Oakland
All-America City
1993

CITY OF OAKLAND

DALZIEL BUILDING • 250 FRANK H. OGAWA PLAZA, SUITE 5301 • OAKLAND, CALIFORNIA 94612-2034

Public Works Agency
Environmental Services

FAX (510) 238-7286
TDD (510) 238-7644

October 29, 2001

NOV 01 2001

Mr. Barney Chan
Alameda County Environmental Health Services
1131 Harbor Bay Parkway
Alameda, California 94502-6577

#3978

Subject: Dual Phase Extraction Workplan
City of Oakland Municipal Service Center
7101 Edgewater Drive
Oakland, California

Dear Mr. Chan:

Enclosed is one copy of the subject workplan, prepared by our consultant, Cambria Environmental Technology Inc., for the City of Oakland Municipal Service Center at 7101 Edgewater Drive.

Please call me at 238-6259, if you have any questions or require additional information.

Sincerely,

Joseph A. Cotton
Environmental Program Specialist

cc: Diane Heinz, Port of Oakland, 530 Water St., Oakland, CA 94604
Xinggang Tong, URS Corporation, 500 12th St., Suite 200, Oakland, CA 94607

C A M B R I A

October 26, 2001

Mr. Joseph Cotton
City of Oakland, Public Works Agency
Environmental Services Division
250 Frank H. Ogawa Plaza, Ste. 5301
Oakland, California 94612-2034

Re: **Dual Phase Extraction Workplan**
City of Oakland, Municipal Services Center
7101 Edgewater Drive
Oakland, California
Cambria Project #153-1653

Dear Mr. Cotton:

On behalf of the City of Oakland, Cambria Environmental Technology (Cambria) has prepared this dual phase extraction (DPE) workplan for the site referenced above. The purpose of this workplan is to facilitate implementation of DPE, the remedial technique recommended by the *Evaluation of Free-Phase Product Removal Alternatives for Petroleum Hydrocarbons* report by URS Greiner dated June 2001. The objective of DPE remediation is to remove separate-phase hydrocarbons at the site, with a secondary objective of removing aqueous-phase hydrocarbons. Described below are the project background, proposed well installation, DPE pilot testing, system design and installation, and reporting.

PROJECT BACKGROUND

The City of Oakland Municipal Services Center has had several investigations conducted on the site subsurface, and groundwater quality is currently monitored on a quarterly basis. Hydrocarbons may have been released from the former pressurized fuel line system, the former USTs, or from imported fill material. The site is underlain by imported fill materials, which overlie tidally affected estuarine sedimentary deposits. Historically, the depth to groundwater at the site has ranged from approximately 1.3 ft (TBW-3) to 13 ft (MW-16) below grade surface (bgs).

Oakland, CA
San Ramon, CA
Sonoma, CA

Cambria Environmental Technology, Inc.

1144 65th Street
Suite B
Oakland, CA 94608
Tel (510) 420-0700
Fax (510) 420-9170

A recent investigation conducted by Baseline Environmental Consulting in July 2000 employed a dynamic assessment technique to delineate the lateral extent of separate-phase hydrocarbons (SPH) in the four SPH areas. Prior remediation activities have included the UST removal, removal of the pressurized fuel distribution system, soil excavation, and the extraction of approximately 62,000 gallons of groundwater from well TBW-1. Current remedial activities include active skimming of SPH from well TBW-5, and skimming from other site wells using manual bailing and passive absorbent 'socks'. The June 2001 URS Greiner report recommended implementation of DPE to remediate four (4) separate source areas with SPH plumes and petroleum-impacted groundwater. DPE involves applying a high vacuum to withdraw both soil vapor and fluids from near the static water table. DPE also enhances natural attenuation of subsurface contaminants.

PROPOSED WELL INSTALLATION

The first step for implementing DPE involves well installation. The proposed well installation will facilitate pilot testing and design of a dual-phase extraction (DPE) remediation system, and well installation to monitor plume stability. In preparing this workplan, Cambria reviewed the extent of the four SPH plumes, the location and screen intervals of existing wells, and the site hydrogeology. Described herein are Cambria's proposed well locations and well design, well installation procedures, and well installation preparation.

Proposed Well Locations and Design

The proposed well locations and design are based on our current understanding of the subsurface hydrogeology. Field observations during well installation will be used to finalize the well design.

