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August 19, 2002

Barney Chan
Alameda County Health Care Services Agency
1131 Harbor Bay Parkway, Suite 250
Alameda, California 94502-6577

Re: **Investigation and Interim Remediation Work Plan**
Shell-branded Service Station
610 Market Street
Oakland, California
Incident # 98995750
Cambria Project # 244-0594

Dear Mr. Chan:

On behalf of Equilon Enterprises LLC dba Shell Oil Products US (Shell), Cambria Environmental Technology, Inc. (Cambria) is submitting this *Investigation and Interim Remediation Work Plan* for the referenced site. This work plan was recommended in our August 12, 2002 *Subsurface Investigation Report* to address the elevated methyl tertiary butyl ether (MTBE) concentrations detected in groundwater beneath the site. Presented below are summaries of the site background and our proposed scope of work.

SITE BACKGROUND

Site Description: The site is a Shell-branded service station located on Market Street, between Sixth and Seventh Streets in Oakland, California (Figure 1). Currently, the site consists of a kiosk, three underground storage tanks (USTs), four dispenser islands and a drive-through car wash facility (Figure 2). The area surrounding the site is primarily of commercial use.

Subsurface Conditions: The site is underlain primarily by silty sands to a total explored depth of 26 feet below grade (fbg).

Groundwater Flow and Direction: Historically, groundwater depths have ranged from approximately 10 to 16 fbg. The groundwater flow direction is primarily to the southwest.

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1995 Site Renovation: During station renovation activities in August 1995, Weiss Associates (Weiss) of Emeryville, California collected soil samples from beneath the gasoline dispensers and product piping locations. The renovation activities included the replacement of the central and western-most gasoline dispensers and the removal of the eastern-most dispensers and associated piping. Approximately 33 cubic yards of soil were removed during dispenser upgrades, and an additional 15 cubic yards were removed during over-excavation of the southern end of the middle dispenser island and the piping of the eastern-most dispenser islands. The details and results of this investigation are summarized in the November 2, 1995 *Dispenser Replacement Sampling* report, prepared by Weiss.

1998 Site Upgrade: In March 1998, site upgrades were performed by Paradiso Mechanical of San Leandro, California (Paradiso). Paradiso added secondary containment to the turbine sumps in the USTs. Cambria inspected the turbine sumps and UST area, and no field indications of petroleum hydrocarbons, such as staining or odor, were observed during the site visit. Based on the field observations, no soil sampling was performed during the site upgrade activities. The details of these activities are summarized in Cambria's *1998 Site Upgrade Inspection Report* dated March 30, 1998.

March 1998 Site Investigation: On March 31, 1998, Cambria conducted a subsurface investigation at the facility which included the installation of three soil borings onsite using a Geoprobe® direct-push drill rig. Less than 2 parts per million (ppm) total petroleum hydrocarbons as gasoline (TPHg), benzene, toluene, ethylbenzene, and xylenes (BTEX), and MTBE were detected in analyzed soil samples from soil borings SB-A, SB-B, and SB-C. A maximum of 2,100 parts per billion (ppb) TPHg, 490 ppb benzene, and 14,000 ppb MTBE was detected in grab groundwater samples collected from soil borings SB-A and SB-B. Concentrations of TPHg, BTEX, and MTBE were below laboratory detection limits in the grab groundwater sample collected from soil boring SB-C. The details of this investigation are summarized in Cambria's *Subsurface Investigation Report* dated July 1, 1998.

November 1998 Subsurface Investigation: On November 17, 1998, Cambria performed additional subsurface investigation activities which included the installation of three groundwater monitoring wells onsite (MW-1, MW-2, and MW-3). No TPHg, BTEX, or MTBE was reported in analyzed soil samples collected from well MW-1. [redacted] TPHg, 8.3 ppm benzene, and 16 ppm MTBE were detected in soil samples collected from well [redacted] The first groundwater samples collected from the monitoring wells were collected as part of the first quarterly monitoring event (fourth quarter 1998) by Blaine Tech Services of San Jose, California. The details of this investigation are summarized in Cambria's April 20, 1999 *Well Installation Report*.

