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BP West Coast Products, LLC

Pre-Excavation Soil Sampling and Excavation Work Plan

Former ARCO Olympia Bulk Terminal
Industrial Petroleum Distributors Site
1120 West Bay Drive
Olympia, Washington 98502
Agreed Order DE 10470
F/S ID: 1436
Cleanup Site ID: 4240

June 2, 2015

ARCADIS

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Myles Perkins
Environmental Engineer, PE

Prajakta Ghatpande, PE
Project Manager

Peter Campbell, PE
Senior Engineer
Professional Engineer, WA-45051

Prepared for:
BP West Coast Products, LLC

Prepared by:
ARCADIS U.S., Inc.
1100 Olive Way
Suite 800
Seattle, WA 98101
Tel 206 325 5254
Fax 206 325 8218

Our Ref.:
GP09BPNA.WA60

Date:
June 2, 2015

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Acronyms and Abbreviations

ARCADIS	ARCADIS U.S., Inc.
ARCO	Atlantic Richfield Company
as-built report	Cleanup Action Completion Report
AST	aboveground storage tank
bgs	below ground surface
BNSF	Burlington Northern Santa Fe
CAP	Cleanup Action Plan
CAR	Cleanup Action Report
CGP	Construction General Permit
COC	constituent of concern
cPAH	carcinogenic polycyclic aromatic hydrocarbon
CPS	Construction Plans and Specifications
CUL	cleanup level
cy	cubic yards
DU	decision unit
Ecology	Washington State Department of Ecology
GPR	ground-penetrating radar
H&S	health and safety
HASP	Health and Safety Plan
LNAPL	light nonaqueous phase liquid
MTCA	Model Toxics Control Act
NWTPH	Northwest Total Petroleum Hydrocarbon
PID	photo ionization detector
PPE	personal protective equipment
PTW	permit to work

RCRA	Resource Conservation and Recovery Act
RI	remedial investigation
ROW	Right of Way
SHA	site hazard assessment
site	former Industrial Petroleum Distributors Site, generally located at 1120 West Bay Drive in Olympia, Washington
SOP	Standard Operating Procedure
SWPPP	Stormwater Pollution Prevention Plan
TBD	to be determined
TPH-DRO	total petroleum hydrocarbons-diesel range organics
TPH-GRO	total petroleum hydrocarbons-gasoline range organics
TPH-HO	total petroleum hydrocarbons-heavy oil range organics
Unanticipated Discovery Plan	Plan and Procedures for Unanticipated Discovery of Cultural Resource and Human Skeletal Remains
USEPA	United States Environmental Protection Agency
VOC	volatile organic compound
Work Plan	Pre-Excavation Soil Sampling and Excavation Work Plan

1. Introduction

On behalf of BP West Coast Products, LLC, ARCADIS U.S., Inc. (ARCADIS) prepared this Pre-Excavation Soil Sampling and Excavation Work Plan (Work Plan) for the lowland portion of the former Industrial Petroleum Distributors Site, generally located at 1120 West Bay Drive in Olympia, Washington (site) as required by Agreed Order No. DE 10470.

Although the site consists of parcels located on both sides of the West Bay Drive, this work plan specifies the excavation work, including pre-excavation soil sampling, to be implemented on the lowland parcel located on the east side of West Bay Drive. The site and surrounding areas are shown on Figures 1 and 2. A Site Plan is presented on Figure 3.

2. Current Status

Several investigations and remedial activities have been conducted at the Site since site operations began in the 1970s. These activities are described in Section 4 of this Work Plan.

In fall 2014, the Washington State Department of Ecology (Ecology) held a public comment period and finalized the Agreed Order (a binding document between Atlantic Richfield Company [ARCO] and Ecology to conduct remedial action at the site) and the Cleanup Action Plan (CAP; Ecology 2014). The characterization and excavation activities proposed in this Work Plan are in accordance with the activities described in the CAP (Ecology 2014) and our communication with Ecology.

3. Regulatory Consultation

ARCADIS conducted a remedial investigation (RI) and submitted a report to Ecology on January 30, 2012 (ARCADIS 2012). The initial horizontal extent proposed in the RI was based on limited historical soil data. To further define vertical and horizontal excavation limits, ARCADIS proposed a cleanup action including grid sampling followed by excavation of impacted grids (ARCADIS 2013). Ecology reviewed and approved this approach. Details of pre-excavation soil sampling and excavation activities are described in Sections 7.2 and 7.3 of this Work Plan, respectively.

Activities associated with the excavation are outlined in this Work Plan. Construction Plans and Specifications (CPS) will be completed within 60 days of the completion of pre-excavation soil sampling field activities, and will present specific design details for this work. Record drawings and other details associated with this work will be presented in a cleanup action completion report (as-built report).

4. Background

The site was placed on the Washington State Confirmed and Suspected Sites List in 1994, following an inspection conducted by Ecology. During the inspection, corrosion around the base of several aboveground storage tanks (ASTs) in the tank farm and soil staining was observed in several areas. In 1998, the Thurston County Health Department conducted a site hazard assessment (SHA); based on the assessment, the site was given a “1” ranking and placed on Ecology’s Hazardous Sites List. During the SHA, the poor condition of the ASTs was again noted and active leakage of the waste stored in the tanks was observed. In 1999, the property owner performed demolition of site features and a total of approximately 160,000 gallons of waste oil materials were removed from the tanks (Associated Environmental Group, LLC 2002). An undocumented underground storage tank, located south of the loading dock, was also removed.

In 2001, SECOR conducted an RI/feasibility study including the installation of 24 direct-push borings, five groundwater monitoring wells, two surface soil samples, and six test pits (SECOR 2001). SECOR also collected 15 soil samples on the lowland parcel that showed evidence of petroleum constituents, including total petroleum hydrocarbons-diesel range organics (TPH-DRO), total petroleum hydrocarbons-heavy oil range organics (TPH-HO), metals, and volatile organic compounds (VOCs) in soil and groundwater samples.

In 2002, an interim action (partial cleanup) was performed at the upland tank farm portion of the site under Ecology’s Voluntary Cleanup Program. Approximately 340 tons of impacted soil were excavated and demolition of site features was conducted.

In 2012, ARCADIS completed the investigation of the lowland portion of the site that SECOR began in 2001. ARCADIS installed 16 soil borings to characterize the extent of petroleum hydrocarbons in soil at the locations shown on Figure 4. Seven of the borings were completed as groundwater monitoring wells to evaluate potential constituent of concern (COC) concentrations in groundwater. Soil sample analytical results are presented in Table 1.

Groundwater analytical results for the site were compared to the Model Toxics Control Act (MTCA) Method A Cleanup Levels (CULs) for Groundwater as presented in Table 720-1 of Chapter 173-340 Washington Administrative Code (Ecology 2007). Groundwater samples did not exhibit concentrations of analyzed chemicals in exceedance of the MTCA Method A CULs. Groundwater sampling results are summarized in Table 2.

5. Constituents of Concern

5.1 Soil

MTCA Method A CULS (MTCA Chapter 173-340) were used to compare site concentrations of residual and dissolved-phase COCs with cleanup criteria. The MTCA Method A CULs were established for groundwater where drinking water is of beneficial use and soil for unrestricted land use.

Naphthalenes, carcinogenic polycyclic aromatic hydrocarbons (cPAHs), total petroleum hydrocarbons-gasoline range organics (TPH-GRO), and TPH-DRO were detected above the applicable MTCA Method A CULs in soil samples collected from several locations in the northwest corner of the site.

COCs detected at the site greater than MTCA Method A CULs are listed below:

- GRO (soil)
- DRO (soil)
- Naphthalene (soil)
- Benzo(a)pyrene (soil)

Historical soil analytical results are presented in Table 1.

5.2 Groundwater

No groundwater impacts have been observed at groundwater wells at the site to date (October 1, 2010 to December 22, 2011). Groundwater analytical results and water table elevations are presented in Table 2.

6. Regional and Site-Specific Settings

6.1 Geology

The site is situated on West Bay, located on the southern end of Budd Inlet in Puget Sound. Puget Sound is located in the Puget Trough, which is bordered by the Cascade Range to the east and the Coast Range to the west. The site elevation is approximately at mean sea level, and the topography of the immediate area is generally flat, with a slope toward West Bay. The site is located in a geographic area known as the Puget Sound lowlands, on an area of Pleistocene-age glacial recessional outwash. The recessional outwash forms a layer ranging from a few feet to 150 feet thick and is characterized as poorly sorted, discontinuously bedded loose gravel with some sand, silt, and clay (Washington State Department of Water Resources 1970).

Subsurface material observed during site investigation activities generally consisted of silty clays and sandy silt to approximately 6 feet below ground surface (bgs) and fine to medium sand and fine gravel between 6 and 13 feet bgs. Wood debris and bark dust were observed between 3 and 9 feet bgs. Observed subsurface conditions are consistent with the location of the site adjacent to West Bay and are indicative of historical glacial deposition.

6.2 Hydrogeology

Groundwater gradient at the site is generally to the southeast, toward West Bay at a hydraulic gradient of approximately 0.033 and 0.031 foot/foot at high and low tides, respectively. Groundwater elevation data from 2010 and 2011 are presented in Table 2. Groundwater in wells MW-7, MW-8, and MW-9 are likely experiencing influence from brackish bay water based on their proximity to the bay.

7. Remedial Excavation Activities

As outlined in the CAP (Ecology 2014), ARCADIS will conduct pre-excavation soil sampling to further define vertical and horizontal excavation limits. Grid locations, referred to as decision units (DUs) in this Work Plan, are located around previously identified areas of impacted soil within the Port of Olympia property boundary and Burlington Northern Santa Fe (BNSF) right of way (ROW) as shown on Figure 4. A direct-push soil boring will be advanced at the center of each DU to collect vertical extent soil samples and define the extent of soil impacts. Excavation activities will then be conducted to the extent determined by pre-excavation sampling. In addition, the exposed pipe elbow shown on Figure 4 will be removed and the remaining pipe will be cut to the soil excavation grade and abandoned.

Construction activities are summarized below. Plans and Specifications for this work will be completed and submitted to Ecology, City of Olympia, Port of Olympia, BNSF, and subcontractors prior to execution of the work. Record drawings and other details associated with this work will be presented in the Cleanup Action Report (CAR).

7.1 Utility Clearance

The site is currently unoccupied. A public utility clearance using Washington 811 dig alert will be conducted prior to initiating excavation activities. A private utility locator will conduct a ground-penetrating radar (GPR) survey prior to conducting field efforts. Additionally, the survey area will be expanded outside of the proposed excavation area to understand the layout of utilities in public ROWs and other off-site areas. The GPR survey will be the first level of effort prior to mobilization of any equipment to the site.

Utility maps will be used to field verify GPR. A combination of field verification, historical data, and a GPR survey will provide a minimum of three lines of evidence that utilities will not be impacted during field activities.

Representatives from the general contractor will be present to verify that equipment maneuverability and site access are adequate around areas of the excavation where utilities might be located.

7.2 Pre-Excavation Soil Sampling

The initial horizontal extent proposed in the RI (ARCADIS 2012) was based on limited historical soil data, and is based on concentrations of petroleum hydrocarbon constituents exceeding MTCA Method A CULs at soil boring locations GP-2, MW-6R, GP-5, and GP-6, and cPAH exceedances at off-site boring locations MW-1 and MW-12. To further define vertical and horizontal excavation limits, sampling locations will be placed on 10-foot centers forming a 10 x 10-foot sampling grid surrounding previously identified areas of impacted soil within the Port of Olympia property boundary (GP-2, GP-5, GP-6, and MW-6R) and BNSF ROW (MW-11 and MW-12). The initial horizontal extent of excavation proposed in the RI (ARCADIS 2012), along with the minimum excavation extent and proposed soil sampling grid with the individual DUs, are shown on Figure 4.

7.2.1 Boring Installation

ARCADIS will oversee the advancement of one soil boring per specified DU (55 total) to approximately 10 feet bgs. The soil borings will be advanced using direct-push methodology at the center of each grid location, as shown on Figure 4. Sample locations will be pre-surveyed, marked and recorded prior to the start of excavation using the grid shown on Figure 4. One soil sample will be collected from 0 to 5 and 5 to 10 feet bgs from each soil boring. If field screening results indicate impacts below 10 feet bgs, the soil boring will be advanced deeper to a depth of 15 feet bgs and additional samples will be collected to delineate the vertical extent of contamination. For all grid locations with existing available data except MW-6R, soil samples will be collected from the 6.5- to 10-foot intervals or deeper to delineate the vertical extent of the proposed excavation.

Drilling activities will be conducted by a licensed subcontractor. During drilling, continuous soil samples will be collected for lithological description from ground surface to the total depth explored. Soil from each sample interval will be screened in the field for VOCs using a photo ionization detector (PID). PID readings, soil types, and other pertinent geological data will be recorded on a boring log. Procedures and methodology will be conducted in accordance with ARCADIS' Standard Operating Procedure (SOP) for Drilling Procedures for Collecting and Screening of Soil Samples (Appendix A).

7.2.2 Sample Analysis

Samples collected for laboratory analysis will be placed in laboratory-provided containers and stored in an ice-chilled cooler prior to delivery to Lancaster Laboratories in Lancaster, Pennsylvania. These samples will be submitted for the following laboratory analysis:

- TPH-GRO by Northwest Total Petroleum Hydrocarbon (NWTPH)-Gx
- TPH-DRO and TPH-HO by NWTPH-Dx
- cPAH and total naphthalenes by United States Environmental Protection Agency (USEPA) Method 8270

Samples will be handled and shipped in accordance with ARCADIS' SOP for Chain-of Custody, Handling, Packing and Shipping, which is included as Appendix A. The laboratory will provide new and certified pre-cleaned sample containers appropriate to the list of analytes. Soil samples require temperature control preservation and will be shipped on ice. The sample method with recommended sample volume, sample container, method detection limits, preservative and maximum holding time are shown in Table 3.

If results from laboratory analysis confirm that the soil left in place is below applicable MTCA Method A CULs, excavation activities will not be conducted within the corresponding DU. However, if results are above the MTCA Method A CULs and soil can be safely removed, excavation activities will be performed at that location. Following submittal and acceptance of this Work Plan, a CPS will be prepared to specify the extent of the excavation determined by pre-excavation soil sampling analytical results.

7.2.3 Field Sampling Quality Control Procedures

Quality control (QC) samples will be collected to ensure Washington Administrative Code (WAC) 173-340-820 requirements are met. The QC samples will include blind field duplicates, trip blanks and sample spikes.

One blind field duplicate will be submitted for every 20 samples (approximately 3 total). Blind duplicates will be labeled with a fictitious sample designation and will be used to assess the percent relative difference for laboratory precision on various analytes. Documentation as to which sample the blind duplicates correspond will be kept on appropriate field sampling forms (Groundwater Sampling Data Form), and ultimately stored in the central project file. Field duplicates will be collected and analyzed for the same parameters as the associated samples, and will be collected to measure the variability inherent in the sampling process.

Trip blanks will be prepared and submitted at a rate of one per shipment (not per cooler). Trip blanks will be requested from and prepared by the laboratory providing the sample containers, and will be prepared by filling bottles with analyte-free water. The vials will be placed in the same transport container as the empty bottles. They will remain with the sample containers during the sampling episode and will be transported to the receiving laboratory in the same shipping or transport container(s) as the collected samples. The trip blanks will be clearly identified on sample tags and chain-of-custody records as trip blanks.

One matrix spike/matrix spike duplicate (MS/MSD) will be performed at the laboratory for every 20 samples. Extra volume for the MS/MSD samples (approximately three times as much as a standard sample) will be collected.

7.2.4 Data Validation

Data validation criteria will be per the EPA National Functional Guidelines. The guidelines provide specific data validation criteria that can be applied to data generated for this investigation.

The following steps will be performed during the data validation process. First, the laboratory data will be reviewed for compliance with the applicable method and the quality of the data report. Second, the following summary QC data and parameters will be reviewed and the individual data points flagged per National Functional Guidelines (the following will be reviewed as applicable to the individual methods):

- Narrative, cross-reference, COC, and method references
- Analytical results
- Holding times, sample preservation
- Surrogate recoveries/system monitoring compounds
- Blank results
- Laboratory control sample recoveries or fortified lab blanks/blank spikes
- Laboratory control sample duplicate sample results or duplicate spike recoveries
- Compound identification and quantification
- System monitoring compounds/surrogates matrix spikes/matrix spike duplicates target compound identification
- Compound method detection limits field duplicate relative percent differences (RPDs; to assess precision of the method relative to field sampling techniques, the specific sample matrix, and the representativeness of the sample aliquot to the area sampled).

Spike recoveries for laboratory control samples, matrix spike samples, and surrogates will be evaluated against laboratory-specific acceptance criteria. In addition, the relative percent differences for the laboratory control and matrix spike duplicates will be evaluated against laboratory-specific acceptance criteria. Laboratories will provide the acceptance criteria for each analytical method on each sample delivery group. Data will be qualified per National Functional Guidance.

7.2.5 Waste Management

Soil cuttings and wastewater generated during field activities will be contained in United States Department of Transportation-approved, 55-gallon steel drums. These drums will be appropriately labeled and temporarily stored on site, pending analytical results. Upon receipt of soil and water analytical results, the drums will be removed from the site and transported to an approved off-site disposal facility.

7.3 Excavation

The pre-excavation soil sampling data will be used to determine the horizontal and vertical excavation extents. Survey data coupled with GPS locators will be utilized to establish DU footprints and will be marked off with spray paint prior to excavation. No additional confirmation sampling will be conducted at the time of excavation unless existing grid data are insufficient in demonstrating that concentrations are below MTCA Method A CULs. Any additional samples collected to complete delineation of the vertical extent during excavation will be sampled in accordance with ARCADIS' SOP for Surface and Subsurface Soil Sampling Using Manual Methods, which is included as Appendix A.

Soil from DUs that exceed MTCA Method A CULs will be excavated and disposed of at an approved disposal facility. Soil in a grid that does not exceed MTCA Method A CULs will be stockpiled and reused if removal is required to access impacted soil. For example, if the 0- to 5-foot bgs grid sample contains concentrations less than MTCA Method A CULs, than soil would be stockpiled and the impacted soil below that would be removed and disposed of. In the DUs where the 5- to 10-foot bgs sample exceeds MTCA Method A CULs, the excavation depth will be extended to the depth determined by pre-excavation soil sampling to a maximum depth of 15 feet bgs.

Soil from the DU location containing MW-6R will be excavated to a depth of 6 feet bgs. A soil sample obtained previously from this location at 6 to 6.5 feet bgs was below MTCA Method A CULs.

The existing piping elbows that are exposed at the surface will be removed. The pipe will be cut at the soil excavation grade and the remaining pipe will be abandoned and capped via cement grout. Railroad ties (if removed) will be disposed of at an approved facility and steel rails will be salvaged.

Depending on the results of the confirmation sampling, a minimum of approximately 370 cubic yards (cy) and up to approximately 2,225 cy of impacted soil will be excavated and disposed of at an appropriate off-site disposal facility. A preliminary extent of excavation indicating initial horizontal extent and minimum excavation extent based on the current available data is shown on Figure 4. Excavation limits will be extended to DUs where COC concentrations are confirmed to be above MTCA Method A CULs during the pre-excavation soil sampling event. The following sections discuss the activities that will be completed under supervision by ARCADIS field staff.

7.3.1 Monitoring Well Abandonment

ARCADIS will remove at least three monitoring wells (MW-6R, MW-11 and MW-12) from the site. Monitoring well MW-10, which is located within a DU to be tested, may be removed if the DU is found to have impacts during pre-excavation sampling activities. Removal of these wells will be conducted according to Ecology procedures (Washington Administrative Code (WAC) 173-160-261) and the ARCADIS SOP for well decommissioning.

The well monument will be removed and the well borehole will be cleared with an air knife to a minimum of 6.5 feet below ground surface bgs. The well casing will then be removed and the well will be overdrilled to its final depth. The borehole will then be filled with hydrated bentonite to approximately 3 to 4 feet bgs. Each well will then be capped with a minimum 18 inch thick Portland cement concrete plug and covered with field and vegetative cover. Final patching material will be dictated by weather, material availability, and surrounding surface material.

Well abandonment logs for each of the wells will be completed and submitted to Ecology.

7.3.2 Work Area Preparation

The entire excavation area will be surrounded with temporary chainlink fencing with a lockable gate at the entrance/exit. Inside the temporary fence, K-rail concrete barricades will be placed on the inside edge of the western side of the site. K-rail will act as a physical barrier to the outside edge of the excavation along West Bay Drive. This area will represent the exclusion zone. Additionally, the entrance and exit to the area will be barricaded with 48-inch orange safety cones and spotters will be present at the entrance and exit during working hours.

All visitors will check in with ARCADIS personnel at the front gate and must go through a site-specific orientation and tailgate safety meeting. First-time visitors will be escorted throughout the site by the site supervisor or site foreman.

7.3.3 Traffic Control Plan

Due to the site's proximity to West Bay Drive, a Traffic Control Plan will be used by all construction vehicles. Drivers will be instructed to use extreme caution while driving on roadways to avoid motor vehicle and pedestrian traffic. A site-specific excavation and backfill route for loading trucks will be produced prior to commencing excavation activities.

7.3.4 Excavation Structural Support

The limits of the excavation will be defined during the pre-excavation sampling event; therefore, no personnel are expected to enter the excavation. If entry to the excavation is needed at shallow depths (0 to 5 feet bgs), ARCADIS field staff will examine the ground for indications of a potential cave-in hazard. If potential indicators of a cave-in hazard are observed, the ARCADIS field staff will require the implementation of some form of cave-in protection before personnel can enter the area. No entry is allowed within an excavation below 5 feet bgs. Established practices and requirements for workplace safety near excavations and trenches are discussed in ARCADIS' Health and Safety Standard for Excavation and Trenching (Appendix A).

In designated DUs, native fill will be excavated from 0 to 5 feet and stockpiled on site. To remove soil from deeper depths, trench boxes will be implemented along the edge of an impacted DU and driven via excavator to the required excavation depth limit to achieve a steeper incline and remove the maximum amount of contaminated soil. If a maximum depth in a DU is greater than one trench box, soil will be excavated to the bottom of the box and another identical interlocking trench box will be placed on top and driven to the excavation depth limit.

Each DU surrounding a clean DU will be excavated and backfilled independently in series prior to moving to the next impacted DU. Only adjacent, impacted shallow soils to 5 feet bgs may be excavated in conjunction. Excavation limits will be defined and discussed with Ecology prior to excavation activities. Final excavation limits will be included in the CPS.A track-mounted 330 excavator (or similar) will be used to excavate DU soil. Impacted soil will be directly loaded and removed from site. Soil that does not exceed MTCA Method A CULs will be stockpiled on site and reused as backfill. At no time will the driver exit the truck while on site.

7.3.5 Dewatering

Groundwater has been encountered at approximately 2 to 7 feet bgs, with little seasonal variation. Because excavation may be to an approximate depth of 10 feet bgs, groundwater containing sheen or light nonaqueous phase liquid (LNAPL) will be containerized. Based on previous site investigations, sheen or LNAPL is not expected to be encountered during excavation activities. If dewatering during excavation is required, it will be conducted via vacuum truck and stored temporarily on site in a poly baker tank if needed. Any extracted water will be transported off site for disposal at an appropriately licensed facility.

7.3.6 Management of Investigation-Derived Waste

Excavation activities will create solid and liquid waste streams for transportation and off-site disposal. Solid waste (e.g., soil, asphalt, concrete) will be taken to an approved disposal facility. If dewatering is implemented, liquid waste will be collected and recycled by an appropriate subcontractor.

Impacted soils will be direct loaded into truck and trailers for offsite disposal for transportation to an appropriate waste disposal facility. Non impacted soils will be stockpiled in a central location prior to disposal or use as backfill. Excavator operators will take extra care while loading trucks and are responsible for ensuring any spilled material is cleaned up in a timely fashion. Non-impacted stockpiled material will be covered in accordance with SWPPP requirements.

After loading solid waste onto trucks and prior to leaving the property, the truck tires will be inspected and cleaned manually to remove visible debris. All loads will be covered to control fugitive dust during transportation. West Bay Drive Northwest will be monitored to confirm that excavated materials are not tracked to the roadway.

7.3.7 Fill Material

To restore the excavations to pre-existing grade and create a stable surface, a mixture of aggregate, previously excavated material/imported general fill, and topsoil will be used to backfill excavated areas. A processed aggregate with minimal fines content will be used as backfill below the groundwater table because it will compact readily by tamping with the excavator bucket and because its strength will not be compromised by being placed underwater. Because of the anticipated difference in grain size between the aggregate and the surrounding in-situ soil, geotextile fabric will be placed in the open excavations before placement of aggregate to prevent comingling with the in-situ soil. Sufficient geotextile will be laid across the excavations to allow the geotextile to be pulled into the excavations by the aggregate backfill, but leave additional fabric on the ground around the excavations. This will allow the geotextile to lap over the top of the aggregate zone prior to placement of general fill above the aggregate.

Aggregate will be placed in approximately horizontal layers, although it should be recognized that backfilling below the water table will limit the operator's control of lift thickness. The aggregate will be compacted by tamping with the excavator bucket. To avoid damaging the geotextile fabric, aggregate nearest the fabric will likely not be directly compacted until the aggregate extends to an elevation where the excavator bucket is visible when tamping. Aggregate placement will continue until the grade is definitively above the groundwater table, at which point the geotextile will lap over the top of the aggregate to prevent the overlying general fill from comingling with the aggregate.

Backfilling above the groundwater table will be accomplished using previously excavated soil with concentrations below MTCA Method A CULs. If additional material is needed, general fill will be imported from an off-site source. Prior to acceptance, any off-site source will be sampled to verify the lack of chemical constituents above applicable criteria and to establish basic geotechnical properties. The previously excavated soil/ imported general fill will be placed in lifts of controlled thickness and compacted using equipment appropriately sized for the excavation. Because of the variable nature of the previously excavated soil/general fill, compaction assessment may be assessed by proof-rolling or similar testing rather than by achieving a percentage of maximum dry density from a laboratory compaction curve. A test pad may also be used to establish the necessary compaction effort so that direct testing of the backfill in the excavations will not be necessary. The final 6 inches of backfill will be performed using imported topsoil to allow a good stand of vegetation to establish and permanently stabilize the work areas. The geotextile and fill material specifications will be presented in the CPS prior to excavation.

7.3.8 Monitoring Well Installation

Following completion of the excavation, one new groundwater monitoring well will be installed within the excavation area in accordance with WAC 173-160-451. Ecology shall review and approve the location for the new well. The well will be advanced with a direct push Geoprobe unit to a depth of approximately 15 feet. The replacement monitoring well will be constructed with 1-inch diameter of 0.02 inch slotted PVC screen from 5 to 15 feet bgs. Sand pack will be installed to one foot above the well screen followed by bentonite chips to completion. The well will be completed with an 8-inch diameter well box to match the existing grade. The well will be installed in accordance with the ARCADIS Monitoring Well Installation SOP and developed using surge and purge methodology following installation in accordance with the ARCADIS Well Development SOP (Appendix A).

8. Groundwater Monitoring

Groundwater monitoring was conducted at the site during RI activities (2010 to 2011); results of the monitoring indicate that concentrations of COCs detected in groundwater are below MTCA Method A cleanup levels (Table 2). Although groundwater was never detected as impacted media at the site, per Ecology requirements this Work Plan proposes to conduct one pre-excavation and one post-excavation groundwater sampling event to assess completion of the cleanup action. Wells will be monitored in accordance with the ARCADIS Low-Flow Groundwater Purging and Sampling Procedures for Monitoring Wells SOP (Appendix A).

8.1 Pre-Excavation Groundwater Monitoring

Monitoring wells MW-6R and MW-7 through MW-12 will be sampled prior to excavation activities for the following dissolved-phase COCs listed below.

- TPH-GRO by Northwest Total Petroleum Hydrocarbon (NWTPH)-Gx
- TPH-DRO and TPH-HO by NWTPH-Dx
- Benzene, toluene, ethlyblezene, total xylenes (BTEX, collectively), methyl tertiary butyl ether (MTBE), 1,2-dibromoethane (ethylene dibromide, EDB) and 1,2-dichloroethane (ethylene dichloride, EDC) by USEPA Method 8260B
- cPAHs and total napthalenes by USEPA Method 8270C SIM
- Total and dissolved lead by USEPA Method 6020

8.2 Post-Excavation Groundwater Monitoring

Following Construction Activities, the newly installed monitoring well within the proposed excavation as well as existing Monitoring wells MW-7 through MW-9 will be sampled for the following dissolved-phase COCs listed below. MW-10 will also be sampled for if it is not abandoned during excavation activities.

- TPH-GRO by Northwest Total Petroleum Hydrocarbon (NWTPH)-Gx
- TPH-DRO and TPH-HO by NWTPH-Dx

- BTEX, MTBE, EDB and EDC by USEPA Method 8260B
- cPAHs and total napthalenes by USEPA Method 8270C SIM
- Total and dissolved lead by USEPA Method 6020

9. Resources, Roles, and Responsibilities

Communication between contractors and personnel during excavation activities will be established and communicated before the excavation begins. Personnel and their roles and responsibilities are as follows:

- Project Manager – Praj Ghatpande (ARCADIS)
- Site Controller – To be determined (TBD)
- Health and safety (H&S) officer – TBD. ARCADIS will prepare a daily permit to work (PTW) and conduct the morning safety meetings and approve the PTW. ARCADIS will have responsibility for conducting visitor orientation. ARCADIS will conduct safety observations during the project.
- Excavation Contractor – TBD
- Competent Individual – TBD
- Soil Transport and Disposal Contractor – TBD
- Project Documentation – ARCADIS (Project Manual, Health and Safety Plan [HASP], Financial Controls Plan, CAR)
- Project Records Control – ARCADIS (daily work logs, truck logs, visitor logs, manifests, weight tickets)
- Manifesting – ARCADIS (with appropriately trained personnel)
- Housekeeping – Shared responsibility (ARCADIS and Excavation Contractor)

10. Health and Safety

10.1 Health and Safety Plan

A HASP that conforms to 29 Code of Federal Regulations 1910 and 1926, and client-specific requirements, will be prepared and reviewed before the start of excavation activities.

A copy of the HASP will be on site during all field activities and available to site personnel. The HASP will discuss methods for protection of site workers and visitors during remedial activities and will include:

- List of COCs, their characteristics, and potential routes of exposure

- Action levels for the COCs
- Field monitoring methods for the COCs
- Emergency procedures and contact information
- Air monitoring procedures
- Identification of routes to emergency facilities
- Identification of potential physical hazards and response actions for specific remedial tasks
- Personal protective equipment (PPE) for specific remedial tasks.

