turbidity.

Immediately prior to well development, the depth to groundwater, with respect to the top of the north side of the wells casing (surveyed reference point), was measured and recorded. A piston-type bottom suction bailer was used to remove heavy sediments that may have accumulated during well construction. Once the well sediments was removed, well development began by surging the well screen with a close fitting surge-block, starting at the bottom of the screen and proceeding upwards, throughout the screened zone. Surging was conducted for three minutes per foot of well screen interval. Following surging, the well was pumped to remove the fine materials that have been drawn into the well. During pumping, measurements of pH, temperature, and specific conductance were recorded.

Development continued by alternately surging and pumping until the discharge water is free from sand and silt, the turbidity is substantially reduced, and the pH, temperature, and specific conductance have stabilized. Development activities were repeated and until the water removed from the well is as clear of turbidity as practicable. Except for wells RMW-03-15 and RMW-06-15, which are low yield wells, a minimum of ten casing volumes of water was removed from each well.

C.1.3 Surveying

All existing and new groundwater monitoring wells, grab groundwater sampling locations, non-residential soil gas sampling locations, non-residential soil sampling locations, and permanent soil gas probe locations were surveyed by a California-licensed land surveyor. The horizontal surveyed point for all monitoring wells was the north side of casing, and the vertical surveyed points included the north side of the top of casing, the north side of the well box, and ground surface immediately north of the well. For all grab groundwater sampling locations, non-residential soil gas sampling locations and non-residential soil sampling locations, the surveyed location was the center of the finished boring. For permanent soil gas probes the surveyed location was the center of the utility box.

Horizontal datum was referenced to the California State Plane Grid System, Zone 2, based on the North American Datum of 1983 (NAD83). The vertical datum was referenced to the National Geodetic Vertical Datum 1988 (NGVD 88) benchmarks. A horizontal and vertical

accuracy of ± 0.01 foot was reported for all locations. Survey reports are available in Appendix B.

C.1.4 Water Level and LNAPL Thickness Measurements

During each groundwater sampling event, depth to groundwater was measured from the marked survey point on the north side of the well casing. Water level measurements for each event were collected on the same day. LNAPL in MW-14 was measured once on March 14, 2005, at the time a LNAPL sample was collected from this well, using an oil-water interface probe. All measurements of depth to water and depth to LNAPL were made to the nearest 0.01 foot.

C.1.5 NAPL Sampling

A disposable polyethylene bailer was used to collect a LNAPL sample from monitoring well MW-14. Approximately 20 mL of LNAPL was placed in two 40 mL VOAs with no preservative. The samples were shipped to the appropriate laboratories in accordance with Department of Transportation (DOT) regulations for exempted quantities of hazardous materials.

C.1.6 Monitoring Well Sampling

The groundwater monitoring program included sampling of monitoring wells constructed as part of this RI as well as the six monitoring wells owned by Union Pacific Railroad at the 1401 3rd Street railroad yard.

C.1.6.1 Purging and Sampling

During groundwater sampling events, all monitoring wells, except monitoring wells RMW-03-15 and BPZ-01, were purged and sampled using low-flow (minimal drawdown) sampling methods. Low-flow groundwater sampling is the process of purging and sampling wells at low-flow rates from within the well screen zone to minimize purging and improve sample quality. Low-flow groundwater sampling has the advantage of producing a groundwater with less disturbance resulting in more representative results for sensitive parameters, and a representative groundwater sample with far less total well purge water than is obtained from conventional sampling of monitoring wells, in which three well volumes are purged prior to sampling (Yeskis and Zavala 2002).

Low-flow sampling procedures used in this investigation were adapted from ASTM method D6771-02 (2002). Low-flow pumps with variable flow rate control were used. From first quarter (March) 2005 to third quarter (September) 2005 Fultz submersible pumps (Lewistown, PA) were used, with a practical flow rate from zero to two gallons per minute (gpm). Beginning in the first quarter (January) 2006 to the present, BESST Blatypus[®] brand (San Rafael, CA) positive displacement pumps were used, with a practical flow rate of zero to two gpm. Fultz pumps are submersible impeller pumps capable of low-flow rates. Blatypus[®] pumps are positive displacement pumps that differ from the more common bladder pumps in that cycling of groundwater up and down in the drive line is used in place of a bladder. The method of sampling was changed because of the advantages of:

- Pumps being dedicated to each well, the positive displacement pumps do not need to be decontaminated between each well. The need for no decontamination reduces the potential for cross contamination and increases the sampling efficiency.
- Less equipment is required to operate the positive displacement pumps increasing efficiency and reducing costs.
- The lower equipment requirements, no below surface electrical usage, and fewer moving parts increase the reliability of the positive displacement pumps.

Fultz pumps were decontaminated between each well in accordance with procedures described below. Blatypus pumps are dedicated to each well, and left in place in EPA monitoring wells or removed and stored individually for UPRR owned wells.

Because of the shallowness of the water table, typically the screen interval of most wells is entirely submerged. The pump intake was placed in the middle of the screen interval. As possible a flow rate for each well was used, between 100 and 500 mL/minute, that did not lower the water level more than 10 percent of the screen length. Monitoring wells RMW-06-15 and RMW-12-32 exhibited slowly declining water levels even when purged at minimum rate of 100 mL/minute. Although the water levels do continually decline in these wells, there is enough yield from the formation that it was determined that low-flow purging could continued to be used for these two wells.

Monitoring wells RMW-03-15 and BPZ-01 purged dry at even the lowest purge rate. For these wells it was determined that low-flow purge was not the appropriate sampling method. Sampling of these two wells is done by bailing the well dry, and collected a sample with 24 hours after purging. For both these wells, less than 80% recovery is achieved in this 24 hour period and often insufficient groundwater is available to fill the full complement of sample bottles.

For the wells sampled using low-flow purging, water quality indicator parameters were measured using direct-reading meters in a flow-through cell. Measurements were taken every three to five minutes at the flow rate described above. Stabilization is achieved after all parameters have stabilized for three successive readings. The stabilization criteria are as follows:

Field Parameter	Stabilization Criteria
pH	± 0.1
Electric conductivity	± 3%
Oxidation-reduction potential	± 10 millivolts (mV)
Dissolved oxygen	± 0.3 mg/L
Turbidity	± 10% (when turbidity > 10 NTU)

NTU = nephelometric turbidity unit.

An initial change in the measurements typically indicates that water is being drawn from a different source (“active” versus “stagnant” water), and stabilization of these parameters indicates that the water is coming from a steady-state source (the formation immediately

surrounding the well screen near the pump intake). If stabilization cannot be achieved, purging was terminated after 45 minutes.

After completion of the purging phase, the flow-through cell was removed and the groundwater samples were collected directly from the pump discharge tubing. All samples were collected in certified, pre-cleaned sample containers. Sample volumes to be field-filtered were filtered using a disposable 0.45-micron in-line filter and collected in the appropriate sample container. The first 500 mL of sample passed through the in-line filter was not collected in the sample container to ensure that the filter media has equilibrated to the sample.

C.1.6.2 Field Analyses

Ferrous iron, alkalinity, and carbon dioxide were measured in the field using a Hach[®] portable colorimeter and test kits. These parameters were recommended for field analysis because they are highly unstable and should be analyzed as soon as possible after sample collection. Procedures for field analysis are summarized in the following subsections.

All glassware or plasticware used in the analyses were cleaned prior to sample collection by thoroughly washing. If the concentration of an analyte is above the range detectable by the titrimetric or colorimetric methods, the analysis were repeated by diluting the groundwater sample with distilled water until the analyte concentration fall to a level within the range of the method.

Field analyses were not regularly conducted on groundwater from the following wells for the reasons given:

- RMW-3-15:
 - Groundwater from this well is considered heavily “disturbed” by the total purge method used for this well that purged dry. For this reason field analyses of unstable parameters were likely not representative of formation water at this location.
 - Insufficient volume often precluded collection of the full complement of samples containers, and the decision was made to fill as many sample containers as possible rather than conduct field analyses that were unlikely to be meaningful for the above reason.
- RMW-12-32:
 - The carbon dioxide method using sodium hydroxide to conduct the titration. The groundwater from this sample reacted with the sodium hydroxide solution creating a flocculate precipitate that interfered with use of the carbon dioxide analysis.
 - The elevated pH due to grout in contact with the filter pack, interfere with the alkalinity field test kit results rendering these values unreliable.