Well Location Rationale

Up to twenty (20) test/observation wells will be installed at the site. The proposed well locations and estimated screen intervals are shown on Figures 1 and 2. Well specifications and relevant data are summarized below on Table A. The proposed test/observation well locations are based on the following rationale:

- Locating all wells away from subsurface features of estimated higher permeability (utility trenches and backfilled areas) to minimize the potential for vacuum short-circuiting (Plumes A and C are near former tank backfill areas, while Plumes B and D are near former hydrant lines or imported fill material)(Cambria understands that former tank locations are filled with pea gravel, former hydrant lines are filled with compacted fill, and wells TBW-1 through TBW-5 are surrounded by pea gravel or crushed rock in the saturated zone.)

- Locating extraction wells within the estimated extent of SPH, not outside of the SPH area where DPE could encourage SPH migration.

- Installing observation wells outside the SPH boundary to evaluation DPE influence beyond the estimated SPH plume boundary.

- Minimizing need for additional wells in the smaller SPH plume areas by installing all anticipated wells (Plumes A and C).

- Spacing wells to allow data collection from increasing distances from test well.

- Placing (test) extraction wells adjacent to existing shallow underground piping (which was installed during hydrant piping removal) to reduce the amount of additional wells and remediation piping required to implement DVE after pilot testing. will this cause short circuiting?

- Keeping wells on the subject property to avoid added difficulty of data collection offsite and beyond the fenced property line, whenever possible.

Cambria does not propose DPE well installation within the tank backfill areas, which are filled with highly permeable pea gravel. DPE from backfill wells may direct energy mostly to groundwater extraction. Large groundwater extraction rates were observed during prior pumping from tank backfill wells.

Won't the test wells remove considerable gw + vapor?

Well Design Rationale

The proposed well design is based on the following rationale:

- DPE wells are commonly screened from approximately 2 to 5 ft above groundwater and approximately 5 to10 feet below static groundwater.
- Well screen intervals will allow SPH extraction with 1-inch PVC vacuum stingers placed approximately 1 to 2 ft below SPH depths.
- To avoid vacuum short-circuiting with the atmosphere, wells will be screened no shallower than 5 ft below grade surface (bgs).
- To also avoid short-circuiting, wells located near shallow conduits will be screened no shallower than 6 ft bgs.
- All test/observation wells will be constructed of 4-inch nominal schedule 40 PVC, while strictly observation wells will be constructed of 2-inch nominal schedule 40 PVC.
- To facilitate SPH flow, all test and observation wells will be constructed with 0.04" slot size.

Summary of Proposed Wells

Table A below summarizes well specifications and relevant data for the proposed wells. Details for the proposed wells are described below for each plume.

Table A – Wells Specifications and Relevant Data for Proposed Wells

Plume	Proposed Well ID	Well Type	Well Diameter[1]	Estimated Screen Interval (ft-ft bgs)	Historic Depth to Water (ft-ft bgs)	Depth to More Permeable Materials in Saturated Zone (ft-ft bgs)
A	RW-A1	Test/Obs	4"	4-14	1.3-4.5[2]	5-6[3] (sand/gravel)
	OB-A1	Obs	2"	4-14		
B	RW-B1	Test/Obs	4"	5-12	7-8	6-8 (sand/gravel)
	RW-B2	Test/Obs	4"	5-12		
	RW-B3	Test/Obs	4"	7-17	9-13	8-15 (sand/gravel)
	RW-B4	Test/Obs	4"	7-17		
C	RW-C1	Test/Obs	4"	5-12	5-10	5-7[4] (sand/gravel)
	RW-C2	Test/Obs	4"	5-12		
	RW-C3	Test/Obs	4"	5-12		
	RW-C4	Test/Obs	4"	5-12		
	RW-C5	Test/Obs	4"	5-12		
	RW-C6	Test/Obs	4"	5-12		
	OB-C1	Obs	2"	5-12		
D	RW-D1	Test/Obs	4"	5-12	6-9	7-9 (sand/gravel)
	RW-D2	Test/Obs	4"	5-12	6-9	
	RW-D3	Test/Obs	4"	5-12	6-9	
	RW-D4	Test/Obs	4"	5-12	6.5-9.5	8-10 (sand/gravel)
	RW-D5	Test/Obs	4"	8-10	6.5-9.5	8-10 (rip rap/rocks)
	OB-D1	Obs	2"	5-15	6.5-9.5	8-10 (sand/gravel)
	OB-D2	Obs	2"	5-15	6.5-9.5	

<u>Notes:</u>

Ft – ft bgs = Feet to feet below grade surface

Obs = Observation

Note 1= 4" diameter wells will be installed with 10-inch diameter augers, 2" wells with 8-inch augers.

