Remedial Investigation Work Plan

Boeing Field Chevron
10805 East Marginal Way South
Tukwila, Washington

May 24, 2016
Terracon Project No. B2157002

Prepared for:
Boeing Field Chevron
Tukwila, Washington

Prepared by:
Terracon Consultants, Inc.
Lakewood, Washington

May 24, 2016

Terracon

Boeing Field Chevron
℅ Mr. Kurt Peterson
Cascadia Law Group PLLC
1201 Third Avenue, Suite 320
Seattle, WA 98101

Attn: Mr. Rajbir Sandhu

Re: Agency Review Draft Work Plan for Remedial Investigation
Boeing Field Chevron
10805 East Marginal Way South
Tukwila, Washington
Terracon Project No. B2157002

Dear Mr. Sandhu:

Terracon Consultants, Inc. (Terracon) is pleased to submit our work plan for a proposed Remedial Investigation at the Site referenced above. The work plan outlines a comprehensive effort to further characterize the documented petroleum releases at the Site. The results will be used to prepare a feasibility study to determine the most cost-effective approach to address the identified soil and ground water impacts. Terracon has prepared this document, which is associated with Agreed Order No. DE 10947, at the request of the Washington State Department of Ecology.

Terracon appreciates this opportunity to provide environmental consulting services to Boeing Field Chevron. Should you have any questions or require additional information, please do not hesitate to contact our office.

Sincerely,
Terracon Consultants, Inc.

Elizabeth Rachman, L.G., L.Hg.
Senior Project Manager

Matt Wheaton, E.I.T, L.G.
Principal

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BOEING FIELD CHEVRON
10805 EAST MARGINAL WAY SOUTH
TUKWILA, WASHINGTON

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1.0 INTRODUCTION

Rajbir and Pradeep Sandhu, RPNP Corporation, and Chevron Environmental Management Company (Chevron) are signatories to an Agreed Order (No. DE 10947, effective July 13, 2015) with the Washington State Department of Ecology (Ecology) under the Model Toxics Control Act (MTCA) requiring a ground water monitoring well assessment, a Remedial Investigation (RI), a Feasibility Study (FS), and possibly an interim action for the Boeing Field Chevron site (Site).

This document presents the Work Plan for the RI specified by the Agreed Order. The RI work under the Agreed Order is intended to provide additional data and analysis to assess the potential risks posed by the Site and to facilitate the evaluation and selection of a cleanup remedy. The Site is defined by the extent of contamination caused by the release of petroleum compounds originating at the Boeing Field Chevron (BFC) property, 10805 East Marginal Way South in Tukwila, Washington (see Figures 1 through 3).

Several underground storage tanks (USTs) were removed in the 1990s, during which releases of gasoline to the soil and ground water at the Site were identified and reported to Ecology. Excavation and off-site disposal of at least 2,500 cubic yards of petroleum-contaminated soil (PCS) were performed by Chevron, as was quarterly ground water monitoring for several years. As of 2003, ground water concentrations were reportedly decreasing but were still not in compliance with MTCA.

During a ground water sampling event performed for Chevron in 2003, approximately four feet of light non-aqueous phase liquid (LNAPL, or free product) was encountered in one of the wells (MW-11) that had no previous history of the presence of LNAPL. A piping leak was found at the west pump island. Based on this new release, Chevron ceased all ground water monitoring activities at the Site. PCS was again reportedly excavated and removed from the Site for off-site disposal by the property owner in 2004, and free product removal activities were performed on a number of occasions. However, no documentation pertaining to this excavation can be located at this time. In addition, several subsurface soil and ground water investigations have been performed to characterize the release.

Despite these efforts, impacted soil and ground water, and LNAPL, remain at the subject Site, the extent of which remains largely unknown. Furthermore, there are multiple data gaps regarding subsurface Site geologic conditions, Site hydrogeology, and subsurface utilities that prevent the full understanding of Site contaminant distribution. Previous explorations and remedial excavation locations are depicted on Figure 4, and maps depicting the most recent concentrations at the Site are provided as Figures 5 (soil) and 6 (ground water).

A ground water monitoring well assessment was recently performed at the Site (Terracon 2015), the results of which were used to refine drilling locations proposed herein, verify or resolve data gaps in Site hydrogeology, and determine which monitoring wells may need to be decommissioned. The assessment results indicated that significant ground water impacts remain across the western portion of the Site, although concentrations of contaminants of potential concern (COPCs) differ significantly between samples collected during low and high tidal events for some wells. Ground water migration at the Site may be affected by the numerous excavations and monitoring well installation and abandonment activities that have occurred at the Site since 1990, and by multiple utility corridors both on- and off-Property. In addition, several existing monitoring wells had up to several feet of sediment accumulation within the inferred saturated zones, resulting in significant reductions in the water column thicknesses and poor communication with the surrounding aquifer for these wells. The wells identified with sediment accumulation in 2015 are currently being evaluated to determine whether they should be redeveloped or decommissioned (and re-installed where necessary), and a Site-wide well assessment and maintenance task is included in this Work Plan (Section 4.2.2).

Specifically, the RI will address the data gaps identified to date, which are summarized in Appendix C and discussed in Section 4.1. The RI will define the vertical and horizontal extents of the soil and ground water contamination, which will update the Conceptual Site Model. Ground water characterization will include installation and sampling of additional permanent ground water monitoring wells on the Site, including the Chevron-branded service station property, adjoining right-of-way (ROW) areas, and, if necessary, the properties along the west side of Tukwila International Boulevard. The RI will also help determine whether interim actions are necessary to address the adverse impacts at the Site, particularly within the utility trenches (if any are identified). Specific RI tasks are described in greater detail in Section 4 of this Work Plan.

1.1 Objectives of the RI Work Plan

The overall objectives of the RI Work Plan are:

- Develop a strategy to obtain data of sufficient quality and quantity to describe the physical and chemical properties (including contaminants) of Site soil, ground water, stormwater, vapors, and catch basin solids;

- Develop a preliminary Conceptual Site Model (CSM), including an evaluation of Site hydrogeologic conditions and possible exposure pathways, and prepare a scope of work to collect data of sufficient quality and quantity to update and finalize the CSM; and

- Provide detailed sampling approaches to address data gaps, including currently known data gaps and others that may be identified during the RI, and complete characterization.

1.2 RI Work Plan Organization

This RI Work Plan consists of the following sections:

- Section 2 provides a summary of historical Site uses, previous investigations, Site COPCs, and Site geology and hydrogeology.
- Section 3 summarizes the preliminary Conceptual Site Model (CSM).
- Section 4 provides a summary of data gaps and describes the RI tasks to be completed as part of the RI activities.
- Section 5 describes the project schedule and deliverables.
- Section 6 presents the Sampling and Analysis Plan (SAP) for the RI tasks described in Section 4.
- A list of references is present after Section 6.
- Appendix A provides copies of figures and tables referenced in the RI. Figures include maps showing the Site location, current and historical Site uses, soil and ground water COPCs, and proposed RI sampling locations. A tabulated summary (Table 1) of proposed RI sampling and analyses, including identification of data gaps addressed for each sample location, is also included in Appendix A.
- Appendix B provides a tabulated historical data summary.
- Appendix C provides a summary of Data Gaps for the Site.
- Appendix D provides a Quality Assurance Project Plan (QAPP) for the Site.
- Appendix E provides Standard Operating Procedures (SOPs) for the field tasks to be performed at the Site.
- Appendix F presents utility maps provided by the City of Tukwila.
- Appendix G presents the most recent tank tightness testing results for the existing Boeing Field Chevron USTs.

2.0 BACKGROUND

This section provides a general summary of current and historical Site uses, previous Site investigations, suspected contaminant source areas, and COPCs. Additional information is available in cited references, Site maps (Appendix A), and historical data tables (Appendix B).

2.1 Setting

2.1.1 Location

The BFC property is located at 10805 Tukwila International Boulevard, Tukwila, Washington, approximately 275 feet east of the Duwamish Waterway (see Figures 1 and 2). The property is located in an industrial part of Tukwila and is bound to the west by Tukwila International Boulevard and to the east by East Marginal Way South, which intersect just north of the Site. Adjacent properties include Blue Star Gas to the east, Gene Juarez Distribution Center, Paramount Supply, Custom Gear, Inc., Gourmet Innovations, and Business Interiors Northwest to the southeast, Mighty-O donuts and The Trust Center to the south, and Roto-Rooter and Seattle Mitsubishi Fuso, truck sales, parts, and service to the west.

The BFC property comprises one tax parcel (King County tax parcel number 0323049064) totaling approximately 0.61 acre of land. According to the King County online iMap website, the full legal description for the BFC property is:

PORTION OF GOV LOT 10 IN SE 1/4 OF SECTION 04-23-04 & OF THE W 1/2 OF SW 1/4 OF SECTION 03-23-04 LY BETWEEN WLY MARGIN OF E MARGINAL WAY & ELY MARGIN OF PACIFIC HIGHWAY SOUTH - BAAP ON WLY MARGIN OF E MARGINAL WAY, BEING N 17-20-00 W 1155.44 FT MEASURED ALONG SAID MARGIN, FROM SOUTH LINE OF SECTION 3 TH S 84-43-30 W 30.68 FT TO POINT OF BEGINNING TH N 17-20-00 W 243.58 FT TH N 82-24-36 W 31 FT TH S 18-27-00 W 267.74 FT TH N 84-43-30 E 188.83 FT TO POB LESS PORTION FOR ROAD UNDER WARRANTY DEED RECORDING NO 9604180862.

As indicated in Section 1, the Site includes the BFC property and any off-property locations (including public ROWs and other private properties) affected by the releases of petroleum products that have occurred on the property. For purposes of this Work Plan, 'Site' refers to the entire area affected by releases, and 'BFC property' refers specifically to the current Chevron-branded service station property (i.e., tax parcel 0323049064).

2.1.2 Surface Features

The portion of the Site located on the BFC property includes a retail gasoline and diesel station, convenience store, and car wash. The 3,255-square-foot convenience store and the 1,049-square-foot car wash were constructed in 1996. The existing gasoline and diesel USTs were installed in 1996. The convenience store is located on the southern portion of the BFC property, the car wash is located on the northeastern portion of the property, and the pump islands are located on the central portion of the property (Figures 2 and 3, Appendix A). Two access driveways to the service station are located along Tukwila International Boulevard and one access driveway to the service station is located along East Marginal Way South.

Most of the Site is covered with pavement and the structures listed above. However, minor landscaping is present in perimeter areas along the eastern, northern and western BFC property boundaries, the median and western margin of the Tukwila International Boulevard right-of-way, and a small island south of the intersection of Tukwila International Boulevard and East Marginal Way. In addition, an off-property bioswale area adjoins the car wash building to the east. The bioswale may collect stormwater runoff from portions of the Site, including those located on the BFC property, and appears to have an overflow discharge to the municipal storm sewer within the East Marginal Way South right-of-way. Stormwater connections, including subsurface pipes and direct surface runoff, to the bioswale represent a data gap and will be evaluated as part of the RI utility survey (Section 4.2.1).

Currently there are three operational USTs at the Site, including one single-compartment 15,000-gallon unleaded gasoline UST, one single-compartment 10,000-gallon unleaded gasoline UST, and one double-compartment 15,000-gallon UST divided into 7,500 gallons unleaded gasoline and 7,500 gallons diesel fuel. The most recent tank tightness testing event for the existing USTs was performed on November 16, 2015. The system was pressurized to 2 inches Water Column (WC) and found to hold tight to the passing standard of 1.92 inches WC. The most recent tank tightness test results are included in Appendix G.

One aboveground storage tank (AST) containing propane is located on the southwest corner of the BFC property. Several USTs were removed from the Site in the 1990s. Locations of current and former USTs and UST removal activities are discussed below in Section 2.2.

The City of Tukwila provided utility maps for the property and adjoining rights-of-way; however, field verification has revealed some inconsistencies between the plans and the actual construction of the on-property system. According to the plans, two separate stormwater drainage systems, with separate discharge points, appear to be present on the Site and were installed in 1996. Six stormwater catch basins appear to be present, including one south of the canopy, one at either end of the canopy, one on the southeast corner of the Site, one north of the car wash, and one between the car wash and the fuel USTs. The catch basins on either end of the canopy appear to convey stormwater to municipal utilities in the Tukwila International Boulevard ROW. The remaining catch basins appear to convey stormwater to an oil-water separator on the east-central portion of the Site, which then discharges to municipal utilities within the East Marginal Way South ROW. Verification of the construction and integrity of the stormwater drainage systems on the Site, including the relationship, if any, to the bioswale area and car wash facilities, will be performed during the RI, as discussed in Section 4.2.1. The results of the utility survey will be used to refine exploration and sampling locations, if necessary, and will be provided in the RI Report. The results of the utility survey, and any proposed modifications to the proposed sampling plan, will be submitted to Ecology for review and approval prior to initiating RI drilling activities at the Site.

Table A-1: Summary of Site Structures

Parcel	Structure	Currently Used?	When Constructed	Notes
323049064	Retail gasoline station	Yes	1996	Located on the central portion of the Site.
323049064	Convenience store	Yes	1996	Located on the southern portion of the Site.
323049064	Carwash	Yes	1996	Located on the eastern portion of the Site.

2.1.3 Geology

As indicated above, a primary objective of this RI is to collect sufficient data to characterize Site geologic and hydrogeologic conditions. For this investigation, borings will be advanced to at least 35 feet bgs and soil will be logged continuously (see Section 6.1) to facilitate characterization of subsurface conditions.

The Site is located in the Duwamish River Valley. Geologic conditions at the Site were initially characterized during previous investigations and remedial actions, but the historical findings do not provide enough information to fully characterize Site geology and update the CSM. Boring logs and descriptions of Site geology from previous investigations (ERI, 2004a, 2004b, 2005a, 2005c; G-Logics, 2008c; Hart Crowser, 1993b, 1993c; PEG, 1997b; RZA, 1990b) provide a good generalized overview of lithologic units beneath the Site (discussed below); however, soil logging intervals and boring depths do not necessarily represent the complete soil sequence. The above-referenced reports provide boring logs for approximately 55 borings advanced at the Site, but most were logged at approximately 5-foot intervals rather than continuously (leaving gaps of up to 4 feet between logged intervals). In addition, borings have not been advanced beyond 25 feet bgs at the Site, and additional data is needed to characterize conditions below this depth.

Based on the boring logs and other information provided in previous investigation reports referenced above, three generalized lithologic units have been described at the Site, as summarized below from top to bottom:

- Fill materials placed above the original, pre-development surface. This includes, but is not necessarily limited to, fill installed prior to (or during) initial development of the Site, backfill associated with environmental excavations, bedding and backfill in and around utility lines and USTs, and backfill associated with Site buildings and facilities. Fill materials described for the Site typically include a mixture of sand, silt, and gravel (including cobbles), and locally include anthropogenic materials (brick, concrete). Based on a review of previous studies, the typical depth range for the fill material at the Site is not clear but may range from 3 to 14 feet bgs (or greater) based on the reported depths of the utilities and remedial excavations.

- Fine-grained soils including silty clay, sandy silt, silty sand, interbedded sand and silt, and organic materials (typically described in boring logs as peat), most likely represent the native materials present prior to development. The top of the finer-grained sequence is typically encountered below fill materials between 10 and 13 feet bgs, although the upper portion has likely been removed from previous excavations (for impacted soil removal and construction of Site facilities such as the car wash and current USTs).

  The specific texture varies across the Site, but overall, a sequence of finer-grained materials was identified in most of the borings advanced throughout the Site beneath the fill materials. In general, clay, silty clay, and clayey silt are described for the western portion of the Site (including the western margin of the BFC property), interbedded silty sand and sandy silt are described for the northern portion (on the BFC property), and silty fine sand in the southeastern portion (on the BFC property). Boring logs for borings located in the southeastern portion of the BFC property typically do not describe any silt or sandy silt deposits (primarily silty sand), but this could be an artifact of the 5-foot soil logging intervals.

- Lower sand unit beneath the fine-grained materials. This top of the lower sand unit is typically encountered at approximately 18-20 feet bgs, but is shallower at some locations [approximately 12.5 feet bgs in the southwest corner of the BFC property (MW-8), and 15 feet bgs west of Tukwila International Blvd (MW-19 and -20)]. The sand unit extends at least to the previously investigated maximum depth of 25 feet bgs. The unit is typically described as poorly graded sand or poorly graded sand with silt. The contact between the lower sand unit and the overlying silty interval varies from sharp to gradational over several feet, as depicted on previous boring logs for the Site.

The geologic units described for the Site are consistent with the surficial geology mapped on a 2005 geologic map of Seattle (Troost, et al., 2005). The Site is mapped as Quaternary alluvium (Qal) on the 2015 geologic map and is generally described as sand, silt, gravel, and cobbles deposited by streams and running water, locally containing soft peat lenses. The 2015 geologic map indicates that the Qal unit is subdivided locally into units described as younger alluvium (Qyal), lake deposits (Ql), fan deposits (Qf), and terrace deposits (Qt). Based on the information provided in historical reports, Site soils appear to be most consistent with the general Qal unit and Qyal and Ql subunits. The 2015 geologic map describes Qal and Qyal deposits as primarily sand and horizontally bedded, with fine- and coarser-grained lenses; and Ql as predominantly fine grained and horizontally bedded including silt and clay with local sand layers, peat, and other organic sediments. Other surficial units mapped in the general vicinity of the Site (Troost, et al., 2005) include: The Tertiary Tukwila Formation (Tpt) generally described as sandstone, tuff, mudflow breccia, and minor lava flows or sills; and Quaternary peat (Qp) deposits described as predominantly organic matter consisting of plant material and woody debris, commonly interbedded with silt and clay, and gradational with Qal and Ql units. Peat lenses have been identified at the Site.

Preliminary cross sections have been included as Figures 9 and 10, and the cross-section locations are shown on Figures 3 and 4.

2.1.4 Hydrogeology

Previous studies have suggested that two separate water-bearing saturated zones underlie the Site, including a shallow, discontinuous perched zone at approximately 9 to 10 feet bgs and a deeper, semi-confined aquifer at approximately 15 to 18 feet bgs (RZA 1990b; Hart Crowser 1993c; G-Logics 2008c). The shallow saturated zone occurs within the fill materials described above and possibly in the upper portion of the silty interval. The deeper saturated zone appears to occur within the lower sand unit, and possibly the lower portion of the silty interval. The two saturated zones are suspected to be interconnected, but the specific nature and degree of any connection and interaction between the saturated zones has not been fully characterized.

Shallow ground water measurements at the Site have ranged from approximately 9 to 15 feet bgs at high tide to 9 to 18 feet bgs during low tide (G-Logics, 2008). Ground water flow directions and gradients vary locally beneath the Site, but, in general, ground water flows to the east during flood tide, and to the west during ebb tide. Historical data shows inconsistencies in tidal effects, depth to water, ground water flow direction and ground water gradient across the Site. Shallow ground water elevations in some locations fluctuate with the tide, where depth to water measurements can vary by as much as 7 feet (Terracon, 2015). In other areas, a correlation was not definitively identified between tidal cycles and depth to water; in fact, at some locations the depth to water was slightly higher at low tide.

The cause of these inconsistencies has not been determined, but may be related to well construction (i.e., screen intervals), extensive historical reworking (i.e., excavations and backfilling) of the Site subsurface, utility corridors, natural fluctuations, or other causes. Many of the wells at the Site may be screened across both units, making it difficult to understand the nature and degree of inter-connection between the two saturated zones. It is currently suspected that the upper, perched zone is not tidally influenced, but the lower, semi-confined aquifer is affected by tidal cycles. The well assessment to be performed during the RI (Section 4.2.2) will include further assessment of the suitability of the existing well screen intervals for hydrogeologic characterization, and all wells that are confirmed to be screened across multiple saturated intervals will be appropriately abandoned.

Hydrogeologic conditions at the Site appear to be generally consistent with regional conditions. Perched saturated zones are encountered within shallow fill materials throughout the Duwamish Valley. In some areas, these fill materials are greater than 20 feet in thickness. The perched aquifer at the Site appears to occur primarily within fill materials. The semi-confined aquifer at the Site may also occur, in part, within shallow fill materials and within the underlying younger alluvial deposits (such as Qal as described above). The deeper alluvial aquifer generally occurs to depths of about 100 feet in the Site vicinity, but tapers to depths of about 30 to 40 feet near the margins of the valley and near those areas where bedrock rises above ground surface (such as the Tukwila Formation described above). Where the alluvial aquifer is the thickest, "upper" and "lower" ground water zones are often differentiated on a site-specific basis, based on locally continuous silt aquitards, the occurrence of upward gradients at depth, and/or the occurrence of saline ground water pockets (Booth and Herman, 1998).

2.2 Site History

The following discussion of Site history is limited to information provided in previous subsurface investigation, remedial action, and ground water monitoring reports. Based on a review of this information, a service station appears to have been in operation on the Site from at least 1940 until the 1980s. The former structures were removed from the Site in the 1980s, but the associated USTs remained onsite until the 1990s. Automotive service operations ceased at the Site in the 1980s, and two associated waste oil USTs were removed from the Site in the 1990s, as discussed in Section 2.2.2.1.

The current Chevron-branded service station was constructed in 1996. Automotive service operations or waste oil USTs are not, nor have they reportedly been, identified in association with the current service station.

2.2.1 Land Ownership, Use, and Prior Operations

The Site was leased and operated by Standard Oil and Chevron from at least 1968 to 1982. The current owner, Mr. Rajbir Sandhu, purchased the property in 1995. According to King County Department of Assessments online records (iMap). Property owners in the mid-1990s (prior to Mr. Sandhu) included Philip W. Usher, Jessie May Zielsdorf, Susan M. Usher, and the City of Tukwila. No further ownership information was reported in the documents reviewed.

2.2.2 Previous Investigations and Remedial Actions

Previous investigation and remedial activities performed at the Site are summarized below. A preliminary Conceptual Site Model based on these investigations is presented in Section 3. Historical analytical data are included in the data tables provided for reference in Appendix B.

2.2.2.1 Site Soils and Ground Water

Several investigations and cleanup actions have been conducted at the Site to address releases from USTs associated with prior and current Site operations and to identify and assess historical release areas and potential source areas. Please refer to Figure 3 for the locations of former USTs, investigation areas, and remediation areas. Investigation activities are summarized below.

- 1990 – Three USTs were removed, including a 2,500- to 5,000-gallon gasoline UST, a 1,000-gallon UST and a 2,000-gallon UST. At the time of discovery, the latter two USTs were filled with water. Releases of gasoline to soil and ground water were identified at the Site and reported to Ecology (RZA, 1990a; RZA, 1990b).

- 1992 – Two additional 550-gallon USTs (one containing waste oil and one containing diesel fuel) were removed from the Site. Although adversely-affected soils were encountered, the impacts were attributed to the previously-identified release (Hart Crowser, 1992; Hart Crowser, 1993a).

- 1997 – An additional 280-gallon UST was removed, which was presumed to contain heating or waste oil, and a second release of gasoline to soil was identified at the Site and reported to Ecology (PEG, 1997a).

- 1990 to 2003 – Excavation and off-Site disposal of PCS were performed, along with quarterly ground water monitoring (RZA, 1990a; RZA, 1990b; Hart Crowser, 1990; Hart Crowser 1992; Hart Crowser, 1993a; Hart Crowser, 1993b; Hart Crowser, 1993c; PEG, 1997a; PEG, 1997b; Gettler-Ryan, 2003).