- BPZ-01:
 - Groundwater from this well was heavily “disturbed” by the total purge method used for this well that purged dry. For this reason field analyses of unstable parameters were likely not representative of formation water at this location.
 - Insufficient volume often precluded collection of the full complement of samples, and the decision was made to fill as many sample containers as possible rather than conduct field analyses that were unlikely to be meaningful for the above reason.
 - This well is screened in organic-rich bay mud or peat, and is black even when filtered. The dark color of this water precluded the accurate usage of the colorimetric method of all the field test kits.
- BMW-8: This well is screened in organic-rich bay mud or peat, and is black even when filtered. The dark color of this water precluded the accurate usage of the colorimetric method of all the field test kits.

C.1.6.2.1 Ferrous Iron Measurements

Ferrous iron [Iron (II)] concentrations were measured in the field using colorimetric analysis with a Hach[®] DR/700 portable colorimeter after appropriate sample preparation. Hach[®] Method 8146 for ferrous iron (0 to 3.0 mg/L) was used to prepare and quantitate the samples.

C.1.6.2.2 Alkalinity Measurements

Alkalinity of the groundwater samples were measured in the field by titrimetric analysis using Hach[®] Method 8221 (0 to 5,000 mg/L as calcium carbonate).

C.1.6.2.3 Carbon Dioxide Measurements

Carbon dioxide were measured in the field use titrimetric analysis after appropriate sample preparation. Hach[®] titrimetric method CA-23 (using a caustic titrant and phenolphthalein indicator) for carbon dioxide was used to prepare and analyze the samples. The Hach[®] method CA-23 is equivalent to the CHMetric[®] kit proposed in the SAP.

C.1.7 Aquifer Testing

To determine the aquifer hydraulic conductivity slug tests were conducted on by performing both falling-head (“slug in”) and rising-head (“slug out”) tests at each location. Because of the ease and rapidity of slug testing, a total of two falling-head and two rising-head test were conducted on each well tested.

Equipment used for slug testing included:

- A 3.5-inch diameter, 5-foot long solid polyethylene “slug.”
- Disposable nylon rope.
- Data logging Mini-Troll[®] pressure transducer.
- Laptop computer for programming the pressure transducer in the field.

C.1.7.1 Falling-Head Test

The falling-head test is the first step in the two-step slug testing procedure. The following steps describe procedures followed during performance of the falling head test.

1. The aquifer test data form was prepared with entries for:
 - Well number
 - Project number
 - Project name
 - Aquifer testing team
 - Climatic data
 - Reference point elevation
 - Identification of measuring equipment being used
 - Static water level
 - Date
2. The static water level in the well was measured to the nearest 0.01 foot.
3. The decontaminated pressure transducer was lowered into the well and the displaced water is allowed to return to its static level. Typically 12 hours or more (i.e., overnight) was allowed for static water level to re-equilibrate. The water level was checked again before testing to ensure the water level had returned to the static level recorded before the transducer was inserted.
4. The decontaminated slug device was lowered into the well to just above the water level in the well.
5. The data logger was started and the slug was quickly lowered, but not dropped, below the water level in the well, not disturbing the pressure transducer.
6. Data recording was not stopped before the water level in the well had recovered to at least 80 percent of the initial water level.

C.1.7.2 Rising Head Test

After completion of the falling head test, the rising head test is performed. The following steps describe the rising head slug test procedure.

1. The water level in the well was measured to the nearest 0.01 foot to ensure that it had returned to the static water level.
2. Data recording was initiated and the slug quickly withdrawn from the well.
3. Data recording was not stopped before the water level in the well had recovered to at least 80 percent of the initial water level.

C.1.7.3 Slug Test Data Analysis

Data obtained during slug testing was analyzed using methods appropriate for the nature of data obtained from the slug tests. Based on the responses of the water levels during slug testing, it was determined that two analytical methods were appropriate for analysis of the data.

- As proposed in the SAP, the common Bouwer and Rice method for unconfined aquifers (Bouwer and Rice 1976, Bouwer 1989) was used for most analysis of the wells tested (i.e., RGW-03-15, RGW-07-15, RGW-08-15, RGW-09-15, and RGW-10-35 slug-in). This method assumes that the only factor affecting the response of the water level in the well is the

flow of groundwater to/from the well, and that release/storage of water from aquifer storage is negligible and can be disregarded.

- An analysis method different than that proposed in the SAP was used for analysis of several wells due to the mid-response curvature of the data in these wells (i.e., RGW-08-35, RGW-10-15, and RGW-10-35 slug-out). This mid-response curvature of the data suggests that in addition to flow of groundwater to/from these wells, that release/storage of water from aquifer storage was also a significant factor in response of the water level in these wells. Use of the KGS [Kansas Geological Survey] method (Hyder et al. 1994) for wells with this type of recovery response provides a more accurate estimation of hydraulic conductivity. Although a value for specific storage (i.e., water storage per unit aquifer volume) is provided by this model, the calculated value for specific storage is mathematically so highly sensitive that this value returned by the model is considered unusably inaccurate.

AQTESOLV for Windows version 3.5 (HydroSOLV 1996-2003) software was used to aid in the analysis of the slug test data. This software contains a large library of methods for analysis of aquifer slug and pumping test, increases the ease and accuracy of analysis, and provides detailed aquifer test reports (Appendix B).

C.1.8 Soil Sampling

C.1.8.1 On-Facility and Off-Facility Soil Sampling

Near-surface soil samples were collected using a Geoprobe[®] rig equipped with a hydraulic percussion hammer for tool advancement. Continuous soil cores were collected with a stainless-steel Macro-Core[®] sample tube (2.125-inch diameter by 48 inches long) lined with clear butyrate sleeves. The soil samples were collected from a depth interval of one to two feet bgs and at four to five-foot bgs, whenever possible. When concrete was present, ground surface was considered to be the bottom of the concrete (as thick as 40 inches in areas). Samples were only collected from unsaturated soils. Saturated soils, likely due to proximity to the water table, were first encountered at approximate depths varying from two to eight feet bgs throughout the on- and off-facility parcels.

Once the core was obtained, moisture content (i.e., degree of saturation) was roughly identified through the clear butyrate sleeve and intervals for analytical sample collection were identified. The sleeve was then horizontally cut, moisture content was verified, and the sleeve was capped at each end with a Teflon[®] sheet covered by a polyethylene cap for submittal for volatile organic compound (VOC) analysis. The clear butyrate sleeve containing the remainder of the soil core was then longitudinally cut to expose the recovered sediments and logged as detailed in Section C.1.1.1. Once logged, soil was collected from the identified analytical sample interval(s) and composited in a disposable, resealable plastic bag. Each composite was placed in a shaded area and allowed stabilize for approximately five minutes. Headspace was then scanned with a photoionization detector (PID), equipped with a 11.6 electron-volt (eV) lamp, for total volatile organic compounds. Finally, additional soil aliquots for laboratory analysis (as required by the Sampling and Analysis Plan) were collected and the remaining soil was added to the drill cuttings for proper disposal.

Following sampling, each borehole was backfilled with a cement grout, and finished to the original surface condition.

C.1.8.2 Residential Soil Sampling

At residential parcels, soil samples were collected for chemical and soil physical property analysis. Soil sampling at all these locations was conducted using hand tools, specifically stainless steel hand augers and slide hammers with a stainless steel sampling shoe. The proposed sampling depth at each location was 0.5 to 1.0 and 2.5 to 3.0 feet bgs. All but one sample was collected at the proposed depth. This one sample was collected at 2.0 to 2.5 feet bgs because of soil conditions that prevent augering to a greater depth. All down-hole sampling tools were decontaminated between locations and between sampling depths.