Note 2 = Depth to water in formation was 4.5 ft bgs during Baseline's July 2000 investigation.

Note 3 = Hydrocarbon sheen observed at approximately 6 ft bgs in Baseline borings E and N.

Note 4 = Free product found at 7 ft bgs by Baseline; same depth as depth to water at the time

Plume A

Plume A is the area near former UST #6, where soil excavation was conducted and tank backfill wells TBW-3 and TBW-4 were installed. To date, no measurable thicknesses of SPH have been detected in wells TBW-3 and TBW-4, only SPH globules. During recent sampling of well TBW-3 a submersible pump yielded significant groundwater extraction rates without significant dewatering of the well. This observation is not surprising given the large volume of the former tank/excavation that is presumably filled with pea gravel, drain rock or other highly permeable material.

The soil around the tank pit area is primarily comprised of relatively low permeability materials. The more permeable materials, where present, are located at approximately 5 to 6 ft bgs. A hydrocarbon sheen was observed at approximately 6 ft bgs in borings E and N. Groundwater in TBW-3 is very shallow, historically at approximately 1.3 to 3.7 ft bgs. Groundwater depth in the formation during Baseline's July 2000 investigation was approximately 4.5 ft bgs.

One test well (RW-A1) is proposed at 7.5 ft downgradient of the tank pit excavation area, screened from 4 to 14 ft bgs. An observation well (OB-A1) is proposed approximately 25 ft downgradient of the tank pit excavation area (between Plumes A and B), also screened from 4 to 14 ft bgs. Tank backfill wells TBW-3 and TBW-4 will be also used as monitoring/observation wells. The well locations are shown on Figures 1 and 2, and well specifications are summarized on Table A.

Plume B

Plume B is located downgradient of Plume A, between onsite well MW-6 and offsite well MW-16. The plume apparently goes beyond the site property boundary. Approximately midway between wells MW-6 and MW-16 the deeper subsurface becomes more permeable in the downgradient direction. The hydrogeology and SPH composition is different near wells MW-6 and MW-16, as described below.

For the MW-6 area, the depth to groundwater is approximately 7 to 8 ft bgs. A one to two ft thick sandy/silt unit or lens is present in the MW-6 vicinity at depths ranging from 6 to 10 ft bgs. The sandy/silt unit is more permeable than the surrounding materials.

As shown on Figures 1 and 2, one test well (RW-B1) is proposed near the upgradient center of Plume B, approximately 20 ft west of MW-6. Another test/observation well (RW-B2) is proposed approximately 60 ft west of MW-6. The proposed well screen interval for these wells is 5 to 12 ft bgs. Well MW-6 will be used as a monitoring/observation well.

For the MW-16 area, the depth to groundwater is approximately 9 to 13 ft bgs. Approximately midway between MW-6 and MW-16 the saturated zone consists of high permeability material. One test well (RW-B3) is proposed near the fenced property line, with a test/observation well (RW-B4) proposed approximately 20 ft away from RW-B3 at the same distance from the fenced property line. Well MW-16, located approximately 30 ft from the proposed test well, will be used as a monitoring/observation well. The proposed screen interval for all wells is 7 to 17 ft bgs. The well locations are shown on Figures 1 and 2, , and well specifications are summarized on Table A.

Plume C

Plume C is the area near former USTs #1, 2 & 3, where soil excavation was conducted and tank backfill wells TBW-1 and TBW-2 were installed. The depth to groundwater has recently ranged from approximately 5 to 10 ft bgs. The SPH thickness was greatest (approximately 0.5 ft) when the depth to water was approximately 9 ft, and the SPH thickness was smallest (approximately 0.01 ft) when the depth to water was approximately 5.3 ft bgs. Baseline's July 2000 investigation suggests that the SPH plume extends approximately 5 to 10 ft in the upgradient and crossgradient directions from the tank pit, and approximately 15 ft in the downgradient direction. Baseline also detected SPH at approximately 7 ft bgs in temporary borings, which corresponded to the water depth at the time. Baseline did not detect hydrocarbon odor in deeper soil. The soil/water interface was approximately 10 ft bgs during sample collection from the excavation sidewall in 1997 (samples S-1 through S-6). The soil around the tank pit area is primarily comprised of relatively low permeability materials (silty clay, and clay with sand and gravel).