PPE will generally consist of hard hats, steel-toed boots with puncture-resistant soles, hand protection, ear protection, and eye protection.

10.2 Additional Monitoring

Air monitoring will be conducted continuously with a PID and a 5-gas meter. In addition, a dust management plan will be implemented to minimize dust generation and monitor wind directions and gusts. If necessary, dry soil will be watered.

10.3 Emergency Action Plans

10.3.1 Emergency Rally Point/Points

Gathering points will be discussed each day prior to work during the daily safety meeting. These gathering points will be located away from site activities and will be easily accessible.

10.3.2 Evacuation Routes

Emergency evacuation routes will be planned prior to commencement of excavation activities and will be communicated to all site workers during each daily safety meeting. Prior to the start of operations, the project H&S officer will evaluate the site for the potential for fire, contaminant release, or other catastrophic event. Unusual conditions, chemicals, and/or activities will justify the use of “stop work authority” and be reported to the H&S officer. If warranted, the site will be evacuated following the evacuation plan reviewed that morning.

10.4 Site Personnel Management

10.4.1 Permit to Work

PTWs will be filled out daily by the ARCADIS H&S officer and will be reviewed and approved by the ARCADIS project supervisor. A high-risk PTW will be issued at the initiation of excavation work. The high-risk PTW will be renewed weekly, unless changing conditions require a more frequent review. If other high-risk activities are conducted (e.g., hot work) a separate high-risk PTW will be completed.

10.4.2 Check-in/Check-out Procedures

Project workers will be accounted for on the PTW. Truck drivers will be logged into a truck driver log, which indicates that they understand where to dump their loads.

10.4.3 Visitors

All visitors are required to review the PTW and must be escorted throughout the site.

10.4.4 Defined Work Area

The perimeter of the excavation will be surrounded with temporary security fencing. This area will represent the exclusion zone. All personnel within the exclusion zone must have full Level D PPE. Work areas will be discussed during the morning and afternoon safety meeting. These work zones are shown on a map of the site during the meeting.

11. Permitting

11.1 Air

No air permits are required; however, an Air Monitoring Plan will be prepared and implemented during project activities. Air monitoring will be conducted to monitor worker and community safety during excavation activities.

Dust meters will be stationed at the site to monitor dust real-time. One dust meter will be placed upwind of the work area and one will be placed downwind. A water source will be obtained for dust suppression if needed.

11.2 Operations

All necessary operation permits will be obtained by ARCADIS and the subcontractor prior to initiating work. The State Environmental Policy Act (SEPA) Checklist and

Determination has been prepared and approved and was part of the public comment period for the Cleanup Action Plan. Requirements of applicable City of Olympia Permits (Grading Permits, Traffic Control Plan, and Right-of-Way Obstruction) shall be completed during production of the CPS.

11.3 Dewatering Discharge

No dewatering discharge permits will be required. Any dewatering liquid removed from the excavation will be hauled off site for disposal.

11.4 Stormwater Pollution Prevention Plan

A Construction General Permit (CGP) and Stormwater Pollution Prevention Plan (SWPPP) will be prepared and submitted to meet Ecology requirements. A Notice of Intent, certifying that the requirements of CGP and SWPPP will be submitted electronically to Ecology at least 14 days prior to earth disturbing activities and maintained, will be submitted to Ecology prior to commencing construction activities. The SWPPP will detail the best management practices selected to handle anticipated stormwater discharges, erosion, and sediment control during excavation activities. The SWPPP will be prepared and submitted to Ecology during production of the CPS.

The Contractor shall be responsible for maintaining good housekeeping for all material (e.g. fuel and oil) and all operating equipment while working at the site. All material generated by the Contractor during construction shall be handled and disposed of appropriately by the Contractor.

11.5 Plan and Procedures for the Unanticipated Discovery of Cultural Resources and Human Skeletal Remains

A Plan and Procedures for Unanticipated Discovery of Cultural Resource and Human Skeletal Remains (Unanticipated Discovery Plan) will be prepared and submitted to Ecology. The Unanticipated Discovery Plan will present procedures required, in accordance with state and federal laws, if archaeological materials or human remains are discovered during excavation activities. The Unanticipated Discovery Plan will provide guidance on role responsibilities, documentation of archaeological materials, and agency notification. The Unanticipated Discovery Plan is included as Appendix B.

12. Schedule

Construction activities are anticipated to occur during the first quarter 2015. This Work Plan will be submitted to subcontractors and Ecology prior to preparation of the CSP and execution of work. Record drawings, analytical results from sampling during excavation, and other information associated with this work will be presented in a construction completion report. Project activities are limited by the City of Olympia noise ordinance and will not be conducted from 10pm to 7am. Work will be completed by spring 2016. A detailed schedule of field activities and deliverables is shown in the table below.

Event or Deliverable	Schedule
Access	Ongoing
Pre Excavation Soil Sampling	Summer 2015
Permitting (Grading Permits, Traffic Control Plan, and Right-of-Way Obstruction), Stormwater Pollution Prevention Plan, Air Monitoring Plan	Prior to excavation
Construction Plans and Specifications	Within sixty (60) days from the completion of the pre-excavation soil investigation field activities.
Pre- Excavation Groundwater Monitoring	Prior to Excavation Activities
Excavation Activities	Anticipated Fall 2015
Post- Excavation Groundwater Monitoring	Post Excavation Activities
Draft Cleanup Action Completion Report	Within sixty (60) days of receipt of validated soil and groundwater sample results.
Groundwater Monitoring Reports	Following each groundwater monitoring event, within thirty (30) days of receipt of validated groundwater sample results and no later than ninety (90) days from the date of sampling.

13. References

ARCADIS U.S., Inc. 2012. Remedial Investigation Report, Former ARCO Olympia Bulk Terminal, Industrial Petroleum Distributors Site (Facility Identification No. 1436), 1120 West Bay Drive, Olympia, Washington. January 30.

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Washington State Department of Ecology. 2014. Preliminary Draft Cleanup Action Plan, Former ARCO Olympia Bulk Terminal, Industrial Petroleum Distributors Site (Facility Identification No. 1436), 1120 West Bay Drive NW, Olympia, Washington. July 17. October 2014.

Associated Environmental Group, LLC. 2002. Final Cleanup Action Plan, Former Industrial Petroleum Distributors, 1117 West Bay Drive, Olympia, Washington. January 15.

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Washington State Department of Ecology. 2007. Model Toxics Control Act Statute and Regulation, Publication No. 94-06. Revised November.

Washington State Department of Ecology. 2014. Cleanup Action Plan, Industrial Petroleum Distributors (1120 West Bay Drive NW, Olympia, Washington. October 2014.

Washington State Department of Water Resources. 1970. Geology and Related Groundwater Occurrence, Southeastern Mason County, Washington

ARCADIS

Tables

TABLE 1
SOIL ANALYTICAL RESULTS - AUGUST 23-25, 2010
WORK PLAN

1120 West Bay Drive, Olympia, WA

Analysis	MTCA Method A Cleanup Levels	Sample ID (Depth below ground surface in feet) Date Collected						
		GP-1 (2-2.5) 8/25/2010	GP-1 (4-4.5) 8/25/2010	GP-1 (6-6.5) 8/25/2010	GP-2 (2-2.5) 8/25/2010	GP-2 (4-4.5) 8/25/2010	GP-3 (2-2.5) 8/24/2010	GP-3 (4-4.5) 8/24/2010
Volatile Organic Compounds	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**
Benzene	0.03	<0.0047	<0.019	--	<0.0042	<0.0086	<0.0034	<0.0038
Ethylbenzene	6	<0.0047	<0.019	--	<0.0042	<0.0086	<0.0034	<0.0038
Toluene	7	<0.0047	**0.0342**	--	<0.0042	<0.0086	<0.0034	<0.0038
Total Xylenes	9	<0.014	<0.0567	--	<0.0126	<0.0259	<0.0101	<0.0113
Total Petroleum Hydrocarbons	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**
Gasoline Range Hydrocarbons	30	<8.6	<47*	--	<9.8	**264**	<6.2	<8.6
Diesel Range Organics	2,000	**30.4**	**60.9**	--	**732**	**3,120**	<21.8	**31.1**
Residual Range/Heavy Oil Organics	2,000	**198**	**481**	--	<124	**296**	<87.1	<103
RCRA 8 Metals	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**
Arsenic	20	<12.3	<4.8	--	<13.3	<4.4	<10.9	<12.4
Barium	NE	**80.6**	**52.7**	--	**53.6**	**50.0**	**107**	**101**
Cadmium	2	<6.2*	<2.4*	--	<6.6*	<2.2*	<5.5*	<6.2*
Chromium (total)	(a)	**26.7**	**10.4**	--	**24.6**	**17.5**	**34.5**	**40.4**
Lead	250	**4.7**	**5.2**	--	**4.1**	**4.9**	**5.2**	**4.0**
Mercury	2	<0.12	<0.27	--	<0.15	<0.24	<0.11	<0.12
Selenium	NE	<6.2	<2.4	--	<6.6	<2.2	<5.5	<6.2
Silver	NE	<6.2	<2.4	--	<6.6	<2.2	<5.5	<6.2
c-Polyaromatic Hydrocarbons	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**
Naphthalene	(b)	**0.0087**	<0.0178	<0.0451	<0.0104	**0.192**	<0.0075	<0.0087
1-Methylnaphthalene	(b)	<0.0087	<0.0178	<0.0451	**0.0217**	**0.449**	<0.0075	**0.0143**
2-Methylnaphthalene	(b)	**0.0111**	<0.0178	<0.0451	**0.0228**	**0.463**	<0.0075	**0.0199**
Naphthalenes	5	*0.0242*	*0.0267*	*0.0677*	*0.0497*	*1.10*	*0.011*	*0.039*
Acenaphthene	NE	<0.0087	<0.0178	<0.0451	<0.0104	**0.0896**	<0.0075	<0.0087
Acenaphthylene	NE	<0.0087	<0.0178	<0.0451	**0.0107**	**0.0688**	<0.0075	<0.0087
Anthracene	NE	<0.0087	<0.0178	<0.0451	<0.0104	**0.194**	<0.0075	<0.0087
Benzo (a) anthracene	(c)	<0.0087	<0.0178	<0.0451	<0.0104	**0.315**	<0.0075	<0.0087
Benzo (a) pyrene	0.1	<0.0087	<0.0178	<0.0451	<0.0104	**0.233**	<0.0075	<0.0087
Benzo (b) fluoranthene	(c)	<0.0087	<0.0178	<0.0451	<0.0104	**0.165**	<0.0075	<0.0087
Benzo (g,h,i) perylene	NE	<0.0087	<0.0178	<0.0451	<0.0104	**0.0429**	<0.0075	<0.0087
Benzo (k) fluoranthene	(c)	<0.0087	<0.0178	<0.0451	<0.0104	**0.205**	<0.0075	<0.0087
Chrysene	(c)	<0.0087	<0.0178	<0.0451	<0.0104	**0.338**	<0.0075	<0.0087
Dibenzo (a,h) anthracene	(c)	<0.0087	<0.0178	<0.0451	<0.0104	**0.0498**	<0.0075	<0.0087
Fluoranthene	NE	<0.0087	**0.0237**	**0.0540**	<0.0104	**0.488**	<0.0075	<0.0087
Fluorene	NE	<0.0087	<0.0178	<0.0451	**0.0136**	**0.294**	<0.0075	<0.0087
Indeno (1,2,3-cd) pyrene	(c)	<0.0087	<0.0178	<0.0451	<0.0104	**0.0550**	<0.0075	<0.0087
Phenanthrene	NE	**0.0114**	**0.0302**	<0.0451	**0.0383**	**0.999**	<0.0075	**0.0103**
Pyrene	NE	<0.0087	<0.0178	**0.0625**	<0.0104	**0.522**	<0.0075	<0.0087
cPAH B(a)P Equivalents	0.1	0.0044	0.0089	0.0226	0.00785	**0.315**	0.0038	0.0044

TABLE 1
SOIL ANALYTICAL RESULTS - AUGUST 23-25, 2010
WORK PLAN

1120 West Bay Drive, Olympia, WA

Analysis	MTCA Method A Cleanup Levels	Sample ID (Depth below ground surface in feet) Date Collected						
		GP-4 (2-2.5) 8/23/2010	GP-4 (4-4.5) 8/23/2010	GP-5 (2-2.5) 8/23/2010	GP-5 (4-4.5) 8/23/2010	GP-5 (6-6.5) 8/23/2010	GP-6 (2-2.5) 8/25/2010	GP-6 (4-4.5) 8/25/2010
Volatile Organic Compounds	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**
Benzene	0.03	<0.0033	<0.0033	<0.0034	<0.0095	--	<0.0031	<0.0029
Ethylbenzene	6	<0.0033	<0.0033	<0.0034	<0.0095	--	<0.0031	<0.0029
Toluene	7	<0.0033	<0.0033	<0.0034	<0.0095	--	<0.0031	<0.0029
Total Xylenes	9	<0.0099	<0.0099	<0.0102	**0.107**	--	<0.0094	<0.0087
Total Petroleum Hydrocarbons	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**
Gasoline Range Hydrocarbons	30	<7.6	<7.4	<7.2	**875**	--	<6.6	**486**
Diesel Range Organics	2,000	<24.7	<26.2	**31.8**	**3,780**	--	<23.3	**899**
Residual Range/Heavy Oil Organics	2,000	<98.6	<105	<98.8	**1,040**	--	<93.1	<98.7
RCRA 8 Metals	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**
Arsenic	20	<13.1	<12.6	<12.4	<21.0*	--	<11.5	<12.1
Barium	NE	**120**	**115**	**107**	**130**	--	**127**	**139**
Cadmium	2	<6.5*	<6.3*	<6.2*	<10.5*	--	<5.7*	<6.1*
Chromium (total)	(a)	**48.1**	**48.3**	**35.1**	**40.7**	--	**41.5**	**42.4**
Lead	250	**4.6**	**7.1**	**8.6**	**31.0**	--	**6.4**	**6.3**
Mercury	2	<0.13	<0.13	<0.11	<0.17	--	<0.093	<0.11
Selenium	NE	<6.5	<6.3	<6.2	<10.5	--	<5.7	<6.1
Silver	NE	<6.5	<6.3	<6.2	<10.5	--	<5.7	<6.1
c-Polyaromatic Hydrocarbons	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**
Naphthalene	(b)	<0.0086	<0.0089	**0.0556**	**4.090**	**0.988**	<0.0079	**0.141**
1-Methylnaphthalene	(b)	<0.0086	<0.0089	**0.0397**	**9.56**	**2.580**	<0.0079	**0.532**
2-Methylnaphthalene	(b)	<0.0086	<0.0089	**0.0771**	**12.300**	**2.840**	<0.0079	**0.627**
Naphthalenes	5	*0.013*	*0.013*	*0.172*	***25.95***	***6.408***	*0.019*	*1.30*
Acenaphthene	NE	<0.0086	<0.0089	<0.0083	**0.205**	**0.0646**	<0.0079	**0.0331**
Acenaphthylene	NE	<0.0086	<0.0089	**0.0105**	**0.155**	**0.0524**	<0.0079	**0.0323**
Anthracene	NE	<0.0086	<0.0089	**0.0214**	**0.0802**	<0.0288	<0.0079	**0.0113**
Benzo (a) anthracene	(c)	<0.0086	<0.0089	**0.0227**	**0.0231**	<0.0288	<0.0079	**0.0177**
Benzo (a) pyrene	0.1	<0.0086	<0.0089	**0.0216**	<0.0147	<0.0288	<0.0079	**0.0124**
Benzo (b) fluoranthene	(c)	<0.0086	<0.0089	**0.0269**	**0.0152**	<0.0288	<0.0079	**0.0081**
Benzo (g,h,i) perylene	NE	<0.0086	<0.0089	**0.0185**	<0.0147	<0.0288	<0.0079	<0.0077
Benzo (k) fluoranthene	(c)	<0.0086	<0.0089	**0.0219**	<0.0147	<0.0288	<0.0079	**0.0120**
Chrysene	(c)	<0.0086	<0.0089	**0.0312**	**0.0352**	<0.0288	<0.0079	**0.0202**
Dibenzo (a,h) anthracene	(c)	<0.0086	<0.0089	<0.0083	<0.0147	<0.0288	<0.0079	<0.0077
Fluoranthene	NE	<0.0086	<0.0089	**0.0645**	**0.0864**	**0.0517**	**0.0140**	**0.0359**
Fluorene	NE	<0.0086	<0.0089	<0.0083	**0.856**	**0.262**	<0.0079	**0.113**
Indeno (1,2,3-cd) pyrene	(c)	<0.0086	<0.0089	**0.0164**	<0.0147	<0.0288	<0.0079	<0.0077
Phenanthrene	NE	<0.0086	<0.0089	**0.0594**	**1.460**	**0.289**	**0.0109**	**0.152**
Pyrene	NE	<0.0086	<0.0089	**0.0530**	**0.125**	**0.048**	**0.0100**	**0.0426**
cPAH B(a)P Equivalents	0.1	0.0043	0.0045	0.0307	0.0123	0.022	0.0056	0.016

TABLE 1
SOIL ANALYTICAL RESULTS - AUGUST 23-25, 2010
WORK PLAN

1120 West Bay Drive, Olympia, WA

Analysis	MTCA Method A Cleanup Levels	Sample ID (Depth below ground surface in feet) Date Collected						
		GP-6 (6-6.5) 8/25/2010	GP-7 (2-2.5) 8/24/2010	GP-7 (6-6.5) 8/24/2010	GP-8 (2-2.5) 8/25/2010	GP-8 (4-4.5) 8/25/2010	GP-8 (6-6.5) 8/25/2010	GP-9 (2-2.5) 8/24/2010
Volatile Organic Compounds	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**
Benzene	0.03	<0.0038	<0.0041	<0.0031	<0.003	--	<0.0031	<0.0031
Ethylbenzene	6	<0.0038	<0.0041	<0.0031	<0.003	--	<0.0031	<0.0031
Toluene	7	<0.0038	<0.0041	<0.0031	<0.003	--	<0.0031	<0.0031
Total Xylenes	9	<0.0114	<0.0122	<0.0093	<0.009	--	<0.0093	<0.0092
Total Petroleum Hydrocarbons	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**
Gasoline Range Hydrocarbons	30	**94.4**	<7.3	<7.2	<6.2	--	<6.6	<7.2
Diesel Range Organics	2,000	**57.1**	<23	<24.5	<19.3	--	<22.3	<24.9
Residual Range/Heavy Oil Organics	2,000	<108	<92.1	<98.2	<77.1	--	<89.3	<99.6
RCRA 8 Metals	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**
Arsenic	20	<13.9	<11.5	<12.7	<10.3	--	<11.8	12.4
Barium	NE	**112**	**154**	**113**	**51**	--	**71.8**	**129**
Cadmium	2	<7.0*	<5.8*	<6.3*	<5.2*	--	<5.9*	<6.2*
Chromium (total)	(a)	**44.2**	**45**	**39.9**	**26.7**	--	**32.8**	**42.7**
Lead	250	**7.1**	**6.8**	**4.3**	**8.8**	--	**10.1**	**7.3**
Mercury	2	<0.11	<0.11	<0.12	<0.096	--	<0.10	<0.12
Selenium	NE	<7.0	<5.8	<6.3	<5.2	--	<5.9	<6.2
Silver	NE	<7.0	<5.8	<6.3	<5.2	--	<5.9	<6.2
c-Polyaromatic Hydrocarbons	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**
Naphthalene	(b)	**0.0135**	<0.0081	<0.0085	**0.0092**	**0.0089**	**0.0112**	**0.0181**
1-Methylnaphthalene	(b)	**0.0218**	<0.0081	<0.0085	**0.0090**	**0.0075**	**0.0102**	**0.0162**
2-Methylnaphthalene	(b)	**0.0217**	<0.0081	<0.0085	**0.0125**	**0.0109**	**0.0148**	**0.0248**
Naphthalenes	5	*0.0570*	*0.012*	*0.013*	*0.031*	*0.027*	*0.0362*	*0.0591*
Acenaphthene	NE	<0.0097	<0.0081	<0.0085	<0.0070	<0.0071	<0.0077	<0.0084
Acenaphthylene	NE	<0.0097	<0.0081	<0.0085	<0.0070	<0.0071	<0.0077	<0.0084
Anthracene	NE	<0.0097	<0.0081	<0.0085	<0.0070	<0.0071	<0.0077	**0.0126**
Benzo (a) anthracene	(c)	<0.0097	<0.0081	<0.0085	<0.0070	<0.0071	<0.0077	**0.0162**
Benzo (a) pyrene	0.1	<0.0097	<0.0081	<0.0085	<0.0070	<0.0071	<0.0077	**0.0147**
Benzo (b) fluoranthene	(c)	<0.0097	<0.0081	<0.0085	**0.0105**	**0.0085**	**0.0089**	**0.0239**
Benzo (g,h,i) perylene	NE	<0.0097	<0.0081	<0.0085	<0.0070	<0.0071	<0.0077	**0.0113**
Benzo (k) fluoranthene	(c)	<0.0097	<0.0081	<0.0085	**0.0078**	<0.0071	<0.0077	**0.0139**
Chrysene	(c)	<0.0097	<0.0081	<0.0085	**0.0111**	**0.0089**	**0.0092**	**0.0220**
Dibenzo (a,h) anthracene	(c)	<0.0097	<0.0081	<0.0085	<0.0070	<0.0071	<0.0077	<0.0084
Fluoranthene	NE	<0.0097	<0.0081	<0.0085	**0.0158**	**0.0143**	**0.0142**	**0.0424**
Fluorene	NE	<0.0097	<0.0081	<0.0085	<0.0070	<0.0071	<0.0077	<0.0084
Indeno (1,2,3-cd) pyrene	(c)	<0.0097	<0.0081	<0.0085	<0.0070	<0.0071	<0.0077	**0.0112**
Phenanthrene	NE	<0.0097	<0.0081	<0.0085	**0.0127**	**0.0122**	**0.0134**	**0.0323**
Pyrene	NE	<0.0097	<0.0081	<0.0085	**0.0124**	**0.0120**	**0.0110**	**0.0290**
cPAH B(a)P Equivalents	0.1	0.0064	0.0041	0.0043	0.0054	0.0048	0.0052	0.0214

TABLE 1
SOIL ANALYTICAL RESULTS - AUGUST 23-25, 2010
WORK PLAN

1120 West Bay Drive, Olympia, WA

Analysis	MTCA Method A Cleanup Levels	Sample ID (Depth below ground surface in feet) Date Collected						
		GP-9 (4-4.5) 8/24/2010	GP-9 (5.5-6) 8/24/2010	MW-6R (2-2.5) 8/23/2010	MW-6R (4-4.5) 8/23/2010	MW-6R (6-6.5) 8/23/2010	MW-7 (2-2.5) 8/24/2010	MW-7 (6-6.5) 8/24/2010
Volatile Organic Compounds	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**
Benzene	0.03	--	<0.0031	<0.0031	<0.0215	--	<0.0030	<0.0031
Ethylbenzene	6	--	<0.0031	<0.0031	<0.0215	--	<0.0030	<0.0031
Toluene	7	--	<0.0031	<0.0031	<0.0215	--	<0.0030	<0.0031
Total Xylenes	9	--	<0.0092	<0.0094	<0.0644	--	<0.0090	<0.0094
Total Petroleum Hydrocarbons	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**
Gasoline Range Hydrocarbons	30	--	**13.8**	<6.5	**665**	--	<4.9	<6.8
Diesel Range Organics	2,000	--	<25.0	<22.5	**7,060**	--	<20.3	<24.3
Residual Range/Heavy Oil Organics	2,000	--	<100	<89.9	**1,360**	--	<81.0	<97.4
RCRA 8 Metals	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**
Arsenic	20	--	<13.0	<12.0	<10.0	--	<10.5	<12.5
Barium	NE	--	**102**	**110**	<100	--	**84.1**	**123**
Cadmium	2	--	<6.5*	<6.0*	<5.0*	--	<5.2*	<6.2*
Chromium (total)	(a)	--	**36.5**	**39.4**	**5.0**	--	**22.8**	**34.4**
Lead	250	--	**10.7**	**4.3**	**12.6**	--	**6.6**	**10.7**
Mercury	2	--	<0.11	<0.11	<0.43	--	<0.11	<0.12
Selenium	NE	--	<6.5	<6.0	<5.0	--	<5.2	<6.2
Silver	NE	--	<6.5	<6.0	<5.0	--	<5.2	<6.2
c-Polyaromatic Hydrocarbons	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**
Naphthalene	(b)	**0.0110**	**0.0184**	<0.0080	**2.4800**	**0.0177**	<0.0072	**0.0092**
1-Methylnaphthalene	(b)	<0.0089	**0.0108**	<0.0080	**13.0000**	**0.0623**	<0.0072	<0.0085
2-Methylnaphthalene	(b)	**0.0123**	**0.018**	<0.0080	**16.7000**	**0.0568**	<0.0072	<0.0085
Naphthalenes	5	*0.028*	*0.047*	*0.012*	***32.18***	*0.137*	*0.0108*	*0.0170*
Acenaphthene	NE	<0.0089	<0.0086	<0.0080	**0.4860**	<0.0101	<0.0072	<0.0085
Acenaphthylene	NE	<0.0089	**0.0086**	<0.0080	**0.3300**	<0.0101	<0.0072	<0.0085
Anthracene	NE	<0.0089	**0.0205**	<0.0080	**0.1190**	<0.0101	<0.0072	<0.0085
Benzo (a) anthracene	(c)	**0.0143**	**0.0339**	<0.0080	<0.0358	<0.0101	<0.0072	<0.0085
Benzo (a) pyrene	0.1	**0.0142**	**0.0317**	<0.0080	<0.0358	<0.0101	<0.0072	<0.0085
Benzo (b) fluoranthene	(c)	**0.0163**	**0.0277**	<0.0080	<0.0358	<0.0101	<0.0072	<0.0085
Benzo (g,h,i) perylene	NE	<0.0089	**0.0177**	<0.0080	<0.0358	<0.0101	<0.0072	<0.0085
Benzo (k) fluoranthene	(c)	**0.0148**	**0.029**	<0.0080	<0.0358	<0.0101	<0.0072	<0.0085
Chrysene	(c)	**0.0184**	**0.0334**	<0.0080	**0.0395**	<0.0101	<0.0072	<0.0085
Dibenzo (a,h) anthracene	(c)	<0.0089	<0.0086	<0.0080	<0.0358	<0.0101	<0.0072	<0.0085
Fluoranthene	NE	**0.0405**	**0.0932**	<0.0080	**0.0544**	<0.0101	<0.0072	<0.0085
Fluorene	NE	<0.0089	**0.0167**	<0.0080	**1.6900**	<0.0101	<0.0072	<0.0085
Indeno (1,2,3-cd) pyrene	(c)	**0.0093**	**0.0172**	<0.0080	<0.0358	<0.0101	<0.0072	<0.0085
Phenanthrene	NE	**0.0253**	**0.0877**	<0.0080	**2.9000**	<0.0101	<0.0072	<0.0085
Pyrene	NE	**0.0290**	**0.0652**	<0.0080	**0.2120**	<0.0101	<0.0072	<0.0085
cPAH B(a)P Equivalents	0.1	0.0199	0.0428	0.0040	0.0183	0.00510	0.0036	0.0043

TABLE 1
SOIL ANALYTICAL RESULTS - AUGUST 23-25, 2010
WORK PLAN

1120 West Bay Drive, Olympia, WA

Analysis	MTCA Method A Cleanup Levels	Sample ID (Depth below ground surface in feet) Date Collected						
		MW-8 (2-2.5) 8/24/2010	MW-8 (6-6.5) 8/24/2010	MW-9 (2-2.5) 8/24/2010	MW-9 (6-6.5) 8/24/2010	MW-10 (2-2.5) 8/24/2010	MW-10 (4-4.5) 8/24/2010	MW-11 (2-2.5) 8/25/2010
Volatile Organic Compounds	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Benzene	0.03	<0.0036	<0.0036	<0.0042	<0.0032	<0.0039	<0.0033	<0.0033
Ethylbenzene	6	<0.0036	<0.0036	<0.0042	<0.0032	<0.0039	<0.0033	<0.0033
Toluene	7	<0.0036	<0.0036	<0.0042	<0.0032	<0.0039	<0.0033	<0.0033
Total Xylenes	9	<0.011	<0.0109	<0.013	<0.0097	<0.0116	<0.010	<0.010
Total Petroleum Hydrocarbons	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Gasoline Range Hydrocarbons	30	<7.0	<7.9	<9.0	<8.36	<8.1	<7.8	<7.0
Diesel Range Organics	2,000	<21.6	<25.4	<24.7	<25.6	<23.4	<26.9	**72.3**
Residual Range/Heavy Oil Organics	2,000	<86.3	<102	<98.7	<102	<93.4	<107	**176**
RCRA 8 Metals	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Arsenic	20	<10.9	<13.1	<10.0	<11.1	<12.4	<13.2	<11.2
Barium	NE	**131**	**140**	**156**	**126**	**118**	**126**	**131**
Cadmium	2	<5.5*	<6.6*	<5.0*	<5.6*	<6.2*	<6.6*	<5.6*
Chromium (total)	(a)	**41.7**	**41.9**	**49.0**	**46.0**	**45.8**	**42.0**	**28**
Lead	250	**5**	**4.1**	**7.7**	**6.1**	**4.9**	**14.0**	**58.3**
Mercury	2	<0.11	<0.12	<0.13	<0.11	<0.12	<0.14	**0.12**
Selenium	NE	<5.5	<6.6	<5.0	<5.6	<6.2	<6.6	<5.6
Silver	NE	<5.5	<6.6	<5.0	<5.6	<6.2	<6.6	<5.6
c-Polyaromatic Hydrocarbons	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Naphthalene	(b)	<0.0074	<0.0090	<0.0087	<0.0089	<0.0081	<0.0089	**0.106**
1-Methylnaphthalene	(b)	<0.0074	<0.0090	<0.0087	<0.0089	<0.0081	<0.0089	**0.146**
2-Methylnaphthalene	(b)	<0.0074	<0.0090	<0.0087	<0.0089	<0.0081	<0.0089	**0.180**
Naphthalenes	5	*0.011*	*0.014*	*0.013*	*0.014*	*0.012*	*0.014*	*0.432*
Acenaphthene	NE	<0.0074	<0.0090	<0.0087	<0.0089	<0.0081	<0.0089	<0.0076
Acenaphthylene	NE	<0.0074	<0.0090	<0.0087	<0.0089	<0.0081	<0.0089	**0.0147**
Anthracene	NE	<0.0074	<0.0090	<0.0087	<0.0089	<0.0081	<0.0089	**0.0277**
Benzo (a) anthracene	(c)	<0.0074	<0.0090	<0.0087	<0.0089	<0.0081	<0.0089	**0.0461**
Benzo (a) pyrene	0.1	<0.0074	<0.0090	<0.0087	<0.0089	<0.0081	<0.0089	**0.0460**
Benzo (b) fluoranthene	(c)	<0.0074	<0.0090	<0.0087	<0.0089	<0.0081	<0.0089	**0.0566**
Benzo (g,h,i) perylene	NE	<0.0074	<0.0090	<0.0087	<0.0089	<0.0081	<0.0089	**0.0231**
Benzo (k) fluoranthene	(c)	<0.0074	<0.0090	<0.0087	<0.0089	<0.0081	<0.0089	**0.0356**
Chrysene	(c)	<0.0074	<0.0090	<0.0087	<0.0089	<0.0081	<0.0089	**0.0701**
Dibenzo (a,h) anthracene	(c)	<0.0074	<0.0090	<0.0087	<0.0089	<0.0081	<0.0089	**0.0087**
Fluoranthene	NE	<0.0074	<0.0090	<0.0087	<0.0089	<0.0081	<0.0089	**0.0943**
Fluorene	NE	<0.0074	<0.0090	<0.0087	<0.0089	<0.0081	<0.0089	**0.0120**
Indeno (1,2,3-cd) pyrene	(c)	<0.0074	<0.0090	<0.0087	<0.0089	<0.0081	<0.0089	**0.0210**
Phenanthrene	NE	<0.0074	<0.0090	<0.0087	<0.0089	<0.0081	<0.0089	**0.125**
Pyrene	NE	<0.0074	<0.0090	<0.0087	<0.0089	<0.0081	<0.0089	**0.0860**
cPAH B(a)P Equivalents	0.1	0.0037	0.0045	0.0044	0.0045	0.0041	0.0045	0.0635