2000 Mobile Dual-Phase Vacuum Extraction (DVE) Treatment: From March to October 2000, Cambria coordinated mobile DVE from wells MW-2 and MW-3. DVE removes soil vapors and separate-phase hydrocarbons from the vadose zone and enhances groundwater removal from remediation or monitoring wells. Mobile DVE equipment consists of a dedicated extraction "stinger" installed in the extraction well, a vacuum truck, and a carbon vapor-treatment system. DVE was discontinued in October 2000 due to low groundwater-extraction volumes. The cumulative mass removal of TPHg and MTBE during the DVE treatment was approximately 35.6 pounds and 15.6 pounds, respectively.

2001 DVE and Soil Vapor Extraction (SVE) Pilot Test: On March 22, 2001, Cambria performed a short-term (1 day) DVE test on well MW-3 and a short-term (1 day) SVE test on tank backfill well T-1. The tests were conducted using an internal combustion engine for vapor abatement. The cumulative mass removal of TPHg and MTBE during the DVE and SVE pilot tests was approximately 1.2 pounds and 1.4 pounds, respectively.

S[redacted]: Between October 8 and 12, 2001, Cambria conducted a long-term (5 day) SVE pilot test on tank backfill well T-1. The[redacted]he SVE pilot test was approximately 14.7 pounds and 32.8 pounds, respectively.

Mobile Groundwater Extraction (GWE): A[redacted]01 *Site Conceptual Model and Pilot Test Report*, Ca[redacted]. [redacted] sch[redacted], a[redacted] *Soil Vapor Extraction Pilot Test Report and Investigation Work Plan*. The recommendation to extract from well MW-2 was approved in a January 2, 2002 Alameda County Health Care Services Agency (ACHCSA) letter. T[redacted] removed through GWE is estimated to be approximately 2.5 pounds and 57.9 pounds, [redacted]vely.

Monthly Vapor Sampling: As described in our December 19, 2001 *Soil Vapor Extraction Pilot Test Report and Investigation Work Plan*, Cambria coordinated monthly vapor measurements in the tank backfill wells using a photo-ionization detector (PID). Due to the elevated concentrations detected on February 7, 2002, Cambria began collecting monthly samples from well T-2 to be submitted to an analytical laboratory in addition to collecting PID readings.

Groundwater Monitoring: Quarterly groundwater monitoring has been ongoing at this site since the fourth quarter of 1998. Up to 7,490 ppb TPHg, 420 ppb benzene and 167 ppb MTBE have been reported in groundwater samples collected from well MW-1. Well MW-2 has contained up to 101 ppb TPHg, 183 ppb benzene, and 17,000 ppb MTBE. Well MW-3 has contained up to

44,500 ppb TPHg, 1,290 ppb benzene and 610,000 ppb MTBE. The results of quarterly monitoring events are summarized in quarterly monitoring reports prepared by Cambria.

PROPOSED SCOPE OF WORK

Proposed Subsurface Investigation

As stated in our August 12, 2002 *Subsurface Investigation Work Plan*, Cambria recommends additional investigation to further characterize the extent of chemicals of concern in groundwater beneath the site and to provide additional potential extraction points for future remediation at the site. To this end, three extraction wells and one monitoring well will be installed in the approximate locations shown on Figure 2. If accessible, a second monitoring well will be installed beneath the Interstate Highway 880 (I-880) overpass southwest of the site. The location of the monitoring well beneath the overpass will be determined based on input from the California Department of Transportation (Caltrans). Our complete scope of work includes the following tasks:

Utility Location: Cambria will notify Underground Service Alert of our drilling activities.