Six test/observation wells (RW-C1 through RW-C6) are proposed around the perimeter of the tank pit area, located approximately 7.5 ft from the tank pit to minimize the potential for short circuiting. Another well (OB-C1) is proposed approximately 30 ft downgradient of the tank pit area, for use as an observation well and to monitor the stability of Plume C. Tank backfill wells TBW-1 and TBW-2 will also be used as monitoring/observation wells. The proposed screen interval for these wells is 5 to 12 ft bgs. The well locations are shown on Figures 1 and 2, and well specifications are summarized on Table A.

Plume D

Plume D is located beneath the former hydrant piping, near and upgradient of tank backfill well TBW-5. The hydrogeology appears fairly uniform for Plume D; a one to two thick sand unit is present approximately 6 to 8 ft bgs, with lower permeability soil (clayey soil) present above and below the sand unit. The depth to groundwater is approximately 6.5 to 9.5 ft bgs near TBW-5, and at slightly shallower at the upgradient edge of Plume D.

Four test/observation wells (RW-D1 through RW-D4) are proposed along the length of the plume (the up/downgradient direction) to facilitate testing across the plume. The wells are proposed at least 15 ft from TBW-5 to minimize short circuiting from the permeable imported rock surrounding TBW-5. Some wells are proposed immediately adjacent to the existing underground PVC piping, which was installed during the hydrant piping removal to assist with any future remediation. The proposed well screen interval is 5 to 12 ft bgs. Wells TBW-5 and RW-1 will also be used as monitoring/observation wells.

One additional test well (RW-D5) will target the rip rap area near the former shoreline, discovered in the excavation area for TBW-5. The well will be located approximately 7.5 ft north of TBW-5 and screened from approximately 8 to 10 ft bgs. Two observation wells (OB-D1 and OB-D2) are proposed downgradient of Plume D to monitor SPH plume stability, each well crossgradient of existing well RW-1 and screened from 5 to 15 ft bgs. Well locations are shown on Figures 1 and 2, and well specifications are summarized on Table A.

Well Installation

All drilling activities will be performed by a 40-hour OSHA trained, California-licensed water well driller experienced in environmental investigation and remediation. Cambria's Standard Field Procedures for remediation well installation are included as Appendix A.

All borings drilled for test extraction wells or observation will be logged continuously from 3 ft bgs to total depth for lithologic description and possible additional analysis. Approximately three samples will be collected per boring for soil property testing, such as permeability testing and sieve analysis.

While anticipated screen intervals are discussed above, the final well screen intervals will be based on field observations of soil type, relative soil permeability, and depth to water during well installation. Test wells will be constructed of 4-inch nominal schedule 40 PVC, with 0.04" well screen slot size and sand pack selected to facilitate product recovery. Observation wells will be constructed of 2-inch nominal schedule 40 PVC with 0.04" well screen slot size. Wells will be developed until they produce relatively clear groundwater.

Installation Preparation

Permits will be obtained from Alameda County for the test/observation well installation. To clear the proposed wells locations for drilling, available construction/building plans will be reviewed and Underground Service Alert will be notified. A private underground utility line locator may be used. A site safety plan will also be prepared to help safeguard human health during workplan implementation.

PROPOSED DUAL-PHASE EXTRACTION PILOT TESTING

Dual phase extraction (DPE) is the process of applying high vacuum (up to 29 inches of mercury) through an airtight well seal to simultaneously extract soil vapor and groundwater from the subsurface. DPE equipment typically consists of dedicated extraction "stingers" installed in each target well, a vacuum source, a knockout drum to separate the extracted vapor and groundwater mix into separate streams, and treatment systems for the vapor and groundwater streams.

Our DPE pilot testing approach consists of the following:

- Extracting from one test well while monitoring vacuum influence, oxygen, carbon dioxide and water levels in nearby wells.
- Testing of one or more wells in each plume as follows:
  - Plume A – the one test well;
  - Plume B – the test well near MW-6 and the test well near the fence near MW-16;
  - Plume C - one well downgradient and one upgradient of the tank pit; and
  - Plume D – the most upgradient and downgradient test wells, and the 'rip rap' well.
- A test duration of at least two weeks for the site, with the majority of the testing being performed on Plumes B and D.
- Monitoring the applied vacuum, induced vapor and water flow rates, hydrocarbon concentrations in extracted vapor and water, and the vacuum influence induced in nearby wells.
- Measuring the water level in nearby wells before and after each test.
- Measurement of SPH volume recovered in treatment system.