TABLE 1
SOIL ANALYTICAL RESULTS - AUGUST 23-25, 2010
WORK PLAN

1120 West Bay Drive, Olympia, WA

Analysis	MTCA Method A Cleanup Levels	Sample ID (Depth below ground surface in feet) Date Collected				
		MW-11 (4-4.5) 8/25/2010	MW-11 (6-6.5) 8/25/2010	MW-12 (2-2.5) 8/25/2010	MW-12 (4-4.5) 8/25/2010	MW-12 (6-6.5) 8/25/2010
Volatile Organic Compounds	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**
Benzene	0.03	<0.0036	--	<0.0034	<0.0035	--
Ethylbenzene	6	<0.0036	--	<0.0034	<0.0035	--
Toluene	7	<0.0036	--	<0.0034	<0.0035	--
Total Xylenes	9	<0.0108	--	<0.010	<0.011	--
Total Petroleum Hydrocarbons	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**
Gasoline Range Hydrocarbons	30	<7.4	--	<6.9	<7.2	--
Diesel Range Organics	2,000	**52.9**	--	**75.7**	**43.1**	--
Residual Range/Heavy Oil Organics	2,000	**142**	--	**153**	**154**	--
RCRA 8 Metals	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**
Arsenic	20	<11.5	--	<12.3	<11.4	--
Barium	NE	**132**	--	**146**	**103**	--
Cadmium	2	<5.8*	--	<6.2*	<5.7*	--
Chromium (total)	(a)	**31.6**	--	**39.9**	**27.9**	--
Lead	250	**55.2**	--	**17.0**	**49.7**	--
Mercury	2	**0.2**	--	<0.12	<0.11	--
Selenium	NE	<5.8	--	<6.2	<5.7	--
Silver	NE	<5.8	--	<6.2	<5.7	--
c-Polyaromatic Hydrocarbons	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**
Naphthalene	(b)	**0.0585**	**0.0891**	**0.147**	**0.101**	**0.0785**
1-Methylnaphthalene	(b)	**0.0814**	**0.105**	**0.141**	**0.110**	**0.0282**
2-Methylnaphthalene	(b)	**0.101**	**0.134**	**0.194**	**0.149**	**0.0458**
Naphthalenes	5	*0.241*	*0.3281*	*0.482*	*0.360*	*0.153*
Acenaphthene	NE	<0.0078	**0.0726**	**0.0186**	**0.0093**	<0.0117
Acenaphthylene	NE	**0.0105**	**0.0210**	**0.0205**	**0.0232**	<0.0117
Anthracene	NE	**0.0209**	**0.112**	**0.0517**	**0.0561**	**0.0225**
Benzo (a) anthracene	(c)	**0.0314**	**0.154**	**0.0871**	**0.0849**	**0.108**
Benzo (a) pyrene	0.1	**0.0328**	**0.168**	**0.0941**	**0.0861**	**0.114**
Benzo (b) fluoranthene	(c)	**0.0445**	**0.181**	**0.118**	**0.136**	**0.106**
Benzo (g,h,i) perylene	NE	**0.0181**	**0.0745**	**0.0504**	**0.0472**	**0.0548**
Benzo (k) fluoranthene	(c)	**0.0352**	**0.120**	**0.0866**	**0.0877**	**0.0882**
Chrysene	(c)	**0.0477**	**0.171**	**0.146**	**0.134**	**0.116**
Dibenzo (a,h) anthracene	(c)	<0.0078	**0.0270**	**0.0198**	**0.0174**	**0.0231**
Fluoranthene	NE	**0.0690**	**0.415**	**0.292**	**0.219**	**0.244**
Fluorene	NE	<0.0078	**0.0367**	**0.0206**	**0.0136**	**0.0126**
Indeno (1,2,3-cd) pyrene	(c)	**0.0173**	**0.0708**	**0.0480**	**0.0492**	**0.0532**
Phenanthrene	NE	**0.0733**	**0.426**	**0.257**	**0.143**	**0.0945**
Pyrene	NE	**0.0564**	**0.358**	**0.228**	**0.165**	**0.195**
cPAH B(a)P Equivalents	0.1	0.0465	**0.225**	**0.132**	**0.125**	**0.153**

TABLE 1
SOIL ANALYTICAL RESULTS - AUGUST 23-25, 2010
WORK PLAN

1120 West Bay Drive, Olympia, WA

Notes:

Concentrations compared to the Model Toxics Control Act (MTCA) Method A soil cleanup levels for unrestricted land uses presented in Table 740-1 of Chapter 173-340 of the Washington Administrative Code (WAC)

The MTCA cleanup level for gasoline range total petroleum hydrocarbons is 100-mg/kg without benzene and 30-mg/kg with benzene present. Benzene was observed in groundwater collected from sample ID-4 in 2001, thus the cleanup level of 30-mg/kg was utilized.

ft = Feet

bgs = Below ground surface

mg/kg = milligram per kilogram

NE = Cleanup level not established under MTCA

-- = not applicable or analyzed

cPAH = Carcinogenic polyaromatic hydrocarbons

B(a)P = Benzo(a)pyrene

< = Chemical not detected above the laboratory reporting limit

* = Laboratory practical quantitation limit is elevated above the MTCA Method A cleanup level, but chemical was not observed above the laboratory method detection limit

Italics = Value calculated for comparison to MTCA cleanup level

Bold = Chemical detected at a concentration above the laboratory reporting limit

Bolded and highlighted font indicates results above the MTCA Method A cleanup level

(a) = Analysis is for total chromium. No MTCA cleanup level has been established for total chromium.

(b) = MTCA cleanup level is 5-mg/kg for total concentration of naphthalene, 1-methylnaphthalene and 2-methylnaphthalene

(c) = See MTCA cleanup level for B(a)P. Total concentration of cPAHs calculated using the toxicity equivalency method in WAC 173-340-708(8)

Lab QA/QC surrogate recovery was outside control limits due to matrix interference for samples GP1-4-4.5, GP1-6-6.5, GP2-4-4.5, GP5-4-4.5, GP6-4-4.5, GP6-6-6.5

Table 2
Groundwater Gauging Data and Select Analytical Results
WA-OLYMP

1117 West Bay Drive, Olympia, WA

All analytical results are presented in micrograms per liter (µg/L)

Well	Date	Notes	TOC	DTW	NAPL	GWE	GRO	DRO	HO	Benzene	Toluene	Ethylbenzene	Total Xylenes	MTBE	EDB	EDC	Total Lead	Dissolved Lead
Model Toxics Control Act (MTCA) Method A Cleanup Levels (CLs) in µg/L							**800/1,000**	**500**	**500**	**5**	**1,000**	**700**	**1,000**	**20**	**0.01**	**5**	**15**	**15**
MW-6R	10/1/2010	(LFP)	14.34	2.42	0.0	11.92	<50	<120	<240	<1.0	<1.0	<1.0	<2.0	--	--	--	<2.0(^)	<2.0(^)
MW-6R	12/29/2010		14.34	2.00	0.0	12.34	--	--	--	--	--	--	--	--	--	--	--	--
MW-6R	12/30/2010	(LFP)	14.34	--	--	--	<50.0	<76	<380	<0.20	<1.0	<1.0	<3.0	--	--	--	<10.0	<10.0
MW-6R	12/30/2010	(Dup)(LFP)	14.34	--	--	--	<50.0	<76	<380	<0.20	<1.0	<1.0	<3.0	--	--	--	<10.0	<10.0
MW-6R	3/17/2011	(LFP)	14.34	1.80	0.0	12.54	<50	<120	<240(^)	<1.0	<1.0	<1.0	<2.0	--	--	--	5.4	<2.0
MW-6R	4/19/2011		14.34	1.96	0.0	12.38	--	--	--	--	--	--	--	--	--	--	--	--
MW-6R	6/11/2011	(LFP)	14.34	2.02	0.0	12.32	<50.0	<85	<430	<0.20	<1.0	<1.0	<3.0	--	--	--	<10.0	<10.0
MW-6R	9/22/2011	(LFP)	14.34	2.35	0.0	11.99	<50.0	<75	<380	<0.20	<1.0	<1.0	<3.0	<1.0	--	--	<10.0	<10.0
MW-6R	12/22/2011	(LFP)	14.34	2.24	0.0	12.10	<50.0	<91	<450	<0.20	<1.0	<1.0	<3.0	--	--	--	<10.0	<10.0
MW-6R	12/22/2011	(Dup)(LFP)	14.34	2.24	0.0	12.10	<50.0	<84	<420	<0.20	<1.0	<1.0	<3.0	--	--	--	<10.0	<10.0
MW-7	10/1/2010	(LFP)	14.54	4.80	0.0	9.74	<50	150(Y)	<250	<1.0	<1.0	<1.0	<2.0	--	--	--	<2.0(^)	<2.0(^)
MW-7	12/29/2010	(LFP)	14.54	2.21	0.0	12.33	<50.0	<77	<380	<0.20	<1.0	<1.0	<3.0	--	--	--	<10.0	<10.0
MW-7	3/17/2011	(LFP)	14.54	2.24	0.0	12.30	<50	<120	<240(^)	<1.0	<1.0	<1.0	<2.0	--	--	--	<2.0	<2.0
MW-7	4/19/2011		14.54	3.61	0.0	10.93	--	--	--	--	--	--	--	--	--	--	--	--
MW-7	6/11/2011	(LFP)	14.54	5.07	0.0	9.47	<50.0	<87	<430	<0.20	<1.0	<1.0	<3.0	--	--	--	<10.0	<10.0
MW-7	6/11/2011	(Dup)(LFP)	14.54	5.07	0.0	9.47	<50.0	<86	<430	<0.20	<1.0	<1.0	<3.0	--	--	--	<10.0	<10.0
MW-7	9/22/2011	(LFP)	14.54	7.21	0.0	7.33	<50.0	<75	<380	<0.20	<1.0	<1.0	<3.0	<1.0	--	--	<10.0	<10.0
MW-7	12/22/2011	(LFP)	14.54	4.79	0.0	9.75	<50.0	<75	<380	<0.20	<1.0	<1.0	<3.0	--	--	--	<10.0	<10.0
MW-8	10/1/2010	(LFP)	13.98	3.93	0.0	10.05	<50	200(Y)	<240	<1.0	<1.0	<1.0	<2.0	--	--	--	<2.0(^)	<2.0(^)
MW-8	12/29/2010	(LFP)	13.98	2.25	0.0	11.73	<50.0	<77	<380	0.21	<1.0	<1.0	<3.0	--	--	--	<10.0	<10.0
MW-8	3/17/2011	(LFP)	13.98	2.19	0.0	11.79	<50	<120	<240(^)	<1.0	<1.0	<1.0	<2.0	--	--	--	<2.0	<2.0
MW-8	3/17/2011	(Dup)(LFP)	13.98	2.19	0.0	11.79	<50	<120	<240(^)	<1.0	<1.0	<1.0	<2.0	--	--	--	<2.0	<2.0
MW-8	4/19/2011		13.98	2.68	0.0	11.30	--	--	--	--	--	--	--	--	--	--	--	--
MW-8	6/11/2011	(LFP)	13.98	3.85	0.0	10.13	<50.0	<83	<420	0.26	<1.0	<1.0	<3.0	--	--	--	<10.0	<10.0
MW-8	9/22/2011	(LFP)	13.98	6.43	0.0	7.55	<50.0	<75	<380	0.35	<1.0	<1.0	<3.0	<1.0	--	--	<10.0	<10.0
MW-8	12/22/2011	(LFP)	13.98	3.89	0.0	10.09	<50.0	<87	<430	0.23	<1.0	<1.0	<3.0	--	--	--	<10.0	<10.0
MW-9	10/1/2010	(LFP)	14.62	3.21	0.0	11.41	110	160(Y)	<250	<1.0	<1.0	<1.0	<2.0	--	--	--	<2.0(^)	<2.0(^)
MW-9	12/29/2010	(LFP)	14.62	2.50	0.0	12.12	56.5	<76	<380	0.21	<1.0	<1.0	<3.0	--	--	--	<10.0	<10.0
MW-9	3/17/2011	(LFP)	14.62	2.28	0.0	12.34	<50	<120	<240(^)	<1.0	<1.0	<1.0	<2.0	--	--	--	<2.0	<2.0
MW-9	4/19/2011		14.62	3.21	0.0	11.41	--	--	--	--	--	--	--	--	--	--	--	--
MW-9	6/11/2011	(LFP)	14.62	3.78	0.0	10.84	84.4	<88	<440	<0.20	<1.0	<1.0	<3.0	--	--	--	<10.0	<10.0
MW-9	9/22/2011	(LFP)	14.62	3.81	0.0	10.81	241	<75	<380	0.37	<1.0	<1.0	<3.0	<1.0	--	--	<10.0	<10.0
MW-9	12/22/2011	(LFP)	14.62	3.10	0.0	11.52	222	<76	<380	0.30	<1.0	<1.0	<3.0	--	--	--	<10.0	<10.0
MW-10	10/1/2010	(LFP)	15.03	3.56	0.0	11.47	<50	<120	<240	<1.0	<1.0	<1.0	<2.0	--	--	--	<2.0(^)	<2.0(^)
MW-10	10/1/2010	(Dup)(LFP)	15.03	3.56	0.0	11.47	<50	<120	<240	<1.0	<1.0	<1.0	<2.0	--	--	--	<2.0(^)	<2.0(^)

Table 2
Groundwater Gauging Data and Select Analytical Results
WA-OLYMP

1117 West Bay Drive, Olympia, WA

All analytical results are presented in micrograms per liter (µg/L)

Well	Date	Notes	TOC	DTW	NAPL	GWE	GRO	DRO	HO	Benzene	Toluene	Ethylbenzene	Total Xylenes	MTBE	EDB	EDC	Total Lead	Dissolved Lead
Model Toxics Control Act (MTCA) Method A Cleanup Levels (CLs) in µg/L							**800/1,000**	**500**	**500**	**5**	**1,000**	**700**	**1,000**	**20**	**0.01**	**5**	**15**	**15**
MW-10	12/29/2010	(LFP)	15.03	2.70	0.0	12.33	<50.0	<77	<380	<0.20	<1.0	<1.0	<3.0	--	--	--	<10.0	<10.0
MW-10	3/17/2011	(LFP)	15.03	2.92	0.0	12.11	<50	<120	<240(^)	<1.0	<1.0	<1.0	<2.0	--	--	--	<2.0	<2.0
MW-10	4/19/2011		15.03	3.08	0.0	11.95	--	--	--	--	--	--	--	--	--	--	--	--
MW-10	6/11/2011	(LFP)	15.03	3.10	0.0	11.93	<50.0	<86	<430	<0.20	<1.0	<1.0	<3.0	--	--	--	<10.0	<10.0
MW-10	9/22/2011	(LFP)	15.03	3.31	0.0	11.72	<50.0	<75	<380	<0.20	<1.0	<1.0	<3.0	<1.0	--	--	<10.0	<10.0
MW-10	12/22/2011	(LFP)	15.03	3.21	0.0	11.82	<50.0	<75	<380	<0.20	<1.0	<1.0	<3.0	--	--	--	<10.0	<10.0
MW-11	10/1/2010	(LFP)	15.75	2.75	0.0	13.00	<50	<120	<240	<1.0	<1.0	<1.0	<2.0	--	--	--	<2.0(^)	<2.0(^)
MW-11	12/29/2010		15.75	2.10	0.0	13.65	--	--	--	--	--	--	--	--	--	--	--	--
MW-11	12/30/2010	(LFP)	15.75	--	--	--	<50.0	110	<380	<0.20	<1.0	<1.0	<3.0	--	--	--	<10.0	<10.0
MW-11	3/17/2011	(LFP)	15.75	1.74	0.0	14.01	<50	<120	<240(^)	<1.0	<1.0	<1.0	<2.0	--	--	--	<2.0	<2.0
MW-11	4/19/2011		15.75	1.94	0.0	13.81	--	--	--	--	--	--	--	--	--	--	--	--
MW-11	6/11/2011	(LFP)	15.75	2.09	0.0	13.66	<50.0	<84	<420	<0.20	<1.0	<1.0	<3.0	--	--	--	<10.0	<10.0
MW-11	9/22/2011	(LFP)	15.75	2.82	0.0	12.93	<50.0	<75	<380	<0.20	<1.0	<1.0	<3.0	<1.0	--	--	<10.0	<10.0
MW-11	12/22/2011	(LFP)	15.75	2.49	0.0	13.26	<50.0	<86	<430	<0.20	<1.0	<1.0	<3.0	--	--	--	<10.0	<10.0
MW-12	10/1/2010	(LFP)	15.60	2.63	0.0	12.97	<50	<120	<240	<1.0	<1.0	<1.0	<2.0	--	--	--	<2.0(^)	<2.0(^)
MW-12	12/29/2010		15.60	1.95	0.0	13.65	--	--	--	--	--	--	--	--	--	--	--	--
MW-12	12/30/2010	(LFP)	15.60	--	--	--	<50.0	89	<380	<0.20	<1.0	<1.0	<3.0	--	--	--	<10.0	<10.0
MW-12	3/17/2011	(LFP)	15.60	1.56	0.0	14.04	<50	<120	<240(^)	<1.0	<1.0	<1.0	<2.0	--	--	--	<2.0	<2.0
MW-12	4/19/2011		15.60	1.86	0.0	13.74	--	--	--	--	--	--	--	--	--	--	--	--
MW-12	6/11/2011	(LFP)	15.60	1.97	0.0	13.63	<50.0	<82	<410	<0.20	<1.0	<1.0	<3.0	--	--	--	<10.0	<10.0
MW-12	9/22/2011	(LFP)	15.60	2.51	0.0	13.09	<50.0	<75	<380	<0.20	<1.0	<1.0	<3.0	<1.0	--	--	<10.0	<10.0
MW-12	12/22/2011	(LFP)	15.60	2.38	0.0	13.22	<50.0	<85	<430	<0.20	<1.0	<1.0	<3.0	--	--	--	<10.0	<10.0

TOC = Top of casing
Wells were surveyed by OTAK on October 7, 2010.
DTW = Depth to water below TOC
NAPL = Nonaqueous phase liquid
GWE = Groundwater elevation. GWE corrected if NAPL present. Corrected GWE = TOC - DTW + (NAPL thickness x 0.80)
TOC/DTW/NAPL/GWE measurements are in feet (ft)
-- = Not analyzed/not applicable
Dup = Duplicate sample
LFP = Low flow purge
^ = Laboratory qualifier: ICV,CCV,ICB,CCB, ISA, ISB, CRI, CRA, DLCK or MRL standard indicastes instrument related QC exceeds the control limits.
Y = Laboratory qualifier: Results in the diesel organics range are primarily due to overlap from a gasoline range product.
GRO = Total petroleum hydrocarbons - gasoline range organics, analysis by Northwest Method NWTPH-Gx
DRO = Total petroleum hydrocarbons - diesel range organics analysis by Northwest Method NWTPH-Dx
HO = Total petroleum hydrocarbons - heavy oil range organics analysis by Northwest Method NWTPH-Dx
EDB = Ethylene dibromide

Table 2
Groundwater Gauging Data and Select Analytical Results
WA-OLYMP

1117 West Bay Drive, Olympia, WA

All analytical results are presented in micrograms per liter (µg/L)

EDC = 1,2-Dichloroethane
MTBE = Methyl tertiary butyl ether
BTEX = Benzene, toluene, ethylbenzene and total xylenes
BTEX, MTBE and EDB analyzed by EPA 8021B and confirmed with 8260B , total and dissolved lead by EPA 6000/7000 Series, EDC by EPA 8011
800/1,000 = GRO MTCA Cleanup Level with benzene present is 800 µg/L and without is 1,000 µg/L
Data collected prior to 2010 have been provided by previous consultants and are included as historical reference only.
Bold

BOLD constituent detected above MTCA Cleanup Levels

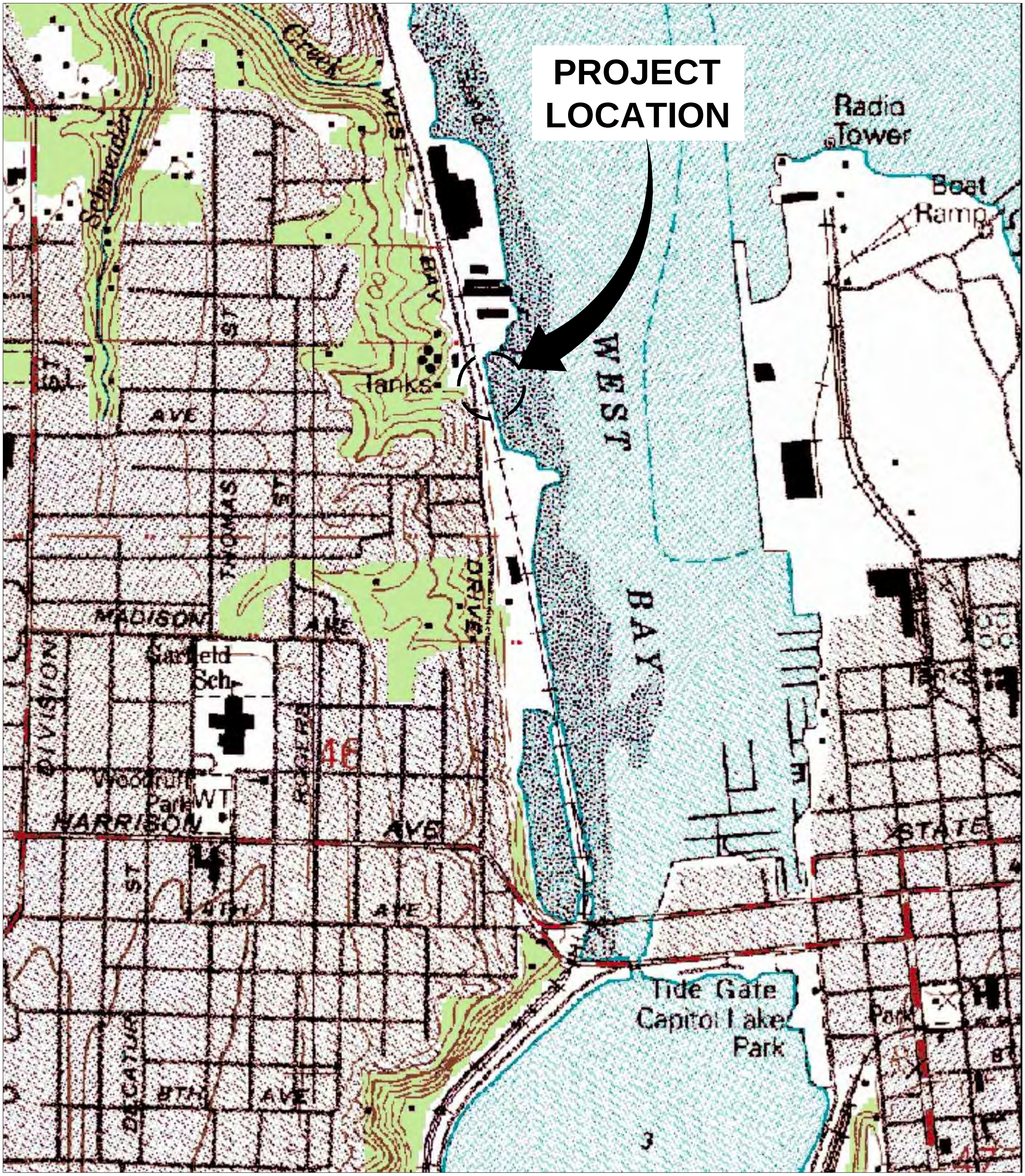
TABLE 3
REQUIREMENTS FOR SAMPLE PRESERVATION AND PREPARATION TECHNIQUES, SAMPLE VOLUME AND HOLDING TIMES
WORK PLAN

1120 West Bay Drive, Olympia, WA

Parameter	Reference Method	Recommended Sample Volume	Sample Container	Preservative	Maxiumum Holding Time	Detection Limits	
Soil (mg/Kg)						LOQ	MDL
TPH-GRO	ECY 97-602 NWTPH-Gx	4 oz	Glass jar	≤6°C with HCl	Samples must be analyzed in 14 days	0.5	0.1
TPH-DRO	ECY 97-602 NWTPH-Dx	8 oz	Glass jar	≤6°C	Samples must be analyzed in 14 days	0.7	0.3
TPH-HO			Glass jar	≤6°C	Samples must be analyzed in 14 days		
cPAH	USEPA Method 8270C SIM	4 oz	Glass jar	≤6°C	Samples must be extracted in 14 days and extracts must be analyzed in 40 days	0.01	0.05
Total napthalenes	USEPA Method 8270C SIM	4 oz	Glass jar	≤6°C	Samples must be analyzed in 14 days	0.017	0.003
Groundwater (μg/L)						LOQ	MDL
TPH-GRO	ECY 97-602 NWTPH-Gx	80 mL	Glass vial	≤6°C with HCl	Samples must be analyzed in 14 days	5.0	0.5
TPH-DRO	ECY 97-602 NWTPH-Dx	1 L	Glass jar	≤6°C	Samples must be analyzed in 14 days	5.0	0.25
Benzene	USEPA Method 8021B	80 mL	Glass vial	≤6°C with HCl	Samples must be analyzed in 14 days	5.0	0.5
Ethylbenzene	USEPA Method 8021B	120 mL	Glass vial	≤6°C with HCl	Samples must be analyzed in 14 days	5.0	0.2
Methyl Tertiary Butyl Ether	USEPA Method 8021B	80 mL	Glass vial	≤6°C with HCl	Samples must be analyzed in 14 days	5.0	0.2
Toluene	USEPA Method 8021B	120 mL	Glass vial	≤6°C with HCl	Samples must be analyzed in 14 days	5.0	0.2
Total xylene	USEPA Method 8021B	120 mL	Glass vial	≤6°C with HCl	Samples must be analyzed in 14 days	5.0	0.2
cPAH	USEPA Method 8270C SIM	2 L	Glass jar	≤6°C	Samples must be extracted in 7 days and extracts must be analyzed in 40 days	0.05	0.01
Total napthalenes	USEPA Method 8270C SIM	500 mL	Glass jar	≤6°C	Samples must be extracted in 7 days and extracts must be analyzed in 40 days	1.70	0.03
EDB	SW-846 8260B	1 L	Glass jar	≤6°C	Samples must be extracted in 7 days and extracts must be analyzed in 40 days	1.00	0.50
EDC	SW-846 8260B	1 L	Glass jar	≤6°C	Samples must be extracted in 7 days and extracts must be analyzed in 40 days	1.00	0.50
Total and Dissolved Lead	USEPA Method 200.8	250 mL	Glass jar	≤6°C with $HN0_3$	6 months	5.00	1.00

Notes:
TPH-GRO = Total Petroleum Hydrocarbon - Gasoline Range Organics
TPH-DRO = Total Petroleum Hydrocarbon - Diesel Range Organics
cPAH = Carcinogenic polyaromatic hydrocarbons
EDB = 1,2-dibromoethane
EDC = 1,2-dichoroethane
USEPA = United States Environmental Protection Agency
oz = ounce
VOA = Volatile organics glass vial
mg/kg = miligrams per kilogram
μg/L = miligrams per liter
LOQ = Level of Quantitation
MDL = Minimum Detection Limit

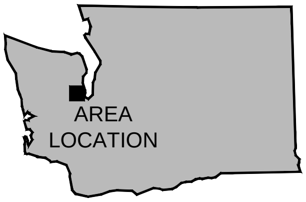
Figures



REFERENCE: BASE MAP USGS 7.5. MIN. TOPO. QUAD., TUMWATER, WASHINGTON, 1959, PHOTOREVISED 1994.

0 1000' 2000'

Approximate Scale: 1 in. = 1000 ft.