Site Health and Safety Plan: We will prepare a comprehensive site safety plan to protect site workers. The plan will be kept onsite during field activities and will be reviewed and signed by each site worker.

Is there GW extraction?

Access/Encroachment Permit: Cambria will contact Caltrans to determine if the installation of a monitoring well beneath the Highway 880 overpass is feasible. If feasible and access to this area is granted, Cambria will obtain an encroachment permit for well installation. If access to this area is not granted by Caltrans, Cambria does not recommend the installation of a monitoring well southwest of I-880 due to the distance from the site.

Well Installation Permits: We will obtain required permits for well installation from the City of Oakland and the Alameda County Public Works Agency.

Soil Borings: Assuming the absence of subsurface and overhead obstructions, Cambria will use a drill rig equipped with hollow-stem augers to advance four soil borings in the approximate locations shown on Figure 2. A fifth boring will be advanced beneath the I- 880 overpass if feasible and if access is granted by Caltrans. The borings will be advanced to approximately 20 fbg. Three of the borings will be completed as extraction wells and the remaining two borings will be completed as groundwater monitoring wells. Soil samples will be collected at 5-foot intervals for lithologic logging and chemical analysis. All collected soil samples will be transported to a State-approved analytical laboratory.

Well Installation and Sampling: The two proposed groundwater monitoring wells will be constructed of 4-inch diameter PVC and screened with 15 feet of 0.010-inch machined slot. The three extraction wells will be constructed of 4-inch diameter PVC and screened with 15 feet of 0.010-inch machined circum slot screen. In each well, a filter pack consisting of No. 2/12 sand will be installed to 1 to 2 feet above the top of the well screen, which will be overlain by 1 to 2 feet of bentonite, and bentonite-cement grout to the surface. A traffic-rated vault-box will be installed to protect each well. At least 72 hours prior to sampling, the wells will be developed by surging and purging at least 10 casing volumes of water. The new wells will be sampled during the next regularly scheduled groundwater monitoring event following installation. Our standard field procedures for monitoring well installation are included as Attachment A. Our standard field procedures for remediation well installation are included as Attachment B.

Chemical Analysis: Selected soil samples will be analyzed by a State-certified analytical laboratory for TPHg, BTEX, and MTBE using EPA Method 8260.

Reporting: Upon receipt of analytical results, we will prepare a report that, at a minimum, will contain:

- A summary of the site background and history;
- Descriptions of the drilling and sampling methods;
- Boring and well logs;
- Tabulated soil analytical results;
- Analytical reports and chain-of-custody forms; and
- Cambria's conclusions and recommendations.

Groundwater Monitoring: Following installation, the monitoring wells will be added to the current quarterly monitoring program. Quarterly groundwater samples will be analyzed for TPHg, BTEX and MTBE.

Proposed GWE

The proposed GWE system will be used to address migration of dissolved MTBE in groundwater at the site. The intent of the proposed GWE system is to hydraulically control MTBE migration in groundwater at the perimeter of the site and in source areas, and to remove dissolved MTBE from groundwater. Conceptual design of the system is described below.

System Design: Cambria will prepare engineering design drawings for permitting and construction of the GWE system. The system will be designed with capacity for easy expansion to additional wells, and to handle additional groundwater flow, if necessary. Depending on the results of future investigation and monitoring activities, additional pumping wells may be added.

Data pertaining to anticipated groundwater flow rates has been collected during mobile GWE events currently conducted on a weekly basis. Although these events do not serve as a formal pump test designed to calculate properties such as transmissivity and hydraulic conductivity, etc., sufficient data was gathered to allow for a reasonable estimation of system flow rates. The wells are anticipated to produce flows of approximately 1.5 gallons per minute each.

Pumping Locations: The proposed interim GWE and treatment system design includes pumping from two existing wells (wells MW-2 and MW-3), and three proposed onsite extraction wells as described above. Piping will be installed to backfill well T-1 to accommodate future consideration of other remedial alternatives (such as SVE). Refer to Figure 2 for the location of these wells.