- 2003 to the present – Approximately four feet of LNAPL (free product) was encountered in 2003 in one of the on-Site wells (MW-11) during a ground water sampling event. A piping leak was found at the west pump island. PCS was reportedly excavated and removed from the Site and free product removal activities were performed on a number of occasions. In addition, Fenton's Reagent was injected on six occasions in 2006 and 2007 with only a minor reduction in the amount of LNAPL at the Site. Free product has most recently been identified only in well IP-7, at a thickness of 0.05 feet. Several subsurface soil and ground water investigations have been performed to characterize the release. These investigations have shown that the soil and ground water on the western portion of the property remains impacted with gasoline-range TPH and associated fuel components from the historical releases, the extent of which has not been fully defined (Gettler-Ryan, 2003; ERI, 2004a; ERI, 2004b; ERI, 2005a; ERI, 2005b; ERI, 2005c; G-Logics, 2006a; G-Logics, 2006b; G-Logics, 2008a; G-Logics, 2008b; G-Logics, 2008c; G-Logics, 2012).

- A recent ground water assessment was performed by Terracon in July 2015. The assessment involved two sampling events, one each during the high and low tide cycles. The assessment is further detailed under separate cover (Terracon 2015). Some of the monitoring wells had several feet of sediment in them, which may have affected the degree to which they were in communication with the aquifer beneath the site. Correlations were not identified between tidal events and water levels in some of the wells, or in COPC concentrations. LNAPL was identified in only one well (IP-7); however, a couple of the nearby wells (EW-7 and EW-9) were found to contain previously-unretrieved sorbent socks that had fallen into the wells. Although these socks were retrieved during the recent assessment, their presence likely prevented accurate assessment of Site conditions and may have prevented LNAPL from entering those well casings at the time of sampling. In addition, the depth to the water and LNAPL interfaces in IP-7 were above the screened interval during both high and low tides, which may have prevented accurate measurement of the thickness of the LNAPL within the well casing.

- The 2015 ground water assessment did not identify adversely-affected ground water (i.e., no COPCs were detected at concentrations above MTCA Method A cleanup levels) in the four wells located on the west-adjoining property (MW-18, MW-19, MW-20 and MW-21), which appeared to be in good communication with the underlying aquifer(s). Additional evaluation of the off-Property wells (Section 4.2.2) and ground water monitoring (Section 4.2.4) is included in the RI to further evaluate the potential migration of COPCs toward the LDW, including installation of new wells if warranted.

2.3 Potential Source Areas and Contaminants of Potential Concern

Figures 5 and 6 (Appendix A) illustrate the distributions of petroleum hydrocarbons and various volatile organic compounds throughout the Site. These figures depict prior sampling locations and analytical results from past investigations where contaminants of interest were detected, and, for illustrative purposes, show the MTCA Method A cleanup levels for soils and/or ground water) for these COPCs. Final Site-specific cleanup levels will be established later in the cleanup process.

Table A-3 below summarizes the potential source areas and their COPCs, based on past sampling results as well as historical Site operations. COPCs have been identified as 1) chemicals reported at concentrations exceeding MTCA Method A cleanup criteria during prior investigations or remediation activities, and 2) chemicals which may be associated with prior Site operations.

Table A-3: Summary of Potential Source Areas

Potential Source Area	Rationale	Contaminants of Potential Concern
Areas southwest to north of the middle dispenser of the existing western pump island	Previously-identified release to soil and ground water (2003)	DRO, GRO, BTEX, MTBE, naphthalenes, n-hexane
Location of former 280-gallon presumed heating or used oil UST on the north-central portion of the Site	Previously-identified release to soil and potentially ground water (1997)	DRO, GRO, HO, BTEX, MTBE, EDC, EDB, naphthalenes, n-hexane, cPAHs, total and dissolved lead
Location of former 550-gallon diesel UST (east-central portion of Site, along eastern property boundary) and 550-gallon waste oil UST (north central portion of Site)	Previously-identified release to soil and potentially ground water (1992)	DRO, GRO, HO, BTEX, MTBE, EDC, EDB, naphthalenes, n-hexane, cPAHs, total and dissolved lead
Location of former fueling USTs on northern portion of property	Previously-identified release to soil and potentially ground water (1990)	DRO, GRO, BTEX, MTBE, EDC, EDB, naphthalenes, n-hexane, total and dissolved lead

DRO = Diesel-range organic hydrocarbon
GRO = Gasoline-range organic hydrocarbon
HO = Heavy-oil range hydrocarbon
BTEX = Benzene, toluene, ethylbenzene, and total xylenes
cPAHs = Carcinogenic polycyclic aromatic hydrocarbons
MTBE = Methyl tertiary butyl ether
EDC = 1,2-dichloroethane
EDB = 1,2-dibromoethane

3.0 PRELIMINARY CONCEPTUAL SITE MODEL

This section of the RI Work Plan synthesizes the data collected during the previous investigations into a preliminary Conceptual Site Model of preliminary COPC occurrence, movement, and potential exposures. A block diagram depicting the preliminary Conceptual Site Model is provided in Figure 7.

The following environmental media have, or may have, become contaminated and may pose a threat to human health and/or the environment:

- Surface soil
- Subsurface soil
- Soil vapor including indoor and ambient air
- Ground water
- Surface water, including possible impacts to LDW surface water and sediments
- Stormwater, including possible contaminant transport to the LDW
- Catch basin solids, including possible contaminant transport to the LDW

Potential exposure pathways associated with these media are discussed below. The potential contaminant sources areas and COPCs are discussed in Section 2.

3.1 Fate and Transport of Contaminants

This section provides narrative of potential transport mechanisms for COPCs at the Site. Collection of additional data to support evaluation of the Site transport and exposure model is included in the ground water monitoring being performed for the RI (Sections 4.2.4 and 4.2.5).

Multiple releases were identified at the pump islands and the former USTs (potential source areas). The contaminants would initially have been located in subsurface soils (including conveyance piping and/or USTs and associated bedding materials) and/or ground water (subsurface releases within the upper saturated zone).

The majority of the Site is covered with buildings and/or pavement. The stormwater falling onto paved portions of the Site is directed via sheet flow into storm drains and/or catch basins, which convey the stormwater to the municipal sewer system; however, the construction details of the stormwater system and its possible interaction with car wash facilities and the drainage swale will be evaluated during the RI (see Section 4.2.1). Stormwater falling onto unpaved areas of the Site (e.g., perimeter landscaping or the east-adjoining bioswale) infiltrates into the subsurface. Contaminants present in surface soils and subsurface soils can dissolve in the rainwater and migrate through the subsurface soils (leaching). Some of the contaminant mass typically remains in the subsurface soils and some of the contaminant mass reaches shallow ground water. Since 1996, pavement over portions of the Site has minimized rainwater infiltration across those paved portions of the property, reducing the potential for leaching of contaminants from soil to ground water. Ground water levels at the Site fluctuate based on seasonal variations in rainfall amounts (and in some areas of the Site are tidally influenced), and contaminants may move between subsurface soils and ground water as the water levels rise and fall.

The COPCs at or below the ground water table exist primarily in four phases: a separate phase (LNAPL), a vapor phase, a dissolved phase, and a sorbed phase where contaminants are bound to the soil particles in the water-bearing zone. Additional data are needed to evaluate the potential for migration of COPCs to surface water and sediment from ground water.

Terrestrial plants and other biota can take up contaminants from surface and subsurface soil. Terrestrial biota can therefore, potentially act as additional contaminated media. Terrestrial biota that may have accumulated contaminants could also act as exposure media for humans and wildlife. A terrestrial ecological evaluation (TEE) will be performed for the Site in accordance with WAC 173-340-7492 to identify potential terrestrial ecological receptors and exposure pathways.

Volatile contaminants in surface and subsurface soil may be present in the vapor phase. After volatilization, these contaminants can be transported to the surface to outdoor air and to indoor air, although the resulting outdoor air concentrations are expected to be minimal due to instantaneous dispersion and mixing that occurs at the soil-air interface. Vapors may enter indoor air if volatile contaminants are present in the subsurface beneath or near a building. Similarly, vapors may also enter utility corridors located on the property and in the ROWs if volatile contaminants are present in the subsurface beneath or near the conduits. Since the backfill materials in the utility trenches can be less dense than the surrounding media, vapors can move preferentially through the trenches and be carried away from the source areas. The identified volatile preliminary COPCs for Site soil include GRO, BTEX, MTBE, EDC, EDB, naphthalenes, and n-hexane. A vapor intrusion study will be performed as part of the RI to evaluate the vapor pathway (Section 4.2.7).

3.2 Potential Receptors

3.2.1 Human Receptors

The Boeing Field Chevron property consists of a public service station, convenience store, and car wash. Property visitors are present on the Site for short periods of time. Site workers spend the majority of their time inside the convenience store; however, people working on the car wash, pump islands, and/or USTs may also be present occasionally for short periods of time. Construction workers and Site visitors will also be present on the property in the future.

3.2.2 Ecological Receptors

Until a TEE is completed for this Site, terrestrial ecological receptors have not been identified. A TEE will be performed for the Site in accordance with WAC 173-340-7492 to identify potential terrestrial ecological receptors and exposure pathways. The TEE will evaluate potential terrestrial and aquatic receptors based on proximity to the LDW (within 275 feet).

3.3 Potential Exposures

3.3.1 Currently Known Exposures to Human Receptors

The Chevron-branded service station located on the Site is open 24 hours per day, 7 days per week. Therefore, the human receptors currently present at the Site include commercial workers that are assumed to be on the service station property up to seven days a week, 8 hours per shift. Visitors are also regularly on the property for short periods of time. Potential human receptors also include utility and other construction workers on the BFC property and the adjoining ROWs.

The Site, including the BFC property, is mostly paved as previously discussed; however, there are some unpaved areas on the Site. Based on normal site operations and the lack of identified surficial contamination, human exposures to affected soils through dermal contact, incidental ingestion, or inhalation of windblown dust would likely be limited to any future excavation activities (e.g., fuel system repairs, utility work, remedial excavations, etc.).

Tier 1 and Tier 2 vapor intrusion assessments have not been completed at the Site to determine whether the vapor exposure pathway is complete. A vapor intrusion study will be performed as part of the RI, which will assess intrusion into the service station mini mart, as well as the risk to the south-adjoining structure, and determine whether the vapor pathway could be complete for utility workers at the Site and/or construction workers during Site remediation activities. The vapor assessment is discussed further in Sections 4.2.7 and 6.1.5.

No drinking water wells are present on the property, and drinking water is supplied by the City of Tukwila. At this time, based on existing data, accidental contact or consumption of ground water during investigation, remediation and/or construction work is a potentially complete pathway for human receptors at the Site. At this time it is not known whether the Site ground water is potable or non-potable, which will be evaluated as part of the RI.

3.3.2 Potential Future Exposures to Human Receptors

There are no current plans for future development or building construction at the property. The property is zoned by the City of Tukwila as Manufacturing Industrial Center/Heavy Industrial (MIC/H). Current activities at the property are commercial in nature and are anticipated to remain as such for the foreseeable future; however, the current zoning for the BFC property does allow for future industrial as well as commercial uses. Potential future receptors include commercial Site workers and property visitors. Construction, utility maintenance, or other workers would likely also be present periodically on the Site in the future.

Future construction workers could be exposed to contaminants in surface and subsurface soil, and in ground water and surface water through dermal contact or incidental ingestion during excavation activities. During any future invasive work (such as removal of pavement, roadway construction activities, Site remediation activities, and utility work), inhalation of windblown dust and/or vapors may also occur. These exposure pathways are, therefore, considered potentially complete for the future construction worker receptor. In addition, because subsurface soils could become exposed during construction activities, the direct subsurface soil contact pathways (including ingestion and dermal contact) and inhalation of windblown particulates and/or vapors in ambient air generated from subsurface soil are also potentially complete for future Site workers, property visitors, and adjoining property occupant receptors.

If a complete transport pathway to LDW surface water and/or sediment is identified, human exposure (recreational and subsistence users) to contaminants by consumption of aquatic organisms is also a potentially complete exposure pathway.

3.3.3 Currently Known and Potential Future Exposures to Ecological Receptors

Until a TEE is completed for this Site, terrestrial ecological receptors have not been identified. As previously discussed, a TEE will be performed as part of the RI for the Site.

4.0 RI TASKS

This section of the RI Work Plan provides a discussion of the proposed RI SOW and the rationale for those activities.

The RI will address the existing data gaps for the Site (Section 4.1 and Appendix C) with an emphasis on collecting sufficient data to characterize Site conditions and to facilitate evaluation of possible cleanup alternatives in the FS.

Procedures for sampling and analysis and quality assurance/quality control (QA/QC) are described in the SAP (Section 6) and QAPP (see Appendix D). A Health and Safety Plan (HASP) that pertains to the tasks to be conducted for this RI will be prepared by Terracon prior to performing any work on the Site.

4.1 Data Gaps

Historical data and prior investigation findings indicate the nature and extent of impacts to environmental media at the Site are not fully characterized. Data gaps exist where the lateral and/or vertical extent of contamination has not been delineated, and in areas that are not yet fully understood.

Specific data gaps that have been identified for the Site, based on the results of the previous investigation and remediation activities and the CSM, are summarized in Table 1 and listed in Appendix C.

As indicated above, Appendix C provides a summary of the data gaps identified for the Site based on historical Site uses, current Site uses, and previous analytical data collected at the Site. The data gaps listed in Appendix C are primarily related to the following general data concerns for the Site (refer to Appendix C for specific details):

- **Extent and thickness of LNAPL**
  LNAPL has historically been identified in wells EW-7, EW-9, IP-7 and MW-15. Approximately 74 gallons of LNAPL have been recovered at the site since May 2008, using methods such as skimmers and sorbent socks. The most recent ground water sampling event (July 2015) identified 0.05 foot of LNAPL in well IP-7. No other wells were found to contain LNAPL in July 2015; however, the condition of many of the wells may have had an adverse effect on the ability of LNAPL to enter the wells. Currently, no LNAPL recovery system is in place at the Site (sorbent socks were removed prior to the July 2015 sampling event and have not been replaced), and the extent of the LNAPL is not fully understood. During the RI, additional ground water sampling is planned for the existing wells and the new wells that will be installed, and ground water grab sampling from test probes will be performed. These tasks will aid in the evaluation of the extent and thickness of LNAPL at the Site.

- **Lateral extent of ground water impacts within the apparent perched unit**
  The lateral extent of adverse impacts to the apparent perched ground water at the Site has not yet been determined to the east, west or south. Furthermore, several of the existing wells are screened across both apparent water-bearing units, complicating the interpretation of the resulting data. During the RI, separate ground water grab samples will be collected from the upper and lower water-bearing zones on the east, west and south portions of the Site and new wells will be installed within the perched unit in order to collect more accurate data regarding COPC concentrations in the shallow ground water. Existing wells will be assessed for suitability as described in Section 4.2.2, possibly included well abandonment and/or replacement. Ground water sampling will continue, possibly in subsequent additional phases, until the lateral extent of perched ground water exhibiting COPC concentrations in excess of MTCA Method A is identified.

- **Lateral extent of ground water impacts within the apparent deeper, semi-confined unit**
  The lateral extent of adverse impacts to the apparent deeper ground water at the Site has not yet been determined to the east, west or south. As discussed above, several of the existing wells are screened across both apparent water-bearing units, complicating the

interpretation of the resulting data. During the RI, separate ground water grab samples will be collected from the upper and lower water-bearing zones on the east, west and south portions of the Site; the deeper ground water grab samples will be collected only after the upper unit has been sealed off with bentonite. In addition, new wells will be installed within the deeper water-bearing unit in order to collect more accurate data regarding COPC concentrations in the deeper ground water. As discussed above, existing wells will be assessed for suitability as described in Section 4.2.2, possibly included well abandonment and/or replacement. Ground water sampling will continue, possibly in subsequent additional phases, until the lateral extent of deeper ground water exhibiting COPC concentrations in excess of MTCA Method A is identified.

- **<u>The lateral and vertical extents of the contaminated soil</u>**
  Although the northern and northeastern extents of the adversely-affected soils are thought to be defined, some of the data pre-dates the 2003 release and may no longer be valid. Furthermore, the lateral extent of impacted soil on the east, west and south areas of the Site are currently unknown. In addition, the vertical extent of the impacted soils is not well understood, particularly on the western portion of the Site. During the RI, soil samples will be collected from various depths at each test probe location, as described in Section 6.1.3, in order to provide more data on the vertical and horizontal profiles of the adversely-affected soils. Soil sampling will continue, possibly in subsequent additional phases, until the vertical and lateral extents of soils exhibiting COPC concentrations in excess of MTCA Method A are identified.

- **<u>Thickness of Lower Hydrogeologic Unit</u>**
  In previous studies at the Site, the lower unit at the Site has been described as fine- to medium-grained dark gray sand, the top of which is usually situated at approximately 15 feet bgs. The base of this unit has not been encountered in any of the previous investigations conducted at the Site. All test probes advanced during the first phase of the RI will extend to a minimum of 35 feet bgs in an effort to determine the vertical extent of this hydrogeologic unit.

- **<u>The degree of soil and ground water impacts within and west of the utility corridor</u>**
  Underground utilities are present in close proximity to the western boundary of the BFC property. Soil and ground water samples collected east of the corridor exhibit elevated COPC concentrations; however, most of the samples collected west of the corridor do not. Therefore, it is possible that the utility trench and/or the utilities themselves have been impacted by the releases at the Site and may be acting as preferential pathways for contaminant migration. During the RI, catch basin solids and stormwater will be sampled from catch basins along the western utility corridor, and soil and ground water grab samples will be collected from within the utility trenches to assess the condition of the utility corridor.

- **<u>The potential vapor intrusion pathway</u>**
  Although a limited vapor sampling study was performed at the site in 1990, the study only focused on the former eastern pump island, was performed prior to the existing development and associated utilities, and the sample collection methods were not in accordance with existing standards (e.g., samples may have been collected using a gasoline-powered post-hole auger, etc.). Based on this limited data and the fact that two additional releases were subsequently reported at the Site, it is doubtful that the 1990 data accurately reflects current conditions. It is not known whether the existing utilities are acting as preferential pathways for vapors in the subsurface, and whether vapor intrusion is occurring into the retail building on the BFC property or any other nearby structures. A Tier 1 vapor study will be performed during the RI, in accordance with the US EPA's *Technical Guide for Addressing Petroleum Vapor Intrusion at Leaking Underground Storage Tank Sites* (USEPA, 2015).

4.2 RI Scope of Work

As previously discussed, the primary focus of the RI is to address data gaps associated with Site, including the extents of the contaminated soil and ground water and the degree of impact west of the utility corridor. The RI SOW was developed to address each of the data needs previously described.

This section provides a summary of each of the work tasks included in the RI. Additional details regarding implementation of the RI tasks (field sampling methodologies, chemical analyses, etc.) are presented in the SAP (Section 6).

4.2.1 Review Utility Construction Details and Compliance Sampling Results

The construction details and compliance sampling results for the utilities located on the eastern portion of the Tukwila International Boulevard ROW (adjacent to the subject property) have been requested from the City of Tukwila. The City provided construction plans for the storm and sanitary utilities within the right-of-way (copies are provided in Appendix F), but has informed Terracon that no compliance sampling data is available. The construction details provided include the depth of the utilities, their construction materials, and the type of backfill used within the utility trench. Based on anecdotal information from city representatives, the utility trenches extend approximately 6 inches below the invert elevations of the pipes. However, the provided plans depict on-property utilities that do not appear to be accurate.

Therefore, the on-property storm and sanitary sewer utilities, including the car wash and bioswale facilities, will be mapped and their integrity inspected by Mt. View Locating, Inc., using wire-insertion and camera surveys. Using the data provided, the scope of work for a utility investigation has been prepared as part of this RI Work Plan and is discussed in 6.1.1 and 6.1.2. This will be done in addition to the standard utility locating activities (see Section 6.1) to be performed prior to any drilling or other invasive work at the Site.

4.2.2 Monitoring Well Suitability Assessment

All existing Site monitoring wells will be evaluated for suitability for RI data collection and evaluation needs (including but not necessarily limited to water elevation and LNAPL measurement, collection of ground water samples, hydrogeologic evaluation of gradients and aquifer interconnectivity, tidal fluctuation monitoring, and evaluation of potential exposure pathways).

The well evaluation will include the following general tasks:

- Inspection by a licensed driller to evaluate general structural integrity and compliance with Ecology's Minimum Standards for Construction and Maintenance of Wells (WAC 173-160).

- Confirmation of screen intervals and saturated zone(s) within screen intervals, including camera survey if warranted.

- Confirmation of well depths and thickness of accumulated silt, if any. Wells identified with silt accumulation greater than two feet during the 2015 ground water assessment included MW-10, MW-12, MW-13, MW-16, MW-17, EW-1, EW-3, EW-4, and EW-6.

Based on the findings of the well evaluation, the proposed plan for each well will be provided to Ecology for review and approval. Recommendations for each well may include abandonment, replacement, redevelopment, repairs, or no action required. For wells recommended for abandonment, the abandonment method, as described in WAC 173-160, will be specified. Wells that are screened through the aquitard/silt layer will be fully drilled out (including the sand filter pack) to seal the aquitard between the two suspected saturated zones. Wells that are screened across only one of the suspected saturated zones will be abandoned by filling the casing with bentonite (if original driller's logs are available and confirm that the well was installed in compliance with WAC 173-160) or fully drilled out.

Based on the findings of the 2015 ground water assessment (Terracon, 2015), the following wells have been identified for abandonment and will therefore be excluded from the inspection. Please refer to the Well Abandonment SOP in Appendix E. The well assessment will include evaluation of the need for replacement wells at these locations.

- Two wells, EX-N and EX-S, were reportedly installed during backfilling of remedial excavations that were performed west of the existing pump islands in approximately 2003 or 2004. The wells were not installed by a licensed well driller and are reportedly screened from the surface to 15 feet bgs. Based on their construction and proximity to the existing pump islands, these wells will be decommissioned as soon as possible.

- Injection well IP-6 will be decommissioned. A broken skimmer pump has been reported in the well, and a blockage was confirmed during the recent ground water assessment work.

Additional well maintenance tasks identified based on the findings of the 2015 ground water assessment (Terracon, 2015) include:

- Replacement of monuments on MW-14 and all remaining IP-series wells.
- Installation of new, expandable, locking well caps on all remaining monitoring wells.

A well abandonment SOP has been included in Appendix E.

4.2.3 Conduct Catch Basin Solids and Stormwater Sampling

Catch basin solids and stormwater samples will be collected from three catch basins and/or manholes immediately west of the Site (upstream, adjacent, and downstream of the Site), within the Tukwila International Boulevard ROW. In addition, catch basin solids and stormwater samples will be collected from at least one location to be determined based on the utility survey described in Section 4.2.1, within the East Marginal Way ROW (east of the Site). The analytical results will be used to determine whether the adversely affected soil or ground water at the Site is entering the stormwater utility. In addition, the sorbent pad filters and iron grates on the service station catch basins and manhole covers will be inspected. Any compromised utility covers and/or materials will be replaced.

A Public Works Permit from the City of Tukwila will be required to perform the ROW portion of the work, which includes the preparation of a traffic control plan. The turnaround time from permit submittal to approval is estimated at one to three weeks. Terracon assumes that the catch basin/manhole sampling and the drilling activities can be performed under the same permit, and that two permits will not be necessary as long as the activities are performed concurrently; however, all RI tasks will be performed regardless of the number of City permits required and whether they can be performed concurrently.