FORMER INDUSTRIAL PETROLEUM DISTRIBUTORS
BULK TERMINAL
1120 WEST BAY DRIVE, OLYMPIA, WASHINGTON

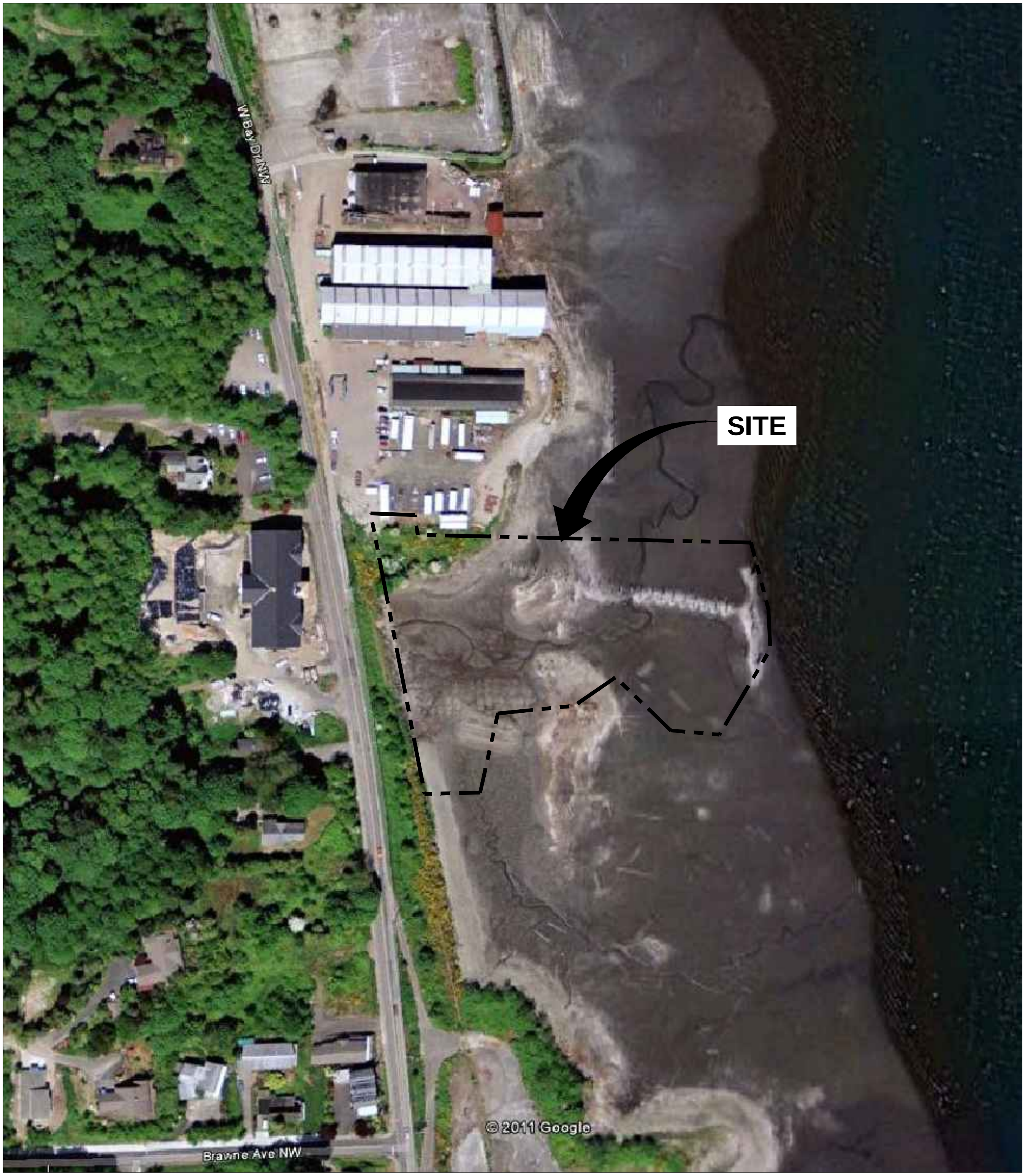
EXCAVATION WORK PLAN

SITE LOCATION MAP

ARCADIS

FIGURE
1

CITY:(Reqd) DIV/GROUP:(Reqd) DB:(Reqd) LD:(Opt) PIC:(Opt) PM:(Reqd) TM:(Opt) LYR:(Opt)ON=*;OFF=*REF*
G:\ENVCAD\Emeryville\ACT\GP09BPNAWA60\K0000\ExcWP\DWG\GP09BPNAWA60-N01.dwg LAYOUT: 1 SAVED: 8/25/2014 1:50 PM ACADVER: 18.1S (LMS TECH) PAGESETUP: ---- PLOTSTYLETABLE: ARCADIS.CTB PLOTTED: 10/30/2014 11:43 AM BY: REYES, ALEC
XREFS: IMAGES: PROJECTNAME: ---
TOPO BulkTerminal OlympiaWA.jpg



SOURCE: GOOGLE EARTH

0 1000' 2000'

Approximate Scale: 1 in. = 1000 ft.

BP WEST COAST PRODUCTS LLC
FORMER INDUSTRIAL PETROLEUM DISTRIBUTORS
BULK TERMINAL, 1117 WEST BAY DRIVE, OLYMPIA, WA
EXCAVATION WORK PLAN

SITE AERIAL PHOTO

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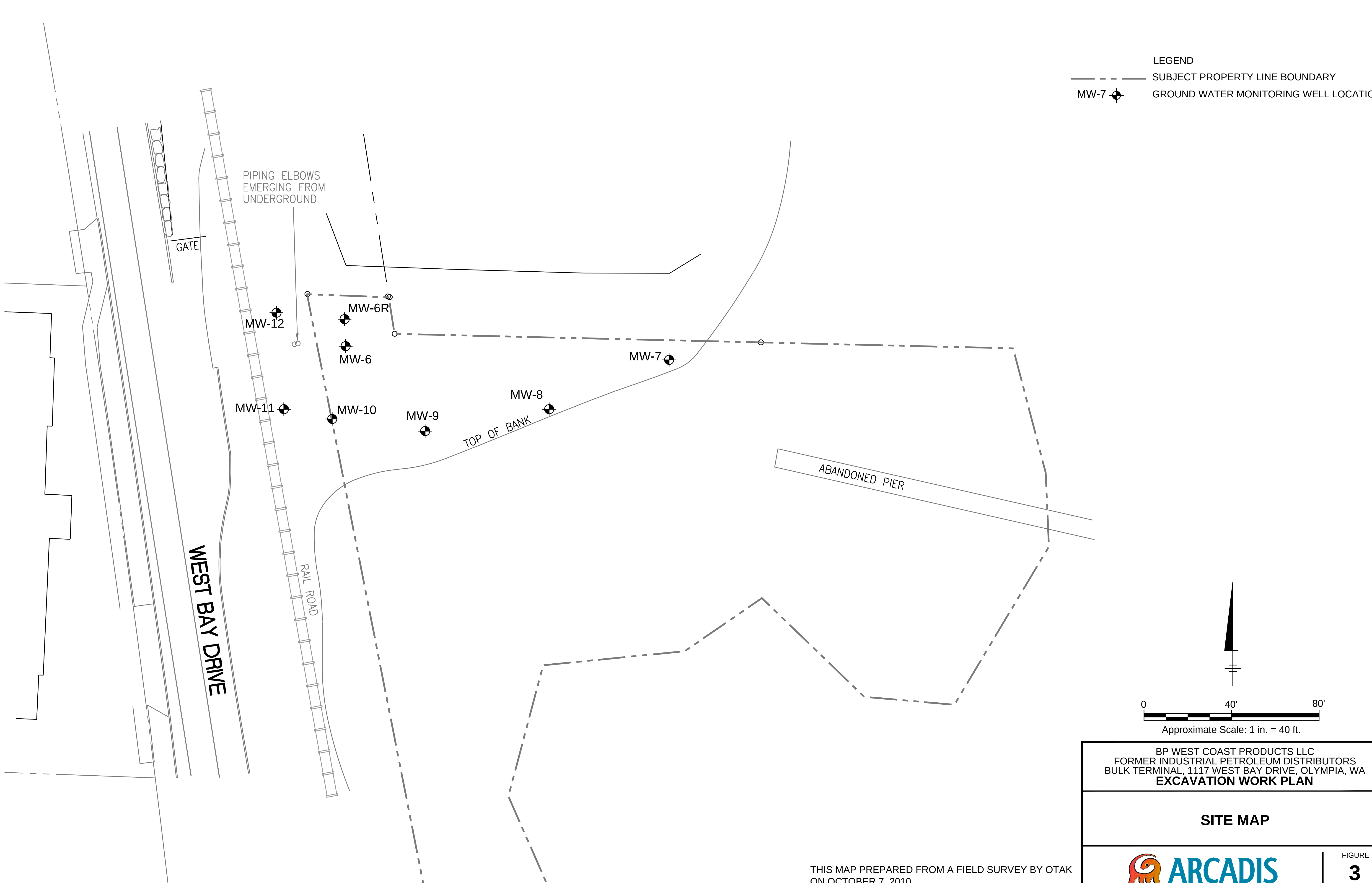
FIGURE
2



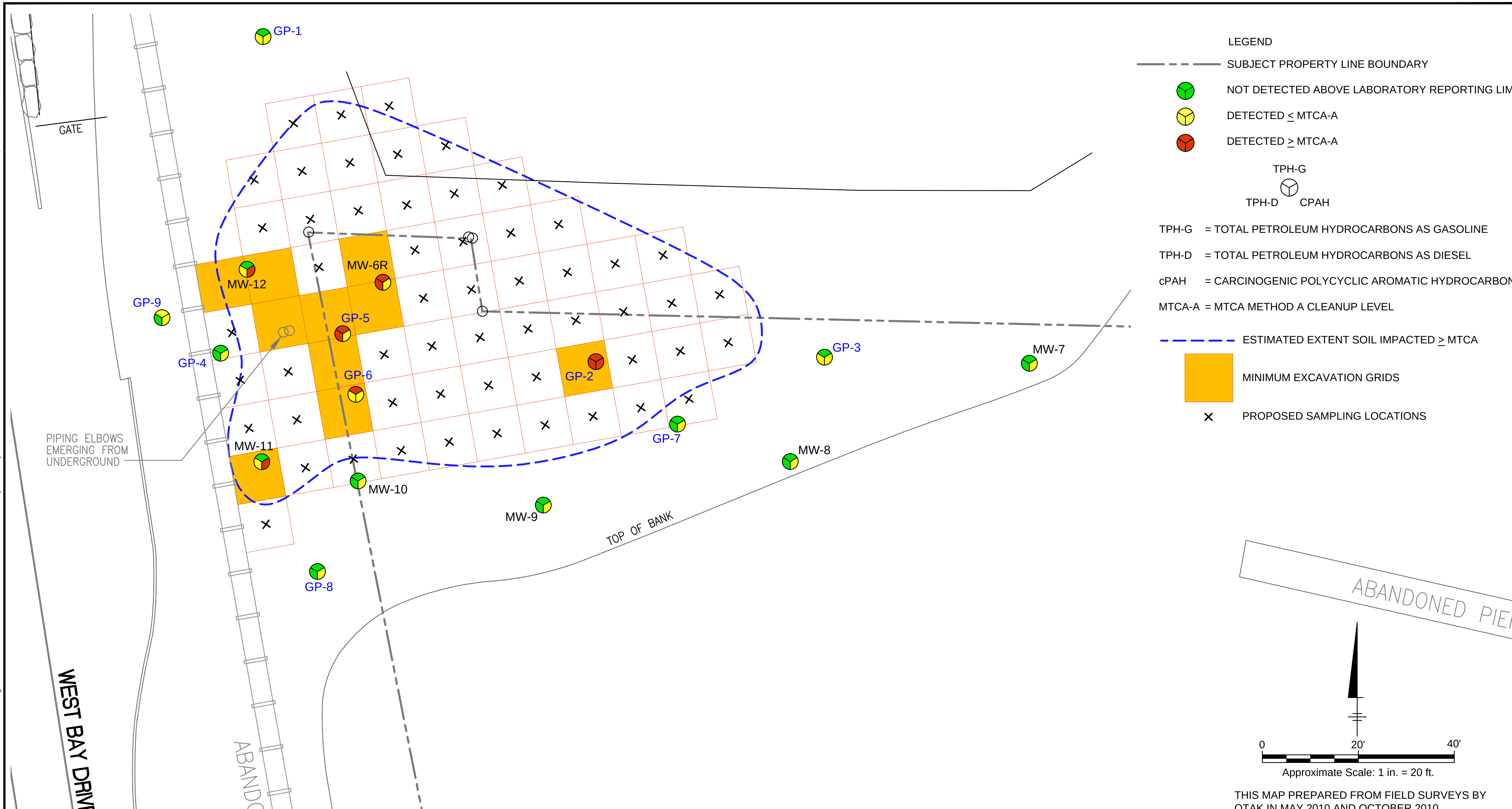
THIS MAP PREPARED FROM A FIELD SURVEY BY OTAK
ON OCTOBER 7, 2010

BP WEST COAST PRODUCTS LLC
FORMER INDUSTRIAL PETROLEUM DISTRIBUTORS
BULK TERMINAL, 1117 WEST BAY DRIVE, OLYMPIA, WA
EXCAVATION WORK PLAN

SITE MAP

ARCADIS

FIGURE
3



THIS MAP PREPARED FROM FIELD SURVEYS BY OTAK IN MAY 2010 AND OCTOBER 2010.

BP WEST COAST PRODUCTS LLC
FORMER INDUSTRIAL PETROLEUM DISTRIBUTORS
BULK TERMINAL, 1117 WEST BAY DRIVE, OLYMPIA, WA
EXCAVATION WORK PLAN

ESTIMATED EXTENT OF SOIL EXCAVATION AND CONFIRMATION SAMPLING GRID

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FIGURE
4

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Appendix **A**

Standard Operating Procedures

ARCADIS
Infrastructure, environment, facilities

Imagine the result

Surface and Subsurface Soil Sampling Using Manual Methods

Rev. #: 1

Rev Date: March 6, 2009

Approval Signatures

Prepared by: ______________________ Date: 3/6/09

Reviewed by: ______________________ Date: 3/6/09
(Technical Expert)

I. Scope and Application

This document describes procedures for surface and subsurface soil sampling using hand tools.

II. Personnel Qualifications

ARCADIS personnel directing, supervising, or leading soil sampling activities should have a minimum of 2 years of previous environmental soil sampling experience. ARCADIS personnel providing assistance to soil sample collection and associated activities should have a minimum of 6 months of related experience or an advanced degree in environmental sciences.

III. Equipment List

The following materials will be available, as required, during soil sampling activities:

- personal protective equipment (PPE), as specified by the site Health and Safety Plan (HASP);
- stainless steel bowls;
- stainless steel spoons;
- stainless steel spades;
- stainless steel hand augers;
- indelible ink pens;
- engineer's ruler or survey rod;
- sealable plastic bags (e.g., Ziploc®);
- equipment decontamination materials
- sample bottles and preservatives appropriate for the parameters to be sampled for laboratory analysis, if any;
- transport container with ice (if sampling for laboratory analysis);
- appropriate sample containers and forms; and

- field notebook and/or personal digital assistant (PDA).

Documentation forms and notebooks to have on hand include: soil sample log forms, chain-of-custody forms, sample labels and seals, field logbook/PDA.

IV. Cautions / Hazards

Task specific Job Safety Analysis (JSAs) must be developed to identify site hazards associated with the investigation and reviewed by all field crew members prior to the start of work. Safe Performance Self-Assessment (SPSA) to be performed by employees before performing a new task. Underground utilities will be cleared per the ARCADIS Utility Location Policy and Procedure.

V. Health and Safety Considerations

Soil sample collection will be performed in accordance with a site-specific Health and Safety Plan (HASP) and task specific JSA forms, copies of which will be present on site during such activities.

VI. Procedure

Soil samples may be collected at intervals from the ground surface to various depths. Sample locations will be identified using stakes, flagging, or other appropriate means, and will be noted in a field logbook, PDA, and/or soil sampling logs. Sample points will be located by surveying, use of a global positioning system (GPS), and/or measurements from other surveyed site features.

1. Equipment that will come in contact with the soil sample should be cleaned in accordance with the appropriate equipment decontamination SOP(s), or else new, disposable equipment should be used. Collect equipment blanks in accordance with the project Quality Assurance Project Plan (QAPP).

2. Clear the ground surface of brush, root mat, grass, leaves, or other debris.

3. Use a spade, spoon, scoop, or hand auger to collect a sample of the required depth interval.

4. Use an engineer's ruler to verify that the sample is collected to the correct depth and record the top and bottom depths from the ground surface.

5. To collect samples below the surface interval, remove the surface interval first; then collect the deeper interval. To prevent the hole from collapsing, it may be

necessary to remove a wider section from the surface or use cut polyvinyl chloride (PVC) tubing or pipe to maintain the opening.

6. Collect samples for volatile organic compounds (VOCs) as discrete samples using Encore® samplers or cut syringes (see Extraction/Preservation of Soil/Sediment Samples for VOCs SOP).

7. Homogenize samples for other analyses across the required interval or mix them with other discrete grab samples to form a composite sample (see Compositing or Homogenizing Samples SOP).

8. Place sample in clean sample container; label with sample identification number, date, and time of collection; and place on ice (if obtained for laboratory analysis). Prepare samples for packaging and shipping to the laboratory in accordance with the Chain-of-Custody Handling, Packing, and Shipping SOP.

9. Backfill sample holes to grade with native material or with clean builder's sand or other suitable material.

VII. Waste Management

Waste soils will be managed as specified in the FSP or Work Plan, and according to state and /or federal requirements. Personal Protective Equipment (PPE) and decontamination fluids will be contained separately and staged at the project site for appropriate disposal. Waste containers must be a sealed and labeled at the time of generation. Labels will indicate date, sample locations, site name, city, state, and description of the matrix (e.g., soil, PPE).

VIII. Data Recording and Management

Field documentation such as log book entries and chain-of –custody records will be transmitted to the ARCADIS PM or Task Manager each day unless otherwise directed. The field team leader will retain all site documentation while in the field and add to project files when the field mobilization is complete.

IX. Quality Assurance

Quality assurance samples (rinse blanks, duplicates, and MS/MSDs) will be collected at the frequency specified in the FSP and/or QAPP and depending on the project quality objectives. Reusable soil sampling equipment will be cleaned prior to use following equipment cleaning SOP. Field rinse blanks will be used to confirm that decontamination procedures are sufficient and samples are representative of site conditions. Any deviations from the SOP will be discussed with the project manager prior to changing any field procedures.

ARCADIS
Infrastructure, environment, facilities

Imagine the result

Drilling Procedures for Collecting and Screening of Soil Samples

Rev. #: 2

Rev Date: March 24, 2008

Approval Signatures

Prepared by: ______________________________ Date: ________________________

Reviewed by: ______________________________ Date: ________________________
(Technical Expert)

I. Scope and Application

This Standard Operating Procedure (SOP) describes the collection and field screening of soils samples using a truck- or track-mounted drill rig using the hollow-stem auger, drive and wash, or mud/water rotary drilling methods after completion of utility clearance procedures. Field screening of the soil samples upon collection may be conducted using a photoionization detector (PID) and/or a flame ionization detector (FID). These instruments are used to measure relative concentrations of volatile organic compounds (VOCs) for the selection of samples for further laboratory or field analysis.

II. Personnel Qualifications

The Project Manager (a qualified geologist, environmental scientist, or engineer) will identify the appropriate soil boring locations, depth and soil sample intervals in a written plan.

Personnel responsible for overseeing drilling operations must have at least 16 hours of prior training overseeing drilling activities with an experienced geologist, environmental scientist, or engineer with at least 2 years of prior experience.

III. Equipment List

- appropriate health and safety equipment;
- PID and FID;
- air-tight sample containers, 8-oz. glass Mason jars or driller's jars, and 40 mL headspace vials;
- aluminum foil;
- extra batteries for the PID;
- calibration gases and regulators;
- spare filter cartridges;
- field notebook and appropriate screening forms; and
- indelible ink pens.

IV. Cautions

Avoid using drilling fluids or materials that could impact groundwater or soil quality, or could be incompatible with the subsurface conditions.

Water used for drilling and sampling of soil or bedrock, decontamination of drilling/sampling equipment, or grouting boreholes upon completion will be of a quality acceptable for project objectives. Testing of water supply should be considered.

Specifications of materials used for backfilling bore hole will be obtained, reviewed and approved to meet project quality objectives.

V. Health and Safety Considerations

To be completed by Preparer and reviewed by Technical Expert.

VI. Procedure

All soil samples will be field screened upon collection with a PID for a relative measure of the total VOCs. Initial PID readings will be recorded in the surface log or field notebook. The true soil sample will be separated from the wash material (if any) by using disposable gloves and a pre-cleaned stainless steel spoon. A representative portion of the sample will be placed in a pre-cleaned air-tight 8-ounce and 40 mL sampling container (as quickly as possible to avoid loss of VOCs), filling the containers half full to allow for the accumulation of vapors above the soil. For the glass 8-ounce jar, an aluminum foil seal will be placed between the glass and metal cap and the cap will be screwed on tightly. For the 40-mL vial, a Teflon septum cap will be placed between the glass and the plastic threaded lid. The sample containers will be stored in a cooler chilled to approximately 4ºC until screening.

Upon completion of sample collection, the headspace of the 8-ounce sample jars will be measured using a PID as follows:

1. Samples will be taken to a warm work space and allowed to equilibrate to room temperature for at least one hour.

2. Prior to measuring the soil vapor headspace concentration, the 8-ounce jar will be shaken.

3. The headspace of the sample will then be measured directly from the 8-ounce sample container with the PID by piercing the aluminum foil seal with the probe

of the PID and measuring the relative concentration of VOCs in the headspace of the soil sample. The initial (peak) reading must be recorded.

Upon completion of sample collection, the headspace of the 40 mL sample vial will be measured using an FID as follows:

1. The 40 mL vials will be placed in a hot water bath for an equal and pre-determined period of time (estimated at 15 minutes).

2. A gas-tight syringe will be used to pierce the teflon septum to extract a volume of headspace (.1 to .5 mL) from the vial.

3. The headspace sample will then be injected directly into the FID of an OVA with a GC attachment. The septum injection port of the OVA should be set on the total field mode. The reading will be recorded on the field screening forms and/or in the field notebook. If a peak is noted in total field mode, a duplicate sample will be injected with the OVA in GC mode and recorded on the strip chart recorder. The retention time will be noted on the GC strip chart, along with the date, time of injection, and the sample identification.

The PID will be calibrated to a benzene-related compound (isobutylene). The FID will be calibrated to methane. The FID/PID must be calibrated according to the manufacturer's specifications at a minimum frequency of once per day prior to collecting FID/PID readings. The time, date, and calibration procedure must be clearly documented in the field notebook and/or the calibration log book. If at any time the FID/PID results appear erratic or inconsistent with field observations, then the unit will be recalibrated. If calibration is difficult to achieve, then the PID's lamp should be checked for dirt or moisture and cleaned. During humid or wet conditions, the unit should be calibrated on a more frequent basis as determined by field personnel. In addition, a blank and a field duplicate will be performed every 10 samples. Maintenance and calibration records will be kept as part of the field quality assurance program.

Sampling for Laboratory Analysis Procedures

Samples will be selected for laboratory analysis based on:

1. Their position in relation to identified source areas;

2. The visual presence of source residues;

3. The relative levels of total VOCs based on field screening measurements; and/or

4. The judgment of the field coordinator.

Samples designated for laboratory analysis will be placed in the appropriate containers. Sample containers for VOC analysis will be filled first. Next, a sufficient amount of the remaining soil will be homogenized by mixing in a stainless steel tray with a clean stainless steel trowel. Then sample containers will be filled for SVOCs, metals, cyanide, and, lastly, for PCBs. For every 20 soil samples obtained, a duplicate soil sample will be obtained by splitting the sample into two sets of sample containers.

VII. Waste Management

Soil cuttings brought to the ground surface during the drilling activities will be handled based on the location of the boring, a visual assessment of the soil, and PID field screening. Soil cuttings from borings located on asphalt or landscaped ground surfaces will be contained in labeled and dated Department of Transportation (DOT)-approved 55-gallon drums. Soil cuttings from borings drilled within the SWMU/disposal areas will be examined and screened with a PID. Soil cuttings will be discarded at ground surface if the soil cuttings consist of cover material above the SWMU/disposal area and no relatively elevated PID readings are measured. If wastes are encountered in the SWMU/disposal area and/or relatively elevated PID readings are measured the soils will be contained in labeled and dated DOT-approved 55-gallon DOT drums.

VIII. Data Recording and Management

A field survey control program will be conducted by a qualified survey crew using standard instrument survey techniques to document boring locations.

IX. Quality Assurance

Equipment cleaning will occur prior to use on the site, between each drilling location, and upon completion of the drilling prior to leaving the site. All drilling equipment and associated tools including augers, drill rods, sampling equipment, wrenches, and any other equipment or tools that may have come in contact with the soils will be cleaned with high-pressure steam cleaning equipment using a tap water source. The drilling equipment will be cleaned after each boring in an area designated by the field coordinator or supervising geologist. Cleaning water will be contained within a water-tight, lined cleaning area. The solids collected on the floor of the cleaning area will be stored in separate labeled and dated DOT-approved 55-gallon drums.

X. References

To be completed by Preparer and reviewed by Technical Expert.

Imagine the result

Chain-of-Custody, Handling, Packing and Shipping

Rev. #: 2

Rev Date: March 6, 2009

Approval Signatures

Prepared by: ______________________ Date: 3/6/09
Caron Koll

Reviewed by: ______________________ Date: 3/6/09
Jane Kennedy(Technical Expert)

I. Scope and Application

This Standard Operating Procedure (SOP) describes the chain-of-custody, handling, packing, and shipping procedures for the management of samples to decrease the potential for cross-contamination, tampering, mis-identification, and breakage, and to insure that samples are maintained in a controlled environment from the time of collection until receipt by the analytical laboratory.

II. Personnel Qualifications

ARCADIS field sampling personnel will have current health and safety training, including 40-hour HAZWOPER training, Department of Transportation (DOT) training, site supervisor training, and site-specific training, as needed. In addition, ARCADIS field sampling personnel will be versed in the relevant SOPs and possess the skills and experience necessary to successfully complete the desired field work.

III. Equipment List

The following list provides materials that may be required for each project. Project documents and sample collection requirements should be reviewed prior to initiating field operations:

- indelible ink pens (black or blue);
- polyethylene bags (resealable-type);
- clear packing tape, strapping tape, duct tape;
- chain of custody
- DOT shipping forms, as applicable
- custody seals or tape;
- appropriate sample containers and labels,;
- insulated coolers of adequate size for samples and sufficient ice to maintain 4°C during collection and transfer of samples;
- wet ice;
- cushioning and absorbent material (i.e., bubble wrap or bags);

- temperature blank
- sample return shipping papers and addresses; and
- field notebook.

IV. Cautions

Review project requirements and select appropriate supplies prior to field mobilization.

Insure that appropriate sample containers with applicable preservatives, coolers, and packing material have been supplied by the laboratory.

Understand the offsite transfer requirements for the facility at which samples are collected.

If overnight courier service is required schedule pick-up or know where the drop-off service center is located and the hours of operation. Prior to using air transportation, confirm air shipment is acceptable under DOT and International Air Transport Association (IATA) regulation

Schedule pick-up time for laboratory courier or know location of laboratory/service center and hours of operation.

Understand DOT and IATA shipping requirements and evaluate dangerous goods shipping regulations relative to the samples being collected (i.e. complete an ARCADIS shipping determination). Review the ARCADIS SOPs for shipping, packaging and labeling of dangerous goods. Potential samples requiring compliance with this DOT regulation include:

- Methanol preservation for Volatile Organic Compounds in soil samples
- Non-aqueous phase liquids (NAPL)

V. Health and Safety Considerations

Follow health and safety procedures outlined in the project/site Health and Safety Plan (HASP).

Use caution and appropriate cut resistant gloves when tightening lids to 40 mL vials. These vials can break while tightening and can lacerate hand. Amber vials (thinner glass) are more prone to breakage.

Some sample containers contain preservatives.

- The preservatives must be retained in the sample container and should in no instance be rinsed out.
- Preservatives may be corrosive and standard care should be exercised to reduce potential contact to personnel skin or clothing. Follow project safety procedures if spillage is observed.
- If sample container caps are broken discard the bottle. Do not use for sample collection.

VI. Procedure

Chain-of-Custody Procedures

1. Prior to collecting samples, complete the chain-of-custody record header information by filling in the project number, project name, and the name(s) of the sampling technician(s) and other relevant project information. Attachment 1 provides an example chain-o- custody record
2. Chain-of-custody information MUST be printed legibly using indelible ink (black or blue).
3. After sample collection, enter the individual sample information on the chain-of-custody:
    a. Sample Identification indicates the well number or soil location that the sample was collected from. Appropriate values for this field include well locations, grid points, or soil boring identification numbers (e.g., MW-3, X-20, SB-30). When the depth interval is included, the complete sample ID would be "SB-30 (0.5-1.0) where the depth interval is in feet. Please note it is very important that the use of hyphens in sample names and depth units (i.e., feet or inches) remain consistent for all samples entered on the chain-of-custody form. DO NOT use the apostrophe or quotes in the sample ID. Sample names may also use the abbreviations "FB," "TB," and "DUP" as prefixes or suffixes to indicate that the sample is a field blank, trip blank, or field duplicate, respectively. NOTE: The sample

nomenclature may be dictated by the project database and require unique identification for each sample collected for the project. Consult the project data management plan for additional information regarding sample identification.

b. List the date of sample collection. The date format to be followed should be mm/dd/yy (e.g., 03/07/09) or mm/dd/yyyy (e.g. 03/07/2009).

c. List the time that the sample was collected. The time value should be presented using military format. For example, 3:15 P.M. should be entered as 15:15.

d. The composite field should be checked if the sample is a composite over a period of time or from several different locations and mixed prior to placing in sample containers.

e. The “Grab”. field should be marked with an “X” if the sample was collected as an individual grab sample. (e.g. monitoring well sample or soil interval).

f. Any sample preservation should be noted.

g. The analytical parameters that the samples are being analyzed for should be written legibly on the diagonal lines. As much detail as possible should be presented to allow the analytical laboratory to properly analyze the samples. For example, polychlorinated biphenyl (PCB) analyses may be represented by entering “PCBs” or “Method 8082.” Multiple methods and/or analytical parameters may be combined for each column (e.g., PCBs/VOCs/SVOCs or 8082/8260/8270). These columns should also be used to present project-specific parameter lists (e.g., Appendix IX+3 target analyte list. Each sample that requires a particular parameter analysis will be identified by placing the number of containers in the appropriate analytical parameter column. For metals in particular, indicate which metals are required.

h. Number of containers for each method requested. This information may be included under the parameter or as a total for the sample based on the chain of custody form used.

i. Note which samples should be used for site specific matrix spikes.

j. Indicate any special project requirements.

k. Indicate turnaround time required.

l. Provide contact name and phone number in the event that problems are encountered when samples are received at the laboratory.

m. If available attach the Laboratory Task Order or Work Authorization forms

n. The remarks field should be used to communicate special analytical requirements to the laboratory. These requirements may be on a per sample basis such as “extract and hold sample until notified,” or may be used to inform the laboratory of special reporting requirements for the entire sample delivery group (SDG). Reporting requirements that should be specified in the remarks column include: 1) turnaround time; 2) contact and address where data reports should be sent; 3) name of laboratory project manager; and 4) type of sample preservation used.

o. The “Relinquished By” field should contain the signature of the sampling technician who relinquished custody of the samples to the shipping courier or the analytical laboratory.

p. The “Date” field following the signature block indicates the date the samples were relinquished. The date format should be mm/dd/yyyy (e.g., 03/07/2005).

q. The “Time” field following the signature block indicates the time that the samples were relinquished. The time value should be presented using military format. For example, 3:15 P.M. should be entered as 15:15.

r. The “Received By” section is signed by sample courier or laboratory representative who received the samples from the sampling technician or it is signed upon laboratory receipt from the overnight courier service.