Wells MW-2 and MW-3 were constructed using 4" diameter PVC casing installed to a depth of 20 fbg. Both wells are screened from 5 to 20 fbg with 0.010-inch slotted perforation. Backfill well T-1 was constructed using 4" diameter PVC casing screened its entire length to a final depth of approximately 10 fbg. Refer to the well installation section of this work plan for construction details of the proposed wells.

Current depth to water is approximately 12 fbg, leaving a water column of approximately 8 feet in each monitoring well.

System Equipment: Groundwater will be extracted from the wells using pneumatic submersible pumps due to the relatively low anticipated flow rates. Selection of pump makes and models will be determined as part of the final design. An air compressor will provide compressed air to drive the pneumatic pumps.

The extracted groundwater will be pumped from the wells into a storage tank, located in a remediation compound. The compound will be located at the southeast planter area as shown in Figure 2. To prevent overflow of the storage tank, a float switch in the storage tank will shut off the system when the tank is full. Extracted groundwater will be pumped from the storage tank, using a transfer pump, through a particulate filter and then through a series of aqueous-phase carbon vessels prior to discharge to the local sanitary sewer. Flow meters, pressure gauges, and sample ports will be installed to control and monitor system operation.

Power requirements for the system will be determined when design drawings are prepared. An electrical control panel with a programmable logic controller will interlock and operate the controls of the GWE system. A telephone autodialer will be installed to remotely notify Cambria of system shutdown events.

Building Permits: Cambria will submit engineered drawings and specifications to the City of Oakland for design review and issuance of applicable construction permits.

Discharge Permitting: Cambria anticipates discharging treated groundwater to the local sanitary sewer system, under the authorization of an East Bay Municipal Utility District (EBMUD) discharge permit. Cambria will submit the necessary permit application materials to EBMUD.

Construction: Cambria will issue engineered drawings, specifications, and a detailed scope of work to a Shell-preferred contractor for submittal of construction costs and schedule. The contractor will begin construction after Shell approves the construction cost and schedule. Cambria will provide oversight of construction activities included in the contractor's scope of work. The contractor will arrange all required inspections.

Utility Location: The contractor will notify Underground Service Alert of the construction activities. A private underground utility locator will be hired to locate utilities in the vicinity of the trench excavations.

Site Health and Safety Plan: Cambria and the contractor will prepare comprehensive site safety plans to protect site workers. The plan will be kept onsite during field activities and will be reviewed and signed by each site worker.

Start-up: After inspection approval, Cambria will collect GWE system start-up samples and operational data as specified by sewer discharge permit. The samples will be transported to a State-approved analytical laboratory for the appropriate chemical analysis. The analytical results will be submitted to the EBMUD for review. Start-up of the GWE system will occur after receiving discharge approval from EBMUD. Copies of any start-up reports submitted to EBMUD will also be sent to the ACHCSA.

CLOSING

Please call Jacquelyn Jones at (510) 420-3316 if you have any questions or comments. Thank you for your assistance.

Sincerely,
Cambria Environmental Technology, Inc.

Jacquelyn L. Jones
Project Geologist

Matthew W. Derby, P.E.
Senior Project Engineer

REGISTERED PROFESSIONAL ENGINEER
MATTHEW W. DERBY
No. C055475
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CIVIL
STATE OF CALIFORNIA

Figures: 1 - Vicinity/Area Well Survey Map
2 - Monitoring Well, Soil Boring and Remediation System Location Map