4.2.4 Conduct Ground Water Sampling

After the well redevelopment and decommissioning activities discussed in Section 4.2.2 have been completed, a ground water assessment will be performed. All remaining wells on the service station property and in the Tukwila International Boulevard right-of-way will be gauged and sampled, both during low tide and during high tide (no new monitoring wells will be installed until at least the first phase of drilling is performed).

Ground water monitoring events, including water elevation monitoring and collection of ground water samples, shall include:

- One round of ground water monitoring following completion of the ground water well assessment described in Section 4.2.2 will be performed for all Site wells deemed suitable for the purposes of this RI.

- Quarterly ground water monitoring shall commence immediately upon establishment of the monitoring well network (i.e., following installation of any new Site wells) and will include any new wells installed as part of the RI. The monitoring well network that will be used for quarterly monitoring will be determined based on the results of the RI, and will be submitted to Ecology for review and approval prior to the first quarterly monitoring event.

4.2.5 Conduct Soil and Ground Water Investigation

During the initial phase of the RI, 19 borings (PB-1 through PB-15 and SS-1 through SS-4) will be advanced at the Site to at least 35 feet bgs. The rationale for each boring location is provided in Table 1. Four of those 19 borings will be located within the utility corridor. An additional 10 soil borings have been proposed as step-out borings and will be advanced during the initial phase only if field indications suggest the presence of impacts (e.g., elevated headspace readings, sheens, or odors observed) at the initial boring locations. Proposed boring locations included in the initial phase of the RI event are shown on Figure 11. Soil and ground water samples will be collected from each boring as described in Sections 6.1.3, and will be submitted for laboratory analysis for the analysis indicated in Section 6.2.1.

It is anticipated that at least one additional round of drilling will be needed to complete the RI at the Site. The specific scope of work for the subsequent phase(s) will be outlined in technical memoranda and/or emails, which will be submitted after the data from the initial phase has been evaluated. Subsequent phases will not be performed without Ecology approval of the scope. It is understood that all field work must be completed within 180 days of Ecology approval of the Remedial Investigation Work Plan.

The results of the initial phase of the investigation will be used to determine the placement of additional soil borings and monitoring wells, as needed, to resolve the remaining data gaps at the Site. If laboratory analytical results from the initial phase of drilling indicate that the vertical and/or horizontal extents of the soil or ground water impacts were not successfully delineated, samples archived at the laboratory (if any) will be analyzed to resolve the data gap provided a sufficient volume of sample is present for the laboratory to perform the analysis, and provided that the sample is within the appropriate method holding times. If the appropriate archived samples do not exist, do not have sufficient volume, or are outside of holding times, or if more information is needed to resolve the data gaps described in Section 4.1 or identified during the initial phase of investigation, remobilization to the Site for additional sample collection will be performed (after submittal of initial findings and proposed sampling locations to Ecology for review and comment).

New monitoring wells installed for this RI may include replacement wells for decommissioned wells, wells at new locations to delineate the lateral and vertical extent of COPC impacts, and wells at margins of the Site to verify current conditions. In addition to any other new or replacement wells proposed for the Site, at least one new monitoring well will be installed along the southern Site boundary and at least two new monitoring wells will be installed along the eastern Site boundary.

The analytical results of the initial phase of drilling will be used to identify locations for new wells, and the proposed locations and screen intervals will be submitted to Ecology for review and approval prior to installation of any new wells. After installation of new wells at the Site, analytical results for ground water samples will be used to evaluate the sufficiency of the ground water monitoring network, and additional well locations will be proposed if necessary.

Additional data regarding Site hydrogeology is needed in order to determine the optimal monitoring well placement and construction. A better understanding of tidal influences on the Site is needed, as is more data on the depth and thickness of the aquifer(s) underlying the Site, and the degree to which they are hydraulically connected, if at all. As soon as possible after Ecology approval of the RI Work Plan, transducers will be placed in select wells to collect static ground water level measurements once per hour until the conclusion of the RI field activities. At that time (and as needed during the RI field work), the readings will be retrieved from the transducers and will be used (along with the other data gathered during the RI field work) to evaluate tidal influences at the Site, and to determine whether any trends exist between screened intervals, tidal influences, COPC concentrations, etc. The wells proposed for transducer placement will be selected following the well assessment task (Section 4.2.2) and submitted to Ecology for review and approval prior to placement of transducers.

4.2.6 Phase 2 Drilling and Well Installation

The results of the initial phase of drilling will be evaluated with regard to the Data Gaps discussed in Section 4.1 and any others identified during the initial phase of drilling. Additional mobilizations to the Site will be performed to resolve any remaining data gaps after the results have been evaluated. For example, step out borings will be advanced in areas where the lateral extents of LNAPL, soil or ground water contamination have not yet been resolved. In addition, areas where the initial phase of drilling did not provide sufficient hydrogeological data (if any) will be further investigated. Remobilization to further characterize utility corridors will be performed if needed.

Additional ground water monitoring wells will be installed at the Site during Phase 2 of the RI. Proposed Phase 2 work tasks, including details on the locations, rationale, and sample intervals, will be submitted to Ecology for review and approval prior to performing Phase 2 field tasks.

4.2.7 Soil Vapor Assessment

Prior to performing any vapor sampling at the Site, an assessment will be performed based on the EPA's *Technical Guide for Addressing Petroleum Vapor Intrusion at Leaking Underground Storage Tank Sites* (USEPA, 2015). The vapor pathway assessment will include data collected during the utility mapping task described in Section 4.2.1, and the initial phase of the soil and ground water investigation described in Section 4.2.5. The results of the vapor pathway assessment, including recommended RI vapor sampling, will be submitted to Ecology for review and approval.
Based on the currently available data available for the Site, and the potential vapor pathways and receptors discussed in Section 3, we anticipate that soil vapor sampling will likely be needed to evaluate the vapor pathway, possibly including:

- Soil vapor sampling in proximity to the buildings, possibly including sub-slab sampling.
- Soil vapor sampling in proximity to source areas.
- Soil vapor sampling in areas where impacted soil and ground water, including NAPL, are identified.
- Soil vapor sampling in proximity to potential preferential transport pathways including utility corridors.

The location and quantity of proposed vapor sampling locations will be based on the assessment described above. Vapor assessment sampling methodology is discussed in Section 6.1.5, and analytical methods are summarized in Section 6.2.2.

4.2.8 Terrestrial Ecological Evaluation

A terrestrial ecological evaluation (TEE) will be performed in accordance with WAC 173-340-7490. The TEE will consider possible ecological receptors in the LDW based on proximity the Site, including a specific evaluation of the MTCA criteria for selection of the appropriate TEE framework for the Site. Based on an initial review, the Site does not appear to qualify for an exclusion based on the criteria outlined in WAC 173-340-7491(1)(a-d), but may qualify for a simplified TEE based on the criteria outlined in WAC 173-340-7491(2)(a). Therefore, it is anticipated that a simplified evaluation will be performed in accordance with WAC 173-340-7492, rather than a site-specific evaluation. If the evaluation cannot be ended using the simplified method, a site-specific TEE will be performed in accordance with WAC 173-340-7493.

4.2.9 Investigation-Derived Waste Disposal

The soil cuttings and purge and decontamination water generated during RI activities will be temporarily stored at the Site in properly labeled 55-gallon drums within the locked shed on the west side of the property. Drums containing separate-phase investigation-derived waste (IDW) will be equipped with a drum vent. Drum contents will be sampled for waste characterization purposes. Upon receipt of the analytical results, the soil and water will be transported off-Site for disposal at licensed facilities. IDW will be removed from the Site within 60 days of its generation.

4.2.10 Surveying

Terracon will survey the horizontal positions and vertical elevations of the new soil borings and new and existing ground water monitoring wells on an ongoing basis during the RI for the purposes of data evaluation. The horizontal positions will be surveyed to the nearest 0.1 foot relative to GIS coordinates. The vertical elevations of the ground surface and well casings will be surveyed to the nearest 0.01 foot, relative to the NAVD 88 datum. At the conclusion of the RI activities, a formal Site survey will be performed by a licensed surveyor and will include ground surface elevations of borings advanced during the RI, top of casing elevations for ground water wells, and the elevations of utility covers and pipes on the Site.

4.3 Data Evaluation

The results of the sampling and analysis conducted during the RI will be used to evaluate contaminant fate and transport, to update the preliminary CSM presented in Section 3, determine the placement of additional permanent ground water monitoring wells on the Site, and determine any additional characterization activities. The final CSM will include an update to the assessment of exposure pathways and potential receptors based on the results of the data collected during the RI event. The final CSM, presented in the RI report, will include a conceptual diagram (such as a block diagram) showing Site features, hydrogeology, and exposure pathways. The preliminary CSM described in Section 3 presents the current understanding of potential pathways and exposure scenarios. These pathways, and any other potential exposure pathways identified during the RI, will be evaluated.

Any additional phases of the RI events will be initiated immediately upon identification of data gaps. For example, if the analytical results from the initial phase of the RI indicate that the lateral extent of soil contamination has not been defined, additional soil boring locations will be proposed that will provide the additional data necessary. As discussed above, a technical memorandum or email detailing the proposed locations, rationale and adjustments will be submitted to Ecology by the PLPs for review and approval prior to implementation of any additional phases of the RI events. Additional investigation activities will be conducted as soon as possible upon approval by

Ecology. In accordance with the Agreed Order, all RI field work, including that detailed in RI Work Plan addenda, will be completed within 180 days of Ecology approval of the RI Work Plan.

Following completion of field sampling activities, analytical results will be compared to the proposed Site cleanup standards. The FS will be prepared following completion of all phases of the RI.

5.0 SCHEDULE AND DELIVERABLES

5.1 Progress Reports

During the RI, progress reports will be submitted to Ecology on a monthly basis, and at a minimum, will contain the following information regarding the preceding reporting report:

- Description of the actions that were completed to comply with the Agreed Order or this RI Work Plan.
- Summary of sampling and testing reports and other collected data.
- Description of any deviations from the Agreed Order or this RI Work Plan.
- Summary of contacts with representatives of the local community, public interest groups, press, and federal, state, or tribal governments.
- Description of any problems or anticipated problems in meeting the schedule or objectives set forth in the Agreed Order or this RI Work Plan.
- Summary of planning or implemented solutions to address any actual or anticipated problems or delays.
- Changes in key personnel.
- Description of work planned for the next reporting period, and anticipated schedule.

5.2 RI Deliverables

The primary RI deliverables consist of progress reports (described above) and draft and final RI reports (see Section 5.3). In addition, proposed changes to the RI scope of work, and the basis for the proposed changes (findings and rationale), may be submitted to Ecology periodically during the RI. We understand that all RI field work, including any proposed changes, needs to be completed within 180 days of approval of this Work Plan by Ecology.

Additional data needs, and the related proposed work tasks, identified during the RI will be submitted to Ecology as technical memoranda or emails (rather than as formal addenda) to facilitate and streamline Ecology's review process. Requests to Ecology for approval for some field tasks, such as changes to boring locations based on field findings or placement of step-out borings during field mobilizations, may also be made by phone to minimize potential delays.

A Draft RI Report will be prepared to summarize the procedures used to investigate the Site, to present the field data and the validated sample analytical data, and to discuss the interpretations of the data and the conclusions. The report will include the proposed preliminary soil, vapor, and ground water cleanup levels and a revised CSM. The Draft RI Report will be submitted to Ecology for review and approval. A Final RI Report will be prepared in response to input from Ecology. All of the data collected during the RI will be entered into Ecology's Environmental Information Management (EIM) database at the time of submittal of the Agency Review Draft RI Report.

In addition, tabulated raw data, copies of original laboratory reports, original laboratory EDD data files, and sample location maps will be submitted to Ecology within 10 days of receipt of data from the analytical laboratory.

5.3 Schedule

The schedule for the RI activities and deliverables, based on the Agreed Order SOW schedule, is presented below.

RI Activities and Deliverables	Due Dates
Progress Reports	15th of every month beginning with execution of the Agreed Order by Ecology
Completion of all phases of RI fieldwork	180 days following Ecology's approval of the Final RI Work Plan
Agency Review Draft RI Report	90 days following receipt of all final laboratory data
Public Review Draft RI Report	30 days after receipt of Ecology comments
Final RI Report	30 days following receipt of Ecology's review comments on the draft report, subsequent to public comment

A key project meeting will be held with the PLPs and Ecology after completion of field work and prior to submittal of the Agency Review Draft RI Report to discuss the data generated during the RI and Ecology expectations for the RI Report. The meeting will be scheduled by Ecology upon notification from the PLPs that field activities have been completed.

6.0 SAMPLING AND ANALYSIS PLAN

The Sampling and Analysis Plan (SAP) presented below is based on the Site data gaps previously discussed and summarized in Section 4.1. The SAP describes the field procedures, methodologies, and analytical methods for each work task based on the SOW presented in Section 4.

All phases of the RI sampling activities at the Site will be performed to provide data of sufficient quality and quantity to satisfy the investigation objectives for affected environmental media at the

Site, including all potential contaminant source areas, as described in previous sections of this Work Plan.

Proposed sample locations are shown on Figure 11. Field procedures and methodologies are described in Section 6.1, including references to SOPs, and the analytical testing requirements are listed in Section 6.2.

6.1 Sampling Plan

Prior to the commencement of drilling activities at the Site, a public utility locate request will be made including the required notification to the public utility locating service, and direct notification of any utilities not included in the public locate request. In addition, a private locator (Mt. View Locating, Inc.) will be contracted to locate buried utilities at all proposed drilling locations. Any proposed changes to sampling locations based on utility locations will be submitted to Ecology for review and approval prior to the start of drilling.

6.1.1 Stormwater Catch Basin Sampling

As discussed in Section 4.2.2, catch basin solids and stormwater samples will be collected from three catch basins and/or manholes immediately west of the property (upstream, adjacent, and downstream of the property), within the Tukwila International Boulevard ROW, and from at least one location within the East Marginal Way ROW to be determined based on the utility survey described in Section 4.2.1. The stormwater sampling event will be performed prior to the catch basin solids sampling event at each catch basin. Both sampling events will be performed 72 hours after a measurable storm event. The locations of the catch basins are shown on Figures 3 and 11 in Appendix A.

Stormwater samples will be collected in accordance with the EPA's Industrial Stormwater Sampling Guide, which is included in Appendix E. The stormwater samples will be collected by using a pre-cleaned polyethylene cup attached to an extension pole, which will be lowered into the stormwater, allowing the water to flow into the cup. The water will then be transferred to pre-cleaned laboratory sample jars for analysis.

Each of the catch basin solids samples will be collected by using the above-referenced cup (or other appropriate sampling device such as a hand auger or core sampler) to collect solids from the catch basin at several discrete locations (from each corner and the center of the catch basin). If standing water is present in a catch basin, then the water will be slowly extracted with a peristaltic pump, if possible, to minimize any disturbance of the solids. An extension pole may be attached to the cup in order to reach the bottom of each catch basin. The catch basin solids will be allowed to settle and the stormwater will be decanted from the cup. A portion of each discrete sample will be immediately set aside for headspace analysis. The catch basin solids not reserved for headspace screening will be described in accordance with the Unified Soil Classification System, and then placed into a decontaminated stainless steel bowl and mixed by hand or with a stainless steel or disposable spoon. New, dedicated, disposable nitrile gloves will be worn to mix the solids. After mixing, the solids will be placed into appropriate pre-cleaned laboratory sample jars for non-volatile analyses. Solids samples intended for volatile analysis will be collected from the discrete location exhibiting the highest headspace result using a 5035 sampling kit. Care will be taken to include fine particles in the samples, and solids from the total depth of accumulated materials. Care shall also be taken to package the samples as soon as possible following collection. The cup will be decontaminated between catch basins. For specific sampling procedures pertaining to catch basin solids sampling, please refer to the SOP included in Appendix E.

Sampling equipment will be decontaminated between sample locations and a new pair of nitrile gloves will be worn during sampling. After filling, the sample containers will be placed on ice in a cooler and handled as described in Section 6.4. Any water that is pumped from the catch basins will be stored and disposed as described in Section 6.6.

In addition, the solids, any debris, staining, and odors in the catch basin will be observed and reported. The thickness of the solids will be measured prior to sampling with a decontaminated metal rod, ruler, or disposable wooden dowel.

If the volume of solids in a selected catch basin is not sufficient to fill the appropriate sample jars, then the sampling will be delayed until a sufficient volume of solids is present within the selected catch basin. Those basins will be inspected after three consecutive days with no measureable rainfall to see if a sufficient volume of solids has accumulated for sampling purposes. If a sufficient volume still has not accumulated within the catch basin, Terracon will coordinate alternatives with Ecology, which will be documented in the final RI report. Catch basin solids will not be composited from multiple catch basins.

Analyses to be performed for catch basin solids samples are listed in Section 6.2.1.

6.1.2 Utility Trench Sampling

The borings located within the stormwater utility trench (SS-1 through SS-4) will be advanced using air-knife techniques unless the backfill material can be easily removed with a hand auger. City of Tukwila as-built plans suggest that the depth of the utility is approximately 4 to 6 feet bgs, and that the utility trench extends an additional ½ foot below the utility. Therefore, a vacuum truck will purge soils from the boring to a depth of two feet bgs, after which a hand auger will be used to advance the boring an additional foot into soils that have not been disturbed by the air-knifing process. Care will be taken to collect samples that are sufficiently intact for VOC analysis using EPA 5035 sampling methodology. A soil sample will be collected at 3 feet bgs from the auger barrel immediately after removal from the borehole. The vacuum purging will then resume to a depth of 5 feet bgs, at which time the hand auger will again be used to advance the boring an additional foot for sample collection at 6 feet bgs. Once the bottom of the utility trench has been attained (estimated at 6 feet bgs), exploration activities will resume within the borehole using the methods described in Section 6.1.3 in an effort to explore the materials beneath the trench. Samples for VOC analyses will be collected using the 5035 method. If ground water is encountered within the trench it will be sampled using the method described in Section 6.1.4.

A sanitary sewer utility lies west of the stormwater utility; however, the utilities are managed by different agencies and the trenches do not appear to be connected, although the utilities are at similar depths. If impacts are observed within the storm sewer trench backfill, the sanitary sewer utility trench will be explored during subsequent phases of this RI.

6.1.3 Soil and Grab Ground Water Sampling Intervals

For the initial phase of the RI, 19 soil borings are planned. Boring locations are shown on Figure 11 and are intended to provide the data needed to define the lateral and vertical extents of the identified soil and ground water impacts at the Site. The actual number and locations of soil borings advanced at the Site and samples collected will vary depending on boring location and associated data gaps, and will ultimately depend on the conditions encountered, as previously described.

Soil and reconnaissance (i.e., grab) ground water samples will be collected from all borings proposed for the Site. Soil conditions will be logged continuously, and soil sample collection depths will be based on lithology (or equivalent depths) as summarized below. At least 6 soil samples will be collected from each boring for laboratory analysis and/or archival (selection of samples for initial laboratory analysis is discussed in Section 6.1.3.2) at the lithologic intervals and/or depths as follows:

- Below the bottom depth of the storm sewer utility trench in vadose-zone soils; approximately 6 to7 feet bgs.
- Lower portion of the shallow saturated zone above the silt layer; approximately 10 to 13 feet bgs. Sample at approximately 11 feet bgs if the silt layer is not encountered.
- Middle portion of the silt layer or silty interval, or approximately 15 feet bgs.
- Top of the deeper saturated zone below the silt layer, typically 19 to 20 feet bgs. Sample at approximately 20 feet bgs if the silt layer is not encountered.

- Middle of the deeper saturated zone, or approximately 25-30 feet bgs if no separate saturated zone is identified.

- Terminus of the boring at approximately 35 feet bgs (sample will be collected at 35 feet even if boring is advanced to greater depth).

Additional soil samples will be collected from select borings based on the Work Plan and field observations:

- Within utility trenches (locations SS-1 through SS-4) at approximately 2 to 3 feet bgs and 5 to 6 feet bgs as described in Section 6.1.2.

- At approximately 5-foot intervals in borings that are advanced beyond 35 feet bgs based on field observations.

- Additional samples as needed to characterize potential COPC impacts identified based on field observations and screening (i.e., from intervals where potential impacts are identified but are not within the intervals described above) as described in Section 6.1.3.1.

Grab ground water samples will be collected from both of the suspected saturated zones at the Site, above and below the silty interval (see Sections 2.1.3 and 2.1.4), or at equivalent depths, as summarized below.

- Shallow-zone ground water samples will be collected from the upper saturated zone approximately 2 feet below the water table interface. This is anticipated to be approximately 8-10 feet bgs, but may vary across the Site. If perched ground water is not present, the water table could be deeper. Regardless of the actual depth, a sample will be collected at the initial water table depth at each boring.

- Deeper-zone ground water samples will be collected from the upper portion of the lower saturated zone immediately beneath the silt layer, with the tubing intake set at approximately 21-22 feet bgs. If the initial water table is deeper than 15 feet bgs, the deeper-zone sample will be collected approximately 10 feet below the water table.

- If separate saturated zones are not encountered, a deeper ground water grab sample will be collected between 20 and 25 feet bgs.

- If contaminated soil is in contact with ground water at depths greater than 25 feet bgs, an additional, deeper grab ground water sample will be collected.

Additional information regarding methodologies for advancing soil borings, collecting soil and ground water samples, and selecting samples for initial laboratory analysis is presented in the following sections.

6.1.3.1 Soil and Grab Ground Water Boring Methods

The soil borings shall be drilled and sampled using techniques selected by Terracon that are suitable for meeting the RI Work Plan objectives and to comply with applicable regulations. Borings will be installed by ESN Northwest, Inc., a driller licensed in the State of Washington, using hydraulic push-probe methods, and soil samples will be collected on a continuous basis. Drilling activities will be performed under the direction of licensed geologist provided by Terracon. After the completion of drilling and sampling activities, each boring will be abandoned with hydrated bentonite. The boreholes will be advanced to a depth of approximately 3 to 5 feet beneath the shallow water table interface of the upper aquifer, and a temporary well screen will be set across the water table interface for grab sampling. The shallow water table interface will be determined by viewing the moisture content of the soil samples retrieved from the borehole and will be confirmed with the use of an audible water level indicator. The tubing intake will initially be positioned approximately two feet below the top of the saturated zone, but may be adjusted based on drawdown. An adequate volume of water will be purged from the borehole, and then a grab sample of the ground water will be collected at that depth using a peristaltic pump under low flow conditions. An SOP for temporary well installation and sampling has been included in Appendix E.

Once the shallow grab sample is collected, drilling will continue until the underlying aquitard is encountered, at which time the borehole will be grouted with bentonite slurry to mitigate potential cross-contamination of the presumed lower aquifer. Only the upper portion of the aquitard will be penetrated prior to installing the bentonite seal (i.e., it will not be fully penetrated until after the seal has set). It is anticipated that the underlying aquitard will be evident by a change in lithology to less permeable materials and possibly decreasing moisture in the soil samples. Based on previous investigations, the depth to the top of the aquitard is anticipated to be between 10 and 13 feet bgs.

Once the slurry seal has set, test probing will then resume through the aquitard and into the lower aquifer. A piston (discrete) sampler with a smaller diameter than that used above the bentonite slurry seal will be used to collect soil samples from underlying saturated zones. The approximate top of the presumed lower aquifer will be identified (typically 18 to 19 feet bgs), and the boring will then be advanced approximately five feet into the lower aquifer. Once the desired depth is obtained, a 5-foot section of temporary well screen will be installed and the tubing intake will be positioned in the middle of the well screen interval. Ground water will be purged from the borehole in accordance with the attached SOP (Appendix E), and a grab sample will be collected using a peristaltic pump under low flow conditions.