To assess aqueous-phase concentration trends and mass removal, water samples at the end of each test will be collected from the extraction system and analyzed for total petroleum hydrocarbons as gasoline (TPHg) using modified EPA Method 8015, benzene, toluene, ethylbenzene, and xylenes (BTEX) and MTBE using EPA Method 8021.

To assess vapor-phase concentration trends and mass removal, vapor concentrations in extracted vapor will be monitored periodically using field instruments and select influent vapor samples will be analyzed for TPHg, BTEX and MTBE using EPA Method TO-3 or equivalent. The following guideline will be used for influent vapor sample analysis: 1) an influent vapor sample from the end of each test will be analyzed, and 2) for tests longer than 24 hours, an influent vapor sample will be analyzed after the first 24 hours of testing. In addition, select influent vapor samples may be analyzed for oxygen, carbon dioxide, and methane using EPA Method 3C.

To further evaluate the influence of DPE, oxygen and carbon dioxide concentrations in observation wells will be measured in the field or by laboratory analysis of vapor samples for selected tests. Vapor samples will be collected from observation wells before and after testing. Changing concentrations of oxygen and carbon dioxide help evaluate the extent of subsurface gas flow, and therefore the extent of influence in a given test area.

Extracted vapors will be treated during the pilot test using a thermal oxidizer, catalytic oxidizer, internal combustion engine, or activated carbon adsorption. A flame ionization detector will be used to monitor the effectiveness of vapor abatement. The Bay Area Air Quality Management District will be notified of the DPE pilot test activities. Water produced during the pilot test will be temporarily stored onsite. The extracted water will either be treated onsite and discharged to the sanitary sewer or transported offsite for recycling.

SYSTEM DESIGN AND INSTALLATION

The DPE pilot test data will be used to estimate soil vapor and groundwater extraction rates, contaminant removal rates, and zone of influence. Interpretation of the test results will be used to select the most appropriate DPE extraction and treatment equipment, and to select supplemental DPE well locations. Upon completing system design, a full-scale DPE system will be permitted and installed at the site.

REPORTING

Upon completion of pilot testing, the following information will be presented in a monitoring report:

- A summary of DPE pilot test activities,
- Installation details for the test and observation wells,
- Tabulated vapor and water analytical results,
- Laboratory reports and chain-of-custody forms, and
- Test findings and conclusion.

After system design and installation, system operation and performance will also be described in quarterly groundwater monitoring reports.