Attachments: A - Standard Field Procedures for Monitoring Well Installation
B - Standard Field Procedures for Remediation Well Installation

cc: Karen Petryna, Shell Oil Products US, P.O. Box 7869, Burbank, CA 91510-7869

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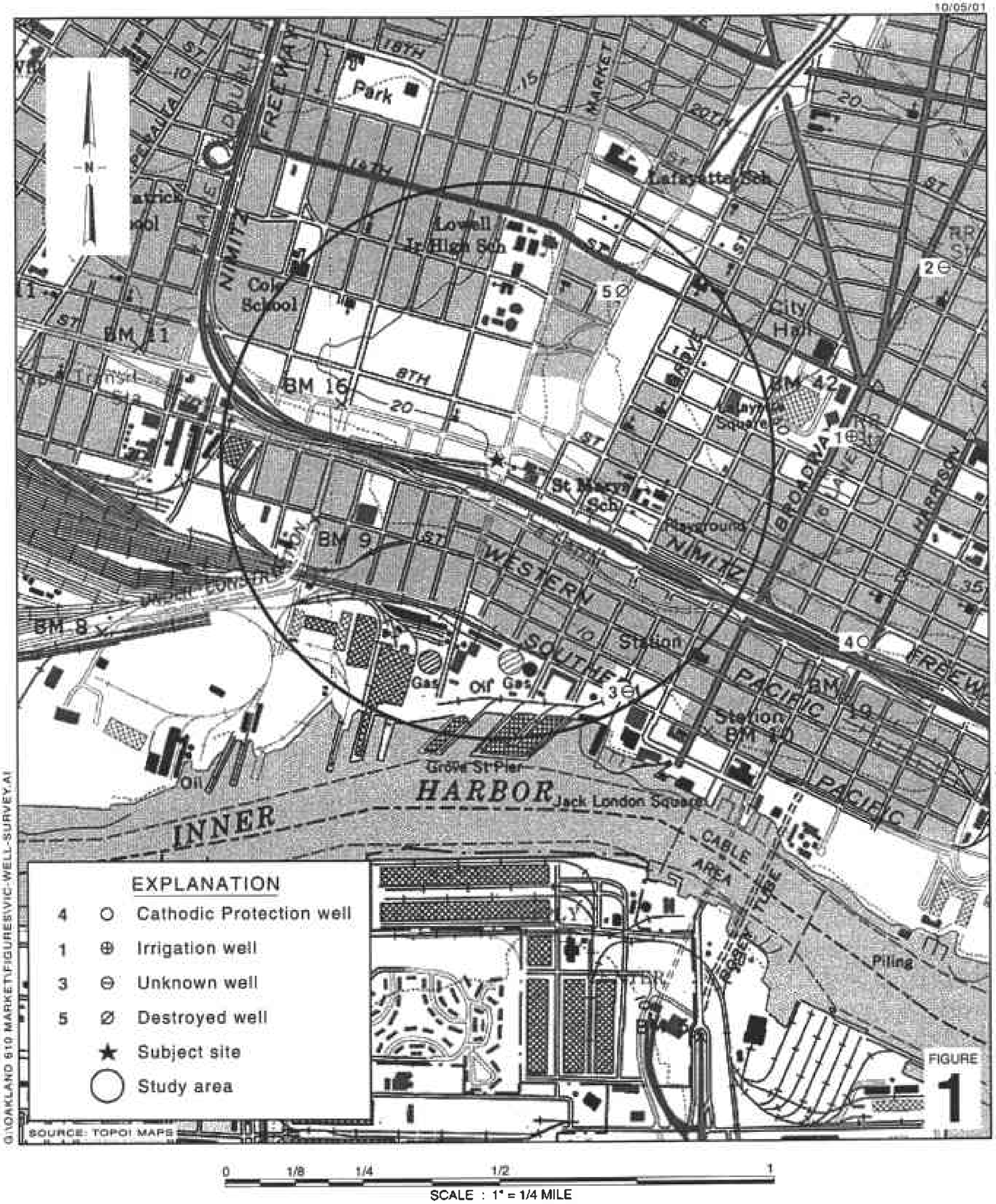