Once the grab sample is collected from the lower aquifer, test probing activities will resume, likely through the use of a piston (discrete) soil sampler if caving occurs. The test probe will be advanced until 1) the bottom of the lower aquifer is reached; or 2) at least 10 vertical feet of soils with no suspected field indications of adverse impacts have been observed using field headspace screening, sheen tests, and/or olfactory observations (minimum depth will be 35 feet for all borings). The test probes will then be abandoned with bentonite in accordance with applicable regulations. If the aquitard is not encountered, sampling will proceed from the ground surface to the final depths described above, after which the borehole will be abandoned in accordance with the attached SOP.

The grab ground water sampling procedures include the following:

- Borings will be advanced as described above, including installation of a bentonite slurry seal between the anticipated saturated zones, and installation of temporary well screens for grab ground water sampling.

- The temporary wells will be purged using low-flow procedures. Ground water samples will be collected using a peristaltic pump fitted with silicon tubing and either Tygon® or polyethylene tubing. Temporary wells will be purged at a rate of less than 0.3 liter per minute.

- Field parameters will be measured in purged ground water as it is discharging through a flow-through cell.

- Ground water samples will be collected after a minimum of three well volumes from each temporary well are purged. If the field parameters have not stabilized within three well volumes, up to two additional well volumes will be purged. If, after five well volumes, the field parameters have not stabilized, the water sample will be collected and the ground water conditions documented. The purge water will be stored and disposed as described in Section 4.2.5.

- Ground water samples will be collected from the discharge line of the peristaltic pump. All samples will be transferred in the field from the sampling equipment into the laboratory-prepared containers and stored in a cooler on ice pending transport to the laboratory. Sample container requirements such as container size and preservatives (if any) will be verified by Terracon for the selected analytical laboratory prior to the start of field sampling activities.

- The sampler(s) will wear new nitrile gloves at each sampling location. New Tygon® or polyethylene tubing will be used at each sampling location.

- Samples will be labeled, handled, and shipping by using the procedures described in Section 6.4. Sample custody will be maintained until delivery to the analytical laboratory. All sampling field activity and data will be recorded on a dedicated purge and sample field form.

- Quality assurance samples will be collected at the frequency described in Section 6.7. Duplicate samples will be collected by alternately filling similar containers until both containers are filled.

- All reusable purging and sampling equipment will be decontaminated by using the procedures described in Section 6.5.

Terracon will continuously log the soils encountered during drilling, and will perform field screening for the potential presence of contamination based on visual appearance (staining or sheen), odor, water sheen tests, and photoionization detector (PID) readings.

As discussed above, the soil borings will be advanced to a depth of 35 feet bgs, 10 feet below any field indications of contamination, and/or to the bottom of the semi-confined aquifer beneath the Site, whichever is deepest. For safety reasons, the upper five feet (at a minimum) will be airknifed at each test probe location to prevent damage to the UST system and/or public utilities within the ROW. If field observations indicate potential COPC impacts above five feet bgs, samples will be collected as described for the utility trenches in Section 6.1.2. If the field observations indicate the potential presence of contaminants at the planned bottom depth at a soil boring location, the boring will be advanced to greater depth until a minimum of 10 vertical feet of soils with no suspected field indications of adverse impacts are observed using the field screening techniques previously described.

The soil sampling procedures generally include the following:

- All sampling equipment and reusable materials that contact the sample will be decontaminated on site in accordance with procedures identified in Section 6.5. The field geologist will use clean nitrile gloves for handling each sample.

- The sample container labels will be filled out and attached to the appropriate containers as described in Section 6.4. The appropriate sample jars for each soil sample are listed in the QAPP (see Appendix D).

- Soil samples intended for non-volatile analyses will be transferred to sample containers using new, disposable nitrile gloves, or a decontaminated or disposable stainless-steel spoon. To protect the sample from possible contamination during handling, the acetate liner will be placed on a clean piece of plastic sheeting. All subsequent handling of the sample will take place over the plastic sheeting.

- Soil samples intended for volatile analyses will be collected into laboratory-provided U.S. Environmental Protection Agency (EPA) Method 5035 kits. The kits will be filled at each sample interval with sufficient volume to meet the needs of the analytical laboratory. If sample recovery volume allows, two additional four-ounce jars will be collected. Soil will be transferred directly from the sampler to the sample containers. Undisturbed soil samples will be collected using 5035 methods for VOC analyses, including gasoline-range TPH. Care will be taken to minimize disturbance of soil placed in the containers. Sample container requirements for Friedman & Bruya, Inc. (F&BI) will be verified by the consultant prior to the start of field sampling activities.

- After filling the sample jars, the sample interval will be logged on a dedicated field boring log form using the Unified Soil Classification System.

- Samples submitted for duplicate chemical analysis will be collected by using the procedures described above. For non-volatile analyses, the soil samples will be homogenized by mixing in a stainless steel bowl prior to filling the sample containers. Samples will be blind labeled when submitted to the lab. The actual location of the duplicate sample will be recorded on the field boring log.

- After filling, the sample containers will be placed on ice in a cooler and handled as described in Section 6.4.

6.1.3.2 Soil and Grab Ground Water Sample Analyses

A minimum of three soil samples from each soil boring will be submitted for initial laboratory analysis for the analyses indicated in Section 6.2.1. The actual number and locations of soil borings advanced at the Site and samples collected will vary depending on boring location and associated data gaps, and will ultimately depend on the conditions encountered. Additional soil samples will be collected and archived at the analytical laboratory for possible follow-up analyses based on field observations, as previously described. Soil samples will be selected for initial laboratory analysis to characterize suspected impacts or to verify that impacts are not present. Samples for initial laboratory analysis will include the following:

- At least one sample from below the suspected vertical extent of impacts (i.e., presumed clean). This will not necessarily be the bottom sample collected from a boring.
- At least one sample from above the silty layer.
- Samples at depth intervals to characterize lateral extent of impacts in nearby borings.
- Samples at depth intervals to address previous or newly-identified data gaps.

- Samples with the greatest field indication of impacts.

If warranted by field observations, additional (i.e., more than three) samples will be submitted for initial laboratory analysis if field observations (staining, odor, NAPL, sheen, and PID readings) indicate the potential presence of contaminants. All initial soil samples will be submitted for the full suite of analyses listed in Section 6.2.1. Select soil samples will also be analyzed for VPH and EPH, within the method holding times, based on GRO and DRO/ORO concentrations as described in Section 6.2.1.

Archived soil samples will be selected for analysis if the initial laboratory analytical results indicate that the targeted data gap(s) has(ve) not been resolved (e.g., the vertical or lateral extent of impacts not attained). Laboratory analysis of archived samples will be performed for analytes that are detected in a vertically adjacent sample at a concentration above the laboratory reporting limit (i.e., for COPCs detected in a sample collected immediately above or below an archived sample), or laterally at similar depth in adjacent boring locations.

Grab ground water samples will all be submitted for initial laboratory analysis for the full suite of analysis listed in Section 6.2.2.

If field observations or analytical results indicate the presence of soil or ground water contaminants at a boring location, additional borings may be advanced as necessary to evaluate the extent (lateral and/or vertical) of impacts. Locations of additional borings, and a description of potential contaminants, will be submitted to Ecology for review and approval prior to installation of additional borings. For reference, 10 additional borings have been included on Figure 11 as step-out borings, if needed. The step-out boring locations depicted on Figure 11 will be cleared using public and private utility locates prior to drilling the initial phase of the RI. Ultimately the exact number and locations of step-out borings will depend on field observations and laboratory analytical results.

6.1.4 Ground Water Monitoring Well Sampling

Sampling of ground water from the existing monitoring wells will be performed in accordance with the SOP included in Appendix E.

6.1.4.1 Ground Water Elevation Monitoring

Water level measurements for each event will include all site monitoring wells deemed suitable for RI purposes. Measurements will be completed within a two-hour time span for each event and will coincide with published times for high and low tides (with at least a 4-foot change in tidal height) forecasted at the Duwamish Waterway at 8th Avenue South Station (#9447029) within the week of proposed sampling activities. Measurements will begin no earlier than half an hour before each tidal extreme. For this assessment, water level measurements will be made on the same day during consecutive tidal cycles (i.e., the high tide immediately following a low tide, or vice-versa). It should be noted that ground water sampling activities will be performed on a different schedule, which is outlined below. Well caps will be loosened prior to collecting the water level measurements to allow the static water level to equilibrate.

Water levels will be measured using an electric interface probe at each well location. The probe will be cleaned between measurements of different wells. The water level in each well will be measured to the nearest 0.01 foot from the north side of the casing by using an electric water level probe.

Where free product is indicated by the interface probe, visual confirmation will be performed using a bailer. Ground water will be collected into the bailer from the water table interface and visually examined for the presence, nature and thickness of free product. If measureable (>0.01 foot) product is present, the sampling program and/or methodology for that monitoring well may be modified. Any proposed changes to ground water sampling based on the presence of measureable product will be submitted to Ecology for review and approval prior to performing ground water sampling.

6.1.4.2 Ground Water Monitoring

Two ground water monitoring events will be performed, one event during high tide conditions and one event during low tide conditions. The tide cycle sampling events will be spread out across each tide occurrence (i.e., high and low) for several consecutive days.

Monitoring well sampling locations are shown on Figure 11. Ground water samples collected from all accessible monitoring wells, during both tidal cycles, will be analyzed for the COPC suite listed in Section 6.2.1.

The ground water sampling procedures include the following:

- Upon loosening and removing the well cap, the vapors at the well head will be screened with a photoionization detector (PID) in order to aid in the determination of well sampling order. Wells will be sampled from the lowest PID reading to the highest in an attempt to avoid cross contamination of the wells.

- The depths to ground water will be measured in the monitoring wells before sampling. The water level in each well will be measured to the nearest 0.01 foot from the north side of the well casing using an electronic water level probe. Water depths will be recorded on a dedicated purge and sample field form, and will include date, time, and sampler’s initials.

- The monitoring wells will be purged using low-flow procedures. Ground water samples will be collected using a peristaltic pump fitted with silicon tubing and either Tygon® or polyethylene tubing. Pump tubing will be lowered to the middle of the saturated screen depth for purging and sampling. Monitoring wells in which the screened interval is fully saturated will be noted and also be sampled. Monitoring wells will be purged at a rate of less than 0.3 liter per minute. The flow rate will be adjusted as necessary to prevent ground water level from dropping more than 10 percent.

- Field parameters will be measured in purged ground water as it is discharging through a flow-through cell. Ground water will be passed through the cell and discharged into a temporary storage container. Field parameters will be periodically measured (every three minutes) and recorded during well purging and upon stabilization. Field parameters will be measured using a multi-parameter meter. All meters used during sampling will be calibrated that day prior to use and either checked or re-calibrated prior to the second round of sampling activities (if any) that day. Field parameter measurements will include:

    - Temperature
    - pH
    - Dissolved oxygen
    - Redox potential
    - Specific conductance
    - Turbidity

- Ground water samples will be collected after the field parameters have stabilized to within 10 percent of the previous reading. If the parameters do not stabilize, a maximum of five well volumes from each well that does not stabilize will be purged. The purge water will be stored in DOT-approved 55-gallon drums pending characterization. The drums will be disposed of in accordance with the characterization results

- Ground water samples will be collected using low-flow sampling techniques. Pump tubing will be maintained at a mid-screen depth for sampling. Ground water samples will be collected after recording final field parameter readings.

- Ground water samples will be collected from the discharge line of the peristaltic pump. All samples will be transferred in the field from the sampling equipment into the laboratory-prepared containers and stored in a cooler on ice pending transport to the laboratory. Sample container requirements will be verified for the selected analytical laboratory prior to the start of field sampling activities.

- Samples will be labeled, handled, and shipped using the procedures described above. Sample custody will be maintained until delivery to the analytical laboratory. All sampling field activity and data will be recorded on a dedicated purge and sample field form.

- The sampler(s) will wear new nitrile gloves at each sampling location. New Tygon® or polyethylene down-well tubing and new silicon pump-head tubing will be used at each sampling location.

- Quality assurance samples will be collected at the frequency described in Section 4 of Appendix C. Duplicate samples will be collected by alternately filling similar containers until both containers are filled.

- Ground water samples intended for dissolved lead will be filtered in the field using an in-line, 0.45-micron, filter cartridge. The ground water will be collected into a nitric acid-preserved polyethylene container.

6.1.5 Soil Vapor Assessment

Soil vapor samples may be collected at the Site based on the findings of the vapor assessment described in Section 4.2.7. If vapor samples are collected from inside the convenience store building, an ACM survey will be conducted on the building's flooring materials in the vicinity of the planned vapor samples in accordance with Puget Sound Clean Air Agency (PSCAA) and Labor and Industries (L&I) regulations, unless areas lacking finishes can be used.

An electric operated rotary hammer drill with an appropriate 5/8-inch concrete bit will be used to penetrate the paved surfaces while dust and cuttings are vacuumed with a HEPA filtered vacuum. After penetrating the pavement, the hole will be brushed to remove accumulated cuttings and/or dust, again while being vacuumed with a HEPA filtered vacuum. Soil gas sampling implants, consisting of a clean (new or decontaminated) Vapor Pin™ with a silicon sleeve, will be hammered into the penetrations with the sampling tips located approximately one inch below the slab. Dedicated Teflon® sample tubing with a dedicated quick-connect valve will be connected to the Vapor Pin™ at the ground surface to allow for purging and collection of the soil gas samples. As an initial check for the vapor pin seal, a water dam will be used to visually identify any potential leaks with placement of the Vapor Pin™ into the concrete foundation.

Approximately three air volumes or greater will be purged from the dedicated sampling tubing connected to the vapor pin. The three air volumes purged from the vapor pin and dedicated tubing will consist of an approximate 30 second purge using a pump and flow rate set at ~150 milliliters per minute (mL/min), Once the vapor pin and tubing have been purged, the inline quick-connect valve will be closed to begin the 2-hour equilibration process, as recommended by the EPA (USEPA, 2015b).

The remainder of the dedicated sampling train will then be connected after the 2-hour equilibration process has begun. This train will consist of a manifold with a pressure gauge connected to the closed Summa® canister and Teflon® sample tubing connected to a second quick-connect valve, which is then connected to a purge pump. Concurrent with the 2-hour equilibration process, the completed sampling train will be leak tested by using the low flow purge pump (~250 mL/m) to generate a vacuum on the system (i.e., between the check valve and the Summa canister), and then allowing the sealed sampling train to sit with an approximate 10 in Hg negative pressure vacuum. In the event that the pressure gauge bleeds off, the sampling train fittings will be inspected and tightened to attempt to obtain a leak-free sampling train.

Following verification of a sufficient seal utilizing the water dam, a plastic dome (shroud) will be placed over the entire sample system during the collection period. The shroud will be sealed to the ground with a non-toxic modeling clay, plumbers putty, or rubber seal. The variety of clay selected, if used, will not contain VOCs that could off-gas into the sampling train. Although the seal will be used to help contain the helium gas within the shroud, it is not 100% leak free and used only to maintain concentrations of helium against the vapor pin seal to identify potential seal break through. In addition to the visual verification of a sufficient vapor pin seal using the water dam, the collected air sample will be analyzed for helium to determine if there was breakthrough during the sampling time. A dedicated valve on the shroud will allow the helium tracer gas to be added into the sealed shroud during the sample collection period. Upon receipt of the laboratory analytical report, the helium concentrations will be checked with a helium analyzer to identify if break though occurred. A detected helium concentration of 10% of the initial shroud concentration or less will be considered acceptable.

Once the sampling train has been determined to be leak free, the 2-hour equilibration time has passed, the check valve will be opened and the shroud will be placed over the entire system so that a soil vapor sample can be collected. Each 6.0-liter sample Summa® canister (the Summa® canisters will be individually certified for cleanliness by the laboratory prior to their use on the Site) will be filled using a dedicated flow controller set to collect the sample over a 30 to 45 minute time interval; however, the gauge will be monitored closely to ensure that at a minimum negative pressure of 2 to 3 inches of mercury is remaining on the dedicated gauge at the time the Summa® canister valve is closed, secured, and appropriately labeled with pertinent sample information. Canister pressures will be recorded upon initiating sample collection, after sample collection, and after receipt at the laboratory. The sample containers will then be transported under chain-of-custody to the selected analytical laboratory for analysis (Section 6.2.2) on standard turnaround time. After the soil vapor samples have been collected, the Vapor Pin™ will be removed from the foundation and the sampling train will be disassembled. The 5/8-inch penetration will be filled with cement flush with nearby surfaces. Damages to existing floor coverings will not be repaired to original condition.

6.2 Analytical Methods

All of the catch basin solids, stormwater, soil, vapor and ground water samples will be submitted to Friedman & Bruya, Inc., of Seattle, for the suite of analyses required for all Site media. A practical quantitation limit (PQL) of each of the sample analyses as described in the SAP will be applied to ensure that the lowest practical detection limit is used. However, if interference in an analysis prevents the use of the PQL, then the laboratory will use the lowest possible reporting limit that is technically feasible for the sample matrix. PQLs and method detection limits are included in the QAPP (see Appendix D). Sample analyses will not be performed without Ecology approval of the selected analytical methods, laboratories, and PQLs.

6.2.1 Catch Basin Solids, Stormwater, Soil, and Ground water

Laboratory analyses and analytical methods anticipated for soil, catch basin solids, ground water, and stormwater samples include the following:

- Gasoline-range TPH using Method NWTPH-Gx.
- Diesel- and oil-range TPH using Method NWTPH-Dx[1].
- Benzene, toluene, ethyl benzene, total xylenes (BTEX) compounds, methyl tertiary butyl ether (MTBE), 1,2-dichloroethane (EDC), 1,2-dibromoethane (EDB), and/or n-hexane, as appropriate, using Method 8021 or 8260.
- Naphthalenes using Method 8270 SIM.
- Total lead using Method 6010a (soil, sediment).
- Total and dissolved lead using Method 200.8 (ground water, stormwater).
- cPAHs[2] by Method 8270 SIM
- VPH by NWVPH (see below)
- EPH by NWEPH (see below)

Soil samples will be selected for VPH and/or EPH analysis as follows:

- The soil sample with the highest gasoline-range TPH concentration from each reported release area will be submitted for VPH analysis if it is above the MTCA Method A soil cleanup level of 30 mg/kg.

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[1] Since peat deposits have been reported at the Site, particularly on its western portion, silica gel cleanup may be used on some soil samples that exhibit high organic content in order to reduce the possibility of organic matter interference that could yield biased-high TPH-Dx results. Silica gel cleanup will not be performed for water samples.
[2] Soil samples will be analyzed for cPAHs only in the area of the former 280-gallon UST removed in 1997 (north-central area of Site) and the former 550-gallon waste oil UST removed in 1992. If no cPAHs are detected during the initial RI phase, subsequent cPAH analyses will not be performed at the Site.

- One additional soil sample will be selected for VPH analysis from each reported release area if the sample with the highest gasoline concentration also contains benzene at a concentration above 1 mg/kg. The additional VPH sample will be the sample with the highest gasoline-range TPH concentration (above the MTCA Method A soil cleanup level of 30 mg/kg) that also contains benzene at a concentration below 1 mg/kg.

- The soil samples with the highest diesel- and/or oil-range TPH concentrations from each reported release area will be submitted for EPH analysis with target analytes if it is above the MTCA Method A soil cleanup level of 2,000 mg/kg.

6.2.2 Soil Gas

Laboratory analyses and analytical methods anticipated for soil gas include the following:

- BTEX, MTBE, EDB, EDC, n-hexane, and naphthalene using Method TO-15 low level.

6.3 Sample Designation

Soil and ground water samples will be identified by the boring from which they are collected. The soil boring samples will be identified by the soil boring number and the sample depth. For example, the sample collected from boring EB-1 from a depth of 9½ to 10 feet bgs, would be designated “EB-1 9.5 -10’.”

Ground water samples will be identified by the boring and depth from which they are collected. For example, the shallow ground water grab sample collected from boring EB-1, would be designated “EB-1 GW-S-x,” and the deep ground water grab sample collected from boring EB-1 would be designated “EB-1 GW-D-x,” where “x” is the screen intake depth. Ground water sampling depths will also be recorded onto sampling forms and will be considered during data interpretation activities.

The catch basin solids and stormwater samples will be identified by the catch basin name and date.

QA samples (field duplicates) will be submitted blind (i.e., not identified as QA samples) to the laboratory. The QA samples will be labeled with a fictitious sample name (e.g., a nonexistent monitoring well). Trip blanks will be identified with sequential sample number and a date suffix (e.g., TB-1-0612) on the container. Extra samples collected for laboratory duplicates and matrix spike and matrix spike duplicate (MS/MSD) analyses will be identified with the same designation as the sample.

6.4 Sample Management

Sampling Labeling. Sample container labels will be completed immediately before or immediately after sample collection. Container labels will include the following information:

- Project name
- Sample number
- Name of collector
- Date and time of collection
- Analyses requested.

Sample Shipping. Samples will be transported in a sealed, iced cooler. In each cooler, glass bottles will be separated by a shock-absorbing and absorbent material to prevent breakage and leakage. Ice sealed in separate plastic bags, will be placed into each cooler with the samples. All sample coolers will be accompanied by a chain-of-custody form. The completed form will be sealed in a plastic bag and will be transported with the cooler(s). Sample coolers will be transported to the laboratory via courier or by the field sampler.

Chain-of-Custody. Once a sample is collected, it will remain in the custody of the sampler or other Terracon personnel until delivered to the laboratory or picked up by the laboratory's courier. Upon transfer of sample containers to subsequent custodians, a chain-of-custody will be signed by each person transferring custody of the sample container. Upon receipt of samples at the laboratory, the condition of the samples will be recorded by the receiver. Chain-of-custody records will be included in the analytical report prepared by the laboratory.

6.5 Decontamination Procedures

A decontamination area will be established for cleaning drilling equipment and soil sampling equipment. All down-hole drilling equipment will be steam-cleaned or hot water pressure-washed prior to beginning drilling and between drilling each boring. Spoons and other sampling equipment that will contact the soil samples will be decontaminated prior to initial use, between sampling locations, and between different sampling depths at the same location. Soil and catch basin solids sampling equipment will be decontaminated by steam cleaning, hot water pressure washing, or by the following procedure:

- Tap water rinse
- Non-phosphatic detergent (Alconox) and tap water wash
- Tap water rinse
- Distilled water rinse (three times)
- Stored in clean, closed container for next use.

Polyethylene tubing will be dedicated to each temporary well.

6.6 IDW Management

The soil generated by the drilling activities, the wastewater generated by the cleaning of the drilling and sampling equipment, the purging of the temporary wells, and the sampling of the catch basins will be temporarily stored at the Boeing Field Chevron property in properly labeled 55-gallon drums, as described in Section 4.2.5.

6.7 Field Quality Assurance

As described in the QAPP (see Appendix D), field QA will be maintained through compliance with the sampling plan, collection of field QA samples, and documentation of sampling plan alterations.

Duplicate soil, catch basin solids, and ground water samples will be collected at a minimum frequency of one duplicate sample per 10 samples. Duplicate samples will be labeled similar to the other samples and submitted blind to the laboratory. The locations for duplicate sample collection will be determined in the field.