CLOSING

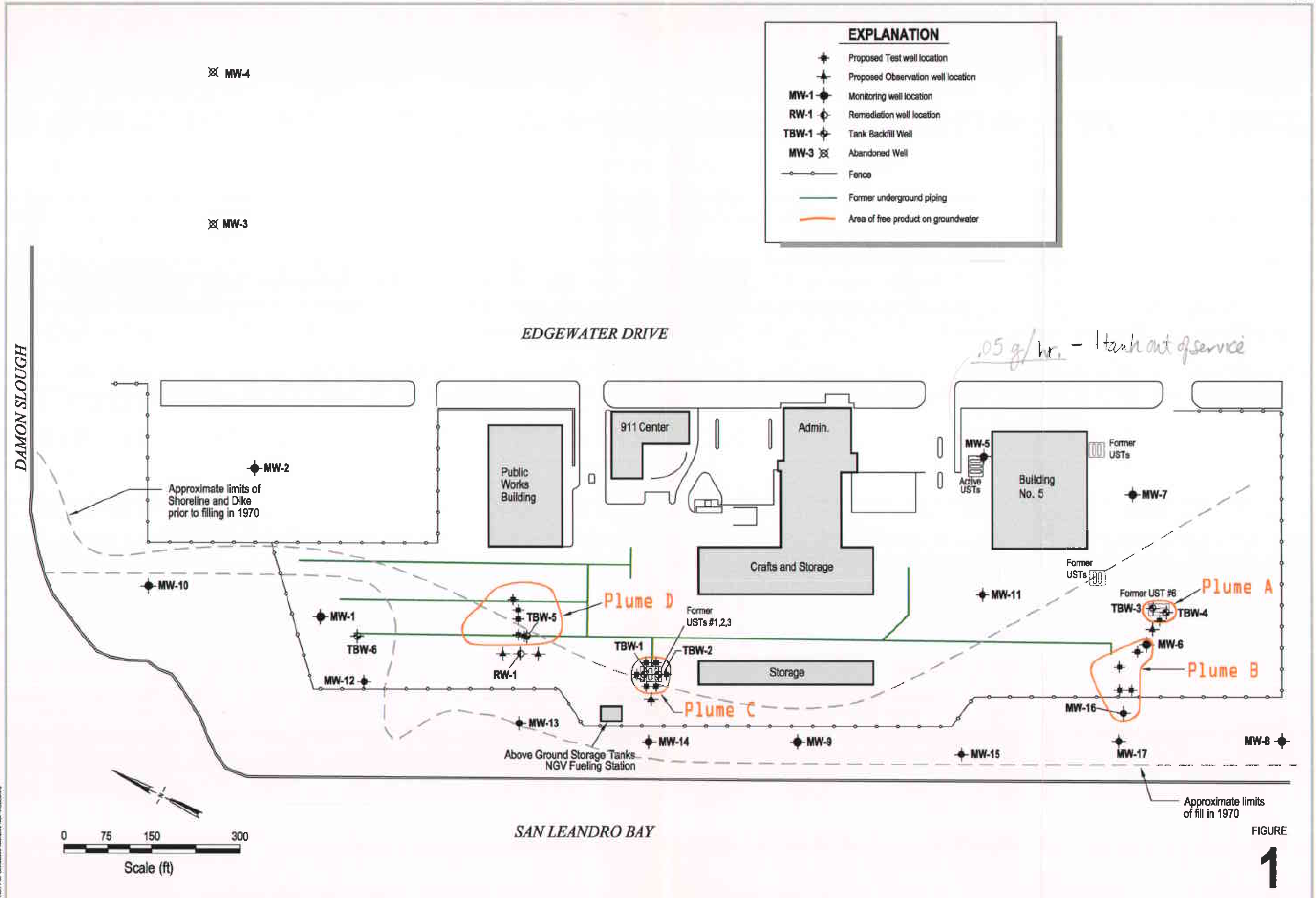
Upon regulatory approval, DPE pilot testing and system design will be performed. A DPE system will be installed at the site upon client and regulatory approval of the DPE design. If you have any questions or comments regarding this workplan, please call me at (510) 420-3303.

Sincerely,
Cambria Environmental Technology, Inc.

Bob Clark-Riddell, P.E.
Principal Engineer

Attachments: Figure 1 – Proposed Test and Observation Wells for DPE Pilot Testing
Figure 2 – Proposed Test and Observation Well Details
Appendix A - Cambria's Standard Field Procedures for Remediation Well Installation

\\SERVER\IR\City of Oakland\Municipal Service Center\workplans\ Test wells & Piezos WP .doc