3. Complete as many chain-of-custody forms as necessary to properly document the collection and transfer of the samples to the analytical laboratory.

4. Upon completing the chain-of-custody forms, forward two copies to the analytical laboratory and retain one copy for the field records.

5. If electronic chain-of-custody forms are utilized, sign the form and make 1 copy for ARCADIS internal records and forward the original with the samples to the laboratory.

Handling Procedures

1. After completing the sample collection procedures, record the following information in the field notebook with indelible ink:

- project number and site name;
- sample identification code and other sample identification information, if appropriate;
- sampling method;
- date;
- name of sampler(s);
- time;
- location (project reference);
- location of field duplicates and both sample identifications;
- locations that field QC samples were collected including equipment blanks, field blanks and additional sample volume for matrix spikes; and
- any comments.

2. Complete the sample label with the following information in indelible ink:

- sample type (e.g., surface water);
- sample identification code and other sample identification information, if applicable;
- analysis required;
- date;
- time sampled; and
- initials of sampling personnel;

- sample matrix; and
- preservative added, if applicable.

3. Cover the label with clear packing tape to secure the label onto the container and to protect the label from liquid.

4. Confirm that all caps on the sample containers are secure and tightly closed.

5. In some instances it may be necessary to wrap the sample container cap with clear packing tape to prevent it from becoming loose.

6. For some projects individual custody seals may be required. Custody seal evidence tape may be placed on the shipping container or they may be placed on each sample container such that the cooler or cap cannot be opened without breaking the custody seal. The custody seal should be initialed and dated prior to relinquishing the samples.

Packing Procedures

Following collection, samples must be placed on wet ice to initiate cooling to 4°C immediately. Retain samples on ice until ready to pack for shipment to the laboratory.

1. Secure the outside and inside of the drain plug at the bottom of the cooler being used for sample transport with “Duct” tape.

2. Place a new large heavy duty plastic garbage bag inside each cooler

3. Place each sample bottle wrapped in bubble wrap inside the garbage bag. VOC vials may be grouped by sample in individual resealable plastic bags). If a cooler temperature blank is supplied by the laboratory, it should be packaged following the same procedures as the samples. If the laboratory did not include a temperature blank, do not add one. Place 1 to 2 inches of cushioning material (i.e., vermiculite) at the bottom of the cooler.

4. Place the sealed sample containers upright in the cooler.

5. Package ice in large resealable plastic bags and place inside the large garbage bag in the cooler. Samples placed on ice will be cooled to and maintained at a temperature of approximately 4°C.

6. Fill the remaining space in the cooler with cushioning material such as bubble wrap. The cooler must be securely packed and cushioned in an upright position and be surrounded (Note: to comply with 49 CFR 173.4, filled cooler must not exceed 64 pounds).

7. Place the completed chain-of-custody record(s) in a large resealable bag and tape the bag to the inside of the cooler lid.

8. Close the lid of the cooler and fasten with packing tape.

9. Wrap strapping tape around both ends of the cooler.

10. Mark the cooler on the outside with the following information: shipping address, return address, “Fragile, Handle with Care” labels on the top and on one side, and arrows indicating “This Side Up” on two adjacent sides.

11. Place custody seal evidence tape over front right and back left of the cooler lid, initial and date, then cover with clear plastic tape.

Note: Procedure numbers 2, 3, 5, and 6 may be modified in cases where laboratories provide customized shipping coolers. These cooler types are designed so the sample bottles and ice packs fit snugly within preformed styrofoam cushioning and insulating packing material.

Shipping Procedures

1. All samples will be delivered by an express carrier within 48 hours of sample collection. Alternatively, samples may be delivered directly to the laboratory or laboratory service center or a laboratory courier may be used for sample pickup.

2. If parameters with short holding times are required (e.g., VOCs [EnCore™ Sampler], nitrate, nitrite, ortho-phosphate and BOD), sampling personnel will take precautions to ship or deliver samples to the laboratory so that the holding times will not be exceeded.

3. Samples must be maintained at 4°C±2°C until shipment and through receipt at the laboratory

4. All shipments must be in accordance with DOT regulations and ARCADIS dangerous goods shipping SOPs.

5. When the samples are received by the laboratory, laboratory personnel will complete the chain-of-custody by recording the date and time of receipt of samples, measuring and recording the internal temperature of the shipping container, and checking the sample identification numbers on the containers to ensure they correspond with the chain-of-custody forms.

Any deviations between the chain-of-custody and the sample containers, broken containers, or temperature excursions will be communicated to ARCADIS immediately by the laboratory.

VII. Waste Management

Not applicable

VIII. Data Recording and Management

Chain-of-custody records will be transmitted to the ARCADIS PM or designee at the end of each day unless otherwise directed by the ARCADIS PM. The sampling team leader retains copies of the chain-of-custody forms for filing in . the project file. Record retention shall be in accordance with project requirements.

IX. Quality Assurance

Chain-of-custody forms will be legibly completed in accordance with the applicable project documents such as Sampling and Analysis Plan (SAP), Quality Assurance Project Plan (QAPP), Work Plan, or other project guidance documents. A copy of the completed chain-of-custody form will be sent to the ARCADIS Project Manager or designee for review.

X. References

Not Applicable

Attachment 1

ARCADIS
Infrastructure, environment, facilities

ID#:

CHAIN OF CUSTODY & LABORATORY ANALYSIS REQUEST FORM

Page ___ of ___

Lab Work Order #

Send Results to:

Contact & Company Name:	Telephone:
Address:	Fax:
City State Zip	E-mail Address:
Project Name/Location (City, State):	Project #:
Sampler's Printed Name:	Sampler's Signature:

Preservative							
Filtered (✓)							
# of Containers							
Container Information							

PARAMETER ANALYSIS & METHOD

Keys

Preservation Key:
A. H_2SO_4
B. HCL
C. HNO_3
D. NaOH
E. None
F. Other: ________
G. Other: ________
H. Other: ________

Container Information Key:
1. 40 ml Vial
2. 1 L Amber
3. 250 ml Plastic
4. 500 ml Plastic
5. Encore
6. 2 oz. Glass
7. 4 oz. Glass
8. 8 oz. Glass
9. Other: ________
10. Other: ________

Matrix Key:
SO - Soil; SE - Sediment; NL - NAPL/Oil
W - Water; SL - Sludge; SW - Sample Wipe
T - Tissue; A - Air; Other: ________

Sample ID	Collection Date	Collection Time	Type (✓) Comp	Type (✓) Grab	Matrix									REMARKS

Special Instructions/Comments:

☐ **Special QA/QC Instructions(✓):**

Laboratory Information and Receipt		Relinquished By	Received By	Relinquished By	Laboratory Received By
Lab Name:	Cooler Custody Seal (✓)	Printed Name:	Printed Name:	Printed Name:	Printed Name:
☐ Cooler packed with ice (✓)	☐ Intact ☐ Not Intact	Signature:	Signature:	Signature:	Signature:
Specify Turnaround Requirements:	Sample Receipt:	Firm:	Firm/Courier:	Firm/Courier:	Firm:
Shipping Tracking #:	Condition/Cooler Temp: ________	Date/Time:	Date/Time:	Date/Time:	Date/Time:

20730826 CofC AR Form 01.12.2007 **Distribution:** **WHITE – Laboratory returns with results** **YELLOW – Lab copy** **PINK – Retained by BBL**

Imagine the result

Monitoring Well Decommissioning

Rev. #: 0

Rev Date: July 25, 2010

Approval Signatures

Prepared by: _______________ Date: 07/25/2010

Reviewed by: _______________ Date: 07/26/2010
(Technical Expert)

I. Scope and Application

This standard operating procedure (SOP) describes the procedures for decommissioning groundwater monitoring wells. Monitoring wells may be decommissioned when it is found they are no longer suitable for collection of groundwater data (i.e., groundwater quality or groundwater elevation) due to damaged and/or questionable construction, when they must be removed to avoid interference to/from other construction activities in the area, or when groundwater monitoring is no longer required at the location. The purpose for decommissioning monitoring wells no longer in use is to:

- Eliminate physical hazards associated with an out-of-use monitoring well;
- Conserve the yield and hydrostatic head of confining aquifers;
- Prevent the intermingling of separate aquifers; and
- Remove a potential conduit for the vertical migration of constituents in groundwater along the well casing.

This SOP covers the decommissioning of single-cased overburden monitoring wells when a replacement well will not be installed within the same borehole. Three potential decommissioning methods (i.e., plugging-in-place, casing removal, and overdrilling) are described below.

Although these procedures are generally applicable for the decommissioning of double-cased monitoring wells or wells installed within bedrock, in most cases a decommissioning strategy should be developed on a well-by well basis. Additional information regarding potential methods to decommission these types of wells may be found in ASTM D5299-99 - Standard Guide for Decommissioning of Ground Water Wells, Vadose Zone Monitoring Devices, Boreholes, and Other Devices for Environmental Activities.

II. Personnel Qualifications

The well decommissioning procedures described below will be carefully adhered to and conducted under the supervision of an experienced geologist, engineer, or other qualified individual. If the overdrilling decommissioning method is utilized, drilling activities will be conducted by a registered well driller.

III. Equipment List

The following materials, as required, shall be available during pre-decommissioning and decommissioning activities:

- Site Health and Safety Plan (HASP);
- Health and safety equipment, as required in the HASP (e.g., air monitoring equipment, personal protective equipment);
- Information concerning the construction of the well to be decommissioned;
- Appropriate field forms or field notebook;
- Well keys;
- Water level probe;
- Cleaning materials;
- Drill rig with registered well driller and experienced personnel if the overdrilling method is utilized;
- Tremie pipe;
- Type I Portland cement;
- Uncoated bentonite pellets;
- Potable water;
- Containers for collecting spoils; and
- Any necessary specialized well drilling/decommissioning equipment.

IV. Cautions

Avoid using drilling fluids or materials that could impact groundwater or soil quality, or could be incompatible with the subsurface conditions.

Water used for over drilling or grouting boreholes upon completion will be of a quality acceptable for project objectives. If the water quality is unknown, testing of water supply should be considered.

Specifications of materials used for backfilling the bore hole will be obtained, reviewed and approved to meet project quality objectives.

No coated bentonite pellets will be used in monitoring well decommissioning, as the coating could be a source of contamination.

V. Health and Safety Considerations

Health and safety protocols should be described in the site-specific health and safety plan.

VI. Procedures

Plug-In Place Method

The plug-in-place method is applicable at locations where available information indicates that the annular space contains an adequate seal and vertical migration of constituents across a confining layer is not a concern in the well casing and screen interval, or if other considerations (e.g., double-cased well construction) preclude removal of the well casing. The well screen is left in place and may be additionally perforated, along with the base of the well, to allow the grout seal to penetrate the surrounding filter pack. The decommissioning process will consist of the following steps:

1. Perform a search of available records concerning the well to be decommissioned. The following activities should be performed to identify the location, construction, and condition of the well, and to determine the appropriate equipment to be utilized based on the depth, diameter, and access to the monitoring well:

    - Review the existing monitoring well log to identify construction characteristics (e.g., total depth, casing diameter, initial borehole diameter, type of casing, type of material(s) used);

    - Locate the monitoring well in the field;

    - Identify if the decommissioning equipment can access the monitoring well and/or if special considerations (e.g., construction of an access road) are necessary to gain access;

    - Conduct total depth measurements and water level measurements;

- Calculate the volume of the well that will need to be filled utilizing field measurements and formulas provided above; and

- Record all observations and measurements.

2. Remove the protective casing and well casing to a depth of approximately 3 to 4 feet below ground surface (bgs), if possible.

3. Perforate the base of the well screen utilizing a length of drilling rod or other equipment.

4. Prepare a neat cement grout. (Note: A neat cement grout is preferred for application through an in-place well; whereas, a bentonite grout or hydrated bentonite pellets may also be considered at locations where the well casing is removed or the well is overdrilled).

5. Place the neat cement grout in the perforated well casing via the tremie method (i.e., the grout will be pumped from the bottom of the well upward). The grout will be added until the well is filled to above the top of the well casing remaining in place (i.e., typically approximately 3 to 4 feet bgs). Verify that the amount of grout added equals or exceeds the calculated volume of the void to be filled.

6. The grout will be allowed to set for a minimum of 24 hours and the remainder of the borehole will be filled with concrete and/or other surface finish materials (see Step 7 below).

7. Where appropriate, a concrete surface finish will be installed by constructing an above-grade concrete slab a minimum of 6 inches thick, with a diameter at least 2 feet greater than the diameter of the borehole. If such a concrete surface finish is not compatible with the existing land use (e.g., roadway, parking lot, residential), the borehole shall be terminated with a minimum 1-foot-thick concrete plug above the grout and the remaining portion of the borehole shall be filled flush with grade with material(s) compatible with the surrounding land surface (e.g., asphalt, gravel, topsoil).

8. A Well Abandonment Log will be completed. A state specific Well Abandonment Log should be used and submitted to the appropriate state agency if required. .

Casing Removal Method

The casing removal method is applicable at shallow locations where vertical migration of constituents across a confining layer is not a concern and where the integrity of the borehole is reasonably expected to be maintained following removal of the well materials. The decommissioning process will consist of the following steps:

1. Perform a search of available records concerning the well to be decommissioned. The following activities should be performed to identify the location, construction, and condition of the well, and determine the appropriate equipment to be utilized based on the depth, diameter, and access to the monitoring well:

   - Review the existing monitoring well log to identify construction characteristics (e.g., total depth, casing diameter, initial borehole diameter, type of casing, type of material(s) used);

   - Locate the monitoring well in the field;

   - Identify if the decommissioning equipment can access the monitoring well and/or if special considerations (e.g., construction of an access road) are necessary to gain access;

   - Conduct total depth measurements and water level measurements;

   - Calculate volume of well that will need to be filled utilizing field measurements and formulas provided above; and

   - Record all observations and measurements.

2. Remove the protective casing, if possible.

3. Remove the well materials (riser and screen).

4. Examine removed well materials to ensure that the entire section has been removed. Also ensure that the borehole has not collapsed and that the tremie pipe will be able to be inserted to the base of well depth. Well decommissioning should be completed by using the overdrilling method if the well casing is broken below grade and cannot be retrieved, or if the tremie pipe will not reach the base of the well.

5. Prepare a neat cement grout or a bentonite grout that is compatible with the soil and groundwater conditions present at the monitoring well. (Note: A neat cement grout or a bentonite grout is preferred for this application. Hydrated bentonite pellets may also be considered if the entire well boring is overdrilled, using procedures similar to those for abandoning boreholes).

6. Place the cement grout in the borehole via tremie method (i.e., the grout will be pumped from the bottom of the borehole upward). The grout will be added until the borehole is filled to approximately 3 to 4 feet bgs. Verify that amount of grout added equals or exceeds the calculated volume of the void to be filled.

7. The grout will be allowed to set for a minimum of 24 hours and the remainder of the borehole will be filled with concrete and/or other surface finish materials (see Step 8 below).

8. Where appropriate, a concrete surface finish will be installed by constructing an above-grade concrete slab a minimum of 6 inches thick, with a diameter at least 2 feet greater than the diameter of the borehole. If such a concrete surface finish is not compatible with the existing land use (e.g., roadway, parking lot, residential), the borehole shall be terminated with a minimum 1-foot-thick concrete plug above the grout and the remaining portion of the borehole shall be filled flush with grade with material(s) compatible with the surrounding land surface (e.g., asphalt, gravel, topsoil).

A Well Abandonment Log will be completed. A state specific Well Abandonment Log should be used and submitted to the appropriate state agency if required.

Overdrilling Method

The overdrilling method is the most conservative decommissioning procedure and should be utilized at locations where a well has penetrated a confining layer and there is no evidence that the annular space around the well casing was adequately sealed, or if attempts to remove the well casing are unsuccessful. The decommissioning process will consist of the following steps:

1. Perform a search of available records concerning the well to be decommissioned. The following activities should be performed to identify the location, construction, and condition of the well, and determine the appropriate equipment to be utilized based on the depth, diameter, and access to the monitoring well:

   - Review the existing monitoring well log to identify construction characteristics (e.g., total depth, casing diameter, initial borehole diameter, type of casing, type of material(s) used);

   - Locate the monitoring well in the field;

- Identify if a drill rig can access the monitoring well and/or if special considerations (e.g., construction of an access road) are necessary to gain access;
- Conduct total depth measurements and water level measurements;
- Calculate the volume of the well/borehole that will need to be filled utilizing field measurements and formulas provided above; and
- Record all observations and measurements.

2. Remove the protective casing, if possible.

3. If the protective casing has been removed, advance a hollow-stem auger or other drill casing (with an outside diameter larger than the well diameter) over the well casing to the bottom of the original borehole.

4. Prepare a neat cement grout or a bentonite grout that is compatible with the soil and groundwater conditions present at the monitoring well. Alternatively, hydrated bentonite pellets may be used to plug the borehole, using procedures similar to those for abandoning boreholes.

5. Place the cement grout in the borehole via tremie method (i.e., the grout will be pumped from the bottom of the borehole upward) at the same time the hollow-stem augers or drill casing are removed from the borehole. Grout will be added until the borehole is filled to approximately 3 to 4 feet bgs. Verify that the amount of grout added equals or exceeds the calculated volume of the void to be filled. If hydrated bentonite pellets are utilized, measure deposition depth with a weighted tape as the hollow-stem augers or drill casing are removed from the borehole to ensure that bridging does not occur. At certain shallow well locations installed in competent formations, it may be possible to remove the hollow-stem augers or drill casing prior to installing the sealant. If this is attempted, confirmatory measurements must be taken to verify that borehole integrity was maintained prior to plugging the hole.

6. The grout will be allowed to set for a minimum of 24 hours and the remainder of the borehole will be filled with concrete and/or other surface finish materials (see Step 7 below).

7. Where appropriate, a concrete surface seal will be installed by constructing an above-grade concrete slab a minimum of 6 inches thick, with a diameter at least 2 feet greater than the diameter of the borehole. If such a concrete surface seal is not compatible with the existing land use (e.g., roadway, parking lot,

residential), the borehole shall be terminated with a minimum 1-foot-thick concrete plug above the grout and the remaining portion of the borehole shall be filled flush with grade with material(s) compatible with the surrounding land surface (e.g., asphalt, gravel, topsoil).

8. A Well Abandonment Log will be completed. A state specific Well Abandonment Log should be used and submitted to the appropriate state agency if required.

Abandoning a Soil Boring

The following steps for abandoning a soil boring are summarized from ASTM D 5299-99:

1. Prepare a neat cement grout using Type I Portland cement and potable water mixed according to the following ratios:

   One (1) 94-pound bag of Type I Portland cement; and 5.5 gallons potable water.

2. As soon as the borehole is completed, place a grout pipe (tremie pipe) to the bottom of the boring and pump sealing grout slowly through the pipe to displace material in the borehole. Inject grout starting from the bottom of the hole. Grout slowly to prevent channeling of the grout. As the grouting progresses, slowly raise the pipe. Complete the grouting in one continuous operation, continuing to pump grout until overflowing grout is seen at the surface. The overflowing grout should be similar in appearance and characteristics to the grout being pumped down the hole.

3. Grout may settle over a 24-hour period. After 24 hours, check the grout in the borehole for settlement. If settling has occurred, place additional grout to the surface. When grouting is complete, finish the surface in a manner appropriate for final use (e.g., concrete).

VII. Waste Management

Waste management protocols should be described in the site-specific work plan.

VIII. Data Recording and Management

To assure that a well is properly plugged and there has been no bridging of the plugging materials, verification calculations and measurements are required to determine whether the volume of material placed in the well/borehole equals or exceeds the volume of the void being filled. Some useful formulas for calculating well and material volumes are provided below.

- 7.481 gallons = 1 cubic foot
- 202.0 gallons = 1 cubic yard
- Volume of well/borehole (in gallons) = π TIMES well/borehole radius (in feet) squared TIMES length of well/borehole (in feet) TIMES 7.481 (gallons per cubic foot)

IX. Quality Assurance

Quality assurance protocols should be described in the site-specific work plan.

X. References

ASTM. D5299-99. Standard Guide for Decommissioning of Ground Water Wells, Vadose Zone Monitoring Devices, Boreholes, and Other Devices for Environmental Activities.

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Monitoring Well Installation

Rev. #: 3

Rev Date: February 2, 2011

Approval Signatures

Prepared by: ______________________ Date: 2/2/2011

Reviewed by: ______________________ Date: 2/2/2011
(Technical Expert)

I. Scope and Application

The procedures set out herein are designed to produce standard groundwater monitoring wells suitable for: (1) groundwater sampling, (2) water level measurement, (3) bulk hydraulic conductivity testing of formations adjacent to the open interval of the well.

Monitoring well boreholes in unconsolidated (overburden) materials are typically drilled using the hollow-stem auger drilling method. Other drilling methods that are also suitable for installing overburden monitoring wells, and are sometimes necessary due to site-specific geologic conditions, include: drive-and-wash, spun casing, Rotasonic, dual-rotary (Barber Rig), and fluid/mud rotary with core barrel or roller bit. Direct-push techniques (e.g., Geoprobe or cone penetrometer) and driven well points may also be used in some cases within the overburden. Monitoring wells within consolidated materials such as bedrock are commonly drilled using water-rotary (coring or tri-cone roller bit), air rotary or Rotasonic methods. The drilling method to be used at a given site will be selected based on site-specific consideration of anticipated drilling/well depths, site or regional geologic knowledge, type of monitoring to be conducted using the installed well, and cost.

No oils or grease will be used on equipment introduced into the boring (e.g., drill rod, casing, or sampling tools). No polyvinyl chloride (PVC) glue/cement will be used in constructing or retrofitting monitoring wells that will be used for water-quality monitoring. No coated bentonite pellets will be used in the well drilling or construction process. Specifications of materials to be installed in the well will be obtained prior to mobilizing onsite, including:

- well casing;
- bentonite;
- sand; and
- grout.

Well materials will be inspected and, if needed, cleaned prior to installation.

II. Personnel Qualifications

Monitoring well installation activities will be performed by persons who have been trained in proper well installation procedures under the guidance of an experienced field geologist, engineer, or technician. Where field sampling is performed for soil or bedrock characterization, field personnel will have undergone in-field training in soil or bedrock description methods, as described in the appropriate SOP(s) for those activities.

III. Equipment List

The following materials will be available during soil boring and monitoring well installation activities, as required:

- Site Plan with proposed soil boring/well locations;
- Work Plan or Field Sampling Plan (FSP), and site Health and Safety Plan (HASP);
- personal protective equipment (PPE), as required by the HASP;
- traffic cones, delineators, caution tape, and/or fencing as appropriate for securing the work area, if such are not provided by drillers;
- appropriate soil sampling equipment (e.g., stainless steel spatulas, knife);
- soil and/or bedrock logging equipment as specified in the appropriate SOPs;
- appropriate sample containers and labels;
- drum labels as required for investigation derived waste handling;
- chain-of-custody forms;
- insulated coolers with ice, when collecting samples requiring preservation by chilling;
- photoionization detector (PID) or flame ionization detector (FID);
- ziplock style bags;
- water level or oil/water interface meter;
- locks and keys for securing the well after installation;
- decontamination equipment (bucket, distilled or deionized water, cleansers appropriate for removing expected chemicals of concern, paper towels);

- field notebook.

Prior to mobilizing to the site, ARCADIS personnel will contact the drilling subcontractor or in-house driller (as appropriate) to confirm that appropriate sampling and well installation equipment will be provided. Specifications of the sampling and well installation equipment are expected to vary by project, and so communication with the driller will be necessary to ensure that the materials provided will meet the project objectives. Equipment typically provided by the driller could include:

- drilling equipment required by the American Society of Testing and Materials (ASTM) D 1586, when performing split-spoon sampling;
- disposable plastic liners, when drilling with direct-push equipment;
- drums for investigation derived waste;
- drilling and sampling equipment decontamination materials;
- decontamination pad materials, if required; and
- well construction materials.

IV. Cautions

Prior to beginning field work, underground utilities in the vicinity of the drilling areas will be delineated by the drilling contractor or an independent underground utility locator service. See separate SOP for utility clearance.

Some regulatory agencies require a minimum annular space between the well or permanent casing and the borehole wall. When specified, the minimum clearance is typically 2 inches on all sides (e.g., a 2-inch diameter well requires a 6-inch diameter borehole). In addition, some regulatory agencies have specific requirements regarding grout mixtures. Determine whether the oversight agency has any such requirements prior to finalizing the drilling and well installation plan.

If dense non-aqueous phase liquids (DNAPL) are known or expected to exist at the site, refer to the DNAPL Contingency Plan SOP for additional details regarding drilling and well installation to reduce the potential for inadvertent DNAPL remobilization.

Similarly, if light non-aqueous phase liquids (LNAPLs) are known or expected to be present as “perched” layers above the water table, refer to the DNAPL Contingency

Plan. Follow the general provisions and concepts in the DNAPL contingency plan during drilling above the water table at known or expected LNAPL sites.

Avoid using drilling fluids or materials that could impact groundwater or soil quality, or could be incompatible with the subsurface conditions.

Similarly, consider the material compatibility between the well materials and the surrounding environment. For example, PVC well materials are not preferred when DNAPL is present. In addition, some groundwater conditions leach metals from stainless steel.

Water used for drilling and sampling of soil or bedrock, decontamination of drilling/sampling equipment, or grouting boreholes upon completion will be of a quality acceptable for project objectives. Testing of water supply should be considered.

Specifications of materials used for backfilling bore hole will be obtained, reviewed and approved to meet project quality objectives. Bentonite is not recommended where DNAPLs are likely to be present. In these situations, neat cement grout is preferred.

No coated bentonite pellets will be used in monitoring well construction, as the coating could impact the water quality in the completed well.

Monitoring wells may be installed with Schedule 40 polyvinyl chloride (PVC) to a maximum depth of 200 feet below ground surface (bgs). PVC monitoring wells between 200 and 400 feet total depth will be constructed using Schedule 80 PVC. Monitoring wells deeper than 400 feet will be constructed using steel.

V. Health and Safety Considerations

Field activities associated with monitoring well installation will be performed in accordance with a site-specific HASP, a copy of which will be present on site during such activities.

VI. Procedures

The procedures for installing groundwater monitoring wells are presented below:

Hollow-Stem Auger, Drive-and-Wash, Spun Casing, Fluid/Mud Rotary, Rotasonic, and Dual-Rotary Drilling Methods

1. Locate boring/well location, establish work zone, and set up sampling equipment decontamination area.

2. Advance boring to desired depth. Collect soil and/or bedrock samples at appropriate interval as specified in the Work Plan and/or FSP. Collect, document, and store samples for laboratory analysis as specified in the Work Plan and/or FSP. Decontaminate equipment between samples in accordance with the Work Plan and/or FSP. A common sampling method that produces high-quality soil samples with relatively little soil disturbance is the ASTM D 1586 - Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils. Split-spoon samples are obtained during drilling using hollow-stem auger, drive-and-wash, spun casing, and fluid/mud rotary. Rotasonic drilling produces large-diameter soil cores that tend to be more disturbed than split-spoon samples due to the vibratory action of the drill casing. Dual-rotary removes cuttings by compressed air and allows only a general assessment of geology. High-quality bedrock samples can be obtained by coring.

3. Describe each soil or bedrock sample as outlined in the appropriate SOP. Record descriptions in the field notebook and/or personal digital assistant (PDA). It should be noted that PDA logs must be electronically backed up and transferred to a location accessible to other project team members as soon as feasible to retain and protect the field data. During soil boring advancement, document all drilling events in field notebook, including blow counts (number of blows required to advance split-spoon sampler in 6-inch increments) and work stoppages. Blow counts will not be available if Rotasonic, dual-rotary, or direct-push methods are used. When drilling in bedrock, the rate of penetration (minutes per foot) is recorded.

4. If it is necessary to install a monitor well into a permeable zone below a confining layer, particularly if the deeper zone is believed to have water quality that differs significantly from the zone above the confining layer, then a telescopic well construction should be considered. In this case, the borehole is advanced approximately 3 to 5 feet into the top of the confining layer, and a permanent casing (typically PVC, black steel or stainless steel) is installed into the socket drilled into the top of the confining layer. The casing is then grouted in place. The preferred methods of grouting telescoping casings include: pressure-injection grouting using an inflatable packer installed temporarily into the base of the casing, such that grout is injected out the bottom of the casing until it is observed at ground surface outside the casing; displacement-method grouting (also known as the Halliburton method), which entails filling the casing with grout and displacing the grout out the bottom of the casing by pushing a drillable plug, typically made of wood to the bottom of the casing, following by tremie grouting the remainder of the annulus outside the casing; or tremie grouting the annulus surrounding the casing using a tremie pipe installed to the base of the borehole. In all three cases, the casing is grouted to the ground

surface, and the grout is allowed to set prior to drilling deeper through the casing. Site-specific criteria and work plans should be created for the completion of non-standard monitoring wells, including telescopic wells.

5. In consolidated formations such as competent bedrock, a monitoring well may be completed with an open borehole interval without a screen and sandpack. In these cases, the borehole is advanced to the targeted depth of the top of the open interval. A permanent casing is then grouted in place following the procedures described in Step 4 above. After the grout sets, the borehole is advanced by drilling through the permanent casing to the targeted bottom depth of the open interval, which then serves as the monitoring interval for the well. If open-borehole interval stability is found to be questionable or if a specific depth interval is later selected for monitoring, a screened monitoring well may later be installed within the open-borehole interval, depending on the annular space and well diameter requirements.

6. Before installing a screened well – or after drilling an open-bedrock well –, it is important to confirm that the borehole has been advanced into the saturated zone. This is particularly important for wells installed to monitor the water table and/or the shallow saturated zone, as the capillary fringe may cause soils above the water table to appear saturated. If one or more previously installed monitoring wells exist nearby, use the depth to water at such well(s) to estimate the water-table depth at the new borehole location.

   To verify that the borehole has been advanced into the saturated zone, it is necessary to measure the water level in the borehole. For boreholes drilled without using water (e.g., hollow-stem auger, cable-tool, air rotary, air hammer), verify the presence of groundwater (and /or LNAPL, if applicable) in the borehole using an electronic water level probe, oil-water interface probe, or a new or decontaminated bailer. For boreholes drilled using water (e.g., drive and wash, spun-casing with roller-bit wash, rotasonic, or water rotary with core or roller bit), monitor the water level in the borehole as it re-equilibrates to the static level. In low-permeability units like clay, fine-grained glacial tills, shale and other bedrock formations, it may be necessary to wait overnight to allow the water level to equilibrate. To the extent practicable, ensure that the depth of the well below the apparent water table is deep enough so that the installed well can monitor groundwater year-round, accounting for seasonal water-table fluctuations. In most cases, the well should be installed at least five feet below the water-table depth, determined as described above. When in doubt, err on the side of slightly deeper well installation.