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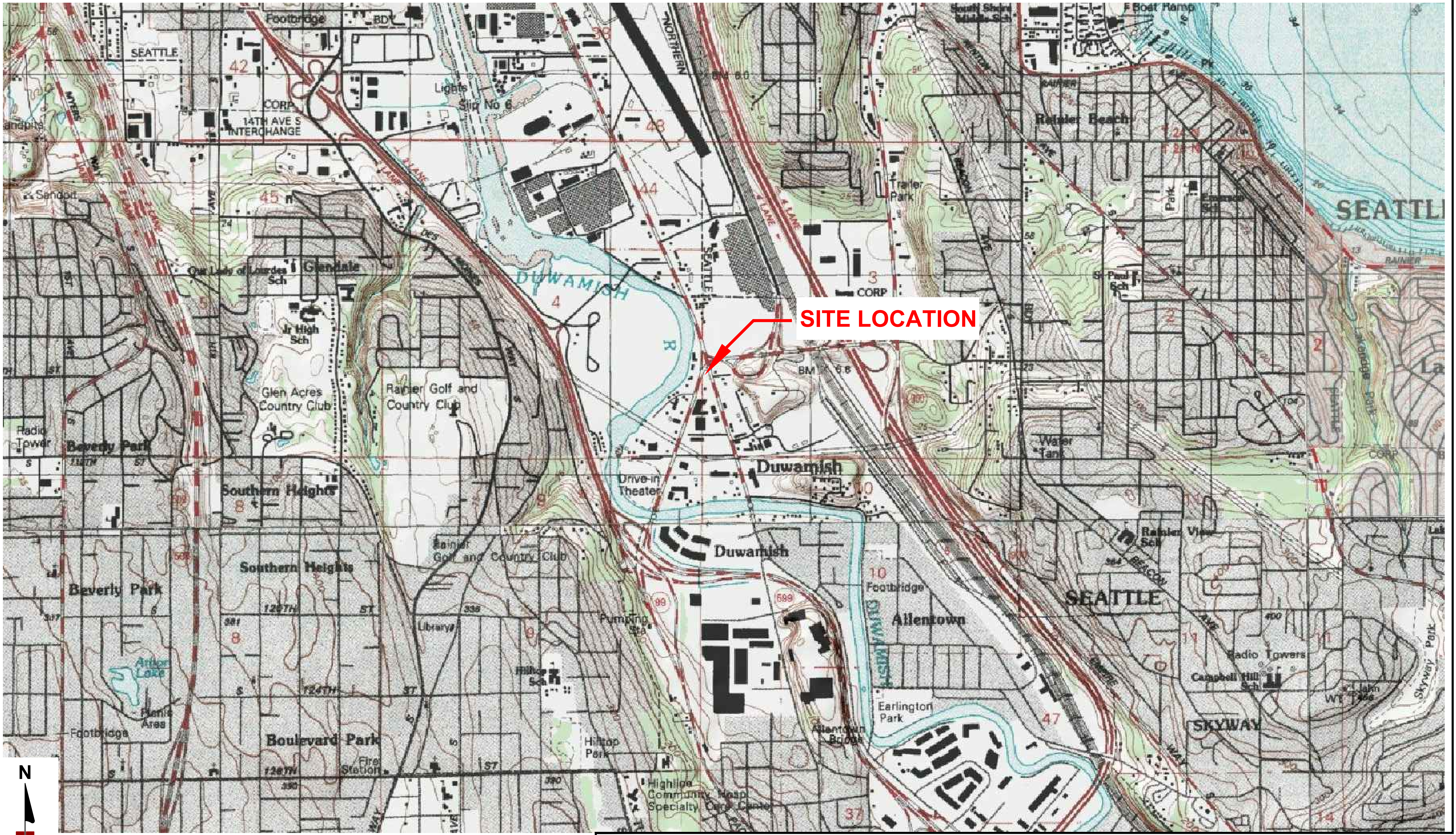
APPENDIX A

Figures and Tables



Project Mngr:	LAR/KLJ
Drawn By:	EMD
Checked By:	~
Approved By:	~

Project No.	B2157002
Scale:	1"=24,000 FT
File No.	EXHIBIT-1
Date:	December 2015

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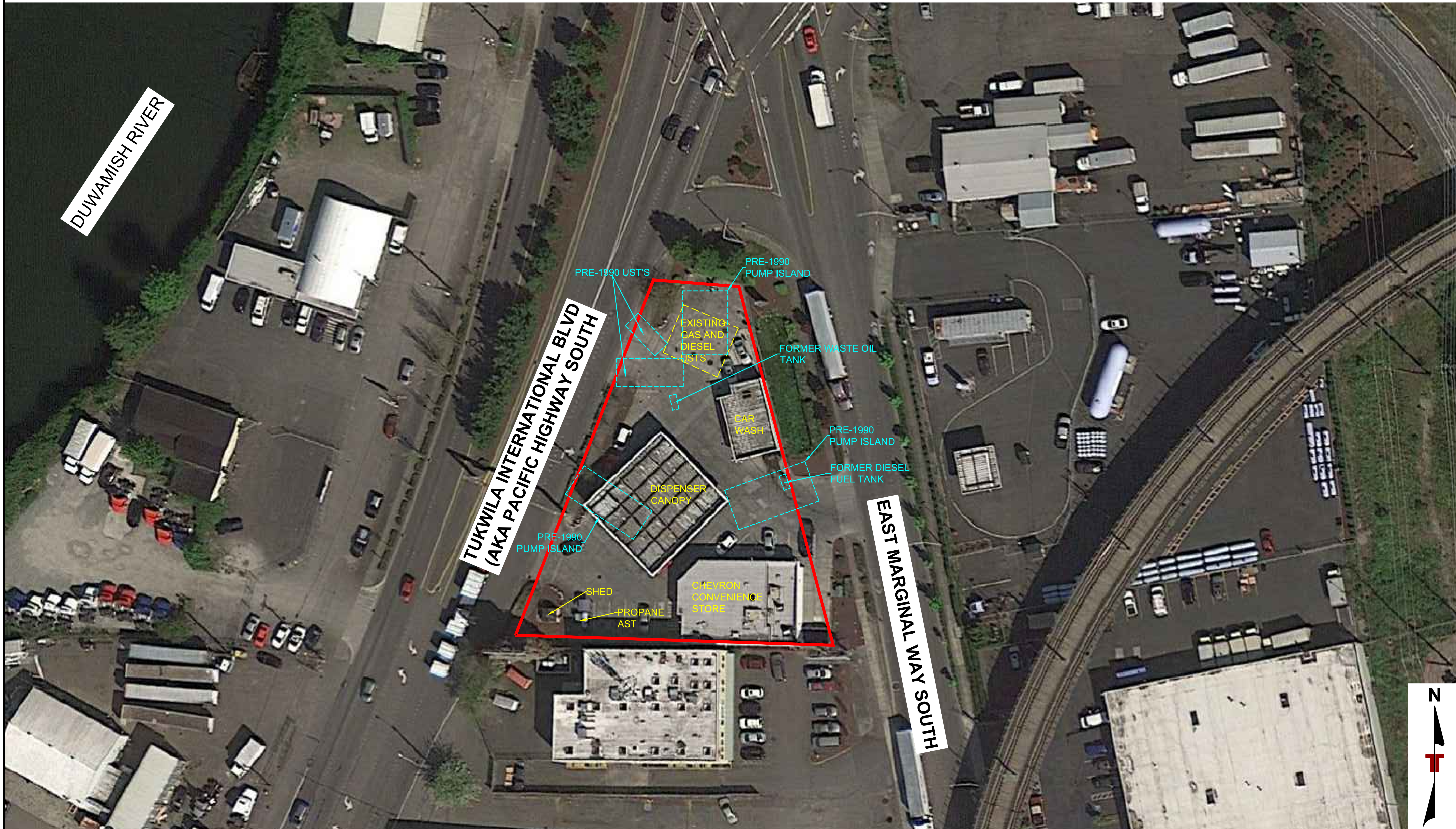
SITE VICINITY MAP

Boeing Field Chevron
10805 East Marginal Way South
Tukwila, King County, Washington

FIGURE
1

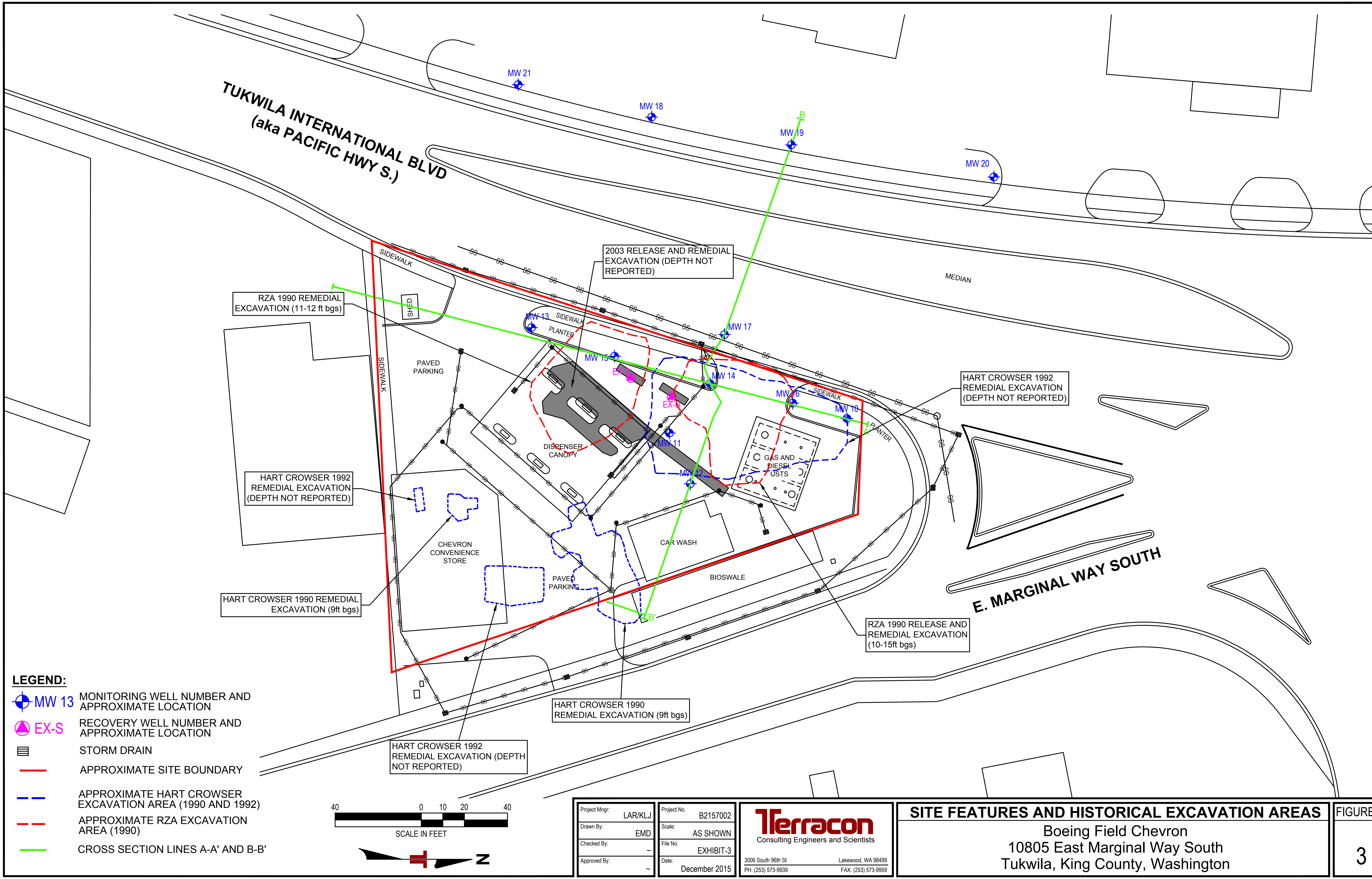


LEGEND:

- SITE BOUNDARY
- EXISTING UST NEST
- APPROXIMATE LOCATION OF HISTORICAL STRUCTURES

Project Mngr: LAR/KLJ	Project No. B2157002	**Terracon** Consulting Engineers and Scientists	**GENERAL SITE LAYOUT**
Drawn By: EMD	Scale: AS SHOWN	3006 South 96th St Lakewood, WA 98499	Boeing Field Chevron
Checked By: ~	File No. EXHIBIT-2	PH. (253) 573-9939 FAX. (253) 573-9959	10805 East Marginal Way South
Approved By: ~	Date: December 2015		Tukwila, King County, Washington

FIGURE 2



TUKWILA INTERNATIONAL BLVD
(aka PACIFIC HWY S.)
MW 21
MW 18
MW 19
MW 20
B
MEDIAN
2003 RELEASE AND REMEDIAL EXCAVATION (DEPTH NOT REPORTED)
RZA 1990 REMEDIAL EXCAVATION (11-12 ft bgs)
SIDEWALK
SHED
MW 13
SIDEWALK
PLANTER
MW 17
PAVED PARKING
MW 15
EX-S
MW 14
EX-N
MW 16
MW 10
SIDEWALK
PLANTER
A'
HART CROWSER 1992 REMEDIAL EXCAVATION (DEPTH NOT REPORTED)
DISPENSER CANOPY
MW 11
GAS AND DIESEL USTS
MW 12
HART CROWSER 1992 REMEDIAL EXCAVATION (DEPTH NOT REPORTED)
CHEVRON CONVENIENCE STORE
CAR WASH
PAVED PARKING
BIOSWALE
HART CROWSER 1990 REMEDIAL EXCAVATION (9ft bgs)
B'
E. MARGINAL WAY SOUTH
RZA 1990 RELEASE AND REMEDIAL EXCAVATION (10-15ft bgs)
HART CROWSER 1990 REMEDIAL EXCAVATION (9ft bgs)
HART CROWSER 1992 REMEDIAL EXCAVATION (DEPTH NOT REPORTED)
LEGEND:
MW 13 MONITORING WELL NUMBER AND APPROXIMATE LOCATION
EX-S RECOVERY WELL NUMBER AND APPROXIMATE LOCATION
STORM DRAIN
APPROXIMATE SITE BOUNDARY
APPROXIMATE HART CROWSER EXCAVATION AREA (1990 AND 1992)
APPROXIMATE RZA EXCAVATION AREA (1990)
CROSS SECTION LINES A-A' AND B-B'
40 0 10 20 40
SCALE IN FEET
N
Project Mngr: LAR/KLJ
Drawn By: EMD
Checked By: ~
Approved By: ~
Project No. B2157002
Scale: AS SHOWN
File No. EXHIBIT-3
Date: December 2015
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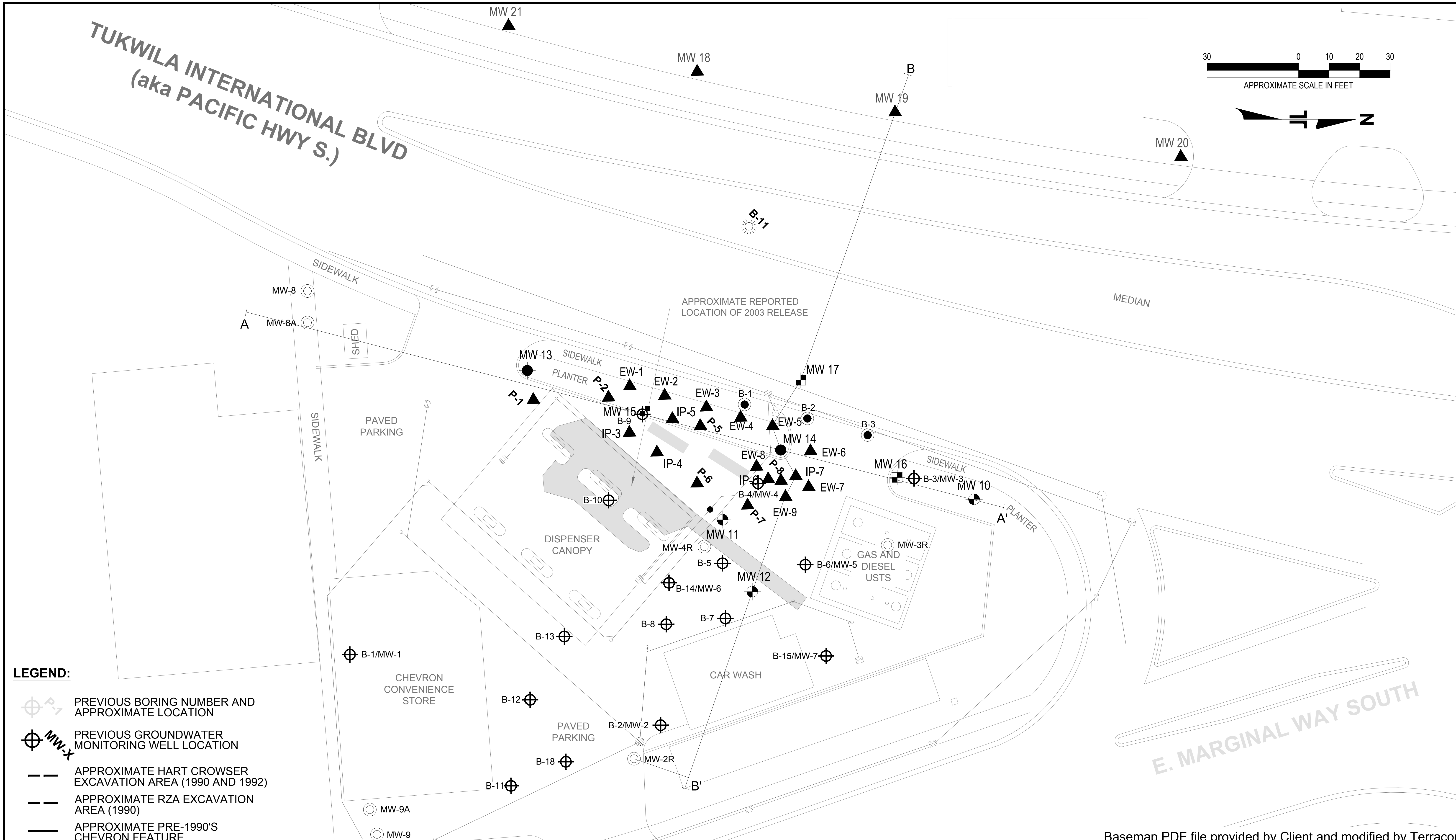
SITE FEATURES AND HISTORICAL EXCAVATION AREAS
Boeing Field Chevron
10805 East Marginal Way South
Tukwila, King County, Washington
FIGURE
3



LEGEND:

- PREVIOUS BORING NUMBER AND APPROXIMATE LOCATION
- MW-X PREVIOUS GROUNDWATER MONITORING WELL LOCATION
- APPROXIMATE HART CROWSER EXCAVATION AREA (1990 AND 1992)
- APPROXIMATE RZA EXCAVATION AREA (1990)
- APPROXIMATE PRE-1990'S CHEVRON FEATURE
- CROSS SECTION LINES A-A' AND B-B'
- Hart Crowser 1993b.
- Hart Crowser 1993c.
- RZA 1990b.
- PEG 1997b.
- ERI 2004b.
- ERI 2005a.
- ERI 2005c.
- G-Logics 2008c.

Basemap PDF file provided by Client and modified by Terracon.

Project Mngr:	LAR/KLJ	Project No.	B2157002
Drawn By:	EMD	Scale:	AS SHOWN
Checked By:	~	File No.	EXHIBIT-4
Approved By:	~	Date:	December 2015

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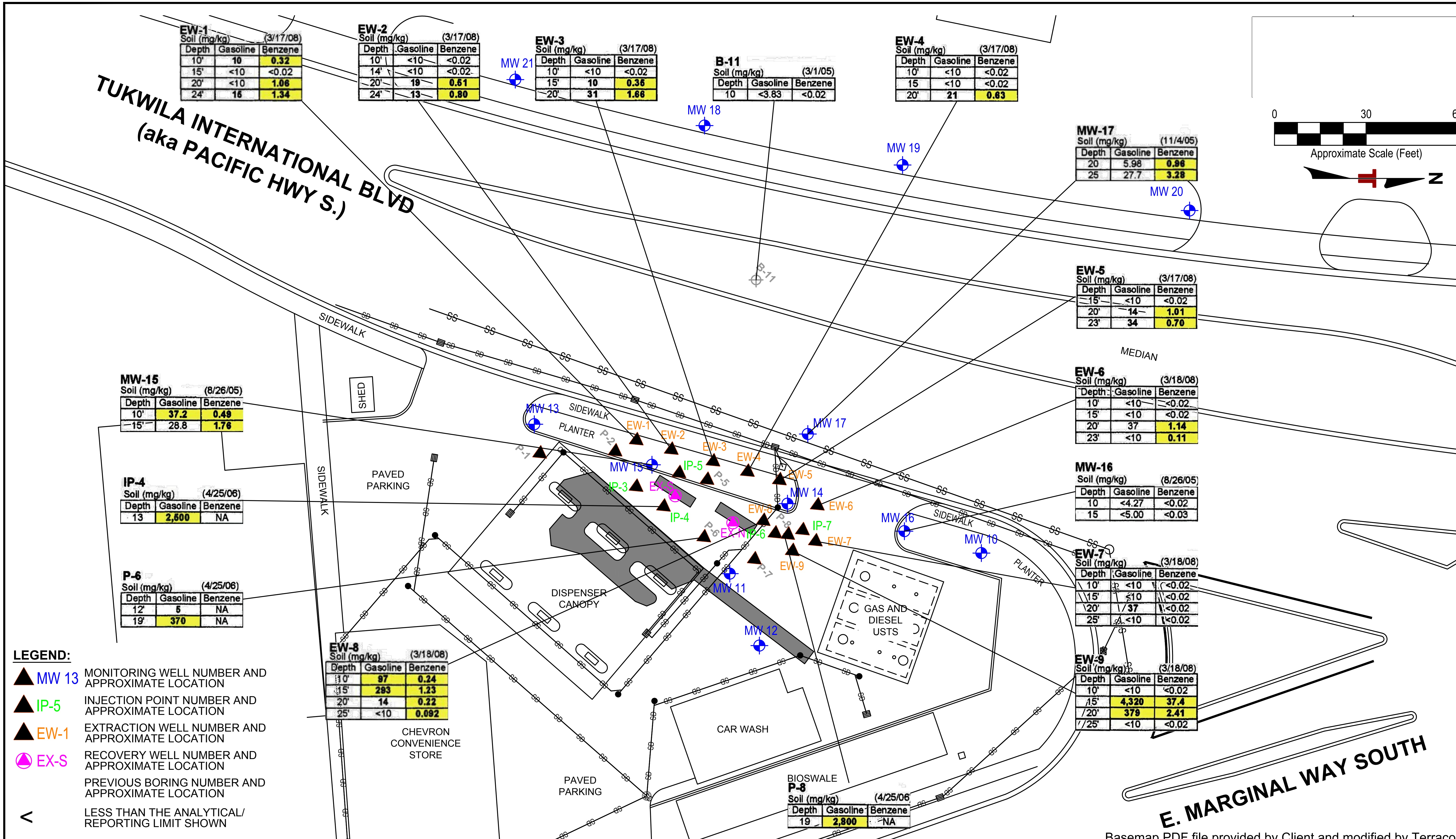
HISTORICAL SUBSURFACE EXPLORATIONS

Boeing Field Chevron
10805 East Marginal Way South
Tukwila, King County, Washington

FIGURE 4



EW-1 Soil (mg/kg) (3/17/08)

Depth	Gasoline	Benzene
10'	**10**	**0.32**
15'	<10	<0.02
20'	<10	**1.06**
24'	**16**	**1.34**

EW-2 Soil (mg/kg) (3/17/08)

Depth	Gasoline	Benzene
10'	<10	<0.02
14'	<10	<0.02
20'	**19**	**0.51**
24'	**13**	**0.80**

EW-3 Soil (mg/kg) (3/17/08)

Depth	Gasoline	Benzene
10'	<10	<0.02
15'	**10**	**0.36**
20'	**31**	**1.66**

B-11 Soil (mg/kg) (3/1/05)

Depth	Gasoline	Benzene
10	<3.83	<0.02

EW-4 Soil (mg/kg) (3/17/08)

Depth	Gasoline	Benzene
10'	<10	<0.02
15	<10	<0.02
20'	**21**	**0.63**

MW-17 Soil (mg/kg) (11/4/05)

Depth	Gasoline	Benzene
20	5.98	**0.96**
25	27.7	**3.28**

EW-5 Soil (mg/kg) (3/17/08)

Depth	Gasoline	Benzene
15'	<10	<0.02
20'	**14**	**1.01**
23'	**34**	**0.70**

EW-6 Soil (mg/kg) (3/18/08)

Depth	Gasoline	Benzene
10'	<10	<0.02
15'	<10	<0.02
20'	37	**1.14**
23'	<10	**0.11**

MW-16 Soil (mg/kg) (8/26/05)

Depth	Gasoline	Benzene
10	<4.27	<0.02
15	<5.00	<0.03

EW-7 Soil (mg/kg) (3/18/08)

Depth	Gasoline	Benzene
10'	<10	<0.02
15'	<10	<0.02
20'	**37**	<0.02
25'	<10	<0.02

EW-9 Soil (mg/kg) (3/18/08)

Depth	Gasoline	Benzene
10'	<10	<0.02
15'	**4,320**	**37.4**
20'	**379**	**2.41**
25'	<10	<0.02

MW-15 Soil (mg/kg) (8/26/05)

Depth	Gasoline	Benzene
10'	**37.2**	**0.49**
15'	28.8	**1.76**

IP-4 Soil (mg/kg) (4/25/06)

Depth	Gasoline	Benzene
13	**2,500**	NA

P-6 Soil (mg/kg) (4/25/06)

Depth	Gasoline	Benzene
12'	**5**	NA
19'	**370**	NA

EW-8 Soil (mg/kg) (3/18/08)

Depth	Gasoline	Benzene
10'	**97**	**0.24**
15'	**293**	**1.23**
20'	**14**	**0.22**
25'	<10	**0.092**

P-8 Soil (mg/kg) (4/25/06)

Depth	Gasoline	Benzene
19	**2,800**	NA

LEGEND:

- MW 13 — MONITORING WELL NUMBER AND APPROXIMATE LOCATION
- IP-5 — INJECTION POINT NUMBER AND APPROXIMATE LOCATION
- EW-1 — EXTRACTION WELL NUMBER AND APPROXIMATE LOCATION
- EX-S — RECOVERY WELL NUMBER AND APPROXIMATE LOCATION
- PREVIOUS BORING NUMBER AND APPROXIMATE LOCATION
- < — LESS THAN THE ANALYTICAL/ REPORTING LIMIT SHOWN
- 30 mg/kg — MTCA METHOD A CLEANUP LEVEL FOR GASOLINE
- 0.03 mg/kg — MTCA METHOD A CLEANUP LEVEL FOR BENZENE

NOTE: See figure 4 for a breakdown of boring and wells by investigation and year.