Residential Samples for Chemical Analysis

Prior to sampling, a hand auger was used to dig to the depth just above the sample interval. Sampling then was completed using a slide hammer to drive a sampling "shoe" containing a 2-inch diameter, 6-inch long stainless steel sleeve. In accordance with EPA method 5035, immediately after retrieval of the sample three Encore™ sample containers were used to collect soil for VOC analysis from "undisturbed" soil core remaining in the sampling "shoe." After collection of the VOC sample, the remaining soil homogenized and then transferred to certified, precleaned 8-ounce glass jars with Teflon® line-lids for distribution to additional laboratories for the remaining analyses.

Residential Samples for Soil Physical Property Analysis

Prior to sampling, a hand auger was used to dig to the depth just above the sample interval. Sampling then was completed using a slide hammer to drive a sampling "shoe" containing a 3-inch diameter, 6-inch long brass sleeve. The physical properties sample in the brass sleeve was then removed from the sampling "shoe." The ends of the brass sleeve were covered with Teflon® sheets and sealed with end caps.

C.1.9 Residential Produce Sampling

The residential backyard produce sampling procedure was developed to minimize the loss of VOCs due to bruising and prevent contamination of the sample from direct contact with any other materials. Other than the one-liter certified pre-clean glass jar with a Teflon® lined-lid, the only other piece of sampling equipment was a pair of cleaned stainless steel scissors. The open jar was positioned below produce. The jar was angled to minimize the impact of the falling produce and thereby minimizing bruising. The stainless steel scissors were used to cut the stem allowing the produce to fall into the jar. To the extent possible each jar was filled with produce. Care was taken that no contact was made with any other objects, including the sampler's gloved hands, to avoid inadvertent contamination of the sample. In most cases, one MS/MSD was collected for each type of produce grown. Fewer than one MS/MSD per type of pepper were collected because of the wide variety of peppers being grown. Immediately after collection, each produce sample was placed on dry ice.

All produce samples were shipped on dry ice in accordance with DOT regulations for shipping exempted quantities of hazardous materials.

C.1.10 Soil Gas Sampling

Soil gas samples were collected from temporary borings on site, in residential backyards, and from permanent soil gas probes.

C.1.10.1 Soil Gas Survey Sampling

The following subsections describe the procedures used to collect soil gas samples from the temporary borings.

C.1.10.1.1 System Set-up

Soil gas survey samples on site were collected from temporary borings advanced by a Geoprobe® direct-push rig (same rig as used for soil sampling) using Post Run Tubing (PRT) equipment. The PRT system consists of a series of hardened steel rods, a PRT drive-point holder, and expendable aluminum drive points. The PRT system was driven to the desired sample depth (approximately 2.5 feet bgs [below concrete bottom/top of soil]), then slightly retracted (3 to 4 inches), allowing the expendable drive point to “fall out” of the drive-point holder and exposing the PRT drive-point holder to the surrounding soil pore space. A PRT adapter and Teflon® tubing were advanced down the inner rods and secured to the expendable point holder. New tubing was used at each sampling point.

Above ground, the sample tubing exits the drilling rods and attaches to the vacuum tank apparatus, equipped with a flow rate meter. A “T-junction” is installed on the intake side of the vacuum tank apparatus and two gas-tight disposable 60-mL syringes are installed on the other branch of the junction. Each syringe was individually pressure tested prior to being attached to the sampling system to ensure that syringe had no defects, which could potentially cause leakage.

To achieve a leak-free seal between the aboveground atmosphere and the probe, hydrated granular (fine) bentonite was packed over the contact point with ground surface.

C.1.10.1.2 Purge Volume Testing

To ensure that stagnant or ambient air was removed from the sampling system and to ensure that samples collected are representative of subsurface conditions, a purge volume test was conducted at the first sampling point (RSG-21). RSG-21 was chosen for the purge volume test as it is located near the center of the Site, where historical concentrations have been greatest. First, a system volume was calculated by:

$$(V \times L) + a \tag{1}$$

where: V = interval volume of tubing per foot.

3/16" inside diameter (ID) tubing (1/4" outside diameter [OD])
= 5.43 mL/ft (milliliters per foot)

1/4" ID tube (5/16" OD) tubing = 9.65 mL/ft.

L = Total length of tubing below and above ground.

a = Annular space around the soil probe implant (this volume was estimated at 25 mL).

Step purge tests of one, three, and seven system purge volumes were conducted as a means to determine the purge volume to be applied at all sampling points. After mobile laboratory analysis of these samples, it was determined that removing seven system volumes yielded the highest VOC concentrations, and therefore, most representative sample. A seven tubing volume purge was used at all subsequent soil gas sampling locations.

C.1.10.1.3 Purging/Flow Rate

Sample points were purged and sampled using the vacuum system on the rig. Once the appropriate purge volume had been calculated (as detailed in the preceding Section), the system was purged at a constant flow rate of 0.4 CFH (189 mL/min), as regulated with the in-line flow meter, until the appropriate volume was purged. Once purging was complete, the line connected to the vacuum apparatus was clamped closed and sampling procedures began as detailed in the following Section.

To ensure a representative soil gas sample was being collected, and that the sampling system was not short-circuiting to the atmosphere, a tracer gas was used to detect leaks. An aerosol can of electronic duster containing 1,1-difluoroethane (DFA)(propellant) was used for leak detection. 1,1-Difluoroethane is an ideal leak detection compound because the on-site mobile laboratory was able to analyze for this compound, it is non-toxic, is not a compound of concern at the facility, and does not react with any of the known contaminants of concern. DFA (and 1,1,1,2 trifluoroethane [TFA], another duster compound propellant) are so highly volatile that when released from pressurized containers, they instantly volatilize and are lost to the atmosphere, and for this reason rarely if ever remain as contaminants at any site. Prior and during purging of each soil gas sample location, the compressed air was sprayed around the base of the boring and at all connections.

1,1-Difluoroethane was detected in two soil gas survey samples (RSG-03 and RSG-42 [duplicate]), indicating that short circuiting or leakage was occurring. These samples were subsequently recollected successfully, with no 1,1-difluoroethane detected in the second sample collected. This second sample was used added to the database for analytical results at this location.

C.1.10.1.4 Soil Gas Sampling Procedure

Once purging was complete, and the line connected to the vacuum pump apparatus was clamped closed, a sample was extracted from the line (from the alternate branch of the "T-junction", on the intake side of the vacuum tank). Two 60 mL, disposable syringes (fitted with valves) were filled in sequence by manually retracting the plungers and drawing soil gas into the body of the syringe. Special care was taken to match the purge rate of approximately 200 mL/min during sample collection.

Following sample collection, the valve on each syringe was closed, wrapped in foil to eliminate exposure to sunlight, and immediately delivered to the mobile laboratory. Once at the mobile laboratory, each sample was logged onto the chain of custody and analyzed. If a sample was not immediately analyzed, then it was stored in a sealed plastic container, and not exposed to any light.

C.1.10.2 Residential Soil Gas Sampling

Soil gas survey samples were collected in residential backyards by using a commercially-available slide-hammer to drive a 3/8-inch-diameter hollow rod with a closed retractable

PRT soil vapor sampling tip attached. The soil gas sampling tool was driven to desired sampling depth of 2.5 feet bgs.. Prior to advancing the bar, small-diameter (1/4 -inch OD by 3/16-inch ID) Teflon[®] tubing was strung through the drive rod and attached the hose-barb fitting retractable tip. Once driven to the desired depth (2.5 feet bgs), the bar was retracted approximately 2 inches, exposing 2-inch stainless steel screen (similar to the procedure described Section C.1.10.1.3). Because of saturated soil due to irrigation, soil gas samples in South Prescott Park were driven to 2 feet bgs. An inert sealing material (e.g., hydrated powdered bentonite) was packed over the contact point with ground surface to seal the hole. The same leak detection methods (including spraying aerosol DFA or TFA) detailed in Section C.1.10.1.4 were used during residential soil gas sampling.