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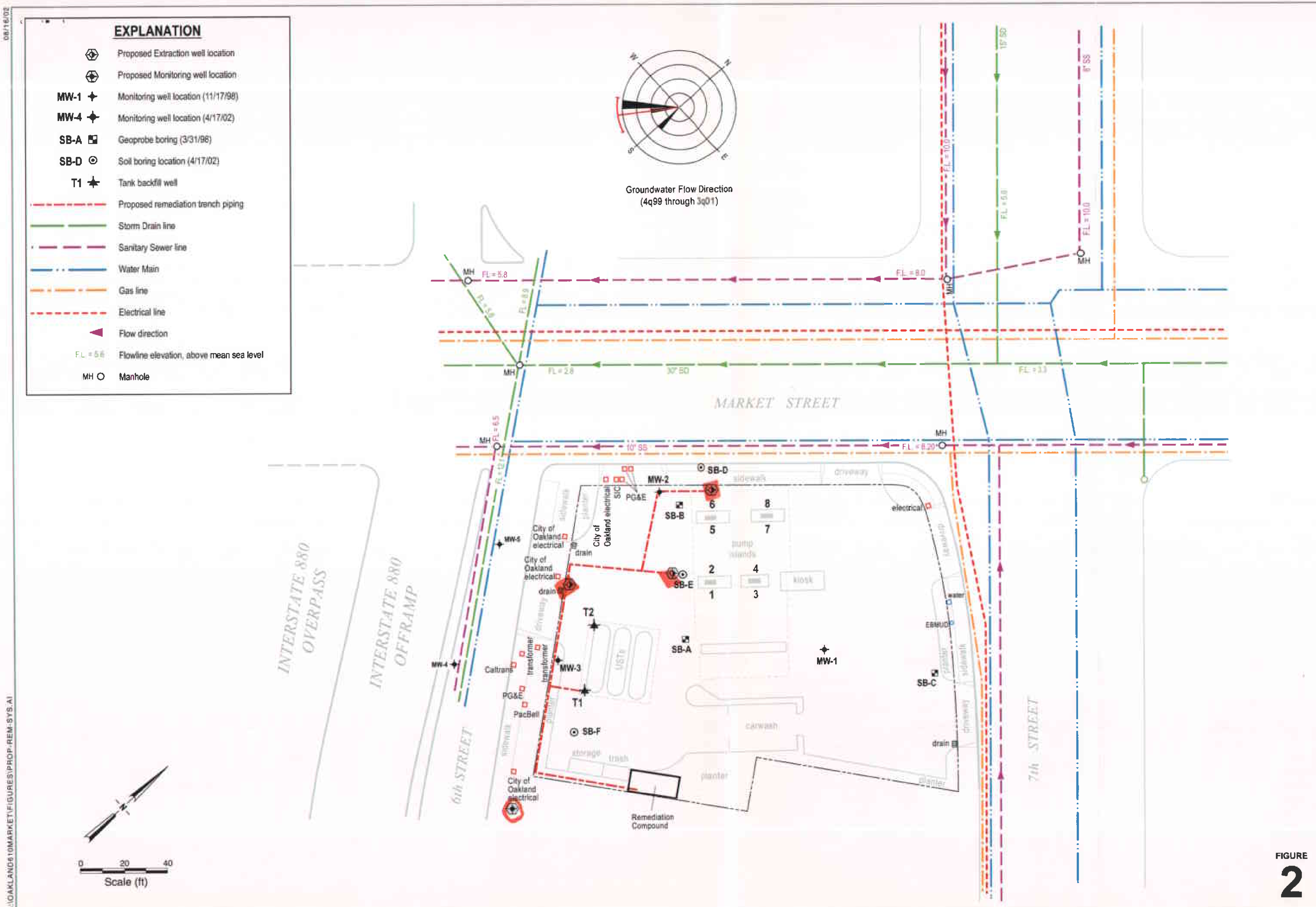
Vicinity / Area Well Survey Map

1/2 Mile Radius



FIGURE

2

Monitoring Well, Soil Boring and Remediation System Location Map

Shell-branded Service Station

610 Market Street
Oakland, California
Incident #98995750

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ATTACHMENT A

Standard Field Procedures for Monitoring Well Installation

STANDARD FIELD PROCEDURES FOR MONITORING WELL INSTALLATION

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

SOIL BORINGS

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).