If necessary, the borehole should be drilled deeper to ensure that the well may intersects the water table or a permeable water-bearing zone.

7. Upon completing the borehole to the desired depth, if a screened well construction is desired, install the monitoring well by lowering the screen and casing assembly with sump through the augers or casing. Monitoring wells typically will be constructed of 2-inch-diameter, flush-threaded PVC or stainless steel slotted well screen and blank riser casing. Smaller diameters may be used if wells are installed using direct-push methodology or if multiple wells are to be installed in a single borehole. The screen length will be specified in the Work Plan or FSP based on regulatory requirements and specific monitoring objectives. Monitoring well screens are usually 5 to 10 feet long, but may be up to 25 feet long in very low permeability, thick geologic formations. The screen length will depend on the purpose for the well and the objectives of the groundwater investigation. Typically, the slot size will be 0.010 inch and the sand pack will be 20-40, Morie No. 0, or equivalent. In very fine-grained formations where sample turbidity needs to be minimized, it may be preferred to use a 0.006-inch slot size and 30-65, Morie No. 00, or equivalent sand pack. Alternatively, where monitoring wells are installed in coarse-grained deposits and higher well yield is required, a 0.020-inch slot size and 10-20, Morie No. 1, or equivalent sand pack may be preferred. To the extent practicable, the slot size and sand pack gradation may be predetermined in the Work Plan or FSP based on site-specific grain-size analysis or other geologic considerations or monitoring objectives. A blank sump may be attached below the well screen if the well is being installed for DNAPL recovery/monitoring purposes. If so, the annular space around the sump will be backfilled with neat cement grout to the bottom of the well screen prior to placing the sand pack around the screen. A blank riser will extend from the top of the screen to approximately 2.5 feet above grade or, if necessary, just below grade where conditions warrant a flush-mounted monitoring well. For wells greater than 50 feet deep, centralizers may be desired to assist in centralizing the monitoring well in the borehole during construction.

8. When the monitoring well assembly has been set in place and the grout has been placed around the sump (if any), place a washed silica sand pack in the annular space from the bottom of the boring to a height of 1 to 2 feet above the top of the well screen. The sand pack is placed and drilling equipment extracted in increments until the top of the sand pack is at the appropriate depth. The sand pack will be consistent with the screen slot size and the soil particle size in the screened interval, as specified in the Work Plan or FSP. A hydrated bentonite seal (a minimum of 2 feet thick) will then be placed in the annular space above the sand pack. If non-hydrated bentonite is used, the bentonite

should be permitted to hydrate in place for a minimum of 30 minutes before proceeding. No coated bentonite pellets will be used in monitoring well drilling or construction. Potable water may be added to hydrate the bentonite if the seal is above the water table. Monitor the placement of the sand pack and bentonite with a weighted tape measure. During the extraction of the augers or casing, a cement/bentonite or neat cement grout will be placed in the annular space from the bentonite seal to a depth approximately 2 feet bgs.

9. Place a locking, steel protective casing (extended at least 1.5 feet below grade and 2 feet above grade) over the riser casing and secure with a neat cement seal. Alternatively, for flush-mount completions, place a steel curb box with a bolt-down lid over the riser casing and secure with a neat cement seal. In either case, the cement seal will extend approximately 1.5 to 2.0 feet below grade and laterally at least 1 foot in all directions from the protective casing, and should slope gently away to promote drainage away from the well. Monitoring wells will be labeled with the appropriate designation on both the inner and outer well casings or inside of the curb box lid.

   When an above-grade completion is used, the PVC riser will be sealed using an expandable locking plug and the top of the well will be vented by drilling a small-diameter (1/8 inch) hole near the top of the well casing or through the locking plug, or by cutting a vertical slot in the top of the well casing. When a flush-mount installation is used, the PVC riser will be sealed using an unvented, expandable locking plug.

10. During well installation, record construction details and actual measurements relayed by the drilling contractor and tabulate materials used (e.g., screen and riser footages; bags of bentonite, cement, and sand) in the field notebook.

11. After completing the well installation, lock the well, clean the area, and dispose of materials in accordance with the procedures outlined in Section VII below.

Direct-Push Method

The direct-push drilling method may also be used to complete soil borings and install monitoring wells. Examples of this technique include the Diedrich ESP vibratory probe system, GeoProbe®, or AMS Power Probe® dual-tube system. Environmental probe systems typically use a hydraulically operated percussion hammer. Depending on the equipment used, the hammer delivers 140- to 350-foot pounds of energy with each blow. The hammer provides the force needed to penetrate very stiff/medium dense soil formations. The hammer simultaneously advances an outer steel casing that contains a dual-tube liner for sampling soil. The outside diameter (OD) of the outer casing ranges from 1.75 to 2.4 inches and the OD of the inner sampling tube ranges from 1.1 to 1.8 inches. The outer casing isolates shallow layers and permits the unit to continue to probe at depth. The double-rod system provides a borehole that may be tremie-grouted from the bottom up. Alternatively, the inside diameter (ID) of the steel casing provides clearance for the installation of small-diameter (e.g., 0.75- to 1-inch ID) micro-wells. The procedures for installing monitoring wells in soil using the direct-push method are described below.

1. Locate boring/well location, establish work zone, and set up sample equipment decontamination area.

2. Advance soil boring to designated depth, collecting samples at intervals specified in the Work Plan. Samples will be collected using dedicated, disposable, plastic liners. Describe samples in accordance with the procedures outlined in Step 3 above. Collect samples for laboratory analysis as specified in the Work Plan and/or FSP.

3. Upon advancing the borehole to the desired depth, install the micro-well through the inner drill casing. The micro-well will consist of approximately 1-inch ID PVC or stainless steel slotted screen and blank riser. The sand pack, bentonite seal, and cement/bentonite grout will be installed as described, where applicable, in Step 7 and 8 above.

4. Install protective steel casing or flush-mount, as appropriate, as described in Step 9 above. During well installation, record construction details and tabulate materials used.

5. After completing the well installation, lock the well, clean the area, and dispose of materials in accordance with the procedures outlined in Section VII below.

Driven Well Point Installation

Well points will be installed by pushing or driving using a drilling rig or direct-push rig, or hand-driven where possible. The well point construction materials will consist of a 1- to 2-inch-diameter threaded steel casing with either 0.010- or 0.020-inch slotted stainless steel screen. The screen length will vary depending on the hydrogeologic conditions of the site. The casings will be joined together with threaded couplings and the terminal end will consist of a steel well point. Because they are driven or pushed to the desired depth, well points do not have annular backfill materials such as sand pack or grout.

VII. Waste Management

Investigation-derived wastes (IDW), including soil cuttings and excess drilling fluids (if used), decontamination liquids, and disposable materials (well material packages, PPE, etc.), will be placed in clearly labeled, appropriate containers, or managed as otherwise specified in the Work Plan, FSP, and/or IDW management SOP.

VIII. Data Recording and Management

Drilling activities will be documented in a field notebook. Pertinent information will include personnel present on site, times of arrival and departure, significant weather conditions, timing of well installation activities, soil descriptions, well construction specifications (screen and riser material and diameter, sump length, screen length and slot size, riser length, sand pack type), and quantities of materials used. In addition, the locations of newly-installed wells will be documented photographically or in a site sketch. If appropriate, a measuring wheel or engineer's tape will be used to determine approximate distances between important site features.

The well or piezometer location, ground surface elevation, and inner and outer casing elevations will be surveyed using the method specified in the site Work Plan. Generally, a local baseline control will be set up. This local baseline control can then be tied into the appropriate vertical and horizontal datum, such as the National Geodetic Vertical Datum of 1929 or 1988 and the State Plane Coordinate System. At a minimum, the elevation of the top of the inner casing used for water-level measurements should be measured to the nearest 0.01 foot. Elevations will be established in relation to the National Geodetic Vertical Datum of 1929. A permanent mark will be placed on top of the inner casing to mark the point for water-level measurements.

IX. Quality Assurance

All drilling equipment and associated tools (including augers, drill rods, sampling equipment, wrenches, and any other equipment or tools) that may have come in contact with soil will be cleaned in accordance with the procedures outlined in the appropriate SOP. Well materials will also be cleaned prior to well installation.

X. References

American Society of Testing and Materials (ASTM) D 1586 - *Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils*.

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Low-Flow Groundwater Purging and Sampling Procedures for Monitoring Wells

Rev. #: 4

Rev Date: February 2, 2011

Approval Signatures

Prepared by: ______________________ Date: 2/2/2011

Reviewed by: ______________________ Date: 2/2/2011
(Technical Expert)

I. Scope and Application

Groundwater samples will be collected from monitoring wells to evaluate groundwater quality. The protocol presented in this standard operating procedure (SOP) describes the procedures to be used to purge monitoring wells and collect groundwater samples. This protocol has been developed in accordance with the United States Environmental Protection Agency (USEPA) Region I Low Stress (Low Flow) Purging and Sampling Procedures for the Collection of Groundwater Samples from Monitoring Wells (USEPA SOP No. GW0001; July 30, 1996). Both filtered and unfiltered groundwater samples may be collected using this low-flow sampling method. Filtered samples will be obtained using a 0.45-micron disposable filter. No wells will be sampled until well development has been performed in accordance with the procedures presented in the SOP titled Monitoring Well Development, unless that well has been sampled or developed within the prior 1-year time period. Groundwater samples will not be collected within 1 week following well development.

II. Personnel Qualifications

ARCADIS personnel directing, supervising, or leading groundwater sample collection activities should have a minimum of 2 years of previous groundwater sampling experience. ARCADIS personnel providing assistance to groundwater sample collection and associated activities should have a minimum of 6 months of related experience or an advanced degree in environmental sciences, engineering, hydrogeology, or geology.

The supervisor of the groundwater sampling team will have at least 1 year of previous supervised groundwater sampling experience.

Prior to mobilizing to the field, the groundwater sampling team should review and be thoroughly familiar with relevant site-specific documents including but not limited to the site work plan, field sampling plan, QAPP, HASP, and historical information. Additionally, the groundwater sampling team should review and be thoroughly familiar with documentation provided by equipment manufacturers for all equipment that will be used in the field prior to mobilization.

III. Equipment List

Specific to this activity, the following materials (or equivalent) will be available:

- Health and safety equipment (as required in the site Health and Safety Plan [HASP]).

- Site Plan, well construction records, prior groundwater sampling records (if available).
- Sampling pump, which may consist of one or more of the following:
  - submersible pump (e.g., Grundfos Redi-Flo 2);
  - peristaltic pump (e.g., ISCO Model 150); and/or
  - bladder pump (e.g., Marschalk System 1, QED Well Wizard, Geotech, etc.).
- Appropriate controller and power source for pump:
  - Submersible and peristaltic pumps require electric power from either a generator or a deep cell battery.
  - Submersible pumps such as Grundfos require a pump controller to run the pump
  - Bladder pumps require a pump controller and a gas source (e.g., air compressor or compressed N_2 or CO_2 gas cylinders).
- Teflon® tubing or Teflon®-lined polyethylene tubing of an appropriate size for the pump being used. For peristaltic pumps, dedicated Tygon® tubing (or other type as specified by the manufacturer) will also be used through the pump apparatus.
- Water-level probe (e.g., Solinist Model 101).
- Water-quality (temperature/pH/specific conductivity/ORP/turbidity/dissolved oxygen) meter and flow-through measurement cell. Several brands may be used, including:
  - YSI 6-Series Multi-Parameter Instrument;
  - Hydrolab Series 3 or Series 4a Multiprobe and Display; and/or
  - Horiba U-10 or U-22 Water Quality Monitoring System.
- Supplemental turbidity meter (e.g., Horiba U-10, Hach 2100P, LaMotte 2020). Turbidity measurements collected with multi-parameter meters have been shown to sometimes be unreliable due to fouling of the optic lens of the

turbidity meter within the flow-through cell. A supplemental turbidity meter will be used to verify turbidity data during purging if such fouling is suspected. Note that industry improvements may eliminate the need for these supplemental measurements in the future.

- Appropriate water sample containers (supplied by the laboratory).
- Appropriate blanks (trip blank supplied by the laboratory).
- 0.45-micron disposable filters (if field filtering is required).
- Large glass mixing container (if sampling with a bailer).
- Teflon® stirring rod (if sampling with a bailer).
- Cleaning equipment.
- Groundwater sampling log (attached) or bound field logbook.

Note that in the future, the client may acquire different makes/models of some of this equipment if the listed makes/models are no longer available, or as a result of general upgrades or additional equipment acquisitions. In the event that the client uses a different make/model of the equipment listed, the client will use an equivalent type of equipment (e.g., pumps, flow-through analytical cells) and note the specific make/model of the equipment used during a sampling event on the groundwater sampling log. In addition, should the client desire to change to a markedly different sampling methodology (e.g., discrete interval samplers, passive diffusion bags, or a yet to be developed technique), the client will submit a proposed SOP for the new methodology for USEPA approval prior to implementing such a change.

The maintenance requirements for the above equipment generally involve decontamination or periodic cleaning, battery charging, and proper storage, as specified by the manufacturer. For operational difficulties, the equipment will be serviced by a qualified technician.

IV. Cautions

If heavy precipitation occurs and no cover over the sampling area and monitoring well can be erected, sampling must be discontinued until adequate cover is provided. Rain water could contaminate groundwater samples.

Do not use permanent marker or felt-tip pens for labels on sample container or sample coolers – use indelible ink. The permanent markers could introduce volatile constituents into the samples.

It may be necessary to field filter some parameters (e.g., metals) prior to collection, depending on preservation, analytical method, and project quality objectives.

Store and/or stage empty and full sample containers and coolers out of direct sunlight.

To mitigate potential cross-contamination, groundwater samples are to be collected in a pre-determined order from least impacted to impacted based on previous analytical data. If no analytical data are available, samples are collected in order of upgradient, then furthest downgradient to source area locations.

Be careful not to over-tighten lids with Teflon liners or septa (e.g., 40 mL vials). Over-tightening can cause the glass to shatter or impair the integrity of the Teflon seal.

V. Health and Safety Considerations

Use caution and appropriate cut resistant gloves when tightening lids to 40 mL vials. These vials can break while tightening and can lacerate hand. Amber vials (thinner glass) are more prone to breakage.

If thunder or lighting is present, discontinue sampling and take cover until 30 minutes have passed after the last occurrence of thunder or lighting.

Use caution when removing well caps as well may be under pressure, cap can dislodge forcefully and cause injury.

Use caution when opening protective casing on stickup wells as wasps frequently nest inside the tops of the covers. Also watch for fire ant mounds near well pads when sampling in the south or western U.S.

VI. Procedure

Groundwater will be purged from the wells using an appropriate pump. Peristaltic pumps will initially be used to purge and sample all wells when applicable. If the depth to water is below the sampling range of a peristaltic pump (approximately 25 feet), submersible pumps or bladder pumps will be used provided the well is constructed with a casing diameter greater than or equal to 2 inches (the minimum well diameter capable of accommodating such pumps). Bladder pumps are preferred over peristaltic and submersible pumps if sampling of VOCs is required to prevent volatilization. For smaller diameter wells where the depth to water is below the sampling range of a peristaltic pump, alternative sampling methods (i.e., bailing or small diameter bladder pumps) will be used to purge and sample the groundwater. Purge water will be collected and containerized.

1. Calibrate field instruments according to manufacturer procedures for calibration.

2. Measure initial depth to groundwater prior to placement of pumps.

3. Prepare and install pump in well: For submersible and non-dedicated bladder pumps, decontaminate pump according to site decontamination procedures. Non-dedicated bladder pumps will require a new Teflon® bladder and attachment of an air line, sample discharge line, and safety cable prior to placement in the well. Attach the air line tubing to the air port on the top of the bladder pump. Attach the sample discharge tubing to the water port on the top of the bladder pump. Care should be taken not to reverse the air and discharge tubing lines during bladder pump set-up as this could result in bladder failure or rupture. Attach and secure a safety cable to the eyebolt on the top of bladder pump (if present, depending on pump model used). Slowly lower pump, safety cable, tubing, and electrical lines into the well to a depth corresponding to the approximate center of the saturated screen section of the well. Take care to avoid twisting and tangling of safety cable, tubing, and electrical lines while lowering pump into well; twisted and tangled lines could result in the pump becoming stuck in the well casing. Also, make sure to keep tubing and lines from touching the ground or other surfaces while introducing them into the well as this could lead to well contamination. If a peristaltic pump is being used, slowly lower the sampling tubing into the well to a depth corresponding to the approximate center of the saturated screen section of the well. The pump intake or sampling tube must be kept at least 2 feet above the bottom of the well to prevent mobilization of any sediment present in the bottom of the well.

4. If using a bladder pump, connect the air line to the pump controller output port. The pump controller should then be connected to a supply line from an air compressor or compressed gas cylinder using an appropriate regulator and air hose. Take care to tighten the regulator connector onto the gas cylinder (if used) to prevent leaks. Teflon tape may be used on the threads of the cylinder to provide a tighter seal. Once the air compressor or gas cylinder is connected to the pump controller, turn on the compressor or open the valve on the cylinder to begin the gas flow. Turn on the pump controller if an on/off switch is present and verify that all batteries are charged and fully operating before beginning to pump.

5. Connect the pump discharge water line to the bottom inlet port on the flow-through cell connected to the water quality meter.

6. Measure the water level again with the pump in the well before starting the pump. Start pumping the well at 200 to 500 milliliters (mL) per minute (or at lower site-specific rate if specified). The pump rate should be adjusted to cause little or no water level drawdown in the well (less than 0.3 feet below the initial static depth to water measurement) and the water level should stabilize. The water level should be monitored every 3 to 5 minutes (or as appropriate, lower flow rates may require longer time between readings) during pumping if the well diameter is of sufficient size to allow such monitoring. Care should be taken not to break pump suction or cause entrainment of air in the sample. Record pumping rate adjustments and depths to water. If necessary, pumping rates should be reduced to the minimum capabilities of the pump to avoid pumping the well dry and/or to stabilize indicator parameters. A steady flow rate should be maintained to the extent practicable. Groundwater sampling records from previous sampling events (if available) should be reviewed prior to mobilization to estimate the optimum pumping rate and anticipated drawdown for the well in order to more efficiently reach a stabilized pumping condition.

   If the recharge rate of the well is very low, alternative purging techniques should be used, which will vary based on the well construction and screen position. For wells screened across the water table, the well should be pumped dry and sampling should commence as soon as the volume in the well has recovered sufficiently to permit collection of samples. For wells screened entirely below the water table, the well should be pumped until a stabilized level (which may be below the maximum displacement goal of 0.3 feet) can be maintained and monitoring for stabilization of field indicator parameters can commence. If a lower stabilization level cannot be maintained, the well should be pumped until the drawdown is at a level slightly higher than the bentonite seal above the well screen. Sampling should commence after one well volume has been removed and the well has recovered sufficiently to permit collection of samples.

   During purging, monitor the field indicator parameters (e.g., turbidity, temperature, specific conductance, pH, etc.) every 3 to 5 minutes (or as appropriate). Field indicator parameters will be measured using a flow-through analytical cell or a clean container such as a glass beaker. Record field indicator parameters on the groundwater sampling log. The well is considered stabilized and ready for sample collection when turbidity values remain within 10% (or within 1 NTU if the turbidity reading is less than 10 NTU), the specific conductance and temperature values remain within 3%, ORP readings remain within ± 10 mV and pH remains within 0.1 units for three consecutive readings collected at 3- to 5-minute intervals (or other appropriate interval, alternate stabilization goals may exist in different geographic regions, consult the site-specific Work Plan for stabilization criteria). If the field indicator parameters do not stabilize within 1 hour of the start of purging, but the groundwater turbidity is below the goal of 50 NTU and the values for all other parameters are within 10%, the well can be sampled. If the parameters have stabilized but the turbidity is not in the range of the 50 NTU goal, the pump flow rate should be decreased to a minimum rate of 100 mL/min to reduce turbidity levels as low as possible. Dissolved oxygen is extremely susceptible to various external influences (including temperature or the presence of bubbles on the DO meter); care should be taken to minimize the agitation or other disturbance of water within the flow-through cell while collecting these measurements. If air bubbles are present on the DO probe or in the discharge tubing, remove them before taking a measurement. If dissolved oxygen values are not within acceptable range for the temperature of groundwater (Attachment 1), then again check for and remove air bubbles on probe before re-measuring. If the dissolved oxygen value is 0.00 or less, then the meter should be serviced and re-calibrated. If the dissolved oxygen values are above possible results, then the meter should be serviced and re-calibrated.

During extreme weather conditions, stabilization of field indicator parameters may be difficult to obtain. Modifications to the sampling procedures to alleviate these conditions (e.g., measuring the water temperature in the well adjacent to the pump intake) will be documented in the field notes. If other field conditions exist that preclude stabilization of certain parameters, an explanation of why the parameters did not stabilize will also be documented in the field logbook.

7. Complete the sample label(s) and cover the label(s) with clear packing tape to secure the label onto the container.

8. After the indicator parameters have stabilized, collect groundwater samples by diverting flow out of the unfiltered discharge tubing into the appropriate labeled sample container. If a flow-through analytical cell is being used to measure field parameters, the flow-through cell should be disconnected after stabilization of the field indicator parameters and prior to groundwater sample collection. Under no circumstances should analytical samples be collected from the discharge of the flow-through cell. When the container is full, tightly screw on the cap. Samples should be collected in the following order: VOCs, TOC, SVOCs, metals and cyanide, and others (or other order as defined in the site-specific Work Plan).

9. If sampling for total and filtered metals and/or PCBs, a filtered and unfiltered sample will be collected. Install an in-line, disposable 0.45-micron particle filter on the discharge tubing after the appropriate unfiltered groundwater sample has been collected. Continue to run the pump until an initial volume of “flush” water has been run through the filter in accordance with the manufacturer’s directions (generally 100 to 300 mL). Collect filtered groundwater sample by diverting flow

out of the filter into the appropriately labeled sample container. When the container is full, tightly screw on the cap.

10. Secure with packing material and store at 4°C in an insulated transport container provided by the laboratory.

11. Record on the groundwater sampling log or bound field logbook the time sampling procedures were completed, any pertinent observations of the sample (e.g., physical appearance, and the presence or lack of odors or sheens), and the values of the stabilized field indicator parameters as measured during the final reading during purging (Attachment 2 – Example Sampling Log).

12. Turn off the pump and air compressor or close the gas cylinder valve if using a bladder pump set-up. Slowly remove the pump, tubing, lines, and safety cable from the well. Do not allow the tubing or lines to touch the ground or any other surfaces which could contaminate them. .

13. If tubing is to be dedicated to a well, it should be folded to a length that will allow the well to be capped and also facilitate retrieval of the tubing during later sampling events. A length of rope or string should be used to tie the tubing to the well cap. Alternatively, if tubing and safety line are to be saved and reused for sampling the well at a later date they may be coiled neatly and placed in a clean plastic bag that is clearly labeled with the well ID. Make sure the bag is tightly sealed before placing it in storage.

14. Secure the well and properly dispose of personal protective equipment (PPE) and disposable equipment.

15. Complete the procedures for packaging, shipping, and handling with associated chain-of-custody.

16. Complete decontamination procedures for flow-through analytical cell and submersible or bladder pump, as appropriate.

17. At the end of the day, perform calibration check of field instruments.

If it is not technically feasible to use the low-flow sampling method, purging and sampling of monitoring wells may be conducted using the bailer method as outlined below:

1. Don appropriate PPE (as required by the HASP).

2. Place plastic sheeting around the well.

3. Clean sampling equipment.

4. Open the well cover while standing upwind of the well. Remove well cap and place on the plastic sheeting. Insert PID probe approximately 4 to 6 inches into the casing or the well headspace and cover with gloved hand. Record the PID reading in the field log. If the well headspace reading is less than 5 PID units, proceed; if the headspace reading is greater than 5 PID units, screen the air within the breathing zone. If the breathing zone reading is less than 5 PID units, proceed. If the PID reading in the breathing zone is above 5 PID units, move upwind from well for 5 minutes to allow the volatiles to dissipate. Repeat the breathing zone test. If the reading is still above 5 PID units, don appropriate respiratory protection in accordance with the requirements of the HASP. Record all PID readings. For wells that are part of the regular weekly monitoring program and prior PID measurements have not resulted in a breathing zone reading above 5 PID units, PID measurements will be taken monthly.

5. Measure the depth to water and determine depth of well by examining drilling log data or by direct measurement. Calculate the volume of water in the well (in gallons) by using the length of the water column (in feet), multiplying by 0.163 for a 2-inch well or by 0.653 for a 4-inch well. For other well diameters, use the formula:

   Volume (in gallons) = π TIMES well radius (in feet) squared TIMES length of water column (in feet) TIMES 7.481 (gallons per cubic foot)

6. Measure a length of rope or twine at least 10 feet greater than the total depth of the well. Secure one end of the rope to the well casing and secure the other end to the bailer. Test the knots and make sure the rope will not loosen. Check bailers so that all parts are intact and will not be lost in the well.

7. Lower bailer into well and remove one well volume of water. Contain all water in appropriate containers.

8. Monitor the field indicator parameters (e.g., turbidity, temperature, specific conductance, and pH). Measure field indicator parameters using a clean container such as a glass beaker or sampling cups provided with the instrument. Record field indicator parameters on the groundwater sampling log.

9. Repeat Steps 7 and 8 until three or four well volumes have been removed. Examine the field indicator parameter data to determine if the parameters have stabilized. The well is considered stabilized and ready for sample collection when turbidity values remain within 10% (or within 1 NTU if the turbidity reading is less than 10 NTU), the specific conductance and temperature values remain

within 3%, and pH remains within 0.1 units for three consecutive readings collected once per well volume removed.

10. If the field indicator parameters have not stabilized, remove a maximum of five well volumes prior to sample collection. Alternatively, five well volumes may be removed without measuring the field indicator parameters.

11. If the recharge rate of the well is very low, wells screened across the water table may be bailed dry and sampling should commence as soon as the volume in the well has recovered sufficiently to permit collection of samples. For wells screened entirely below the water table, the well should only be bailed down to a level slightly higher than the bentonite seal above the well screen. The well should not be bailed completely dry, to maintain the integrity of the seal. Sampling should commence as soon as the well volume has recovered sufficiently to permit sample collection.

12. Following purging, allow water level in well to recharge to a sufficient level to permit sample collection.

13. Complete the sample label and cover the label with clear packing tape to secure the label onto the container.

14. Slowly lower the bailer into the screened portion of the well and carefully retrieve a filled bailer from the well causing minimal disturbance to the water and any sediment in the well.

15. The sample collection order (as appropriate) will be as follows:

    a. VOCs;

    b TOC;

    c. SVOCs;

    d. metals and cyanide; and

    e. others.

16. When sampling for volatiles, collect water samples directly from the bailer into 40-mL vials with Teflon®-lined septa.

17. For other analytical samples, remove the cap from the large glass mixing container and slowly empty the bailer into the large glass mixing container. The

sample for dissolved metals and/or filtered PCBs should either be placed directly from the bailer into a pressure filter apparatus or pumped directly from the bailer with a peristaltic pump, through an in-line filter, into the pre-preserved sample bottle.

18. Continue collecting samples until the mixing container contains a sufficient volume for all laboratory samples.

19. Mix the entire sample volume with the Teflon® stirring rod and transfer the appropriate volume into the laboratory jar(s). Secure the sample jar cap(s) tightly.

20. If sampling for total and filtered metals and/or PCBs, a filtered and unfiltered sample will be collected. Sample filtration for the filtered sample will be performed in the field using a peristaltic pump prior to preservation. Install new medical-grade silicone tubing in the pump head. Place new Teflon® tubing into the sample mixing container and attach to the intake side of pump tubing. Attach (clamp) a new 0.45-micron filter (note the filter flow direction). Turn the pump on and dispense the filtered liquid directly into the laboratory sample bottles.

21. Secure with packing material and store at 4°C in an insulated transport container provided by the laboratory.

22. After sample containers have been filled, remove one additional volume of groundwater. Measure the pH, temperature, turbidity, and conductivity. Record on the groundwater sampling log or bound field logbook the time sampling procedures were completed, any pertinent observations of the sample (e.g., physical appearance, and the presence or lack of odors or sheens), and the values of the field indicator parameters.

23. Remove bailer from well, secure well, and properly dispose of PPE and disposable equipment.

24. If a bailer is to be dedicated to a well, it should be secured inside the well above the water table, if possible. Dedicated bailers should be tied to the well cap so that inadvertent loss of the bailer will not occur when the well is opened.

25. Complete the procedures for packaging, shipping, and handling with associated chain-of-custody.

VII. Waste Management

Materials generated during groundwater sampling activities, including disposable equipment, will be placed in appropriate containers. Containerized waste will be disposed of by the client consistent with the procedures identified in the HASP.

VIII. Data Recording and Management

Initial field logs and chain-of-custody records will be transmitted to the ARCADIS PM at the end of each day unless otherwise directed by the PM. The groundwater team leader retains copies of the groundwater sampling logs.

IX. Quality Assurance

In addition to the quality control samples to be collected in accordance with this SOP, the following quality control procedures should be observed in the field:

- Collect samples from monitoring wells in order of increasing concentration, to the extent known based on review of historical site information if available.

- Equipment blanks should include the pump and tubing (if using disposable tubing) or the pump only (if using tubing dedicated to each well).

- Collect equipment blanks after wells with higher concentrations (if known) have been sampled.

- Operate all monitoring instrumentation in accordance with manufacturer's instructions and calibration procedures. Calibrate instruments at the beginning of each day and verify the calibration at the end of each day. Record all calibration activities in the field notebook.

- Clean all groundwater sampling equipment prior to use in the first well and after each subsequent well using procedures for equipment decontamination.

X. References

United States Environmental Protection Agency (USEPA). 1986. RCRA Groundwater Monitoring Technical Enforcement Guidance Document (September 1986).

USEPA Region II. 1998. *Ground Water Sampling Procedure Low Stress (Low Flow) Purging and Sampling*.

USEPA. 1991. Handbook Groundwater, Volume II Methodology, Office of Research and Development, Washington, DC. USEPN62S, /6-90/016b (July, 1991).

U.S. Geological Survey (USGS). 1977. National Handbook of Recommended Methods for Water-Data Acquisition: USGS Office of Water Data Coordination. Reston, Virginia.