Once the tip was driven to the desired depth, the tubing was attached to a hand vacuum pump (with an approximate volume of 15 mL per stroke) through a “T-junction” as described in Section C.1.10.1.4. The other branch of the “T-junction” was attached to the swage fitting on the Summa canister sample train (canister and in-line stainless-steel filter) after removing the brass cap used during transport. Once all connections were made approximately three tubing volumes were purged prior to sample collection using the hand pump. Following purging, the pump tubing was clamped off and the twist valve on the canister was opened, drawing soil gas into the canister, and the beginning sample time was recorded. Once the vacuum in the canister had dissipated, the twist valve was closed, and the time recorded. After the final canister pressure had been verified, the brass cap was replaced and tightened over the swage fitting. Ideally -5 to -0.5 pounds per square inch (psi) of vacuum would remain in the Summa canister. This remaining vacuum allows the lowest possible detection limit and allows a check of the canister pressure upon receipt by the laboratory. Any loss of vacuum during from the time of sample to receipt by the laboratory would indicate leakage of the canister during storage and/or transit.

C.1.10.3 Permanent Soil Gas Probe Installation and Sampling

Permanent soil gas probes (Geoprobe[®] Permenant Soil Vapor Implants; Salina, KS) were installed at depths ranging from 2 to 4 feet bgs. Permanent soil gas probes at the facility were installed using a Geoprobe[®] rig (RSP-1 through RSP-6), and permanent soil gas probes installed in the interceptor trench backfill (RPS-7) and in the utility trench backfill sand (RSP-8 through RSP-12) were installed using hand tools. Each probe was constructed with a 6-inch stainless-steel mesh screen implant attached to 5/16-inch OD by 1/4-inch ID Teflon[®] tubing extending to the ground surface. The screen implants were imbedded in RMC No. 2/12 Monterey sand that extended above and below the screen interval of the probe. One quarter foot of dry granular bentonite was placed on top of the sand pack, then the borehole was grouted to near-surface with neat Portland cement grout. Each probe was completed with a flush-mounted traffic-rated (aircraft runway) well box, which was set in concrete. At ground surface, within the well box, the Teflon[®] tubing was fitted with stainless-steel Swagelock[®] fittings that can be connected to soil gas sampling equipment and sealed when not in use. Construction diagrams of the permanent soil gas probes are provided in Appendix B.

Sampling of permanent soil gas probes began by attaching a sampling “T”-junction with attached Summa canister and purge pump to the soil gas probe fitting. Purging and

sampling of the permanent soil gas probes was conducted in the same manner as the residential soil gas sampling, as described in Sections C.1.10.1.3 and C.1.10.1.4.

C.1.11 Crawl Space Air and Ambient Air Sampling

C.1.11.1 Summa Canister Sampling

Crawl space air and ambient air samples were collected on the same day as the soil gas samples at each residential location. Each crawl space air or ambient air sample was collected as an integrated sample over a period of approximately 4 hours. The Summa canisters and flow controllers were pre-calibrated by the laboratory to collect the necessary volume over the specified time period.

The sampling train (Summa canister, vacuum gauge, flow controller, in-line particulate filter) for ambient air samples was placed so that the sample inlet was approximately 1 meter (3.3 feet) aboveground surface, the approximate breathing level of a child. For crawl space samples, the Teflon[®] tubing connected to the Summa canister was advanced inside the crawl space area.

The following information was recorded on the sampling log: the canister serial number, the flow controller serial number, the ambient temperature, the initial and ending pressure of the canister, and sampling start and end time. The pressure of each canister was checked prior to and after sampling. To accomplish the pressure check, a vacuum gauge was attached directly to the canister without the flow controller in place; the canister valve was opened; the pressure recorded; and the valve was closed.

Background ambient air samples were collected at an off-site location over two 4-hour periods during the morning and afternoon times of the sampling date.

C.1.11.2 Low Detection Limit Naphthalene Sampling

Although not originally proposed in the SAP, to evaluate that vapor intrusion potential of naphthalene low-detection detection limit sampling was completed in May 11 and 12, 2005. To meet the low detection limit analysis high volume air samples are required. To perform this sampling a Tisch[™] TE-5170V (Tisch Environmental Inc.; Village of Cleves, OH) electrically powered high volume air sampler with a Tisch[™] PUF (polyurethane foam) TE-1000 sample cartridge holder.

Prior to sampling each of the seven Tisch[™] air sampler was individually calibrated to adjust and determine the exact air flow through rate. In accordance with manufactures manual, calibration was conducted in by adjusting a flow adjustment valve while measuring a series of values for the internal vacuum (magnehelic reading) and the pressure drop (in inches of water) across test PUF sample cartridge. Then using a manufacturer provided Excel spreadsheet (Tisch undated) a flow rate calibration curve was developed using the pressure drop across the sampler at various magnehelic readings which also required, the barometric pressure and ambient temperature at the time of calibration and the time of sampling. The corresponding magnehelic readings and pressure drop during calibration were recorded in a field notebook. Temperature and barometric pressure readings for Oakland for the period of calibration and sampling were obtained hourly reading from automated weather stations

(Wunderground.com 2005). Based on the final calibration air flow rates for each sampler were estimated as shown in Table C-1.

TABLE C-1
Tisch™ PUF High Volume Air Sampler Sampling Operation Parameters
AMCO Superfund Site
Oakland, California

Sample ID	Sampler SN	Flow Rate (m ³ /min)	Operation Time (min)	Sample Volume	
				m ³	liters
322-BA-AM-0505*	1839	0.217	400	86.8	86,800
322-BA-PM-0505*		0.212	406	86.1	86,100
1428AA-0505	1836	0.215	404	86.9	86,900
1428AA-0505 (Duplicate)	1837	0.213	403	85.8	85,800
1432AA-0505	1841	0.208	403	83.8	83,800
1436AA-0505	1840	0.213	404	86.1	86,100
326AA-0505	1838	0.204	445	90.8	91,800
360AA-0505	1842	0.191	405	77.4	77,400

Notes:

m³ = cubic meters
min = minutes
SN = serial number

*Background samples using same sampler for morning and afternoon samples

Temperature at calibration = 65.5°F

Barometric pressure at calibration = 30.05 inches of water

Average temperature during sampling = 61.8°F

Average barometric pressure at sampling = 30.07 inches of water

Tisch™ samplers were set up in the backyards of each residence sampled and at the background location (the sampler intake is 4 feet above the ground surface). PUF sample cartridges provided by the analytical laboratory (Air Toxics; Rancho Cordova, CA) were loading into the sampler. Each glass sample cartridge was pre-cleaned, and packed with a precise amount of SVOC sorbant material held in place between polyurethane foam pads, which in turn were secured with stainless steel screen at each end. The Tisch™ samples were then turned on and operated for a prescribed amount of time at a flow rate set at the time of calibration. A run time (400 minutes or more) was established to obtain total air sample volume, as indicated by the laboratory, that was necessary to achieve the method detection limit.

After completion of the sample time, the sample cartridge removed, wrapped in aluminum foil, and placed in a ziplock bag provided by the analytical laboratory. The sample cartridges were placed on ice and couriered to the analytical laboratory the following day. The total air sample volume was reported to the analytical laboratory for the calculation of the air concentration of naphthalene.

The information recording on the sampling datasheets included the Tisch™ sampler location, sampler serial number, sampler field designation (PUF-1 through PUF-7), sampling start and stop time, and sampling crew.

C.2 Quality Control Samples

QC samples were collected or prepared to assist in determining data reliability. These QC samples include field duplicates, equipment blanks, and laboratory QC samples (for MS/MSDs). QC samples are normally collected from locations that are suspected to be of moderate contamination. QC samples were collected using the same procedures as the collection of the target sample.

C.2.1 Field Duplicates

The field duplicate is an independent sample collected as close as possible to the original sample from the same source and is used to document sampling precision. The duplicate samples were labeled and packaged in the same manner as other samples so that the laboratory cannot distinguish between samples and duplicates. To the extent possible duplicate samples were taken from locations that were suspected or known to be at least moderately contaminated. Field duplicates were collected by alternately filling sample and sample duplicate containers at a location of known or suspected contamination. Each duplicate was taken using the same sampling and preservation method as other samples. Field duplicates were collected at a minimum frequency of one in every 10 samples.

C.2.2 Equipment Blanks

Equipment blanks were collected to verify that contamination was not introduced to samples through the use of decontaminated equipment.