Soil Boring and Sampling

Soil borings are typically drilled using hollow-stem augers or direct-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 volatile vapor analyzer measures volatile hydrocarbon vapor concentrations in the tube headspace, extracting the vapor through a slit in the cap. Volatile vapor analyzer measurements are used along with the field observations, odors, stratigraphy and groundwater depth to select soil samples for analysis.

Water Sampling

Water samples, if they are collected from the boring, are either collected using a driven Hydropunch® type sampler or are collected from the open borehole using bailers. The groundwater samples are decanted into the appropriate containers supplied by the analytic laboratory. Samples are labeled, placed in protective foam sleeves, stored on crushed ice at or below 4°C, and transported under chain-of-custody to the laboratory. Laboratory-supplied trip blanks accompany the samples and are analyzed to check for cross-contamination. An equipment blank may be analyzed if non-dedicated sampling equipment is used.

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.

MONITORING WELL INSTALLATION, DEVELOPMENT AND SAMPLING

Well Construction and Surveying

Groundwater monitoring wells are installed to monitor groundwater quality and determine the groundwater elevation, flow direction and gradient. Well depths and screen lengths are based on groundwater depth, occurrence of hydrocarbons or other compounds in the borehole, stratigraphy and State and local regulatory guidelines. Well screens typically extend 10 to 15 fee below and 5 feet above the static water level at the time of drilling. However, the well screen will generally not extend into or through a clay layer that is at least three feet thick.

Well casing and screen are 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 feet above the well screen. A two feet thick hydrated bentonite seal separates the sand from the overlying sanitary surface seal composed of Portland type I,II cement.

Well-heads are secured by locking well-caps inside traffic-rated vaults finished flush with the ground surface. A stovepipe may be installed between the well-head and the vault cap for additional security.

The well top-of-casing elevation is surveyed with respect to mean sea level and the well is surveyed for horizontal location with respect to an onsite or nearby offsite landmark.

Well Development

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.

Groundwater Sampling

Depending on local regulatory guidelines, three to four well-casing volumes of groundwater are purged prior to sampling. Purging continues until groundwater pH, conductivity, and temperature have stabilized. Groundwater samples are collected using bailers or pumps and are decanted into the appropriate containers supplied by the analytic laboratory. Samples are labeled, placed in protective foam sleeves, stored on crushed ice at or below 4°C, and transported under chain-of-custody to the laboratory. Laboratory-supplied trip blanks accompany the samples and are analyzed to check for cross-contamination. An equipment blank may be analyzed if non-dedicated sampling equipment is used.

Waste Handling and Disposal

Soil cuttings from drilling activities are usually stockpiled onsite and covered by plastic sheeting. At least three individual soil samples are collected from the stockpiles and composited at the analytic laboratory. The composite sample is analyzed for the same constituents analyzed in the borehole samples in addition to any analytes required by the receiving disposal facility. Soil cuttings are transported by licensed waste haulers and disposed in secure, licensed facilities based on the composite analytic results.

Groundwater removed during development and sampling is typically stored onsite in sealed 55-gallon drums. Each drum is labeled with the drum number, date of generation, suspected contents, generator identification and consultant contact. Upon receipt of analytic results, the water is either pumped out using a vacuum truck for transport to a licensed waste treatment/disposal facility or the individual drums are picked up and transported to the waste facility where the drum contents are removed and appropriately disposed.

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ATTACHMENT B

Standard Field 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.

8/16/02