NOTE: Laboratory results are **bolded**, MTCA Method A exceedances are highlighted.
-Data shown on figure is for sampling conducted subsequent to 2003 release.

SOURCE: G-Logics, 2008, Subsurface Site Characterization.

Project Mngr:	LAR/KLJ
Drawn By:	EMD
Checked By:	~
Approved By:	~

Project No.	B2157002
Scale:	AS SHOWN
File No.	EXHIBIT-5
Date:	December 2015

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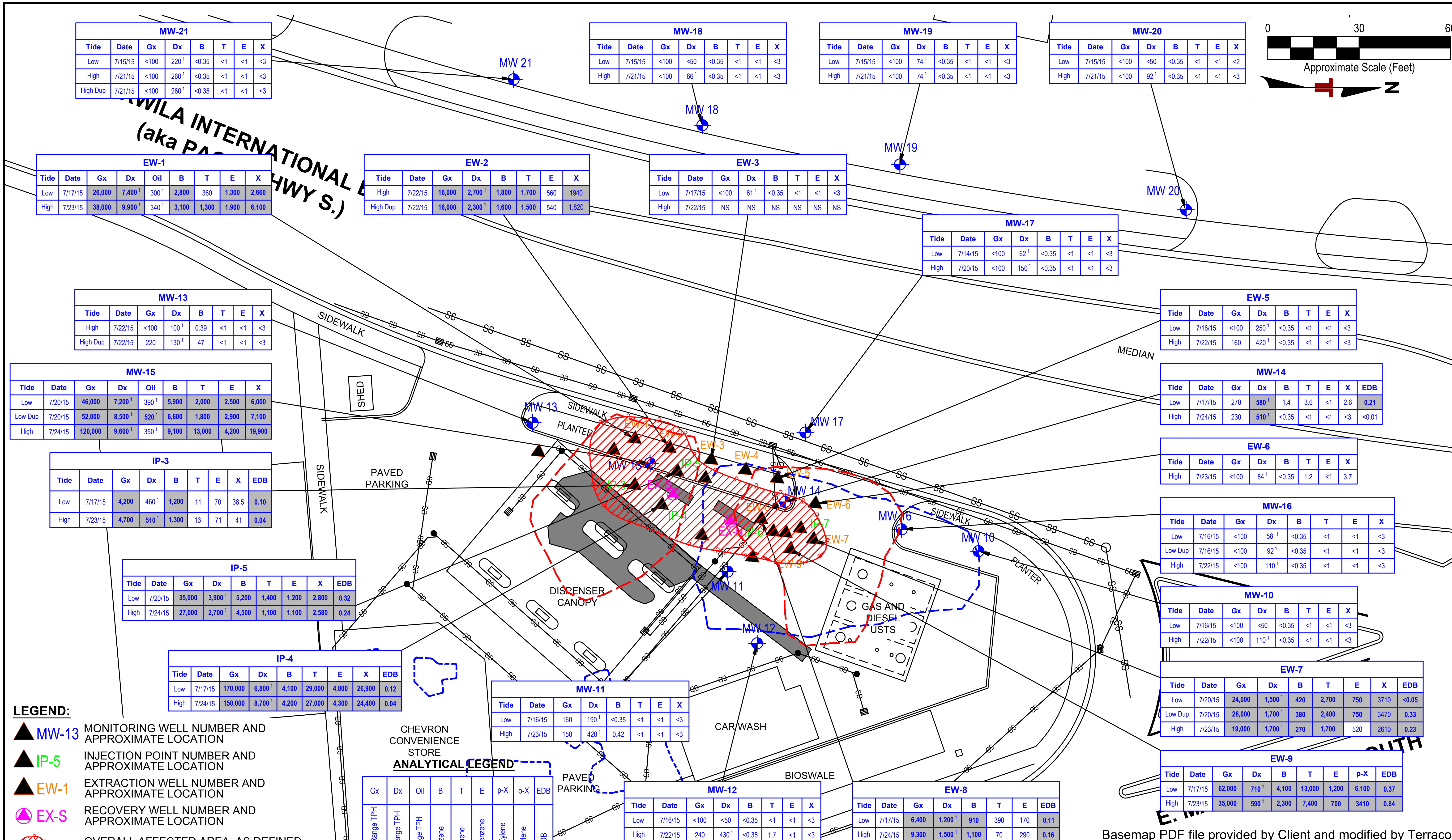
GASOLINE AND BENZENE IN SOIL

Boeing Field Chevron
10805 East Marginal Way South
Tukwila, King County, Washington

FIGURE 5



MW-21							
Tide	Date	Gx	Dx	B	T	E	X
Low	7/15/15	<100	220 [1]	<0.35	<1	<1	<3
High	7/21/15	<100	260 [1]	<0.35	<1	<1	<3
High Dup	7/21/15	<100	260 [1]	<0.35	<1	<1	<3

MW-18							
Tide	Date	Gx	Dx	B	T	E	X
Low	7/15/15	<100	<50	<0.35	<1	<1	<3
High	7/21/15	<100	66 [1]	<0.35	<1	<1	<3

MW-19							
Tide	Date	Gx	Dx	B	T	E	X
Low	7/15/15	<100	74 [1]	<0.35	<1	<1	<3
High	7/21/15	<100	74 [1]	<0.35	<1	<1	<3

MW-20							
Tide	Date	Gx	Dx	B	T	E	X
Low	7/15/15	<100	<50	<0.35	<1	<1	<2
High	7/21/15	<100	92 [1]	<0.35	<1	<1	<3

EW-1								
Tide	Date	Gx	Dx	Oil	B	T	E	X
Low	7/17/15	26,000	7,400 [1]	300 [1]	2,800	360	1,300	2,660
High	7/23/15	38,000	9,900 [1]	340 [1]	3,100	1,300	1,900	6,100

EW-2							
Tide	Date	Gx	Dx	B	T	E	X
High	7/22/15	16,000	2,700 [1]	1,800	1,700	560	1940
High Dup	7/22/15	16,000	2,300 [1]	1,600	1,500	540	1,820

EW-3							
Tide	Date	Gx	Dx	B	T	E	X
Low	7/17/15	<100	61 [1]	<0.35	<1	<1	<3
High	7/22/15	NS	NS	NS	NS	NS	NS

MW-17							
Tide	Date	Gx	Dx	B	T	E	X
Low	7/14/15	<100	62 [1]	<0.35	<1	<1	<3
High	7/20/15	<100	150 [1]	<0.35	<1	<1	<3

MW-13							
Tide	Date	Gx	Dx	B	T	E	X
High	7/22/15	<100	100 [1]	0.39	<1	<1	<3
High Dup	7/22/15	220	130 [1]	47	<1	<1	<3

EW-5							
Tide	Date	Gx	Dx	B	T	E	X
Low	7/16/15	<100	250 [1]	<0.35	<1	<1	<3
High	7/22/15	160	420 [1]	<0.35	<1	<1	<3

MW-15								
Tide	Date	Gx	Dx	Oil	B	T	E	X
Low	7/20/15	46,000	7,200 [1]	390 [1]	5,900	2,000	2,500	6,000
Low Dup	7/20/15	52,000	8,500 [1]	520 [1]	6,600	1,800	2,900	7,100
High	7/24/15	120,000	9,600 [1]	350 [1]	9,100	13,000	4,200	19,900

MW-14								
Tide	Date	Gx	Dx	B	T	E	X	EDB
Low	7/17/15	270	580 [1]	1.4	3.6	<1	2.6	0.21
High	7/24/15	230	510 [1]	<0.35	<1	<1	<3	<0.01

EW-6							
Tide	Date	Gx	Dx	B	T	E	X
High	7/23/15	<100	84 [1]	<0.35	1.2	<1	3.7

IP-3								
Tide	Date	Gx	Dx	B	T	E	X	EDB
Low	7/17/15	4,200	460 [1]	1,200	11	70	38.5	0.10
High	7/23/15	4,700	510 [1]	1,300	13	71	41	0.04

MW-16							
Tide	Date	Gx	Dx	B	T	E	X
Low	7/16/15	<100	58 [1]	<0.35	<1	<1	<3
Low Dup	7/16/15	<100	92 [1]	<0.35	<1	<1	<3
High	7/22/15	<100	110 [1]	<0.35	<1	<1	<3

IP-5								
Tide	Date	Gx	Dx	B	T	E	X	EDB
Low	7/20/15	35,000	3,900 [1]	5,200	1,400	1,200	2,800	0.32
High	7/24/15	27,000	2,700 [1]	4,500	1,100	1,100	2,580	0.24

MW-10							
Tide	Date	Gx	Dx	B	T	E	X
Low	7/16/15	<100	<50	<0.35	<1	<1	<3
High	7/22/15	<100	110 [1]	<0.35	<1	<1	<3

IP-4								
Tide	Date	Gx	Dx	B	T	E	X	EDB
Low	7/17/15	170,000	6,800 [1]	4,100	29,000	4,800	26,900	0.12
High	7/24/15	150,000	8,700 [1]	4,200	27,000	4,300	24,400	0.04

EW-7								
Tide	Date	Gx	Dx	B	T	E	X	EDB
Low	7/20/15	24,000	1,500 [1]	420	2,700	750	3710	<0.05
Low Dup	7/20/15	26,000	1,700 [1]	380	2,400	750	3470	0.33
High	7/23/15	19,000	1,700 [1]	270	1,700	520	2610	0.23

MW-11							
Tide	Date	Gx	Dx	B	T	E	X
Low	7/16/15	160	190 [1]	<0.35	<1	<1	<3
High	7/23/15	150	420 [1]	0.42	<1	<1	<3

EW-9								
Tide	Date	Gx	Dx	B	T	E	p-X	EDB
Low	7/17/15	62,000	710 [1]	4,100	13,000	1,200	6,100	0.37
High	7/23/15	35,000	590 [1]	2,300	7,400	700	3410	0.84

MW-12							
Tide	Date	Gx	Dx	B	T	E	X
Low	7/16/15	<100	<50	<0.35	<1	<1	<3
High	7/22/15	240	430 [1]	<0.35	1.7	<1	<3

EW-8							
Tide	Date	Gx	Dx	B	T	E	EDB
Low	7/17/15	6,400	1,200 [1]	910	390	170	0.11
High	7/24/15	9,300	1,500 [1]	1,100	70	290	0.16

Basemap PDF file provided by Client and modified by Terracon.

LEGEND:

- ▲ MW-13 — MONITORING WELL NUMBER AND APPROXIMATE LOCATION
- ▲ IP-5 — INJECTION POINT NUMBER AND APPROXIMATE LOCATION
- ▲ EW-1 — EXTRACTION WELL NUMBER AND APPROXIMATE LOCATION
- EX-S — RECOVERY WELL NUMBER AND APPROXIMATE LOCATION
- (hatched area) — OVERALL AFFECTED AREA, AS DEFINED BY MTCA METHOD A EXCEEDANCES

NOTE: See figure 4 for a breakdown of boring and wells by investigation and year.

ANALYTICAL LEGEND

Gx	Dx	Oil	B	T	E	p-X	o-X	EDB
Gasoline-Range TPH	Diesel-Range TPH	Oil-Range TPH	Benzene	Toluene	Ethylbenzene	m,p-Xylene	o-Xylene	EDB

-All concentrations in micrograms per liter (ug/L)

1 SAMPLE CHROMATOGRAPHIC PATTERN DOES NOT RESEMBLE THE FUEL STANDARD USED FOR QUANTIFICATION

GRAY-SHADED BOXES INDICATE MTCA METHOD A GROUND WATER CLEANUP LEVEL EXCEEDANCES.

Source of Analytical Data (Terracon, 2015)

Project Mngr:	LAR/KLJ	Project No.	B2157002
Drawn By:	EMD	Scale:	AS SHOWN
Checked By:	~	File No.	EXHIBIT-6
Approved By:	~	Date:	December 2015

Terracon
Consulting Engineers and Scientists
3006 South 96th St Lakewood, WA 98499
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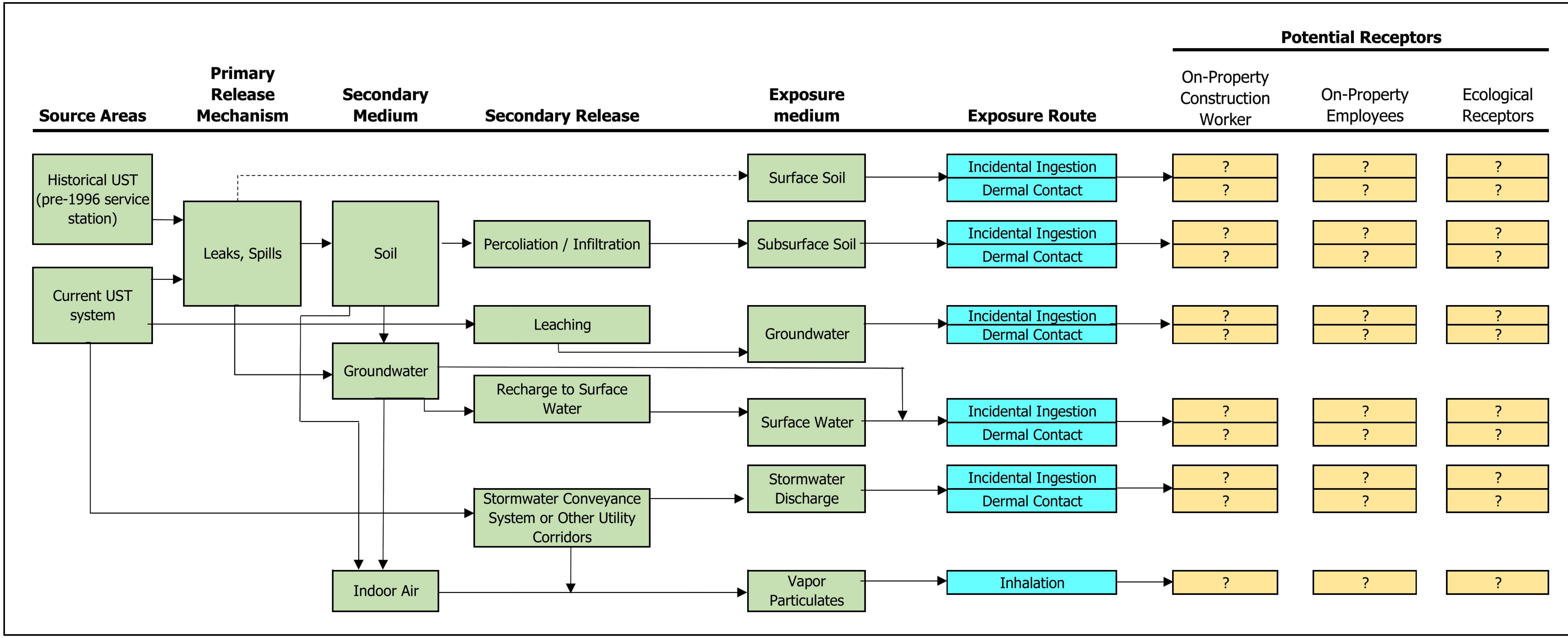
GROUNDWATER RESULTS FOR COPC'S - JULY 2015

Boeing Field Chevron
10805 East Marginal Way South
Tukwila, King County, Washington

FIGURE 6



? — Potentially complete exposure pathway

Conceptual Site Model

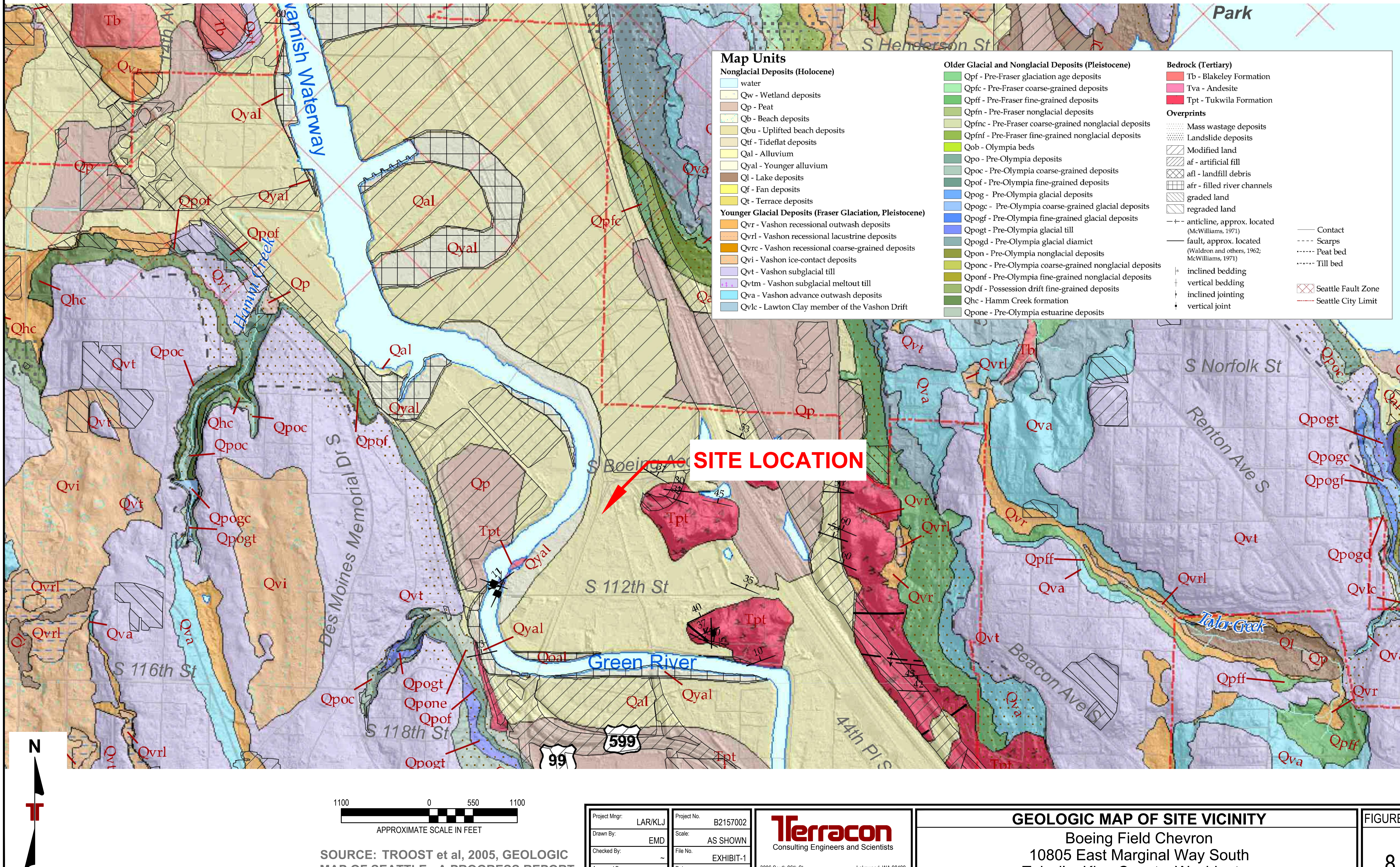
Preliminary Conceptual Site Exposure Model

NOTE: Figure depicts a preliminary assessment of potential exposure pathways. All potential pathways are to be fully evaluated as part of the RI/FS.