Attachment 1

Groundwater Sampling Log

Attachment 2

Oxygen Solubility in Fresh Water

Temperature (degrees C)	**Dissolved Oxygen** (mg/L)
0	14.6
1	14.19
2	13.81
3	13.44
4	13.09
5	12.75
6	12.43
7	12.12
8	11.83
9	11.55
10	11.27
11	11.01
12	10.76
13	10.52
14	10.29
15	10.07
16	9.85
17	9.65
18	9.45
19	9.26
20	9.07
21	8.9
22	8.72
23	8.56
24	8.4
25	8.24
26	8.09
27	7.95
28	7.81
29	7.67
30	7.54
31	7.41
32	7.28
33	7.16
34	7.05
35	6.93

Reference: Vesilind, P.A., *Introduction to Environmental Engineering*, PWS Publishing Company, Boston, 468 pages (1996).

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Monitoring Well Development

Rev. #: 2.2

Rev. Date: March 22, 2010

Approval Signatures

Prepared by: ______________________ Date: 03/22/2010

Reviewed by: ______________________ Date: 03/22/2010
(Technical Expert)

I. Scope and Application

Monitoring wells (or piezometers, well points, or micro-wells) will be developed to clear them of fine-grained sediment to enhance the hydraulic connection between the well and the surrounding geologic formation. Development will be accomplished by evacuating well water by either pumping or bailing. Prior to pumping or bailing, the screened interval will be gently surged using a surge block, bailer, or inertia pump with optional surgeblock fitting as appropriate. Accumulated sediment in the bottom of the well (if present) will be removed by bailing with a bottom-loading bailer or via pumping using a submersible or inertia pump with optional surge-block fitting. Wells will also be gently brushed with a weighted brush to assist in removing loose debris, silt or flock attached to the inside of the well riser and/or screen prior to development. Pumping methods will be selected based on site-specific geologic conditions, anticipated well yield, water table depth, and groundwater monitoring objectives, and may include one or more of the following:

- submersible pump
- inertial pump (Waterra™ pump or equivalent)
- bladder pump
- peristaltic pump
- centrifugal pump

When developing a well using the pumping method, the pump (or, with inertial pumps, the tubing) is lowered to the screened portion of the well. During purging, the pump or tubing is moved up and down the screened interval until the well yields relatively clear water.

Submersible pumps have a motor-driven impeller that pushes the groundwater through discharge tubing to the ground surface. Inertial pumps have a check valve at the bottom of stiff tubing which, when operated up and down, lifts water to the ground surface. Bladder pumps have a bottom check valve and a flexible internal bladder that fills from below and is then compressed using pressurized air to force water out the top of the bladder through the discharge tubing to the ground surface. These three types of pumps have a wide range of applicability in terms of well depth and water depth.

Centrifugal and peristaltic pumps use atmospheric pressure to lift water from the well, and therefore can only be practically used where the depth to water is less than 25 feet.

II. Personnel Qualifications

Monitoring well development activities will be performed by persons who have been trained in proper well development procedures under the guidance of an experienced field geologist, engineer, or technician.

III. Equipment List

Materials for monitoring well development using a pump include the following:

- health and safety equipment, as required by the site Health and Safety Plan (HASP):
- cleaning equipment
- photoionization detector (PID) to measure headspace vapors
- pump
- polyethylene pump discharge tubing
- plastic sheeting
- power source (generator or battery)
- field notebook and/or personal digital assistant (PDA)
- graduated pails
- appropriate containers

- monitoring well keys
- water level indicator

Materials for monitoring well development using a bailer include the following:

- personal protective equipment (PPE) as required by the HASP
- cleaning equipment
- PID to measure headspace vapors
- bottom-loading bailer, sand bailer
- polypropylene or nylon rope
- plastic sheeting
- graduated pails
- appropriate containers
- keys to wells
- field notebook and/or PDA
- water level indicator
- weighted brush for well brushing

IV. Cautions

Where surging is performed to assist in removing fine-grained material from the sand pack, surging must be performed in a gentle manner. Excessive suction could promote fine-grained sediment entry into the outside of the sand pack from the formation.

Avoid using development fluids or materials that could impact groundwater or soil quality, or could be incompatible with the subsurface conditions.

In some cases it may be necessary to add potable water to a well to allow surging and development, especially for new monitoring wells installed in low permeability formations. Before adding potable water to a well, the Project Manager (PM) must be notified and the PM shall make the decision regarding the appropriateness and applicability of adding potable water to a well during well development procedures. If potable water is to be added to a well as part of development, the potable water source should be sampled and analyzed for constituents of concern, and the results evaluated by the PM prior to adding the potable water to the well. If potable water is added to a well for development purposes, at the end of development the well will be purged dry to remove the potable water, or if the well no longer goes dry then the well will be purged to remove at least three times the volume of potable water that was added.

V. Health and Safety Considerations

Field activities associated with monitoring well development will be performed in accordance with a site-specific HASP, a copy of which will be present on site during such activities.

VI. Procedure

The procedures for monitoring well development are described below. (Note: Steps 7, 8, and 10 can be performed at the same time using an inertial pump with a surge-block fitting.)

1. Don appropriate PPE (as required by the HASP).

2. Place plastic sheeting around the well.

3. Clean all equipment entering each monitoring well, except for new, disposable materials that have not been previously used.

4. Open the well cover while standing upwind of the well, remove well cap. Insert PID probe approximately 4 to 6 inches into the casing or the well headspace and cover with gloved hand. Record the PID reading in the field notebook. If the well headspace reading is less than 5 PID units, proceed; if the headspace reading is greater than 5 PID units, screen the air within the breathing zone. If the PID reading in the breathing zone is below 5 PID units, proceed. If the PID reading is above 5 PID units, move upwind from well for 5 minutes to allow the volatiles to dissipate. Repeat the breathing zone test. If the reading is still above 5 PID units, don the appropriate respiratory protection in accordance with the requirements of the HASP. Record all PID readings.

5. Obtain an initial measurement of the depth to water and the total well depth from the reference point at the top of the well casing. Record these measurements in the field log book.

6. Prior to redeveloping older wells that may contain solid particulate debris along the inside of the well casing and screen, gently lower and raise a weighted brush along the entire length of the well screen and riser to free and assist in removing loose debris, silt or flock. Perform a minimum of 4 “passes” along the screened and cased intervals of the well below the static water level in the well. Allow the resulting suspended material to settle for a minimum of one day prior to continuing with redevelopment activities.

7. Lower a surge block or bailer into the screened portion of the well. Gently raise and lower the surge block or bailer within the screened interval of the well to force water in and out of the screen slots and sand pack. Continue surging for 15 to 30 minutes.

8. Lower a bottom-loading bailer, submersible pump, or inertia pump tubing with check valve to the bottom of the well and gently bounce the bailer, pump, pump tubing on the bottom of the well to collect/remove accumulated sediment, if any. Remove and empty the bailer, if used. Repeat until the bailed/pumped water is free of excessive sediment and the bottom of the well feels solid. Alternatively, measurement of the well depth with a water level indicator can be used to verify that sediment and/or silt has been removed to the extent practicable, based on a comparison with the well installation log or previous measurement of total well depth.

9. After surging the well and removing excess accumulated sediment from the bottom of the well, re-measure the depth-to-water and the total well depth from the reference point at the top of the well casing. Record these measurements in the field log book.

10. Remove formation water by pumping or bailing. Where pumping is used, measure and record the pre-pumping water level. Operate the pump at a relatively constant rate. Measure the pumping rate using a calibrated container and stop watch, and record the pumping rate in the field log book. Measure and record the water level in the well at least

once every 5 minutes during pumping. Note any relevant observations in terms of water color, visual level of turbidity, sheen, odors, etc. Pump or bail until termination criteria specified in the Field Sampling Plan (FSP) are reached. Record the total volume of water purged from the well.

11. If the well goes dry, stop pumping or bailing. Note the time that the well went dry. After allowing the well to recover, note the time and depth to water. Resume pumping or bailing when sufficient water has recharged the well.

12. Contain all water in appropriate containers.

13. When complete, secure the lid back on the well.

14. Place disposable materials in plastic bags for appropriate disposal and decontaminate reusable, downhole pump components and/or bailer.

VII. Waste Management

Materials generated during monitoring well installation and development will be placed in appropriate labeled containers and disposed of as described in the Work Plan or Field Sampling Plan.

VIII. Data Recording and Management

Well development activities will be documented in a proper field notebook and/or PDA. Pertinent information will include personnel present on site; times of arrival and departure; significant weather conditions; timing of well development activities; development method(s); observations of purge water color, turbidity, odor, sheen, etc.; purge rate; and water levels before and during pumping.

IX. Quality Assurance

All reused, non-disposable, downhole well development equipment will be cleaned in accordance with the procedures outlined in the Field Equipment Cleaning-Decontamination SOP.

X. References

Not applicable.

EXECUTIVE SUMMARY

This Standard sets forth the accepted practice for and establishes the requirements for workplace safety near excavations and trenches and employee and subcontractor entry into such.

It is ARCADIS' policy that ARCADIS staff will not enter excavations and trenches unless it is absolutely necessary and that an OSHA-defined Excavation Competent Person is on-site for all excavation work under ARCADIS contractual control. The competent person will be provided by the entity on site responsible for performing the excavation work unless otherwise required by the client. Thus, if an ARCADIS subcontractor is conducting the excavation work, that subcontractor will provide the competent person. If ARCADIS is self-performing the excavation services, then ARCADIS will provide a competent person whether a specialized subcontractor or authorized employee.

An excavation Competent Person must be involved in the excavation/trenching hazard assessment process. This will assist in determining the need for an engineering opinion when excavating near or adjacent to structures and determining the need and timing of inspections.

Prior to excavation, all underground installations (water, electric, telephone, gas, etc.) must be located and documented in accordance with ARCADIS Utility Clearance Policy and Standard ARC HSFS019.

All excavations over four feet in depth (or less than 4 feet in depth if deemed necessary by the Competent Person) shall be provided with a stairway, ladder, ramp, or other safe means of egress so as to require no more than 25 feet of lateral travel.

Water must not be allowed to accumulate in open excavations where employees are working. When necessary, means such as diverting natural drainage around the excavation or actively pumping water must be used to prevent or control water accumulation.

Excavated materials (spoil) must be placed no closer than 2 feet from the edge of an open excavation, and otherwise retained to prevent loose material from falling into the excavation.

Each employee at the edge of an excavation 6 feet (1.8 m) or more in depth shall be protected from falling by guardrail systems, fences, or barricades *when the excavations are not readily seen because of plant growth or other visual barrier*.

Any excavation over 5 feet in depth into which employees will enter that is not entirely in stable rock as defined in this Standard requires use of a protective system.

All excavations over 20 feet in depth must be designed by a registered professional engineer regardless of whether personnel will enter it or not.

All excavations over 4 feet in depth must be tested for hazardous atmospheres whenever personnel are required to enter and a potential exists for the existence of hazardous contaminants or oxygen deficiency. Excavations less than 4 feet in depth must be evaluated by the competent person and at the competent person's discretion be tested for hazardous atmospheres whenever personnel are required to enter and a potential exists for the existence of hazardous contaminants or oxygen deficiency.

1. POLICY

It is ARCADIS US policy to be proactive in the identification, assessment and control of health and safety hazards and associated risks. To those means, any work involving trenching and excavation that is under the control or direction of ARCADIS or an ARCADIS subcontractor will be accomplished following, at a minimum, this Standard.

It is ARCADIS' policy that ARCADIS staff will not enter excavations and trenches unless it is absolutely necessary. If there are no suitable alternatives and it becomes necessary to enter excavations or trenches, this standard, at a minimum will be strictly followed.

It is also the policy of ARCADIS to ensure an OSHA-defined Excavation Competent Person is on-site for all excavation work under ARCADIS contractual control. The competent person will be provided by the entity on site responsible for performing the excavation work unless otherwise required by the client. Thus, if an ARCADIS subcontractor is conducting the excavation work, that subcontractor will provide the competent person. If ARCADIS is self-performing the excavation services, then ARCADIS will provide a competent person whether a specialized subcontractor or authorized employee.

2. PURPOSE AND SCOPE

2.1 Purpose

To effectively control or eliminate the hazards presented by working near or entry into excavations or trenches, this Standard sets forth the accepted practice for and establishes the requirements for workplace safety near excavations and trenches and employee and subcontractor entry into such.

2.2 Scope

This standard along with associated checklists and the Utility Location Standard (ARC HSFS019) apply to all employees of ARCADIS-US. Only trained and authorized personnel are permitted to work near or enter excavations and trenches, perform rescue services, or act as the excavation competent person.

3. DEFINITIONS

Exhibit 1 includes relevant definitions to this Standard including that for competent person qualifications.

4. RESPONSIBILITIES

4.1 Corporate H&S with Division and Practice Experts

- On a routine basis, review and update, as necessary, this standard.
- As requested by Operations Leadership, review cancelled checklists periodically to ensure conformance to this standard.
- Coordinate with the Training Group to ensure that the excavation competent person qualifications and training/retraining requirements are met.

- Conduct excavation competent person evaluations for nominated individuals as necessary, in order to approve and designate them as competent.
- Recommend qualified training provider for excavation awareness training for employees working in or around excavation/trenching operations.
- Provide technical assistance regarding excavation and trench protocol, atmospheric testing equipment, PPE, hazard assessment and research information on unusual hazards.
- Audit project-specific excavation sites for compliance with this standard.

4.2 Principal in Charge (PIC), Project Manager (PM), and/or Task Manager (TM)

- Verify that excavation and trench protocols are properly identified and addressed within the project work plan, project health & safety plan, and/or other project-related documents.
- Verify that their divisional or project team employees have received the proper training provided by Corporate Health & Safety or qualified training source prior to conducting excavation/trenching entry activities.
- Verify that any ARCADIS employee acting as the Excavation Competent person has been designated and authorized to do so per the requirements specified in section 4.4 of this standard.
- Verify that the proper entry equipment, including personal protective equipment (PPE), atmospheric testing equipment and safety equipment, is available for use by their divisional employees.
- Verify that copies of the completed checklists are available for Corporate Health and Safety review and retained with the project files.
- Request that Corporate Health and Safety review cancelled checklists as necessary and appropriate

4.3 Health and Safety Plan Writers and Reviewers

Use this standard as guidance to ensure the appropriate identification, assessment and control of excavation and trenching hazards for documentation in project HASPs and development of task specific Job Safety Analysis (JSA).

4.4 Competent Person

Competent Person responsibilities include:

- Anticipation, identification and control of excavation and trenching hazards, as well as the signs and symptoms of exposure to the hazard(s), and the Authority to implement all corrective actions including Stopping Work.

  Note: An excavation Competent Person must be involved in the excavation/trenching hazard assessment process. This will assist in determining the need for an engineering opinion when excavating near or adjacent to structures and determining the need and timing of inspections.

- Review existing soil sampling data (if any) or other pertinent hazard characterization information recorded by the client.
- Investigate the client's excavation/trenching protocol, to verify that any identified hazards and previous experience with earthwork at the site is properly communicated.
- Coordinate entry operations with the client's employees when both client and ARCADIS employees will be working in or near an excavation/trench.
- Offer all entrants an opportunity to review the applicable control measures and testing results and an opportunity to request a reevaluation as necessary.
- Design of structural ramps that are used solely by employees as a means of access or egress from excavations.
- Monitoring of water removal equipment and operations, if water is controlled or prevented from accumulating by the use of water removal equipment,
- Inspection of excavations subject to runoff from heavy rains.
- Daily inspections of excavations, the adjacent areas, and protective systems when required.
- If evidence of a situation that could result in a possible cave-in, indications of failure of protective systems, hazardous atmospheres, or other hazardous conditions are present, the Competent Person is responsible for ensuring that exposed employees are removed from the hazardous area until the necessary precautions have been taken to ensure their safety.
- Examining material or equipment used for protective systems that is damaged to evaluate its suitability for continued use. If the competent person cannot assure the material or equipment is able to support the intended loads or is otherwise suitable for safe use, then such material or equipment shall be removed from service, and shall be evaluated and approved by a registered professional engineer before being returned to service.
- For excavations less than 5 feet (1.52 m) in depth, in which employees will be entering, a Competent Person must examine the ground to determine if there are indications of a potential cave-in hazard. If there are potential indicators of a cave-in hazard, the Competent Person will require some form of cave-in protection be implemented before employees can enter.
- Classifying soil and rock deposits based on site and environmental conditions, and on the structure and composition of the earth deposits.
- Soil and rock deposits shall be classified by a Competent Person as Stable Rock, Type A, Type B, or Type C based on the results of at least one visual and at least one manual analysis.

- If, after classifying a deposit, the properties, factors, or conditions affecting its classification change in any way, the changes shall be evaluated by a Competent Person. The deposit shall be reclassified as necessary to reflect the changed circumstances.

- When surcharge loads from stored material or equipment, operating equipment, or traffic are present, a competent person shall determine the degree to which the actual slope must be reduced below the maximum allowable slope, and shall assure that such reduction is achieved.

- Order evacuation of the excavation/trench if an uncontrolled hazard develops, either within or outside the space, or upon observing a behavioral effect of hazard exposure among excavation/trench entrants.

- Verify that all tests and precautionary measures identified on the Daily/Periodic Inspection Checklist located in Exhibit 2 and the ARCADIS Utility Location Policy and Standard ARC HSFS019 has been performed prior to authorizing subsurface work or entry into an excavation or trench.

ARCADIS employees must meet the following requirements to be a designated and approved Competent Person:

- Attend an Excavation Competent Person training course approved by Corporate Health and Safety or have equivalent training; and

- Approval by Corporate Health and Safety through demonstration of practical field experience and/or knowledge of the subject matter.
  - Documentation of the evaluation and approval of each excavation competent person will be completed using the form provided in Exhibit 3.
  - This documentation and a listing of the approved ARCADIS excavation competent person will be maintained by the Training Group; and

- If on an Environmental project where HAZWOPER training is required by ARCADIS, the Competent Person must also have completed the 40 Hour HAZWOPER training, be current on their annual 8 Hour HAZWOPER refresher and it is recommended, but not required, that the Competent Person completed the HAZWOPER Supervisor training course.

4.5 Site Safety Officer (SSO)

When ARCADIS and/or our subcontractor is in control of an excavation project, the SSO will be responsible for the following:

- Interface with the client representative and Competent Person to identify and understand hazards associated with the client’s excavation and trenching and/or work permit programs.

- Implement the ARCADIS Utility Clearance Policy and Procedure and complete the Daily/Periodic Excavation Inspection Checklist, when the excavation project is under the control of ARCADIS.

- Verify adequate training and experience of those ARCADIS employees working in and around excavations.
- Verify that the safety procedures identified in this Standard, the site specific HASP, and applicable regulatory requirements are used when required to protect employees during excavation activities.
- Verify that the client takes the necessary precautions in notifying their employees that our employees will be installing an excavation or trench.
- Review the lockout/tagout and isolation measures implemented by ARCADIS, our subcontractor and/or the client as necessary based on proximity of utilities or other energy sources in the area of the excavation/trench.
- Immediately report any unusual or unplanned excavation or trenching hazards to both the Competent Person and the Project Manager or Task Manager.
- Keep unauthorized persons away from the excavation area.
- Confirm that the ARCADIS Utility Location Policy and Standard ARC HSFS019 has been performed prior to authorizing subsurface work or entry into an excavation or trench.
- Issue, authorize, and have the Utility Clearance and Daily/Periodic Inspection forms readily available for review
- Verify that copies of the completed clearance forms and checklists are properly disseminated to Corporate Health and Safety and retained with the project files, as specified in Section 8.0 – Records.

4.6 Employees

- Notify the PIC, PM, TM or SSO if they have not received appropriate training.
- Review the site specific HASP, task specific JSAs, and other written plans that are associated with their work.
- Use the TRACK process regularly and frequently to recognize the hazards which may be faced during work around or in excavation/trenches, as well as to understand the signs and symptoms of exposure to airborne hazard(s).
- Never enter an excavation/trench without verifying that the required Utility Location Procedure, Daily/Periodic Inspection Checklist and required air monitoring is conducted.
- Use Stop Work Authority if excavation/trenching hazard(s) have not been appropriately addressed. Immediately consult with SSO, Competent Person and ARCADIS Project/Task Manager.
- Use the PPE, air monitoring and testing equipment that has been provided or have access to the information documenting that results are within the defined Action Levels established within the HASP.

- Maintain an awareness of all required hazard controls and consult with the Competent Person as necessary.

- If unexpected conditions arise during entry, immediately notify other entrants, evacuate the space and inform the designated Competent Person

- Obey evacuation orders given by the Competent Person, SSO, automatic alarm activation, or when self-perceived.

- At least one person on site must maintain current certification in basic first aid and cardiopulmonary resuscitation (CPR).

5. PROCEDURE

5.1 General Safety Requirements for all Excavations

- If excavation work encounters unanticipated groundwater contamination, soil contamination or other unanticipated contaminants, ARCADIS staff will Stop Work and notify the Project Manager. An appropriate work plan to sample the suspected contaminants shall be developed, samples collected by HAZWOPER trained personnel, the HASP modified and a contaminant management plan developed, as necessary.

- All surface obstructions must be moved or supported so as to protect employees and equipment.

- Prior to excavation, all underground installations (water, electric, telephone, gas, etc.) must be located and documented in accordance with ARCADIS Utility Clearance Policy and Standard ARC HSFS019.

- When excavating in areas near underground installations, proper precautions must be taken to determine the exact location of the installations and to adequately protect and support them. While an excavation is open, underground installations shall be protected, supported or removed as necessary to protect employees.

- Structural ramps that are used solely by employees as a means of access or egress from excavations shall be designed by a competent person.

- Structural ramps used for access or egress of equipment shall be designed by a competent person qualified in structural design, and shall be constructed in accordance with the design.

- Ladders must extend at least 36” (3 feet) above the landing surface.

- All excavations over four feet in depth shall be provided with a stairway, ladder, ramp, or other safe means of egress so as to require no more than 25 feet of lateral travel. As deemed necessary by the competent person, excavations less than 4 feet in depth will be provided with a stairway, ladder, ramp, or other safe means of egress so as to require no more than 25 feet of lateral travel.

- If personnel are working in a location exposed to vehicular traffic they must be provided with and be required to wear reflective safety vests. Adequate, signs, barriers or other equivalent traffic controls must be used to protect employees.

- Personnel are not permitted to be beneath elevated loads handled by equipment or be in excavations when heavy equipment is digging in or near the excavation.

- Mobile equipment located near open excavations must be adequately protected from falling or rolling into excavations by the use of barricades or warning devices.

- Employees entering bell-bottom pier holes, or other similar deep and confined footing excavations, shall wear a harness with a lifeline securely attached to it. The lifeline shall be separate from any line used to handle materials, and shall be individually attended at all times while the employee wearing the lifeline is in the excavation.

- Water must not be allowed to accumulate in open excavations where employees are working. When necessary, means such as diverting natural drainage around the excavation or actively pumping water must be used to prevent or control water accumulation.

- Where the stability of adjoining buildings, walls, or other structures is endangered by excavation operations, support systems such as shoring, bracing, or underpinning shall be provided to ensure the stability of such structures for the protection of employees.

- All structures adjacent to an open excavation must be supported, or a registered professional engineer (PE) must determine that the structure will not be affected by the excavation activities.

- Excavated materials (spoil) must be placed no closer than 2 feet from the edge of an open excavation, and otherwise retained to prevent loose material from falling into the excavation.

- Each employee at the edge of an excavation 6 feet (1.8 m) or more in depth shall be protected from falling by guardrail systems, fences, or barricades when the excavations are not readily seen because of plant growth or other visual barrier.

- Employees at the edge of a well, pit, shaft, and similar excavation 6 feet (1.8m) or more in depth shall be protected from falling by guardrail systems, fences, barricades, or covers.

- Work tasks will be designed to limit the number of personnel required to enter any excavation. All tasks that can be completed remotely from outside the excavation (such as soil sampling) will be conducted in such a manner.

- Personnel will not be allowed to enter any excavation unless required protective systems and procedures are used to prevent accidents and injury.

Best Management Practice: *In some instances, an excavation will not have any protective systems in place when employees will not be entering into the excavation. Even if employees are not entering into this type of excavation, a competent person should be consulted to establish a safe zone distance away from the edge of any open excavation to minimize the hazard of falling into this type of excavation. Standing at the edge of an excavation places an employee at risk of falling into the excavation, thereby subjecting themselves to the hazard of excavation/trench collapse, which then triggers the requirement for protective system use as defined in this standard. General guidance would be for employees to remain 6 feet or more away from the edge of any excavation.*

- Dust control measures will be implemented during excavation and soil-moving activities as required by the Health and Safety Plan (HASP). As necessary, dust control measures will also be used to manage soil located in temporary storage areas or stockpile areas. Specific dust control measures will be detailed in the HASP. The Competent Person must be consulted prior to initiating "wet" dust control measures to discuss limits/impact to protective systems.

- Excavations cut through a firewall or containment berm/bund shall provide alternate means of containment while the job is progressing. A specific containment procedure or diversion procedure will be included as a supplement to the HASP or defined in the Remedial Work Plan.

- Excavating in archeological sites requires special consideration and compliance with local legal requirements and shall be avoided wherever possible. Archaeological investigations on federal and state lands have additional requirements. For example, permit provisions are established in federal (specifically the federal Archaeological Resources Protection Act) and some state statutes. If an artifact or archeological feature is unearthed during excavation, ARCADIS shall stop work and consult with client, regulatory agencies and professional archaeologist, as necessary.

5.2 Excavations Requiring Protective Systems

This section defines excavations that require protective systems.

- All excavations into which employees will enter, regardless of depth, where the potential for cave-in exists.

- Any excavation over 5 feet in depth into which employees will enter that is not entirely in stable rock as defined in this Standard.

- Any excavation near a structure, (e.g. foundations, piers, footers, walls, sidewalks, tanks, roadways, etc.), as required by the registered professional engineer reviewing the stability of the excavation and the structure.

- All excavations over 20 feet in depth must be designed by a registered professional engineer regardless of whether personnel will enter it or not.

- All excavations that could potentially impact adjacent structures shall be reviewed by a registered professional engineer to determine if the stability of the structure will be affected by the excavation.

- Support systems for an adjacent structure must be designed by a registered professional engineer.

5.3 Selection and Use of Protective Systems

5.3.1 Shoring or Shielding

If shoring or shielding is selected as the protective system for an excavation, soil classification in accordance with 1926 Subpart P Appendix A is required.

One of the following options must be used for excavations which will be shored or shielded.

- Timber shoring as specified in 1926 Subpart P Appendix C must be utilized
- Hydraulic shoring, trench jacks, air shores, or shields as required in 1926.652 (c)(2) must be utilized following the system manufacturer's data
- A system which follows other tabulated data (approved by a registered professional engineer) must be utilized
- The excavation must be designed by a registered professional engineer

5.3.2 Sloping

If sloping is selected as the protective system for an excavation, the excavation sides must be sloped at a maximum of 34 degrees (1.5 Horizontal: 1 Vertical), unless the procedure listed above is followed.

Soil classification is required for all excavations with sides which will be sloped greater than 34^{o} (1.5 Horizontal: 1 Vertical). If it will be sloped greater than 34^{o}, the one of the following options must be utilized:

- Option 1 - assume Type C and slope 1.5/1 - default sloping classification
- Option 2 - classify soil according to the standard and use Type A/B sloping requirements
- Option 3 – use other tabulated data with PE approval
- Option 4 – PE approval of sloping/benching design

5.4 Atmospheric Testing for Entry

All excavations over 4 feet in depth must be tested for hazardous atmospheres whenever personnel are required to enter and a potential exists for the existence of hazardous contaminants or oxygen deficiency. Excavations less than 4 feet in depth must be evaluated by the competent person and at the competent person's discretion be tested for hazardous atmospheres whenever personnel are required to enter and a potential exists for the existence of hazardous contaminants or oxygen deficiency.

Emergency rescue equipment, such as breathing apparatus, a safety harness and line, or a basket stretcher, shall be readily available where hazardous atmospheric conditions exist or may reasonably be expected to develop during work in an excavation. This equipment shall be attended when in use.

The site designated "Competent Person" and/or SSO will document initial and periodic air monitoring results for all activities requiring entry into the excavation. All atmospheric testing of excavations must be conducted in the following sequence and meet the following air quality criteria.

- Oxygen content must be between 19.5% to 23.5%
- Combustible gas or vapor less than (<) or equal to 5% of its lower explosive limit (LEL): Level D. Continue to monitor atmospheric conditions as detailed in project specific Health and Safety Plan.
- Combustible gas or vapor levels greater than (>) 5%, but < 10% of its LEL: Continuous atmospheric monitoring required; review use/implementation of engineering controls (ventilation, etc.) and PPE; evaluate potential source(s) of ignition and where feasible, remove from the area; fire extinguisher must be available; and use TRACK to assess condition/controls and proceed with caution.
- Combustible gas or vapor levels > or equal to 10% of its LEL: Stop Work; evacuate the excavation/trench; contact the Competent Person and SSO; and re-evaluate source/controls of combustible gas,
- Carbon monoxide levels must not exceed 25 ppm as an 8-hour Time Weighted Average (TWA).
- Hydrogen sulfide must not exceed 5 ppm as a Short-Term Exposure Limit (STEL) value or 1 ppm as an 8-hour TWA.
- Toxic air contaminant levels must not exceed 50% of the PEL or the TLV for the specific contaminant (whichever is lower).

5.5 Location of Underground/Overhead Utilities

- The competent person and the project manager shall both verify that local underground facilities location/protection agencies are notified within the required time frame prior to the initiation of excavation activities and meet all requirements in the ARCADIS Utility Location Policy and Standard ARC HSFS019.
- Prior to initiation of excavation or trenching operations the competent person shall verify that all utilities have been located.

5.6 Daily/Periodic Inspections

Daily inspections of excavations, the adjacent areas, and protective systems shall be made by a Competent Person for evidence of a situation that could result in possible cave-ins, indications of failure of protective systems, hazardous atmospheres, or other hazardous conditions. An inspection shall be conducted by the Competent Person:

- Prior to initiation of daily excavation or trenching operations the competent person shall complete a daily inspection of the excavation.

- During excavation or trenching operations the competent person shall complete a periodic inspection after any event (e.g., thunderstorm, vibration, excessive drying) that may affect excavation stability.

Note: In order to correctly ascertain the soil types, the competent person must identify the locations and the limits of each type of soil, and must conduct visual and all appropriate manual tests to classify the initial (opening) soil types observed.

Note: These inspections are only required when employee exposure can be reasonably anticipated. Not just in-trench exposure, but also ANY hazardous condition in the area that an employee could be exposed to.