FIGURE

1

Proposed Test and Observation Wells for DPE Pilot Testing

CAMBRIA

Municipal Service Center
7101 Edgewater Drive
Oakland, California

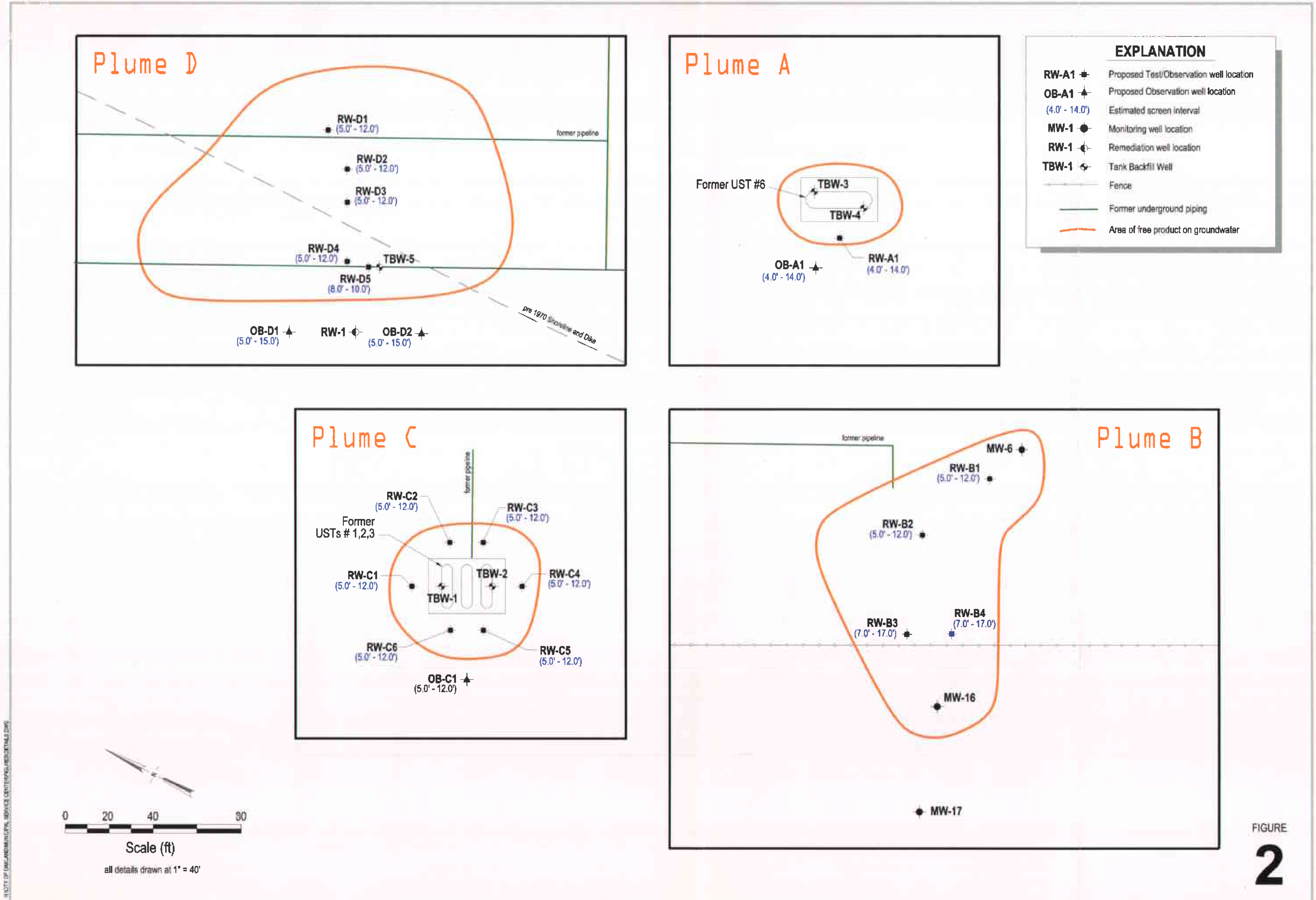


FIGURE 2

Proposed Test and Observation Well Details

CAMBRIA

Municipal Service Center
7101 Edgewater Drive
Oakland, California

Appendix A

Standard Procedures for Remediation Well Installation

STANDARD FIELD PROCEDURES FOR REMEDIATION WELL INSTALLATION

This document presents standard field methods for drilling and sampling soil borings and installing remediation wells. These procedures are designed to comply with Federal, State and local regulatory guidelines. Specific field procedures are summarized below.

SOIL BORING AND SAMPLING

Objectives

Soil samples are collected to characterize subsurface lithology, assess whether the soils exhibit obvious hydrocarbon or other compound vapor or staining, and to collect samples for analysis at a State-certified laboratory. All borings are logged using the Unified Soil Classification System by a trained geologist working under the supervision of a California Registered Geologist (RG) or a Certified Engineering Geologist (CEG).

Soil Boring and Sampling

Soil borings are typically drilled using hollow-stem augers or push technologies such as the Geoprobe. Soil samples are collected at least every five ft to characterize the subsurface sediments and for possible chemical analysis. Additional soil samples are collected near the water table and at lithologic changes. Samples are collected using lined split-barrel or equivalent samplers driven into undisturbed sediments at the bottom of the borehole.

Drilling and sampling equipment is steam-cleaned prior to drilling and between borings to prevent cross-contamination. Sampling equipment is washed between samples with trisodium phosphate or an equivalent EPA-approved detergent.