During groundwater and soil sampling, equipment blanks were generally collected at minimum frequency of once per day by pouring blank water over or through decontaminated sampling equipment into the sample bottles. Commercially available ultra-pure water was used, using the same preservation methods and packaging and sealing procedures used during collection of groundwater samples. Exceptions to the frequency of sampling are described in Appendix D. After the installation of the positive displacement pumps for groundwater sampling, it was determined because of the exclusive use of dedicated and disposable equipment that the equipment blanks on unused disposable equipment could be reduced to once per event.

Because background air concentrations could not be considered “clean” for the purposes of collecting equipment blanks (see Section 5.0), Summa canister equipment blanks were collected.

C.2.3 Trip Blanks

The purpose of trip blanks is to verify that volatile contamination is not introduced to samples during transportation or through transportation materials. Commercially available trip blanks prepared with ultra-pure water were purchased and analyzed for VOCs only.

One trip blank was submitted each day of monitoring well sampling for VOCs. The trip blank was carried in a sample cooler throughout the day and were returned to the laboratory with the field samples.

C.2.4 Ambient Blanks

The use of ambient blanks was introduced for the groundwater monitoring program after the installation of the positive displacement pumps in the monitoring well. Ambient blanks were generally collected twice per week. Ambient blanks were collected at the well head by filling sample containers with ultra-pure blank water.

C.2.5 Laboratory QC Samples

Laboratory QC samples were collected to perform MS and MSD analyses. An MS is an aliquot of a sample spiked, at the laboratory, with a known concentration of target analyte(s) and provide a measure of the method accuracy. The MSD is a laboratory split sample of the MS and is used to determine the precision of the method.

For groundwater, twice the normal water volume was collected for laboratory QC samples. Extra volumes collected for laboratory QC samples were labeled as such on sample bottles and paperwork. For soil and groundwater, an MS/MSD was collected at the discretion of the field crew, at a frequency of one in every 20 consecutively collected samples. For produce, generally one MS/MSD was collected for each type of produce sample. The exception to this frequency was for peppers, which were present in a large number of different types.

C.3 Decontamination

C.3.1 Drilling Equipment

Downhole rods, drill pipes, and any other non-dedicated drilling or sampling equipment that came in contact with soil or groundwater was steam-cleaned prior to drilling subsequent borings. Steam cleaning occurred at containment areas where decontamination water was collected for disposal.

C.3.2 Sampling and Measurement Equipment

A decontamination station was established at the Site for cleaning reusable equipment. Detergent, brushes, and water were stored at the decontamination station in 5-gallon plastic buckets. All decontamination water was contained and collected for disposal.

The following is the general procedure that was used for decontaminating non-dedicated field equipment that directly or indirectly contacted samples during sampling activities:

- Physically remove any visible solids.
- Wash with non-phosphate detergent (i.e., Liquinox®).
- Rinse with potable water.
- Rinse with deionized water.

Any equipment that came in contact with NAPL (e.g., oil-water interface probe) also was rinsed with isopropyl alcohol prior to the deionized water rinse.

Cleaned equipment was stored in a clean area, and potentially-contaminated equipment was restricted to the decontamination area. Rinse water was transferred to labeled 55-gallon drums for subsequent storage prior to disposal.

Summa canisters and flow controllers used during soil gas and air sampling were certified clean by the laboratory. The PRT soil gas sampling equipment was decontaminated in the same manner as soil sampling equipment.

C.4 Investigation-derived Waste Management

In the process of conducting the RI field activities, the field team generated the following different types of potentially-contaminated IDW:

- Used personal protective equipment (PPE)
- Disposable sampling equipment
- Soil cuttings
- Free product (NAPL)
- Purge water
- Decontamination fluids

The procedures used for managing of these IDW are listed below:

- Used PPE and disposable equipment was bagged, tied off, and placed in a municipal refuse dumpster on site. These wastes are generally not considered hazardous and can be sent to a municipal landfill. None of the PPE used during the investigation was grossly-contaminated (e.g., contaminated with NAPL) and therefore did not require decontaminated prior to disposal.
- A small amount (< 1 liter) of LNAPL generated during sampling of monitoring well MW-14. This product was placed in partially filled drum containing groundwater that was prior to testing suspected to be hazardous waste. DOT-approved 55-gallon drums with secondary containment were used. This drum was designated and labeled as hazardous waste.
- Soil cuttings generated using the direct-push or drilling rigs were typically placed into DOT-approved 55-gallon drums. During rotosonic drilling in some locations “heaving sand” conditions required water washing, which generated large volumes of mixed soil and water. This saturated soil and water mixture was placed in a 4,900 gallon upright polyethylene tank with secondary containment. All drums and tanks were labeled as potential waste pending analysis.
- All purge water and decontamination fluids generated during the RI were placed into DOT-approved 55-gallon drums or the abovementioned polyethylene storage tank. All drums and tanks were labeled as potentially hazardous waste pending analysis.
- All IDW generated during field activities was stored on site in a locked and fenced yard at 1448 3rd Street where the field office was located.

- All IDW stored in drums and storage tanks were sampled and analyzed for chemical constituents as required by the destination disposal facility. All materials were designated and labeled as non-hazardous or hazardous waste in accordance with state and federal regulations. The wastes were transported and disposed by a certified waste-handling subcontractor. Wastes characterized as hazardous was disposed within 90 days of waste generation.

C.5 Sample Management Procedures and Documentation Requirements

This section discusses the sample management procedures that were followed during the performance of field activities. This section includes information regarding sample containers and preservatives and procedures for sample packaging and transportation, sample identification, sample labeling, and sample documentation.

C.5.1 Sample Containers and Preservatives

Sample containers for soil and groundwater were typically purchased with certificates of cleanliness from approved laboratory-product suppliers. Clean butyrate sleeves were provided by the drilling subcontractor. Sample containers for produce, soil gas, and air samples were provided by the laboratories.

C.5.1.1 Groundwater and NAPL

For VOC samples submitted to a fixed laboratory, a sufficient amount of 1:1 hydrochloric acid were inside the vials to lower the sample pH to less than 2 (2 mL). The vials were filled so that no gas was present after sample collection. Filled containers were checked by inverting the vial and tapping to reveal any air bubbles. If air bubbles were present, up to two more attempts were made to top off with vial without air bubbles, after which a new container was used. If the chemistry of the groundwater was such that the acid preservative generated gas bubbles, a preservative free VOA was used. Preservative free VOAs were noted on the COC to alert the laboratory to the shortened holding time. VOA containing sample were placed on ice after collection and during shipping. The holding time for preserved VOC samples was 14 days and the holding time for unpreserved samples was 7 days.

In accordance with recommendations of the EPA chemist at the Region IX laboratory (Richmond, CA) groundwater samples for 1,4-dioxane and SVOC analysis were collected in unpreserved 1-liter glass amber bottles and chilled on ice. The analytical holding time for this analysis were 7 days prior to extraction and 40 days following extraction. The exception was a grab groundwater sample collected for 1,4-dioxane analysis were collected in VOAs using the same procedures for collection of VOC samples in VOAs.

Samples for total metals or silica analysis were placed into 1-liter polyethylene bottles preserved by nitric acid and cooled to 4 °C. The maximum holding time is 28 days for mercury and silica and 6 months for other metals.

Samples for field-filtered metals analysis were passed through a disposable 0.45-micron in-line filter immediately prior to collection. In accordance with recommendations of the EPA

chemist at the Region IX laboratory (Richmond, CA), the samples were subsequently were placed into 500 mL polyethylene bottles preserved by nitric acid and ice. The maximum holding time is 28 days for dissolved mercury and 6 months for other dissolved metals.

Samples for hexavalent chromium were placed in one 125-mL polyethylene bottle and on ice. The analytical holding time for this method is 24 hours.

Samples for cyanide analysis were placed in 250 mL polyethylene bottles preserved with sodium hydroxide and placed on ice. The maximum holding time for cyanide is 14 days.

Samples to be analyzed for major anions (chloride, sulfate, nitrate, nitrite) or TDS were placed in a 500 mL polyethylene bottle without headspace and ice. The maximum analytical holding time for chloride and sulfate were 28 days; the maximum analytical holding time for nitrate and nitrite was 48 hours; the maximum analytical holding time for TDS were 7 days. Because of the short holding time for the anions sample, all samples were delivered to the EPA laboratory in Richmond, CA within 24 hours of collection.