Source: Ecology

Project Mngr: LAR/KLJ	Project No. B2157002	Terracon — Consulting Engineers and Scientists	PRELIMINARY CONCEPTUAL SITE MODEL
Drawn By: EMD	Scale: NOT TO SCALE	3006 South 96th St, Lakewood, WA 98499	Boeing Field Chevron
Checked By: ~	File No. EXHIBIT-1	PH. (253) 573-9939 FAX. (253) 573-9959	10805 East Marginal Way South
Approved By: ~	Date: December 2015		Tukwila, King County, Washington

FIGURE 7



1100 0 550 1100

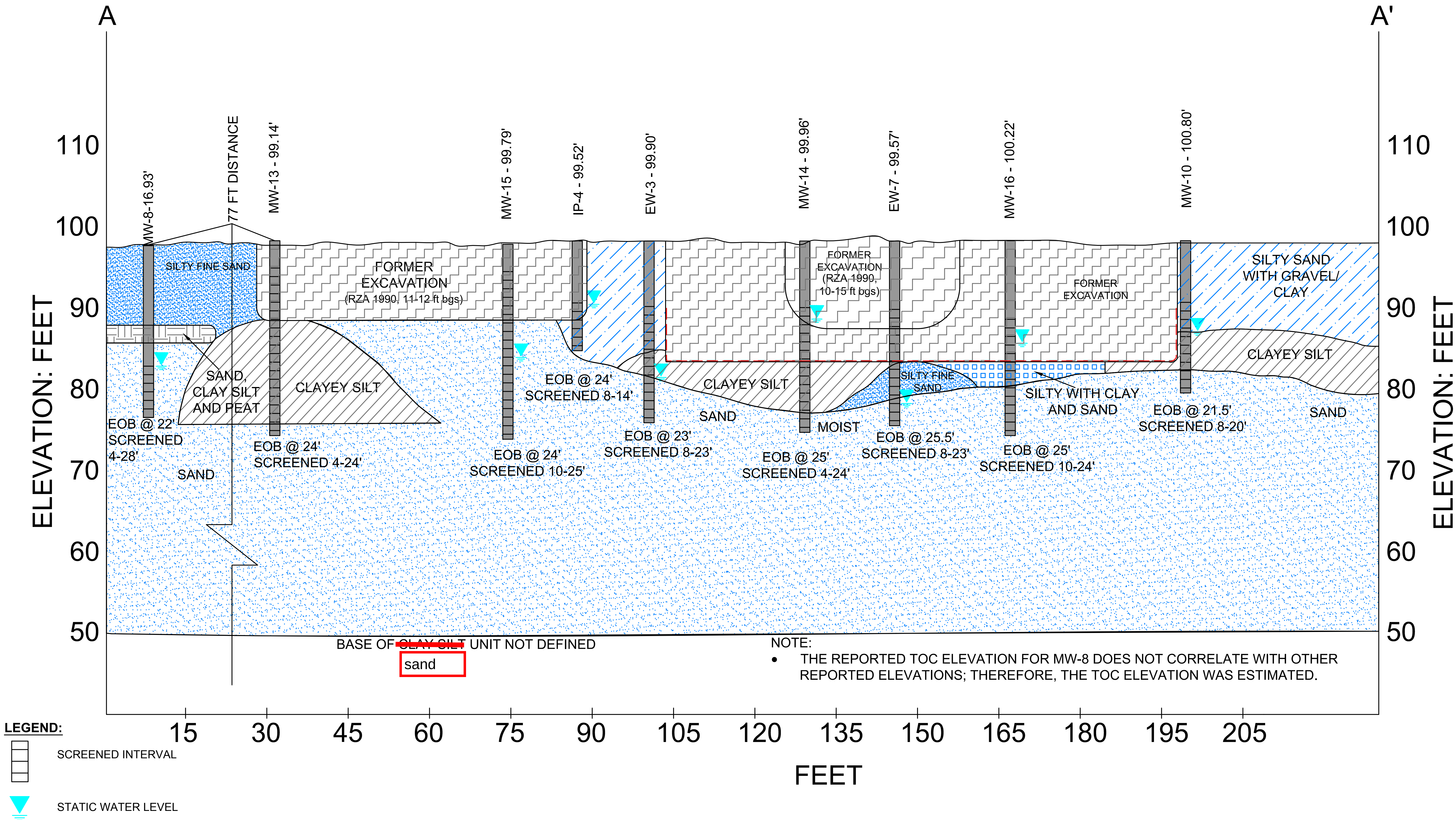
APPROXIMATE SCALE IN FEET

SOURCE: TROOST et al, 2005, GEOLOGIC MAP OF SEATTLE - A PROGRESS REPORT

Project Mngr: LAR/KLJ	Project No. B2157002	**Terracon** Consulting Engineers and Scientists	**GEOLOGIC MAP OF SITE VICINITY**
Drawn By: EMD	Scale: AS SHOWN	3006 South 96th St Lakewood, WA 98499	Boeing Field Chevron
Checked By: ~	File No. EXHIBIT-1	PH. (253) 573-9939 FAX. (253) 573-9959	10805 East Marginal Way South
Approved By: ~	Date: December 2015		Tukwila, King County, Washington

FIGURE

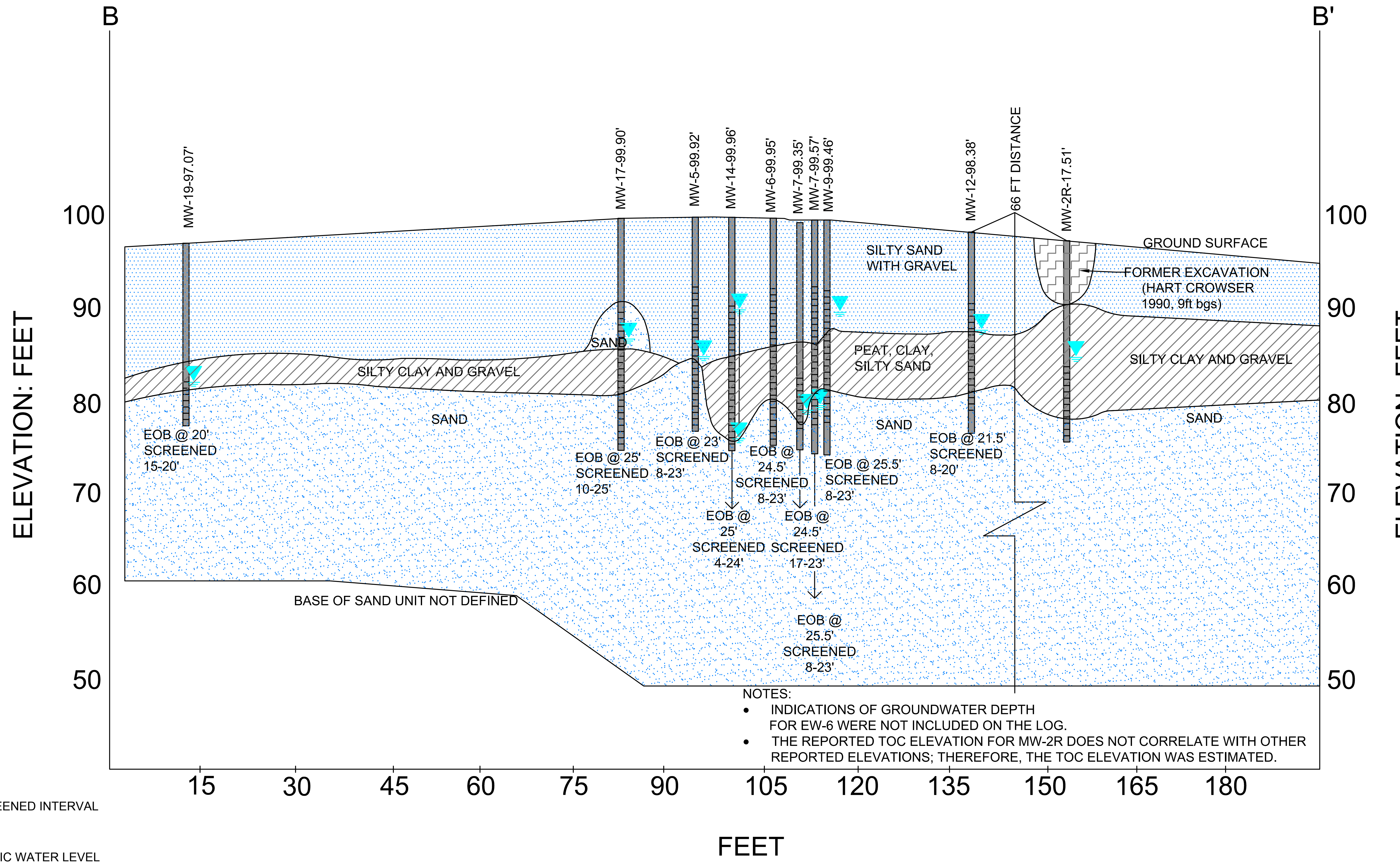
8



NOTES:
- PLEASE REFER TO CROSS SECTION LINES ON FIGURES 3-4.
- ELEVATIONS BASED ON ARBITRARY DATUM.
- EOB= END OF BORING

Project Mngr: LAR/KLJ	Project No. B2157002	Terracon Consulting Engineers and Scientists 3006 South 96th St Lakewood, WA 98499 PH. (253) 573-9939 FAX. (253) 573-9959	**GENERALIZED CROSS SECTION A-A** Boeing Field Chevron 10805 East Marginal Way South Tukwila, King County, Washington
Drawn By: EMD	Scale: AS SHOWN		
Checked By: ~	File No. EXHIBIT-8		
Approved By: ~	Date: December 2015		

FIGURE 9



NOTES:

- INDICATIONS OF GROUNDWATER DEPTH FOR EW-6 WERE NOT INCLUDED ON THE LOG.
- THE REPORTED TOC ELEVATION FOR MW-2R DOES NOT CORRELATE WITH OTHER REPORTED ELEVATIONS; THEREFORE, THE TOC ELEVATION WAS ESTIMATED.

LEGEND:

SCREENED INTERVAL

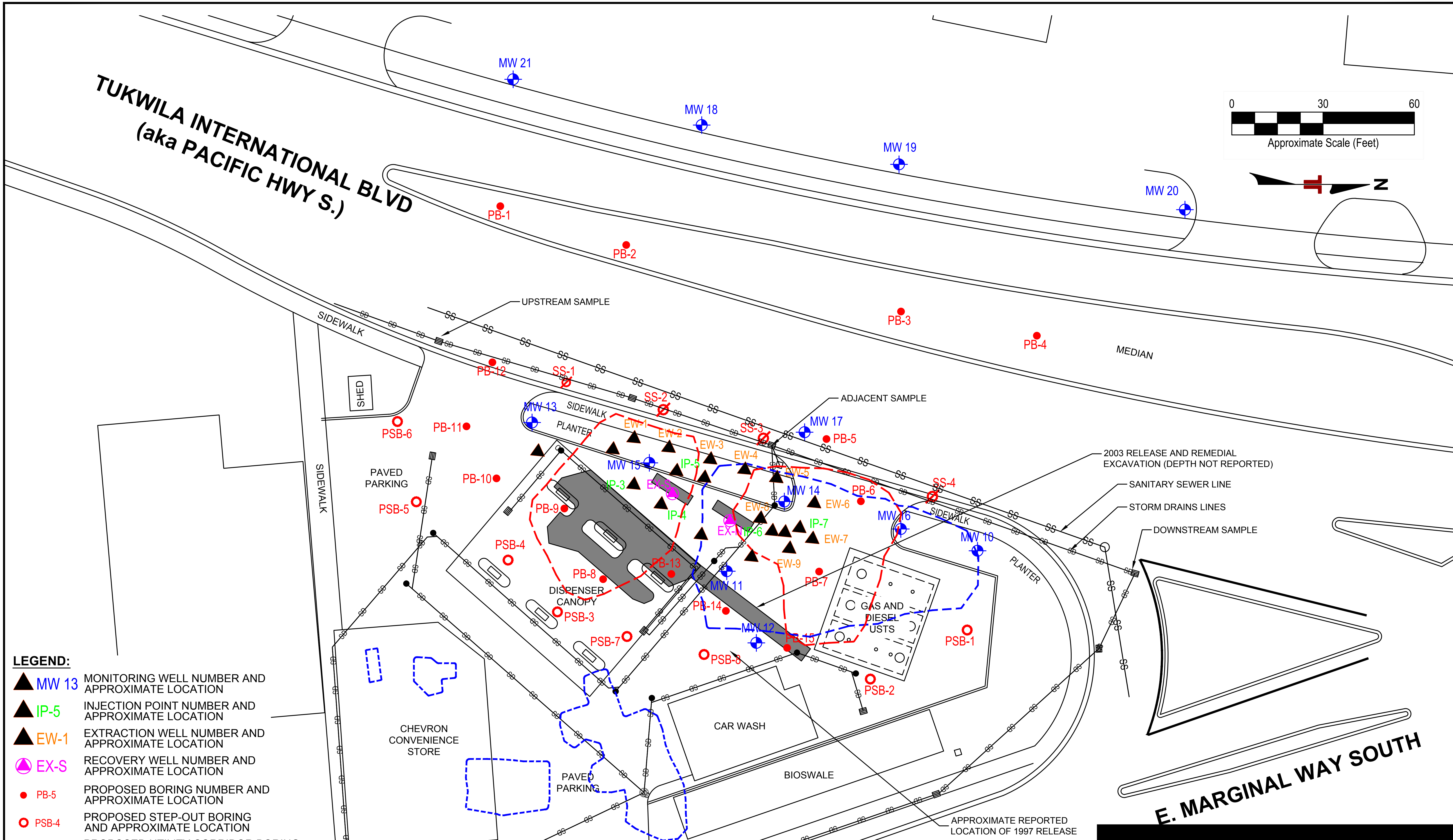
STATIC WATER LEVEL

NOTES:

- PLEASE REFER TO CROSS SECTION LINES ON FIGURES 3-4.
- ELEVATIONS BASED ON ARBITRARY DATUM.
- EOB= END OF BORING

Project Mngr: LAR/KLJ	Project No. B2157002	Terracon Consulting Engineers and Scientists	**GENERALIZED CROSS SECTION B-B**
Drawn By: EMD	Scale: AS SHOWN	3006 South 96th St Lakewood, WA 98499	Boeing Field Chevron
Checked By: ~	File No. EXHIBIT-9	PH. (253) 573-9939 FAX. (253) 573-9959	10805 East Marginal Way South
Approved By: ~	Date: December 2015		Tukwila, King County, Washington

FIGURE 10



LEGEND:

MW 13	MONITORING WELL NUMBER AND APPROXIMATE LOCATION
IP-5	INJECTION POINT NUMBER AND APPROXIMATE LOCATION
EW-1	EXTRACTION WELL NUMBER AND APPROXIMATE LOCATION
EX-S	RECOVERY WELL NUMBER AND APPROXIMATE LOCATION
PB-5	PROPOSED BORING NUMBER AND APPROXIMATE LOCATION
PSB-4	PROPOSED STEP-OUT BORING AND APPROXIMATE LOCATION
SS-3	PROPOSED UTILITY CORRIDOR BORING AND APPROXIMATE LOCATION

NOTE: See figure 4 for a breakdown of boring and wells by investigation and year.

Project Mngr: LAR/KLJ	Project No. B2157002
Drawn By: EMD	Scale: AS SHOWN
Checked By: ~	File No. EXHIBIT-10
Approved By: ~	Date: December 2015

Terracon
Consulting Engineers and Scientists
3006 South 96th St Lakewood, WA 98499
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PROPOSED RI SAMPLE LOCATION MAP
Boeing Field Chevron
10805 East Marginal Way South
Tukwila, King County, Washington

FIGURE 11

TABLE 1 SUMMARY OF PROPOSED SAMPLE LOCATIONS AND DATA GAPS ADDRESSED
Boeing Field Chevron Site
10805 Tukwila International Blvd., Tukwila, Washington

Sample Location Designation	Sample Location[a]	General Data Gap(s) Evaluated (see Appendix C for full list)						Rationale for Boring Location and Specific Data Needs Addressed	Soil Samples			Ground Water Samples			Proposed Step-out Locations in Proximity to Location[a]
		1	2	3	4	5	6		Standard Intervals[b]	Utility Trench[c]	Shallow Soil[d]	Shallow Zone[e]	Deeper Zone[f]	Utility Trench[g]	
Initial Soil Borings															
PB-1	Tukwila International Blvd Median Area West of BFC Property		x	x	x	x		Evaluation of soil and groundwater conditions west of the TIB utility corridor. Geologic/hydrogeological characterization to update CSM.	X			X	X		None specified, but additional step-out locations will be identified if necessary based on initial boring findings.
PB-2	Tukwila International Blvd Median Area West of BFC Property		x	x	x	x		Evaluation of soil and groundwater conditions west of the TIB utility corridor. Geologic/hydrogeological characterization to update CSM.	X			X	X		None specified, but additional step-out locations will be identified if necessary based on initial boring findings.
PB-3	Tukwila International Blvd Median Area West of BFC Property		x	x	x	x		Evaluation of soil and groundwater conditions west of the TIB utility corridor. Geologic/hydrogeological characterization to update CSM.	X			X	X		None specified, but additional step-out locations will be identified if necessary based on initial boring findings.
PB-4	Tukwila International Blvd Median Area West of BFC Property		x	x	x	x		Evaluation of soil and groundwater conditions west of the TIB utility corridor. Geologic/hydrogeological characterization to update CSM.	X			X	X		None specified, but additional step-out locations will be identified if necessary based on initial boring findings.
PB-5	Tukwila International Blvd Traffic Lane West of BFC Property (at MW-17)	x	x	x	x	x	x	Evaluation of soil, groundwater, and NAPL conditions in the vicinity of the 1990/1992/2003 release area. Geologic/hydrogeological characterization to update CSM.	X			X	X		None specified, but additional step-out locations will be identified if necessary based on initial boring findings.
PB-6	West of 1990/1992 release excavation, north of LNAPL detection	x	x	x	x	x	x	Evaluation of soil, groundwater, and NAPL conditions in the vicinity of the 1990/1992/2003 release area. Geologic/hydrogeological characterization to update CSM.	X			X	X		None specified, but additional step-out locations will be identified if necessary based on initial boring findings.
PB-7	South of existing USTs, central portions of 1990/1992 excavation areas, north of LNAPL detection	x	x	x	x	x		Evaluation of soil, groundwater, and NAPL conditions in the vicinity of the 1990/1992/2003 release area. Geologic/hydrogeological characterization to update CSM.	X			X	X		PSB-1, PSB-2 and PSB-8 north, northeast and east of initial sample location, and additional locations to be determined if needed.
PB-8	Under canopy east of 2003 release excavation area, eastern portion of 1990 excavation area	x	x	x	x	x		Evaluation of soil, groundwater, and NAPL conditions in the vicinity of the 2003 release area. Geologic/hydrogeological characterization to update CSM.	X			X	X		PSB-3, PSB-4, PSB-7 east of initial sample location, and additional locations to be determined if needed.
PB-9	Under canopy south of 2003 release excavation area, southeastern portion of 1990 excavation area	x	x	x	x	x		Evaluation of soil, groundwater, and NAPL conditions in the vicinity of the 2003 release area. Geologic/hydrogeological characterization to update CSM.	X			X	X		PSB-3, PSB-4, PSB-5 east of initial sample location, and additional locations to be determined if needed.
PB-10	South of canopy, south of 1990/2003 release excavation areas		x	x	x	x		Evaluation of soil and groundwater conditions in the vicinity of the 2003 release area. Geologic/hydrogeological characterization to update CSM.	X			X	X		PSB-4, PSB-5 and PSB-6 east and south of initial sample location, and additional locations to be determined if needed.
PB-11	South of canopy, south of 1990/2003 release excavation area		x	x	x	x		Evaluation of soil and groundwater conditions in the vicinity of the 2003 release area. Geologic/hydrogeological characterization to update CSM.	X			X	X		PSB-5 and PSB-6 south of initial sample location, and additional locations to be determined if needed.
PB-12	Southwest of 1990/2003 release excavation area		x	x	x	x	x	Evaluation of soil and groundwater conditions in the vicinity of the 2003 release area. Geologic/hydrogeological characterization to update CSM.	X			X	X		PSB-6 southeast of initial sample location, and additional locations to be determined if needed.
PB-13	Under canopy within 2003 release excavation area, south of 1992 excavation area, between 1990 excavation areas	x	x	x	x	x		Evaluation of soil, groundwater, and NAPL conditions in the vicinity of the 1990/1992/2003 release areas. Geologic/hydrogeological characterization to update CSM.	X			X	X		PSB-3, PSB-7, PSB-8 east of initial sample location, and additional locations to be determined if needed.
PB-14	North of canopy, northeast of 2003 release excavation area, within 1992 excavation area		x	x	x	x		Evaluation of soil, groundwater, and NAPL conditions in the vicinity of the 1990/1992/2003 release areas. Geologic/hydrogeological characterization to update CSM.	X			X	X		PSB-7 and PSB-8 east of initial sample location, and additional locations to be determined if needed.
PB-15	Southeast of existing USTs, northeast of 2003 release excavation area, east of 1990/1992 release excavation areas		x	x	x	x		Evaluation of soil, groundwater, and NAPL conditions in the vicinity of the 1990/1992/2003 release areas. Geologic/hydrogeological characterization to update CSM.	X			X	X		PSB-2 and PSB-8 north and south of initial sample location, and additional locations to be determined if needed.
SS-1	Within the stormwater utility trench adjoining the BFC property to the west.	x	x	x	x	x	x	Evaluation of soil, groundwater, and possibly NAPL within and beneath the utility corridor located west of the BFC property. Geologic/hydrogeological characterization to update CSM.	X	X	X	X	X	X	None specified, but additional borings will be advanced if necessary within the utility corridor, within adjacent utility corridor(s), and/or between the utility corridors and TIB median area.
SS-2	Within the stormwater utility trench adjoining the BFC property to the west.	x	x	x	x	x	x	Evaluation of soil, groundwater, and possibly NAPL within and beneath the utility corridor located west of the BFC property. Geologic/hydrogeological characterization to update CSM.	X	X	X	X	X	X	None specified, but additional borings will be advanced if necessary within the utility corridor, within adjacent utility corridor(s), and/or between the utility corridors and TIB median area.
SS-3	Within the stormwater utility trench adjoining the BFC property to the west.	x	x	x	x	x	x	Evaluation of soil, groundwater, and possibly NAPL within and beneath the utility corridor located west of the BFC property. Geologic/hydrogeological characterization to update CSM.	X	X	X	X	X	X	None specified, but additional borings will be advanced if necessary within the utility corridor, within adjacent utility corridor(s), and/or between the utility corridors and TIB median area.
SS-4	Within the stormwater utility trench adjoining the BFC property to the west.	x	x	x	x	x	x	Evaluation of soil, groundwater, and possibly NAPL within and beneath the utility corridor located west of the BFC property. Geologic/hydrogeological characterization to update CSM.	X	X	X	X	X	X	None specified, but additional borings will be advanced if necessary within the utility corridor, within adjacent utility corridor(s), and/or between the utility corridors and TIB median area.