Sample Analysis

Sampling tubes chosen for analysis are trimmed of excess soil and capped with Teflon tape and plastic end caps. Soil samples are labeled and stored at or below 4°C on either crushed or dry ice, depending upon local regulations. Samples are transported under chain-of-custody to a State-certified analytic laboratory.

Field Screening

One of the remaining tubes is partially emptied leaving about one-third of the soil in the tube. The tube is capped with plastic end caps and set aside to allow hydrocarbons to volatilize from the soil. After ten to fifteen minutes, a portable photoionization detector (PID) measures volatile hydrocarbon vapor concentrations in the tube headspace, extracting the vapor through a slit in the cap. PID measurements are used along with the field observations, odors, stratigraphy and groundwater depth to select soil samples for analysis.

Grouting

If the borings are not completed as wells, the borings are filled to the ground surface with cement grout poured or pumped through a tremie pipe.

REMEDIATION WELL INSTALLATION

Well Construction

Remediation wells are commonly installed for dual phase extraction (DPE), soil vapor extraction (SVE), groundwater extraction (GWE), oxygenation, air sparging (AS), and vapor monitoring (VM). Well depths and screen lengths will vary depending upon several factors including the intended use of the well, groundwater depth, occurrence of hydrocarbons or other compounds in the borehole, stratigraphy and State and local regulatory guidelines.

Well casing and screen are typically one to four inch diameter flush-threaded Schedule 40 PVC. Screen slot size varies according to the sediments screened, but slots are generally 0.010 or 0.020 inches wide. A rinsed and graded sand occupies the annular space between the boring and the well screen to about one to two ft above the well screen. A two ft thick hydrated bentonite seal separates the sand from the overlying sanitary surface seal composed of Portland type I,II cement. Well-heads are typically connected with remediation piping set in traffic-rated vaults finished flush with the ground surface. Typical well screen intervals for each type of well are described below.

DPE Wells: DPE wells are screened in the vadose zone targeting horizons with the highest hydrocarbon concentrations and a few feet into the saturated zone, targeting SPH on or submerged by the water table. A vacuum is applied to the well casing and/or a 'stinger' (a one-inch diameter tube) placed in the well about 1 to 2 feet below the static fluid level. Vacuums can be adjusted to fine tune the performance of the well/system and to optimize the removal of SPH without excessive production of ground water.

SVE Wells: SVE wells are screened in the vadose zone targeting horizons with the highest hydrocarbon concentrations. SVE wells are also occasionally screened as concurrent soil vapor and groundwater extraction wells with screen interval above and below the water table.

GWE Wells: Groundwater extraction wells are typically screened ten to fifteen ft below the first water-bearing zone encountered. The well screen may or may not be screened above the water table depending upon whether the water bearing zone is unconfined or confined.

Oxygenation Wells: Oxygenation wells are installed above or below the water table to supply oxygen and enhance naturally occurring hydrocarbon biodegradation. Oxygenation wells installed in the vadose zone typically have well screens that are two to ten feet long and target horizons with the highest hydrocarbon concentrations. Oxygenation wells installed below the water table typically have a two foot screen interval set ten to fifteen ft below the water table.

AS Wells: Air sparging wells are installed below the water table and typically have a two foot screen interval set ten to fifteen ft below the water table.

VM Wells: Vapor monitoring wells are installed in the vadose zone to check for hydrocarbon vapor migration during air injection. The wells are typically constructed with short screens to target horizons through which hydrocarbon vapor migration could occur. These wells can also be constructed in borings drilled using push technologies such as the Geoprobe by using non-collapsible Teflon tubing set in small sand packed regions overlain by grout.

Well Development

Groundwater extraction wells are generally developed using a combination of groundwater surging and extraction. Surging agitates the groundwater and dislodges fine sediments from the sand pack. After about ten minutes of surging, groundwater is extracted from the well using bailing, pumping and/or reverse air-lifting through an eductor pipe to remove the sediments from the well. Surging and extraction continue until at least ten well-casing volumes of groundwater are extracted and the sediment volume in the groundwater is negligible. This process usually occurs prior to installing the sanitary surface seal to ensure sand pack stabilization. If development occurs after surface seal installation, then development occurs 24 to 72 hours after seal installation to ensure that the Portland cement has set up correctly.

All equipment is steam-cleaned prior to use and air used for air-lifting is filtered to prevent oil entrained in the compressed air from entering the well. Wells that are developed using air-lift evacuation are not sampled until at least 24 hours after they are developed.