In accordance with recommendations of the EPA chemist at the Region IX laboratory (Richmond, CA), samples collected for methane, ethane, and ethene (dissolved gasses) were collected in three preserved 40 mL VOA. The VOAs were filled so that no headspace is present after sample collection. If air bubbles were present, up to two more attempts were made to top off with vial without air bubbles, after which a new container was used. If the chemistry of the groundwater was such that the acid preservative generated gas bubbles, a preservative free VOA was used. Preservative free VOAs were noted on the COC to alert the laboratory to the shortened holding time. The container was cooled on ice prior to shipping. The maximum analytical and contract holding times for methane, ethane, and ethene is 14 days for preserved samples and 7 days for unpreserved samples. All samples for dissolved gasses were delivered to the EPA laboratory in Richmond, CA within 24 hours of collection.

Samples for total petroleum hydrocarbons as diesel and motor oil were placed in two 1-liter amber bottle and chilled on ice. The analytical holding time for this method is 28 days.

Samples collected for TOC were placed in one 250-mL polyethylene bottle preserved with sulfuric acid (H_2SO_4) and cooled to on ice. No headspace was allowed to remain in the sample bottle. The analytical holding time for TOC is 28 days.

C.5.1.2 Soil

All soil samples at on and off-facility parcels were collected using a Geoprobe[®] in clear butyrate sleeves (see Section C.2.8.1). In accordance with the SAP, samples submitted for VOC analysis were collected the bottom 4-inch section of the butyrate sleeves, that was cut from the remaining 4 feet of the sleeve, and capped with Teflon[®] sheet and plastic end caps. The remaining portion of the butyrate sleeve was split longitudinally, and after lithological logging, the remaining soil homogenized and distributed to 8-ounce glass jars to be shipped to various laboratories analysis of SVOC, 1,4-dioxane, organochlorine pesticides, PCBs, metals, and dioxins/furans, as indicated by SAP.

Residential soil samples were collected in 2-inch-diameter, 6-inch-long stainless steel sleeves. Samples for VOC analysis were sub-coned using Encore[®] sample containers, which

were then sealed in an Encore[®] sample pouch. The sleeve was then sealed with Teflon[®] sheeting end caps for all other analyses.

The maximum analytical holding time for VOCs in soil is 48 hours. The analytical holding time for 1,4-dioxane, SVOCs, polychlorinated biphenyls, and organochlorine pesticides is 14 days prior to extraction and 40 days following extraction. The analytical holding time for mercury is 28 days, and 6 months for other metals. The analytical holding time for dioxins/furans is 30 days prior to extraction and 45 days following extraction.

Soil samples for physical parameter analyses were collected in 2-inch-diameter, 3-inch-long stainless-steel sleeves, and capped with Teflon[®] sheeting and end caps to retain moisture. Holding times do not apply.

C.5.1.3 Soil Gas and Air

C.5.1.3.1 VOC Soil Gas and Air Samples

On and off-facility soil gas samples for analysis by the on-site laboratory were collected in 60 mL gas tight syringes, wrapped in aluminum foils (to prevent degradation of sensitive VOCs by sunlight), and delivered to the on-site mobile laboratory for immediate analysis.

All VOC samples of air and soil gas from South Prescott Soil, residential soil gas sampling, permanent soil gas probes were collected in Summa canisters, as described in Sections C.1.10.1.4. The samples were kept at room temperature until analysis. The samples collected in syringes were analyzed as soon as possible by the mobile laboratory. The samples collected in Summa canisters have a maximum analytical holding time of 14 days.

C.5.1.3.2 Naphthalene Air Samples

Ambient air samples for naphthalene (SVOC) analysis were collected using 80 grams of sorbent material packed in a PUF cartridge provided by the analytical laboratory. The precleaned glass PUF cartridges are 6.5 cm in diameter and 12 cm long. The sorbent is held in place between two polyurethane pads, which are secured by stainless steel screens. The hold time is 7 days for the sorbent once the SVOC sample was collected.

C.5.2 Sample Identification and Labeling

RI sample names were designated by the location ID and date (month and year). Other identifying designations were included to differentiate between media.

For samples being shipped to EPA Region IX laboratory or to one of the CLP ("EPA" contract laboratory program) laboratories, sample labels were generated using the Field Operations and Records Management System (FORMS) II Lite[™] software (DynCorp 2002). In addition to the unique RI sample designation, each sample shipped to a CLP laboratory had a unique CLP ID, as provided in the case assignment. The following information was printed on each sample container and was covered with clear plastic tape:

- Field Sample ID
- CLP ID (provided by the CLP manager)
- Case number
- Type of analysis requested
- Preservative used
- Date and time collected

For non-CLP samples, sample labels include the same information, minus the case number and CLP ID, which were not applicable. COCs were completed on paper forms in accordance with standard chain-of-custody requirements.

Custody seals were placed over the lids of each sample container. Custody seals on the VOA vials were placed around the lid to prevent covering the septum.

Immediately following sample collection, the filled sample containers with completed labels were sealed with custody seals, placed in plastic ziplock bags and placed in a cooler containing ice. VOA vials (three vials per sample) were wrapped together in bubble wrap, secured with tape, and placed into labeled, plastic ziplock bags. All other glass bottles were bubble-wrapped and placed into labeled, plastic ziplock resealable bags.

C.5.3 Sample Packaging and Shipment

The following procedures apply to samples to be shipped to a laboratory. Samples to be analyzed by a mobile laboratory were directly relinquished to the laboratory as soon as possible after sample collection.

C.5.3.1 Preparation of Sample Coolers

1. All previous labels used on the cooler were removed.
2. All drain plugs were sealed inside and out with duct tape.
3. A layer of cushioning bubble wrap was placed at the bottom of the cooler.
4. A sorbant pad was placed at the base of each cooler to collect any water in the event of a release.
5. The cooler was lined with a large plastic bag to contain samples.
6. All ice was double-bag and seal.

C.5.3.2 Packing Samples in Coolers

Unfrozen Samples

1. Chain-of-custody (COC) forms were placed in the ziplock bag and taped to the underside of the cooler lid.
2. All glass sample containers were packaged in bubble wrap and secured with clear mailing tape.
3. Samples were placed in an upright position in the cooler.
4. The void space between samples was filled with recyclable cornstarch popcorn, double-bagged ice, or bubble wrap.
5. Ice was placed on top of and between the samples.
6. The remaining voids were filled with recyclable cornstarch popcorn, double-bagged ice, or bubble wrap.
7. The large plastic bag containing samples and packing material was custody sealed.

Frozen Samples

The packing procedure for shipping frozen samples differs from shipping other samples in that no bagging is used and the cooler must not be fully sealed. Use of bagging and/or sealing material can cause the cooler to explode in transit due to pressure from expanding gas as the dry ice sublimates (evaporates). Frozen conditions inside the cooler prevent any liquids from being released in transit.

1. At least three 1/4-inch diameter holes were drilled in the upper portion of the cooler.
2. The chain-of-custody (COC) form was placed in the Ziplock bag and taped to the underside of the cooler lid.
3. The bottom of the cooler was lined with dry ice. The dry ice was not bagged.
4. All glass sample containers were packaged in bubble wrap and secured with clear mailing tape.
5. Samples were placed in an upright position in the cooler.
6. The void space between samples was filled with recyclable cornstarch popcorn, double-bagged ice, or bubble wrap.
7. The remaining dry ice was placed on top of and between the samples.
8. The remaining voids were filled with recyclable cornstarch popcorn, double-bagged ice, or bubble wrap.

C.5.3.3 Closing and Shipping of Cooler

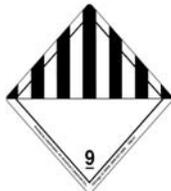
Coolers were packed with packing material surrounding the bottles to prevent breakage during transport. Water ice were sealed in plastic bags to prevent melting ice from soaking the packing material. No bagging of was done for coolers containing dry ice. Sample documentation was enclosed in sealed plastic bags taped to the underside of the cooler lid. Coolers were secured with packing tape and custody seals as described below. For coolers shipped using dry ice, while taping the coolers closed, care was taken to not tape over or seal the three vent holes.