The competent person shall complete the daily/periodic inspection checklist (A copy of the checklist is attached to this Policy as Exhibit A) – Subcontractors must complete the ARCADIS checklist or an equivalent inspection form for each inspection of excavation and trenching activities.

5.7 Soil Classification for Selection of Protective Systems

5.7.1 Soil Classification

This section describes a method of classifying soil and rock deposits based on site and environmental conditions, and on the structure and composition of the earth deposits. This section contains definitions, sets forth requirements, and describes acceptable visual and manual tests for use in classifying soils.

This section applies when a sloping, benching or shoring system is utilized as a method of protection for employees from cave-ins.

5.7.2 Soil Classification Definitions

5.7.2.1 Types/Classes of Soil

5.7.2.1.1 Type Class A Soils

Type/Class A Soils are cohesive soils with an unconfined, compressive strength of 1.5 ton per square foot (tsf) (144kPa) or greater. Examples of cohesive soils are: Clay, silty clay, sandy clay, clay loam and in some cases, silty clay loam and sandy clay loam. Cemented soils such as caliche and hardpan are also considered Type A. However, no soil is Type A if the following apply.

- The soil is fissured;
- The soil is subject to vibration from heavy traffic, pile driving, or similar effects;
- The soil has been previously disturbed;
- The soil is part of a sloped, layered system where the layers dip into the excavation on a slope of four horizontal to one vertical (4 Horizontal:1 Vertical) or greater;
- The material is subject to other factors that would require it to be classified as a less stable material

5.7.2.1.2 Type Class B Soils

Type/Class B Soils are:

- Cohesive soils with an unconfined compressive strength greater than 0.5 tsf (48 kPa) but less than 1.5 tsf (144 kPa)
- Granular cohesion-less soils including angular gravel (similar to crushed rock), silt, silt loam, sandy loam and, in some cases, silty clay loam and sandy clay loam
- Previously disturbed soils except those which would otherwise be classed as Type C soil
- Soil that meets the unconfined compressive strength or cementation requirements for Type A, but is fissured or subject to vibration
- Dry rock that is not stable
- Material that is part of a sloped, layered system where the layers dip into the excavation on a slope less steep than four horizontal to one vertical (4 Horizontal:1 Vertical), but only if the material would otherwise be classified as Type B

5.7.2.1.3 Type/Class C Soils

Type/Class C Soils are:

- Cohesive soil with an unconfined compressive strength of 0.5 tsf (48 kPa) or less
- Granular soils including gravel, sand, and loamy sand
- Submerged soil or soil from which water is freely seeping
- Submerged rock that is not stable
- Material in a sloped, layered system where the layers dip into the excavation or a slope of four horizontal to one vertical (4 Horizontal:1 Vertical) or steeper

5.7.2.2 Methods for Classifying Soils

Each soil and rock deposit shall be classified by a competent person as Stable Rock, Type A, Type B, or Type C in accordance with the definitions set forth in this section. The classification of the deposits shall be made based on the results of at least one visual and at least one manual analysis conducted by a competent person using tests described below, or in other recognized methods of soil classification and testing such as those adopted by the American Society for Testing Materials, or the U.S. Department of Agriculture textural classification system.

The visual and manual analyses, such as those noted as being acceptable in this section, shall be designed and conducted to provide sufficient quantitative and qualitative information as may be necessary to identify properly the properties, factors, and conditions affecting the classification of the deposits. Visual analysis is conducted to determine qualitative information regarding the excavation site in general, the soil adjacent to the excavation, the soil forming the sides of the open excavation, and the soil taken as samples from excavated material.

Observe the following:

- Samples of soil that are excavated and soil in the sides of the excavation. Estimate the range of particle sizes and the relative amounts of the particle sizes. Soil that is primarily composed of fine grained material is cohesive material. Soil composed primarily of coarse grained sand or gravel is granular material.

- Soil as it is excavated. Soil that remains in clumps when excavated is cohesive. Soil that breaks up easily and does not stay in clumps is granular.

- The side of the open excavation and the surface area adjacent to the excavation. Crack like openings such as tension cracks could indicate fissured material. If chunks of soil spall off a vertical side, the soil could be fissured. Small spalls are evidence of moving ground and are indications of potentially hazardous situations.

- The area adjacent to the excavation and the excavation itself for evidence of existing utility and other underground structures, and to identify previously disturbed soil.

- The open side of the excavation to identify layered systems. Examine layered systems to identify if the layers slope toward the excavation. Estimate the degree of slope of the layers.

- The area adjacent to the excavation and the sides of the opened excavation for evidence of surface water, water seeping from the sides of the excavation, or the location of the level of the water table.

- The area adjacent to the excavation and the area within the excavation for sources of vibration that may affect the stability of the excavation face.

Manual analysis of soil samples is conducted to determine quantitative as well as qualitative properties of soil and to provide more information in order to classify soil properly.

5.7.2.3 Classifications

- *Plasticity*. Mold a moist or wet sample of soil into a ball and attempt to roll it into threads as thin as 1/8 inch in diameter. Cohesive material can be successfully rolled into threads without crumbling. For example, if at least a two inch (50 mm) length of 1/8 inch thread can be held on one end without tearing, the soil is cohesive.

- *Dry strength*. If the soil is dry and crumbles on its own or with moderate pressure into individual grains or fine powder, it is granular (any combination of gravel, sand, or silt).

If the soil is dry and falls into clumps which break up into smaller clumps, but the smaller clumps can only be broken up with difficulty, it may be clay in any combination with gravel, sand or silt. If the dry soil breaks into clumps which do not break up into small clumps and which can only be broken with difficulty, and there is no visual indication the soil is fissured, the soil may be considered unfissured.

- *Thumb penetration*. The thumb penetration test can be used to estimate the unconfined compressive strength of cohesive soils. Type A soils with an unconfined compressive strength of 1.5 tsf can be readily indented by the thumb; however, they can be penetrated by the thumb only with very great effort. Type C soils with an unconfined compressive strength of 0.5 tsf can be easily penetrated several inches by the thumb, and can be molded by light finger pressure. This test should be conducted on an undisturbed soil sample, such as a large clump of spoil, as soon as practicable after excavation to keep to a minimum the effects of exposure to drying influences. If the excavation is later exposed to wetting influences (rain, flooding), the classification of the soil must be changed accordingly.

- *Other strength tests*. Estimates of unconfined compressive strength of soils can also be obtained by use of a pocket penetrometer or by using a hand operated shearvane.

- *Drying test*. The basic purpose of the drying test is to differentiate between cohesive material with fissures, unfissured cohesive material, and granular material. The procedure for the drying test involves drying a sample of soil that is approximately one inch thick (2.54 cm) and six inches (15.24 cm) in diameter until it is thoroughly dry:

  1. If the sample develops cracks as it dries, significant fissures are indicated.

  2. Samples that dry without cracking are to be broken by hand. If considerable force is necessary to break a sample, the soil has significant cohesive material content. The soil can be classified as an unfissured cohesive material and the unconfined compressive strength should be determined by using the thumb penetration or other test.

5.7.2.4 Cohesive with Fissures vs Granular

If a sample breaks easily by hand, it is either a fissured cohesive material or a granular material. To distinguish between the two, pulverize the dried clumps of the sample by hand or by stepping on them. If the clumps do not pulverize easily, the material is cohesive with fissures. If they pulverize easily into very small fragments, the material is granular.

5.7.2.5 Layered system

A layered system shall be classified in accordance with its weakest layer. Each layer may be classified individually where a more stable layer lies under a less stable layer.

5.7.2.6 Reclassifying Soils

A layered system shall be classified in accordance with its weakest layer. Each layer may be classified individually where a more stable layer lies under a less stable layer.

In most instances the ARCADIS designated Excavation/Trenching Competent person will assume Type C soil, unless they have conclusive data to validate Type A or B.

5.7.2.7 Excavation Construction Based on Soil Type

The maximum allowable slope means the steepest incline of an excavation face that is acceptable for the most favorable site conditions as protection against cave-ins, and is expressed as the ratio of horizontal distance to vertical rise (H:V). Short-term exposure means a period of time less than or equal to 24 hours that an excavation is open. Soil and rock deposits must be classified in accordance with Appendix A to Subpart P of Part 1926. The maximum allowable slope for a soil or rock deposit must be determined from the table provided below. The actual slope must not be steeper than the maximum allowable slope. The actual slope must be less steep than the maximum allowable slope, when there are signs of distress. If that situation occurs, the slope must be cut back to an actual slope which is at least horizontal to one vertical (1/2H:1V) less steep than the maximum allowable slope. When surcharge loads from stored material or equipment, operating equipment, or traffic are present, a competent person must determine the degree to which the actual slope must be reduced below the maximum allowable slope, and must assure that such reduction is achieved. Surcharge loads from adjacent structures must be evaluated in accordance with 1926.651(I). Configurations of sloping and benching systems must be in accordance with 29 CFR 1926 Subpart P, Appendix B.

EXCAVATION SLOPE INFORMATION FROM 29 CFR 1926 SUBPART P APPENDIX B MAXIMUM ALLOWABLE SLOPES	
Soil or Rock Type	**Maximum Allowable Slopes (H:V)[1] for Excavations Less Than 20 Feet Deep[2]**
Stable Rock	Vertical (90 degrees)
Type A[3]	¾:1 (53 degrees)
Type B	1:1 (45 degrees)
Type C	1½:1 (34 degrees)

1. Numbers shown in parentheses next to maximum allowable slopes are angles expressed in degrees from the horizontal (H). Angles have been rounded off.
2. Sloping or benching for excavations greater than 20 feet deep must be designed by a registered professional engineer.
3. A short-term maximum allowable slope of 1/2H:1V (63 degrees) is allowed in excavations in Type A soil that are 12 feet (3.67 m) or less in depth. Short-term maximum allowable slopes for excavations greater than 12 feet (3.67 m) in depth must be 3/4H:1V (53 degrees).

6. TRAINING

6.1 Project - Specific Orientation

All staff working on a site where trenching and excavation activities are being conducted by ARCADIS or its subcontractors will be provided with site orientation on excavation projects and participate in daily safety meetings that include a discussion of the following:

- Site excavation hazards and procedures;
- Requirements for conducting activities remotely whenever possible;
- Client requirements and procedures for excavation activities;
- Review of applicable federal, state and/or local excavation requirements; and
- This Excavation and Trenching Standard, as appropriate

6.2 Employee Training

Besides site orientation training, additional training will be provided as follows based on the employee's activities:

- All employees who work in the area of potential excavation/trenching sites will receive awareness level training as provided and/or approved by ARCADIS Corporate H&S in order to recognize and to understand the hazards associated with trenching/excavation work.
- On an as needed basis, employees will receive site specific instruction regarding the excavation/trenching operation from the Competent Person and/or the SSO.

6.3 Competent Person Training

Competent Persons will be provided training as follows:

In order for ARCADIS employees to be assigned duties as a competent person, with respect to excavation and trenching, in addition to the criteria noted in section 4.4, personnel must attend an Excavation Competent Person training course approved by Corporate Health and Safety or have equivalent training. The course shall include, but is not limited to the following:

- Introduction to and definition of trenches and excavations.
- General requirements of OSHA 29 CFR 1926 Subpart P.
- Responsibilities and requirements of a competent person.
- Hazards associated with trenches/excavations and Identification and Assessment of these hazards.
- Hazard controls

- Soil analysis and testing (visual and manual;
- Protective systems;
- Personal protective equipment;
- Utility location;
- Atmospheric testing;
- Water drainage and pumping;
- Site housekeeping and management;
- Communications;
- Access and egress

· Emergency Procedures.

· Inspections.

All training provided must be reviewed and approved by Corporate Health & Safety and will be managed through the Training Team.

Documentation of training certification received by attendance at any training course including externally provided training courses will be kept by the employee with copies provided to the Training Team.

7. REFERENCES

ARCADIS Health and Safety Standard ARC HSFS010– Health and Safety Planning

ARCADIS Health and Safety Standard ARC HSFS004 – Control of Hazardous Energy (Lockout/Tagout)

ARCADIS Utility Clearance Policy and Standard ARC HSF019

OSHA 29 CFR Part 1926 Subpart P - Excavations

8. RECORDS

8.1 Training records will be kept by the individual employee with copies of such certificates kept by the Training Team. Training dates and times will be kept by the Training Team.

8.2 Completed clearance forms and checklists will be kept in the project files with copies available for Corporate H&S review.

8.3 Copies of all HASPs that document excavation trenching procedures will be kept in the project files.

9. APPROVALS AND HISTORY OF CHANGE

Approved By: Anthony Tremblay, CSP, CIAQP

History of Change

Revision Date	Revision Number	Standard Developed/Reviewed By or Revised By	Reason for change
12 May 2008	01	Greg Ertel	Original document
13 June 2008	02		Modified Section 5.1 – 4th bullet related to structural ramps. Modified Section 5.2 to designate a 6x factor for structural integrity of structures near the excavation. Revised Exhibit 1 to modify the definition of a Competent person
9 January 2009	03		Cleaned up definitions, deleted training requirements from Section 5.0 and moved them to Section 6.0, modified purpose statement
31 March 2011	04		Updated Competent Person training and qualification requirements in section 4.6, section 6.2 and definition in Exhibit 1.
27 March 2012	05	Tremblay	Section 4 competent person, SSO and employee responsibilities revised; Confined Space references eliminated; Training requirements clarified; use of ladders detailed; Fall prevention requirements clarified in section 5.1; depth of protective system requirement corrected to 5 feet; spoils pile must be minimum 2 feet from edge of excavation; Atmospheric Monitoring Action Levels revised; Employee Awareness Training and Competent Person Training requirements clarified

Revision Date	Revision Number	Standard Developed/Reviewed By or Revised By	Reason for change
4 June 2012	06	Tremblay	Section 4.4 typo corrected; 8-hour HAZWOPER Supervisor course for competent person was made a recommended practice instead of a requirement; Section 4.5 SSO responsibilities revised to eliminate those responsibilities that belong with the Competent Person; Section 5 Best Management Guidance to maintain safe distance from the edge of excavation; checklists hyperlinked
18 September 2013	07	Tremblay	Tracking table format updated; Section 5.1 revised to include information about encountering unanticipated contaminants, implementing dust control measures, instituting containment measures when breeching a containment berm and avoiding excavating in archeological sites
26 September 2013	08	Tremblay	Section 5.7.2.7 Maximum Allowable Slope Table had a typo in Type C soil line H:V ratio (corrected the ratio to read 1 ½ : 1). The value of 34 degrees is correct; Header format update and pages renumbered

Exhibit 1 – Definitions

Attendant is a trained qualified individual stationed outside the excavation whose duty is to monitor authorized entrants inside the excavation or trench and have a means of communication with the designated rescue services.

Benching/Benching system means a method of protecting employees from cave-ins by excavating the sides of an excavation to form one or a series of horizontal levels or steps, usually with vertical or near-vertical surfaces between levels.

Cave-in means the separation of a mass of soil or rock material from the side of an excavation, or the loss of soil from under a trench shield or support system, and its sudden movement into the excavation, either by falling or sliding, in sufficient quantity so that it could entrap, bury or otherwise injure and immobilize a person.

Cemented soil means a soil in which the particles are held together by a chemical agent, such as calcium carbonate, such that a hand size sample cannot be crushed into powder or individual soil particles by finger pressure.

Cohesive soil means clay (fine grained soil), or soil with a high clay content, which has cohesive strength. Cohesive soil does not crumble, can be excavated with vertical sides, and is plastic when moist. Cohesive soil is hard to break up when dry, and exhibits significant cohesion when submerged. Cohesive soils include clayey silt, sandy clay, silty clay, clay and organic clay.

Competent person means one who, through education, training, and/or experience, is capable of identifying existing and predictable hazards or working conditions which are unsanitary, hazardous, or dangerous to employees and who has authorization to take prompt corrective measures to eliminate them.

Dry soil means soil that does not exhibit visible signs of moisture content.

Excavation means any man-made cut, cavity, trench, or depression in an earth surface formed by earth removal into which a person can bodily enter.

Entry constitutes the act by which an employee proceeds into an excavation or trench. Consideration of hazards, especially cave-ins and fall protection must still be considered and accounted for when equipment or personnel are near an excavation or trench, even if personnel will not be entering.

Entrants are employee's who are trained and authorized to enter a trench or excavation. Entrants must have attended a Qualified Excavation Training course offered or approved by Corporate Health and Safety.

Failure means the breakage, displacement, or permanent deformation of a structural member or connection so as to reduce its structural integrity and its supportive capabilities.

Fissured means a soil material that has a tendency to break along definite planes of fracture with little resistance, or a material that exhibits open cracks, such as tension cracks, in an exposed surface.

Granular soil means gravel, sand, or silt (coarse grained soil) with little or no clay content. Granular soil has no cohesive strength. Some moist granular soils exhibit apparent cohesion. Granular soil cannot be molded when moist and crumbles easily when dry.

Hazardous Atmosphere is an atmosphere which exposes employees to a risk of death, incapacitation, injury, or acute illness from one or more of the following:

- An atmospheric concentration of any substance in excess of 50% of its established permissible exposure limit (PEL); or its assigned threshold limit value (TLV) or other value listed on the Material Safety Data Sheet (MSDS) for the chemical constituent, whichever is lower.
- A flammable gas, vapor, or mist in excess of 10% of its lower explosive limit (LEL).
- An airborne combustible dust at a concentration that obscures vision at a distance of 5 feet or less.
- An atmospheric oxygen concentration below 19.5% (oxygen-deficient atmosphere) or above 23.5% (oxygen-enriched atmosphere).
- An atmosphere which is immediately dangerous to life and health.

Immediately Danger to Life and Health (IDLH) means any condition which poses an immediate threat to loss of life; may result in irreversible or immediate-severe health effects; may result in eye damage, irritation, or other conditions which could impair escape from the space.

Layered system means two or more distinctly different soil or rock types arranged in layers. Micaceous seams or weakened planes in rock or shale are considered layered.

Moist soil means a condition in which a soil looks and feels damp. Moist cohesive soil can easily be shaped into a ball and rolled into small diameter threads before crumbling. Moist granular soil that contains some cohesive material will exhibit signs of cohesion between particles.

Plastic means a property of a soil which allows the soil to be deformed or molded without cracking, or appreciable volume change.

Protective system means a method of protecting employees from cave-ins, from material that could fall or roll from an excavation face or into an excavation, or from the collapse of adjacent structures. Protective systems include support systems, sloping and benching systems, shield systems and other systems that provide protection.

Ramp means an inclined walking or working surface that is used to gain access to one point from another, and is constructed from earth or from structural materials such as steel or wood.

Registered Professional Engineer means a person who is registered as a professional engineer in the state where the work is to be performed. However, a professional engineer, registered in any state is deemed to be a "registered professional engineer" within the meaning of this standard when approving designs for "manufactured protective systems" or "tabulated data" to be used in interstate commerce. To oversee an excavation/trench activity the PE must have experience with and expertise in excavation, soil and stability considerations.

Saturated soil means a soil in which the voids are filled with water. Saturation does not require flow. Saturation, or near saturation, is necessary for the proper use of instruments such as a pocket penetrometer or sheer vane.

Sheeting means the members of a shoring system that retain the earth in position and in turn are supported by other members of the shoring system.

Shield (Shield system) means a structure that is able to withstand the forces imposed on it by a cave-in and thereby protect employees within the structure. Shields can be permanent structures or can be designed to be portable and moved along as work progresses. Additionally, shield can be either pre-manufactured or job-built in accordance with 1926.652 (c)(3) or (c)(4). Shields used in trenches are usually referred to as "trench boxes" or "trench shields".

Shoring (Shoring system) means a structure such as a metal hydraulic, mechanical or timber shoring system that supports the sides of an excavation and which is designed to prevent cave-ins.

Sloping (Sloping system) means a method of protecting employees from cave-ins by excavating to form sides of an excavation that are inclined away from the excavation so as to prevent cave-ins. The angle of incline required to prevent a cave-in varies with differences in such factors as the soil type, environmental conditions of exposure, and application of surcharge loads.

Soil classification system means, for the purpose of this procedure, a method of categorizing soil and rock deposits in a hierarchy of Stable Rock, Type A, Type B and Type C, in decreasing order of stability. The categories are determined based on an analysis of the properties and performance characteristics of the deposits and the characteristics of the deposits and the environmental conditions of exposure.

Stable rock means natural solid mineral material that can be excavated with vertical sides and will remain intact while exposed. Unstable rock is considered to be stable when the rock material on the side or sides of the excavation is secured against caving-in or movement by rock bolts or by another protective system that has been designed by a registered professional engineer.

Submerged soil means soil which is underwater or is free seeping.

Support system means a structure such as underpinning, bracing, or shoring, which provides support to an adjacent structure, underground installation, or the sides of an excavation.

Trench means a narrow excavation (in relation to its length) made below the surface of the ground to which a person can bodily enter. In general, the depth is greater than the width, but the width of a trench (measured at the bottom) is not greater than 15 feet (4.6 meters). If forms or other structures are installed or constructed in an excavation so as to reduce the dimension measured from the forms or structure to the side of the excavation to 15 feet (4.6 meters) or less (measured at the bottom of the excavation), the excavation is considered to be a trench.

Unconfined compressive strength means the load per unit area at which a soil will fail in compression. It can be determined by laboratory testing, or estimated in the field using a pocket penetrometer, by thumb penetration tests, and other methods.

Wet soil means soil that contains significantly more moisture than moist soil, but in such a range of values that cohesive material will slump or begin to flow when vibrated. Granular material that would exhibit cohesive properties when moist will lose those cohesive properties when wet.

Exhibit 2 – Daily / Periodic Excavation Inspection Checklist

Daily / Periodic Excavation Inspection Checklist

ARCADIS Infrastructure · Water · Environment · Buildings	Daily / Periodic Excavation Inspection Checklist
Project Name:	**Date / Time:**
Project Number:	**Location:**
Prepared By:	**Project Manager:**

This checklist must be completed for all excavations. It documents that daily and post-event / periodic inspections are conducted.

Soil Classified As:	☐ Stable Rock	☐ Type A	☐ Type B	☐ Type C
Soil Classified On:		By:		

Type of Protective System in Use	☐ Sloping	☐ Shoring	☐ Shielding	☐ Benching	☐ Other
Description:					

Inspection Item	YES	NO	N/A	Comments
Has the ARCADIS Utility Clearance Procedure been completed?	☐	☐	☐	
Are underground installations protected from damage?	☐	☐	☐	
Has a Competent Person been identified?	☐	☐	☐	
Are adequate means of entry / exit available in the excavation – at least every 25 feet?	☐	☐	☐	
If exposed to traffic, are personnel wearing reflective vests and adequate barriers/traffic controls installed?	☐	☐	☐	
Do barriers exist to prevent equipment from rolling into the excavation?	☐	☐	☐	
Was air monitoring conducted prior to and during excavation entry?	☐	☐	☐	
Was the stability of adjacent structures reviewed by a registered P.E.?	☐	☐	☐	
Are spoil piles at least 2 feet from the excavation edge?	☐	☐	☐	
Is the excavation(s) readily visible ? If no, employees must be protected from falling by guardrail systems, fences, or barricades?	☐	☐	☐	
If the well, pit, shaft, or similar excavation is 6 feet (1.8m) or more in depth, are employees protected from falling by guardrail systems, fences, barricades?	☐	☐	☐	
Are work tasks completed remotely if feasible?	☐	☐	☐	
Is a protective system in place and in good repair?	☐	☐	☐	
Is excavation isolated from the effects of vibration?	☐	☐	☐	
Are employees protected from falling / elevated material?	☐	☐	☐	
Is soil classification adequate for current environmental / weather conditions?	☐	☐	☐	
Do portable ladders extend at least 3feet above the excavation?	☐	☐	☐	
Are portable ladders or ramps secured in place?	☐	☐	☐	
Have all personnel attended safety meeting on excavation hazards?	☐	☐	☐	
Are support systems for adjacent structures in place?	☐	☐	☐	
Is the excavation free from standing water?	☐	☐	☐	
Is water control and diversion of surface runoff adequate?	☐	☐	☐	
Are employees wearing required protective equipment?	☐	☐	☐	
Excavation Competent Person:				**Date/Time:**

Exhibit 3 – Competent Person Evaluation Form for Excavation / Trenching

Exhibit 3 – Competent Person Evaluation Form for Excavation / Trenching

Name of Employee:________________________________Job Title:________________________

Department: _____________________________________Office Location: __________________

Experience with Excavations/ Trenching:

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Relevant Training:

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Other Relevant Qualifications:

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*Include documentation from employee's Supervisor that acknowledges their capacity to work as a designated competent person.

Based on the information listed above and an evaluation of this employee's knowledge and experience, I consider them to be a Competent Person for Excavation and Trenching.

Evaluation By: ________________________________ Job Title: __________________________

Signature: ______________________________________ Date: ___________________________

ARCADIS

Appendix **B**

Unanticipated Discovery Plan

1. INTRODUCTION

Remedial excavation activities are planned by ARCADIS at the Former Olympia Bulk Plant located at 11720 Unoco Road in Edmonds, WA. Hydrocarbon impacts will be remediated through soil excavation. The following is an Unanticipated Discovery Plan (UDP) that outlines procedures to follow in the event archaeological materials or historical resources are identified during project activities. If archaeological materials or historical resources such as human remains are discovered, ARCADIS will follow procedures in accordance with state and federal laws.

2. RECOGNIZING CULTURAL RESOURCES

Examples of a cultural resource discovery, either prehistoric or historic, include the following:

- An accumulation of shell, burned rocks, or other food-related materials
- Bones or small pieces of bone
- An area of charcoal or very dark stained soil with artifacts
- Stone tools or waste flakes (i.e. an arrowhead, or stone chips)
- Clusters of tin cans or bottles, logging or agricultural equipment that appears to be older than 50 years
- Buried railroad tracks, decking, or industrial materials

When in doubt, ARCADIS will assume material discovered is a cultural resource.

3. ON-SITE RESPONSIBILITY

3.1 Stop Work

At any point during project activities, work will be immediately stopped if any ARCADIS employee, contractor or subcontractor believes that a cultural resource has been uncovered. All work in the area of the discovery will stop and the location will be secured until a proper examination can be conducted.

3.2 Notify ARCADIS PM

The ARCADIS project manager will be notified immediately so that he or she can make all necessary calls and notifications. If human remains are found, they will be covered with a tarp or other materials that will not damage or alter the remains. They will be treated with respect and dignity at all times. Remains will be shielded from being photographed and media will not be alerted or spoken to. 911 will not be called.

The project manager contact information is as follows:

PM Name: Prajakta Ghatpande
Office Phone: 206-726-4762
Mobile: 206-579-7498
Email: Praj.Ghatpande@arcadis-us.com

4. PROJECT MANAGER RESPONSIBILITIES

4.1 Protect the Find

It is the responsibility of the ARCADIS project manager to take appropriate steps to protect the discovery site. In order to provide total security, protection and the integrity of the remains, all work in the discovery area will stop. Unauthorized personnel, vehicles and equipment will not be permitted to traverse the discovery site.

4.2 Direct Construction Activities Elsewhere On Site

The ARCADIS project manager will direct construction activities away from the discovery area prior to contacting concerned parties.

4.3 Coordinate Identification of the Find

The ARCADIS project manager will coordinate examination of the find by a qualified, professional archaeologist to determine whether or not the find is archaeological.

If it is determined that findings are not archaeological, work may proceed with no further delay.

If it is determined that the findings are archaeological, the ARCADIS project manager will continue with the notification of concerned parties.

If the find may be human remains or funerary objects, the ARCADIS project manager will ensure a qualified physical anthropologist conducts an examination. Special procedures detailed in Section 5 of this report will be performed if the remains are determined to be human.

4.4 Notification of Concerned Parties

The ARCADIS project manager will contact the Squaxin Island Tribe if applicable, as well as involved federal agencies (if any).

Squaxin Island Tribe:
Contact Name: Rhonda Foster, CR Director, THPO
Address: SE10 Squaxin Lane, Shelton, WA 98584
Phone Number: 360-432-3850

4.5 Further Activities

Archaeological discoveries will be documented as described in Section 6. Refer to Section 7 prior to continuing construction activities.

5. SPECIAL PROCEDURES FOR THE DISCOVERY OF HUMAN SKELETAL MATERIAL

Regardless of antiquity or ethnic origin, any human skeletal remains will be treated with dignity and respect at all times. ARCADIS staff will comply with applicable state and federal laws. The procedures below will be followed:

5.1 Notify Law Enforcement Agency or Coroner's Office

The project manager will immediately notify the local law enforcement agency or coroner's office in addition to taking action described in Sections 3 and 4.

The coroner, along with law enforcement personnel assistance, will determine if the remains are human and whether the discovery constitutes a crime scene, and will notify DAHP.

Agency: City of Olympia Police Department
Phone: 360-753-8300

5.2 Participate in Consultation

Revised Code of Washington (RCW) 27.53.030, RCW 68.50 states that DAHP will have jurisdiction over non-forensic human remains. ARCADIS staff will participate in consultation.

5.3 Further Activities

Through the consultation process described in RCW 27.53.030, RCW 68.50, and RCW 68.60, documentation of human skeletal remains and funerary objects will be agreed upon. Once consultation and documentation are complete, construction in the discovery area may resume as described in Section 7.

6. DOCUMENTATION OF ARCHAEOLOGICAL MATERIALS

All archaeological deposits discovered during construction will be assumed eligible for inclusion in the National Register of Historic Places under Criterion D until formal Determination of Eligibility is made.

Proper documentation and assessment of discovered cultural resources will be documented by archeological specialist in cooperation with federal agencies (if any), DAHP, affected tribes, and a contracted consultant (if any).

A professional archaeologist will record all prehistoric and historic cultural material discovered during project construction on State of Washington cultural resource site or isolate form using standard techniques. Site overviews, features, and artifacts will be photographed and stratigraphic profiles and soil/sediment descriptions will be prepared for subsurface exposures. Discovery locations will be documented on scaled site plans and site location maps.

Processes described in Section 5 will be followed if assessment activity exposes human remains (burials, isolated teeth or bones).

7. PROCEEDING WITH CONSTRUCTION

Project construction outside the discovery location may continue while documentation and assessment of the cultural resources proceed. An archaeological specialist must determine the boundaries of the discovery location. In consultation with DAHP and any affected tribes, the ARCADIS project manager will determine the appropriate level of documentation and treatment of any findings. If federal agencies are involved, the agencies will make the final determinations about treatment and documentation.

Construction may continue at the discovery location only after the process outlined in this plan is followed and ARCADIS and Federal agencies (if any) determine the compliance with state and federal laws.

8. REFERENCES

This plan was created in reference to the Washington State Department of Transportation Discovery Form Template.