The coolers were then delivered to the appropriate laboratory by the sampling team or by overnight courier the day of sample collection. Each day's sample shipment was reported to the EPA Region 9 Regional Sample Control Center (RSCC) Coordinator. For Friday shipments, the RSCC was contacted prior to noon to coordinate with laboratories that received sample shipments on Saturday. Samples were only shipped on Friday if the laboratory provided assurance that analytical holding times would not be exceeded.

Frozen Samples

Shipping coolers with frozen samples required additional labeling as follows:

1. The DOT class 9 miscellaneous hazardous materials label (provided below) were affixed to the top and front of the cooler.



2. A label was affixed to the front of the cooler, including the weight of dry ice in kilograms:

Carbon Dioxide, Solid
UN 1845
_____kg

C.5.4 Sample Custody and Documentation

A sample is physical evidence collected from a hazardous waste site, from the immediate environment, or from another source. Because of the potential evidentiary nature of samples, the possession of samples must be traceable from the time the samples are collected until they are introduced as evidence. In addition to field notebooks, there are a number of documents for tracking sample custody.

Sample labels and traffic reports/chain of custody records were generated using the FORMS II Lite™ software (DynCorp Systems & Solutions, LLC, 2002). Chain-of-custody procedures were used to maintain and document sample collection and possession. After sample packaging, the following one or more of the COC paperwork forms were generated, as necessary, for the appropriate samples:

- Organic traffic report & chain of custody record
- Inorganic traffic report & chain-of-custody record
- EPA Region IX Chain-of-Custody Record
- Overnight shipping courier air bill

Completed field quality assurance/quality control summary forms were sent to the RSCC at EPA's Region 9 Quality Assurance Office at the conclusion of each sampling event.

The following sample custody documentation procedures applied to all samples, including those to be analyzed by a mobile laboratory.

C.5.4.1 Chain of Custody

Because samples collected during any investigation could be used as evidence, their possession must be traceable from the time the samples are collected until they are introduced as evidence in legal proceedings. Chain-of-custody procedures are followed to document sample possession.

C.5.4.1.1 Definition of Custody

A sample is under custody, if one or more of the following criteria are met:

- It is in your possession.
- It is in your view, after being in your possession.
- It was in your possession and then you locked it up to prevent tampering.
- It is in a designated secure area.

C.5.4.1.2 Field Custody

In collecting samples for evidence, only enough sample quantity to provide a good representation of the media being sampled was collected. To the extent possible, the quantity and types of samples and sample locations were determined before the actual field work.

The field sampler was personally responsible for the care and custody of the samples collected until they were transferred or dispatched properly.

The site manager and/or the task manager determined whether proper custody procedures were followed during the field work, and decided if additional samples are required.

C.5.4.1.3 Transfer of Custody and Shipment

Samples were accompanied by a COC record. When transferring samples, both the individuals relinquishing and receiving the samples signed, dated, and noted the time on the record. This record documents custody transfer from the sampler, often through another person, to the analyst at the laboratory.

Samples were packaged properly for shipment and dispatched to the appropriate laboratory for analysis, with a separate COC record accompanying each shipping container (one for each field laboratory and one for samples driven to the laboratory). Shipping containers were sealed with custody seals for shipment to the laboratory. Courier names and other pertinent information were entered in the "Received by," section of the COC record.

All shipments were accompanied by the COC record identifying its contents. The original record and copy accompanies the shipment to the laboratory, and a separate copy was sent to be retained by the site manager.

If sent by mail, the package was registered with return requested. If sent by common carrier, a bill of lading was used. Freight bills, postal service receipts, and bills of lading are retained as part of the permanent documentation.

C.5.4.1.4 Laboratory Custody Procedures

A designated sample custodian accepted custody of the shipped samples and verified that the packing list sample numbers match those on the COC records. Pertinent information as to shipment, pickup, and courier was entered in the "Remarks" section. The custodian then entered the sample numbers into a bound notebook, which is arranged by project code and station number.

The laboratory custodian used the sample identification number or assigns a unique laboratory number to each sample and was responsible for seeing that all samples were transferred to the proper analyst or stored in the appropriate secure area.

The custodian distributed samples to the appropriate analysts. Laboratory personnel were responsible for the care and custody of samples from the time they were received until the sample is exhausted or returned to the custodian. The data from sample analyses were recorded on the laboratory report form.

When sample analyses and necessary QA checks have been completed in the laboratory, the unused portion of the sample was disposed of properly. All identifying stickers, data sheets, and laboratory records have been retained as part of the documentation. Sample containers and remaining samples were disposed of in compliance with all federal, state, and local regulatory requirements.

C.5.4.2 Custody Seals

When samples were shipped to the laboratory, they were placed in containers sealed with custody seals. Sample custody seals were obtained from the RSCC in the EPA's QAO. One or more custody seals must be placed on each side of the shipping container (cooler).

C.5.4.3 Field Notebooks

In addition to COC records, a bound field notebook was maintained by each sampling team leader to provide a daily record of significant events, observations, and measurements during field investigations. All entries were signed and dated. The field notebooks have been kept as a permanent record.

C.5.4.4 Corrections to Documentation

All original data recorded in field notebooks, sample identification tags, COC records, and receipts-for-sample forms were written with waterproof ink, unless prohibited by weather conditions. None of these accountable serialized documents are to be destroyed or thrown away, even if they are illegible or contain inaccuracies that require a replacement document.

If an error was made on an accountable document assigned to one team, the team leader may make corrections simply by drawing a single line through the error and entering the correct information. The erroneous information should not be obliterated. Any subsequent error discovered on an accountable document should be corrected by the person who made the entry. All subsequent corrections must be initialed and dated.

References

- ASTM 2000a. *Method D2487-00. Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System)*. American Society of Testing and Materials.
- ASTM 2000b. *Method D2488-00. Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)*. American Society of Testing and Materials.
- ASTM 2002. *Method D6771-02. Standard Practice for Low-Flow Purging and Sampling for Wells and Devices Used for Ground-Water Quality Investigations*. American Society of Testing and Materials.
- Bouwer, H. and R.C. Rice 1976. *A Slug Test Method for Determining Hydraulic Conductivity of Unconfined Aquifers with Completely or Partially Penetrating Wells*. *Water Resources Research*. 12(3): 423-428.

- Bouwer, H. 1989. *The Bouwer and Rice Slug Test – An Update*. *Groundwater*. 27(3): 304-309.
- Hyder, Z., J.J. Bulter Jr., C.D. Elwee, and W. Liu 1994. *Slug Tests in Partially Penetrating Wells*. *Water Resources Research*. 30(11): 2945-2957.
- HydroSOLV Inc. 1996-2003. AQTESOLV for Windows version 3.5 - Professional. [Software]. Reston, VA
- Robertson, P.K. (1990), *Soil classification by the cone penetration test*. *Canadian Geotechnical Journal*, 27:151-158.
- Tisch undated. *TE-5170 Total Suspended Particulate MFC High Volume Air Sampler: Operations Manual*. Tisch Environmental, Inc. Village of Cleves, Ohio.
- Tisch undated. *PUF Sampler Calibration [Worksheet]*. Vendor provided Excel worksheet. Tisch Environmental, Inc. Village of Cleves, Ohio.
- Wunderground.com 2005. <http://www.wunderground.com/> [website]
- Yeskis, D. and B. Zavala 2002. *Ground-Water Sampling Guidelines for Superfund and RCRA Project Managers*. Ground Water Form Issue Paper, Office of Solid Waste and Emergency Response. United States Environmental Protection Agency Document# 542/S-02-001

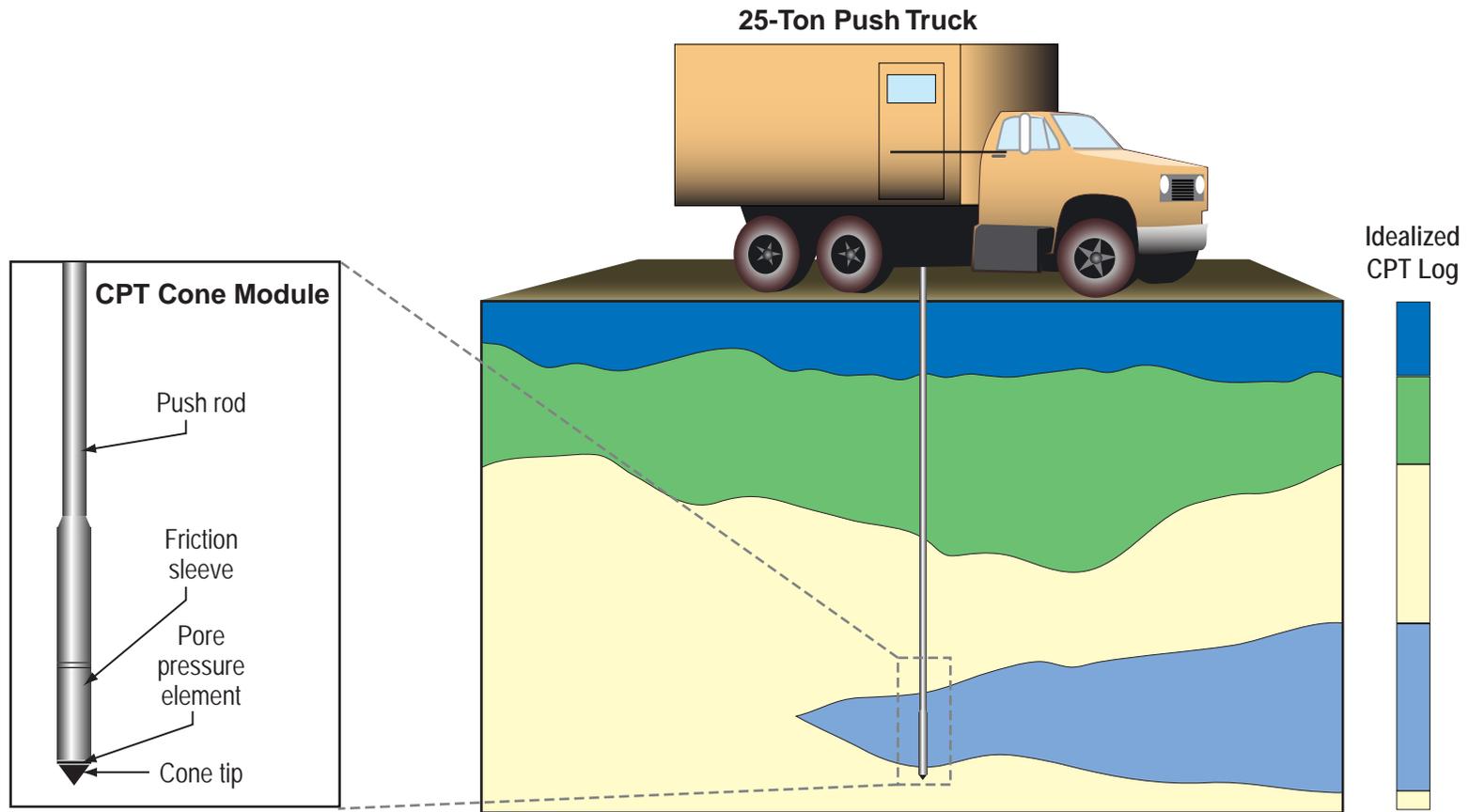
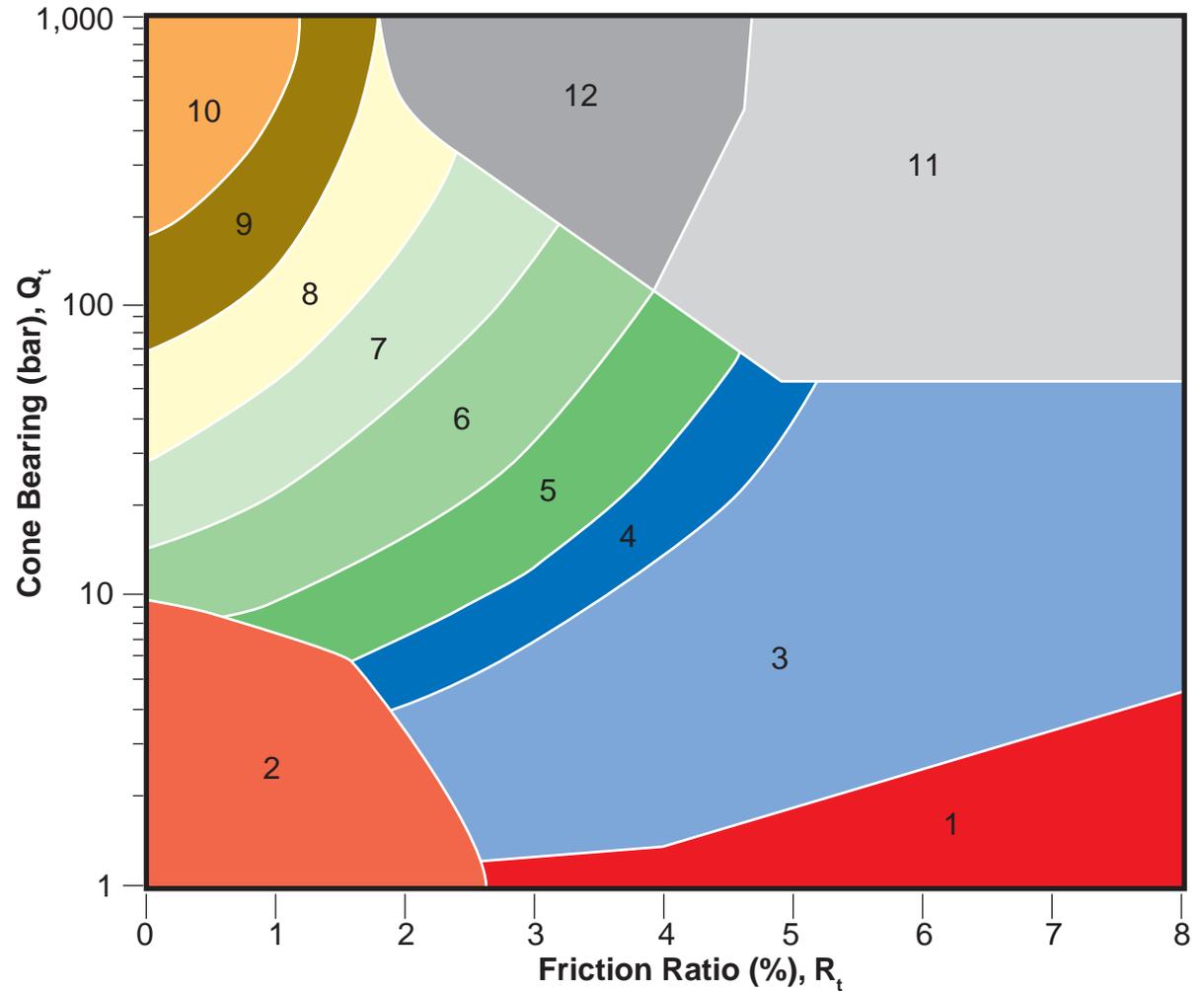


FIGURE C-1
CPT RIG ASSEMBLY AND CONE MODULE
 REMEDIAL INVESTIGATION REPORT
 AMCO CHEMICAL SUPERFUND SITE
 OAKLAND, CALIFORNIA

LEGEND

ZONE	Soil Behavior Type
1	Sensitive fine grained
2	Organic clay
3	Clay
4	Silty clay to clay
5	Clayey silt to silty clay
6	Sandy silt to clayey silt
7	Silty sand to sandy silt
8	Sand to silty sand
9	Sand
10	Gravelly sand to sand
11	Very stiff fine grained, overconsolidated or cemented
12	Sand to clayey sand, over consolidated or cemented

$$R_t = \frac{F_3 \text{ (sleeve friction)}}{Q_t} \times 100$$



After Robertson, P.K. 1990. Soil classification using the cone penetration test. *Canadian Geotechnical Journal*.

FIGURE C-2
CONE PENETROMETER TESTING:
SOIL BEHAVIOR TYPE INTERPRETATION
 REMEDIAL INVESTIGATION REPORT
 AMCO CHEMICAL SUPERFUND SITE
 OAKLAND, CALIFORNIA