Notes:

(a) Proposed initial and possible step-out boring locations are shown on Figure 11.
(b) Standard soil sample intervals will be from 6-7 feet bgs, 10-13 feet bgs, 15 feet bgs, 19-20 feet bgs, 25-30 feet bgs, and 35 feet bgs
(c) Utility trench soil sample intervals will be at 3 and 6 feet bgs
(d) Shallow soil sample intervals will be at 3 and 6 feet bgs
(e) Shallow ground water sample interval will be at 8-10 feet bgs
(f) Deeper ground water sample interval will be at 21-22 feet bgs
(g) Ground water will be sampled from the utility trench where encountered

Acronyms:

BFC Boeing Field Chevron
CSM Conceptual Site Model
NAPL Non-Aqueous Phase Liquid (i.e., free product)
TIB Tukwila International Boulevard

APPENDIX B

Historical Investigation Data Tables

W-6774

Table 1. Sumary of Analytical Test Results on Soil

Sample No.	Sample Location	Depth (ft)	Date Sampled	TPH 418.1	TPH 8015	Fuel Species	B	T	E	X
CS-2	Stockpile		3/27/90	239.00	<10		ND	ND	ND	ND
CS-3	Stockpile		3/27/90	254.00	29.8	Gas	ND	ND	0.09	0.44
TS-1*	UST Contents		3/27/90		3,736.0	Gas	4.25	29.60	2.57	22.30
S-1	Sub-slab	3	4/16/90	54.3	<10		0.05	0.10	ND	0.07
S-2	Sub-slab	3	4/16/90	47.7	<10		0.06	0.17	ND	0.07
S-3	West Wall	8	4/16/90	29.1	<10		ND	ND	ND	ND
S-4	West Bottom	10	4/16/90	65.6	<10		ND	ND	ND	ND
S-5	North Wall	9	4/16/90	8.2	<10		ND	ND	ND	ND
S-6(R)	South Wall	8	4/16/90	244.0	207.0	Gas	ND	0.09	2.01	3.09
S-7(R)	East Wall	10	4/16/90	433.0	428.0	Gas	ND	ND	0.11	3.35
S-8(R)	East Bottom	10	4/16/90	2,137.0	1,980.0	Gas	0.21	0.11	0.24	4.42
S-11	Stockpile		4/16/90	551.0			0.06	0.08	0.09	0.24
S-1(R)	South wall west	8	4/23/90	295.0	98.0	Gas	0.54	0.59	0.49	1.15
S-2	East Wall	9	4/23/90	7.6	<10		ND	0.29	0.08	0.28
S-3	Southeast Bottom	9	4/23/90	7.9	<10		0.07	0.19	0.47	0.66
S-1	Southeast Bottom	13-15	4/24/90	34.9	<10		ND	ND	ND	ND
S-2(R)	South Wall	12	4/24/90	18.6	<10		0.12	0.27	0.11	0.80
S-3(R)	South Wall East	11	4/24/90	1,148.0	1,140.0	Gas	0.25	0.20	0.08	0.24
S-4	North Bottom	12	4/24/90	69.8	10.0		0.13	0.17	0.07	0.20
C-1	Stockpile		5/1/90	230.0	220.0	Gas	0.073	ND	0.110	0.55
C-2	Stockpile		5/1/90	130.0	9.0	Gas	0.046	ND	0.076	0.210
C-3	Stockpile		5/1/90	31.0	<5		ND	ND	ND	ND
C-4	Stockpile		5/1/90	270.0	140.0	Gas	0.042	ND	0.220	0.630
C-5	Stockpile		5/1/90	750.0	32.0	Gas	ND	ND	ND	ND
C-6	Stockpile		5/1/90	460.0	<5		ND	ND	ND	ND
S-101(R)	South Wall Central	11-12	5/2/90	450.0			2.70	6.40	0.47	31.00
S-102(R)	South Wall	11-12	5/2/90	58.0	110.0		0.16	0.87	0.33	1.90
S-103(R)	South Wall	11-12	5/2/90	620.0	370.0	Gas	0.08	0.78	0.16	3.40
S-104	South Wall West	11-12	5/2/90	70.0	390.0	Gas	0.04	0.20	ND	0.28
S-105	West Wall South	11-12	5/2/90	9.0	ND		ND	ND	0.04	0.07
C-7	Stockpile		5/2/90	200.0	580.0	Gas	0.56	5.30	0.34	21.00
C-8	Stockpile		5/2/90	240.0	440.0	Gas	1.00	7.10	3.70	32.00
S-A	New Bldg.	3	5/2/90	290.0	30.0	Diesel	ND	ND	ND	0.15
S-1A	South Wall	5-8	6/13/90		16.00		ND	ND	0.15	1.20
S-2A	South Wall	5-8	6/13/90		<10		ND	ND	0.08	0.16
S-3A	South Wall	5-8	6/13/90		<10		ND	ND	ND	0.08
S-4A	South Wall	5-8	6/13/90		<10		ND	ND	ND	ND

*NOTE: Also - TOX <10 ppm; PCB < 0.01 ppm.

ND = Not detected - BTEX <0.005 ppm, TPH <10 ppm

(R) = Sample location removed during excavation

Table 2. Summary of analytical test results on soil and groundwater samples from Phase I borings and monitoring wells.

Sample	Depth (ft.)	Date Sampled	TPH 8015	Fuel Type	B	T	E	X
				Soil				
B-1/S-2	7.5 - 9.0	6/7/90	ND		ND	ND	ND	ND
B-1/S-3	12.5 - 14.0	6/7/90	ND		ND	ND	ND	ND
B-2/S-2	7.5 - 9.0	6/7/90	ND		ND	ND	ND	ND
B-2/S-3	12.5 - 14.0	6/7/90	ND		ND	ND	ND	ND
B-3/S-2	7.5 - 9.0	6/7/90	ND		ND	ND	ND	ND
B-3/S-3	12.5 - 14.0	6/7/90	ND		ND	ND	ND	ND
B-4/S-1	2.5 - 4.0	6/7/90	21	gasoline	ND	0.06	0.24	2.86
B-4/S-2	7.5 - 9.0	6/7/90	ND		ND	ND	ND	ND
B-5/S-2	7.5 - 9.0	6/7/90	ND		ND	ND	ND	ND
B-5/S-3	12.5 - 14.0	6/7/90	ND		ND	ND	ND	ND
B-6/S-2	7.5 - 9.0	6/7/90	ND		ND	ND	ND	ND
B-6/S-3	12.5 - 14.0	6/7/90	ND		ND	0.06	ND	0.05
B-7/S-2	7.5 - 9.0	6/7/90	ND		ND	ND	ND	ND
B-7/S-3	12.5 - 14.0	6/7/90	ND		ND	ND	ND	ND
B-8/S-1	2.5 - 4.0	6/7/90	40	gasoline	ND	ND	0.12	0.93
B-8/S-2	7.5 - 9.0	6/7/90	74	gasoline	0.05	0.11	4.25	38.5
B-9/S-2	7.5 - 9.0	6/7/90	1,079	gasoline & mineral spirits	ND	ND	0.32	2.85
B-9/S-3	12.5 - 14.0	6/7/90	ND		ND	0.08	0.06	1.34
B-10/S-2	7.5 - 9.0	6/7/90	516	mineral spirits	ND	ND	0.68	7.56
B-10/S-3	12.5 - 14.0	6/7/90	ND		0.11	ND	ND	1.23
				Groundwater				
MW-1		6/13/90	ND		0.006	ND	ND	ND
MW-2		6/13/90	ND		0.100	0.004	0.120	0.922
MW-2		6/22/90	ND		0.249	0.002	0.127	0.555
MW-3		6/13/90	ND		ND	ND	ND	0.006
MW-4		7/18/90	ND		0.085	ND	0.003	0.007
MW-5		7/18/90	ND		0.010	ND	ND	ND

ND = below method detection limit
TPH = total petroleum hydrocarbons
B = benzene; T = toluene; E = ethylbenzene; x = total xylenes
All results are given in part per million concentrations

Table 3. Summary of analytical test results on soil samples from the west pump island excavation.

Sample No.	Sample	Depth (ft.)	Date Sampled	TPH 8015	Fuel Type	B	T	E	X
S-2(R)	west wall	10	6/18/90	936	aged gasoline and mineral spirits	ND	0.44	2.36	17.4
S-3	north wall	10	6/18/90	ND		ND	ND	ND	ND
S-4	north wall	10	6/18/90	ND		ND	ND	ND	ND
S-A	south wall	7 - 10	6/19/90	ND		ND	ND	ND	0.09
S-B	bottom	11	6/19/90	ND		ND	0.06	ND	2.32
S-C	south wall	7 - 10	6/19/90	ND		ND	ND	ND	ND
S-D	bottom	12	6/19/90	ND		0.05	ND	0.39	2.91
S-E	east wall	7 - 10	6/19/90	ND		ND	ND	ND	0.76
PI-1	west wall	11	6/25/90	ND		ND	ND	ND	ND
PI-3	west wall	11	6/25/90	ND		ND	ND	ND	ND
PI-4	bottom	12	6/25/90	ND		ND	ND	ND	ND

ND = below method detection limit
TPH = total petroleum hydrocarbons
B = benzene; T = toluene; E = ethylbenzene; X = xylenes
All results are given in part per million concentrations
(R) = Sample location removed during excavation.

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Table 4. Summary of Vapor Probe Information

Vapor Probe Number	Depth (ft)	Benzene	Toluene	Ethyl benzene	Xylenes	Total Vapor Concentration
VP-1	10.5	ND	2.41	ND	ND	2.41
VP-2	10.5	2.06	105.12	9.93	40.04	157.15
VP-3	10.5	ND	ND	ND	ND	ND
VP-4	10.5	ND	114.66	ND	ND	114.66
VP-5	10.5	2.07	7.05	4.80	ND	13.92
VP-6	10.5	ND	3.20	ND	ND	3.20
VP-7	8.0	1.66	470.00	ND	ND	471.66
VP-8	8.0	ND	ND	ND	ND	ND
VP-9	3.0	ND	26.44	ND	ND	26.44
VP-10	8.0	1.00	60.35	ND	ND	61.35
MDL	---	1.0	1.1	3.5	3.7	---

All results are given in parts per million concentrations

ND = below method detection limit

MDL = Method Detection Limit as determined by 40 CFR Part 136 Appendix B

Table 5. Summary of analytical test results on soil and groundwater samples from Phase II borings and monitoring wells.

Sample	Depth (ft.)	Date Sampled	TPH 8015	Fuel Type	B	T	E	X
				Soil				
B-11/S-2	7.5 - 9.0	7/26/90	21	diesel & heavy oil	ND	ND	ND	ND
B-11/S-3	12.5 - 14.0	7/26/90	ND		ND	ND	ND	ND
B-12/S-1	2.5 - 4.0	7/26/90	19	diesel & heavy oil	ND	ND	ND	ND
B-12/S-2	7.5 - 9.0	7/26/90	ND		ND	ND	ND	ND
B-13/S-2	7.5 - 9.0	7/26/90	ND		ND	ND	ND	ND
B-13/S-3	12.5 - 14.0	7/26/90	ND		ND	ND	ND	ND
B-14/S-2	7.5 - 9.0	7/26/90	ND		ND	ND	ND	ND
B-14/S-3	12.5 - 14.0	7/26/90	ND		ND	ND	ND	ND
B-15/S-2	7.5 - 9.0	7/26/90	ND		ND	ND	ND	ND
B-15/S-3	12.5 - 14.0	7/26/90	ND		ND	ND	ND	ND
B-16/S-1	2.5 - 4.0	7/26/90	ND		ND	ND	ND	ND
B-16/S-2	7.5 - 9.0	7/26/90	ND		ND	ND	ND	ND
				Groundwater				
MW-6		7/30/90	ND		0.173	ND	ND	0.015
MW-7		7/30/90	ND		ND	ND	ND	ND

ND = below method detection limit
TPH = total petroleum hydrocarbons
B = benzene; T = toluene; E = ethylbenzene; X = total xylenes
All results are given in part per million concentrations

Table 6. Relative Groundwater Elevations Measured in Site Monitoring Wells

Monitoring Well	Relative Groundwater Elevation 6/13/90	6/27/90	7/30/90	8/03/90
MW-1	86.79	87.62	86.54	86.04
MW-2	90.67	89.83	89.11	88.52
MW-3	86.19	86.37	84.20	83.44
MW-4	91.08	90.93	90.55	90.53
MW-5	91.07	90.97	90.91	90.90
MW-6	---	---	90.35	90.26
MW-7	---	---	90.35	90.17

*based on arbitrary datum of 100.00 feet

W-6774

Table 7. Summary of Monitoring Well Construction Elevations

Well No.	Top of Casing Elevation (ft)	Surface Seal Elevation (ft)	Top of Screen Elevation (ft)	Bottom of Screen Elevation (ft)
MW-1	101.44	100.33 to 98.33	97.33	82.63
MW-2	100.52	99.34 to 97.34	96.84	81.84
MW-3	101.44	100.15 to 98.15	97.15	82.15
MW-4	101.03	99.86 to 97.86	96.86	86.86
MW-5	101.07	100.05 to 98.05	97.05	87.05
MW-6	100.91	100.31 to 98.31	96.31	81.81
MW-7	100.86	100.12 to 99.12	96.12	81.12

Table 1 - Analytical Results for Product and Verification Soil Samples - Waste Oil Tank

Product Sample			Concentration in mg/kg							WTPH-		
Sample	Location	Date	PCB 8080	8270	VOA 8240	Cr	Cu	Pb	Zn	HCID-G	HCID-D	Heavy Oil
PRO-1	Waste oil tank	9/04/92	ND	(A)	(B)	1.9	13	1,400	280	Present	Present	Present

Waste Oil Tank Excavation			Concentration in mg/kg						
Sample	Location	Date	WTPH-G	WTPH-D	Total Pb	B	T	E	X
TW-1	West Wall	9/04/92	ND	ND	26	ND	ND	ND	ND
TS-1	South Wall	9/04/92	ND	12	24	ND	ND	ND	ND
TN-1	North Wall	9/04/92	ND	12	47	ND	ND	ND	ND
TE-1	East Wall	9/04/92	ND	ND	ND	ND	ND	ND	ND
TB-1	Bottom	9/04/92	ND	ND	13	ND	ND	ND	ND

(A)	2-Methylnaphthalene	520 mg/kg
	Naphthalene	520 mg/kg
(B)	Acetone	70 mg/kg
	Benzene	5 mg/kg
	Ethylbenzene	550 mg/kg
	Toluene	1,800 mg/kg
	Total Xylenes	2,300 mg/kg

Notes:
ND = Not detected at laboratory detection limit, refer to laboratory certificates in Attachment B for detection limits.

datatbl.tab

Table 2 - Analytical Results for Verification Soil Samples - Diesel Tank

Sample ID	Location	Depth in Feet	Date	WTPH-D	WTPH-G	Total Pb	B	T	E	X
Diesel Tank Excavation				Concentration						
TWN-1	North Wall	6	9/18/92	ND						
TWE-1	East Wall	6 to 8	9/18/92	ND						
TWS-1	South Wall	6	9/18/92	1,400						
TWW-1	West Wall	5 to 6	9/18/92	17						
TB-1	Bottom	8	9/18/92	ND						
E Tank	Overexcavated South Side Wall	6	9/23/92	ND	ND	ND	ND	ND	ND	ND

Notes:
ND = Not detected at laboratory detection limit, refer to laboratory certificates in Attachment B for detection limits.

datatab2.tab

Table 1 - Analysis Results for Main Excavation Samples

Sample ID	Location	Date	Concentrations in mg/kg						
			WTPH-G	WTPH-D	Total Lead	B	T	E	X
Soil Borings									
B1-S2	West side of Main Excavation	9/4/92	ND	ND	18	ND	ND	ND	ND
B1-S4		9/4/92	ND	ND	11	ND	ND	ND	ND
B1-S6		9/4/92	ND	ND	13	ND	ND	ND	ND
B2-S2		9/4/92	ND	ND	11	ND	ND	ND	ND
B2-S4		9/4/92	ND	ND	ND	ND	ND	ND	ND
B2-S5		9/4/92	ND	ND	ND	ND	ND	ND	ND
B3-S2		9/4/92	ND	210	25	ND	ND	ND	ND
B3-S4		9/4/92	ND	ND	ND	ND	ND	ND	ND
B3-S5		9/4/92	ND	ND	ND	ND	ND	ND	ND
Verification Samples from East Wall of Main Excavation Sampled during Initial Excavation Activities									
CESW-1	East Side Wall	9/4/92	ND	ND	ND	ND	ND	ND	ND
CSSW-1	West Side Wall	9/4/92	ND	ND	ND	ND	ND	ND	ND
CSSW-WET	West Side Wall - Water Saturation	9/4/92	ND	ND	ND	ND	ND	ND	ND
Main Excavation									
TB-NE-1	Northeast side wall	9/9/92	NA	ND(1)	ND	0.032	ND	ND	ND
TN-2	North side wall	9/9/92	NA	73(1)	ND	ND	ND	1.2	0.47
TB-SW-1	Southwest side wall	9/9/92	NA	ND(1)	ND	0.020	ND	ND	ND
TWW-A	Depth = 9'	9/21/92	2.0	11	15	ND	ND	ND	ND
TWW-B	West side of main excavation	9/21/92	15	ND	ND	ND	ND	ND	ND
TWW-C			37	ND	ND	0.029	ND	ND	0.13

Table 1 - Analysis Results for Main Excavation Samples

Sample ID	Location	Date	Concentrations in mg/kg						
			WTPH-G	WTPH-D	Total Lead	B	T	E	X
North and South Trench									
North Trench	Bottom	9-17-92	ND	ND	ND	ND	ND	ND	ND
South Trench	Bottom	9-17-92	ND	ND	ND	ND	ND	ND	ND
Main Excavation Composite Samples									
EWN 1-2	Excavation Wall North	9-22-92	51	28	20	ND	ND	0.011	0.017
EWE 1-4	Excavation Wall East	9-22-92	ND	ND	ND	ND	ND	ND	ND
EB 1-7	Excavation Bottom	9-22-92	ND	ND	ND	ND	ND	ND	ND

Notes:

NA = Not analyzed
ND = Not detected

(1) WTPH-D extended

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Table 2 - Analysis Results for Soil Samples Collected in the Vicinity of the Waste Oil Tank

Sample	Location	Date	Concentrations in mg/kg							
			PCB 8080	Semivolatile 8270	VOA 8240	Cr	Cu	Pb	Zn	8015 Mod.
Product Sample										
PRO-1	Waste Oil Tank	9/4/92	ND	(A)	(B)	1.9	13	1,400	280	ND

Sample	Location	Date	Concentrations in mg/kg						
			WTPH-G	WTPH-D	Pb	B	E	T	X
TW-1	West	9/4/92	ND	ND	26	ND	ND	ND	ND
TS-1	South	9/4/92	ND	12	24	ND	ND	ND	ND
TN-1	North	9/4/92	ND	12	47	ND	ND	ND	ND
TB-1	Bottom	9/4/92	ND	ND	13	ND	ND	ND	ND
TE-1	East	9/4/92	ND	ND	ND	ND	ND	ND	ND

(A)	2-Methylnaphthalene	520 ppm
	Naphthalene	520 ppm
(B)	Acetone	70 ppm
	Benzene	500 ppm
	Ethylbenzene	550 ppm
	Toluene	1,800 ppm
	Total Xylenes	2,300 ppm

Notes:
ND = Not detected

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Table 3 - Analysis Results for East Tank Excavation Samples

Sample ID	Location	Date	Concentrations in mg/kg						
			WTPH-D	WTPH-G	Total Pb	B	T	E	X
East Tank Excavation Sidewall and Bottom Samples									
	(depth from top of excavation)								
TWN-1	depth 6'	9/18/92	ND	NA	NA	NA	NA	NA	NA
TWE-1	depth 6-8'	9/18/92	ND	NA	NA	NA	NA	NA	NA
TWS-1	depth 6'	9/18/92	1,400	NA	NA	NA	NA	NA	NA
TWW-1	depth 5-6'	9/18/92	17	NA	NA	NA	NA	NA	NA
TB-1	Bottom @ 8'	9/18/92	ND	NA	NA	NA	NA	NA	NA
E Tank	Southwall #1	9/23/92	ND	ND	ND	ND	ND	ND	ND
E Tank Southwall	East Tank Excavation South Wall Closure	9/23/92	ND	ND	ND	ND	ND	ND	ND
Cesspool									
DW-1	Northern most edge 5'	9/21/92	ND	ND	ND	ND	ND	ND	ND
DW-2	@ depth ≈ 8 - 9'	9/21/92	ND	ND	ND	ND	ND	ND	ND

Notes:
ND = Not detected
NA = Not analyzed

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Table 4 - Analysis Results for Test Pit Excavation Samples

Sample ID	Location	Date	Concentrations in mg/kg							
			HCID Gas	HCID Diesel	HCID Heavy Oil	Total Lead	B	T	E	X
Test Pit Samples										
TP-1A	First Excavation	9/4/92	ND	Present	Present	ND	ND	0.026	ND	0.020
TP-1B	First Excavation	9/4/92	ND	ND	ND	ND	ND	ND	ND	ND
TP-B-1	Test Pit Bottom (2nd Excavation)	9/4/92	NA	200/100(1)	NA	ND	ND	0.013	ND	ND
Test Pit Excavation										
TPWN-1	N. Wall	9/18/92	NA	ND(2)	NA	NA	NA	NA	NA	NA
TPWE-1	E. Wall 3-4'	9/18/92	NA	ND(2)	NA	NA	NA	NA	NA	NA
TPWS-1	S. Wall 3-4'	9/18/92	NA	150(2)	NA	NA	NA	NA	NA	NA
TPWW-1	W. Wall 3-4'	9/18/92	NA	ND(2)	NA	NA	NA	NA	NA	NA
TPB-2	5 point composite @ 8' on bottom	9/18/92	NA	ND(2)	NA	NA	NA	NA	NA	NA

Notes:
NA = Not analyzed
ND = Not detected

(1) WTPH-D Extended/WTPH-D
(2) WTPH-D

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Table 5 - Analysis Results for Stockpile Samples

Sample	Location	Date	TCLP Metals								WTPH-D		PCB Screen
			As	Ba	Cd	Cr	Pb	Hg	Si	Se	(1)	(2)	
			Concentrations in mg/kg										
Stockpile Samples (West Side) 5 Point Composites													
SP-1	SW Stockpile	9/21/92	ND	ND	ND	ND	ND	ND	ND	ND	190	90	ND
SP-2	W Stockpile	9/21/92	ND	ND	ND	ND	ND	ND	ND	ND	250	190	ND
SP-3	NW Stockpile	9/21/92	ND	ND	ND	ND	ND	ND	ND	ND	120	85	ND
SP-4	SSE Stockpile	9/21/92	ND	ND	ND	ND	ND	0.0015	ND	ND	760	120	ND
SP-5	SE Stockpile	9/22/92	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	ND
SP-6	NE Stockpile	9/22/92	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	ND
SP-7	NNE Stockpile	9/22/92	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	ND

Notes:

NA = Not analyzed
ND = Not detected above detection limit

(1) WTPH-D
(2) WTPH-D Extended

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Table 6 - Landfarm Verification Samples

Sample ID	Location	Date	Concentrations in mg/kg B	T	E	X
VS-1-MAH		12/11/92	ND	ND	ND	ND
VS-2-MAH		12/11/92	ND	ND	ND	ND
VS-3-MAH		12/11/92	ND	ND	ND	ND
VS-4-MAH		12/11/92	ND	ND	ND	ND
VS-5-MAH		12/11/92	ND	ND	ND	ND

Table 7 - Groundwater Sample from Excavation

Sample ID	Date	Concentrations in mg/l WTPH-G	WTPH-D Extended	Total Pb	B	T	E	X
S-1	10/2/92	0.48	ND	0.0045	ND	ND	0.0011	ND
MTCA Method A		1.000	1.000	0.005	0.005	0.040	0.030	0.020

Note:
ND = Not detected

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Table 1 - Water Level Elevation Data

		Well Identifier	MW-1	MW-2R	MW-3R	MW-4R	MW-7	MW-8	MW-8A	MW-9	MW-9A
		MP ELEV.	17.97	17.51	17.68	18.14	17.91	16.93	16.84	16.72	16.68
DATE	TIME										
2/5/93	08:20				4.03	7.19					
2/5/93	11:00			3.61							
2/5/93	12:20			3.59							
2/5/93	13:50				4.51	8.08	7.81				
2/5/93	14:50			4.04						4.22	
2/8/93	08:10				4.99						
2/8/93	08:20			4.34							
2/8/93	08:30					7.00					17.57
2/8/93	08:40							4.69	7.82		4.28
2/8/93	09:45		5.74	3.95	4.43	6.98	7.64		7.75	4.19	7.90
2/8/93	10:30		5.79	3.65	4.04	7.03	7.66			3.93	7.93
2/8/93	11:45		5.66	3.14	3.37	7.01	7.64	3.31	7.69	3.41	7.53
2/8/93	13:15		5.54	2.89	2.79	3.03	7.64	3.10	7.75	3.04	7.88
2/9/93	09:00		5.44	4.11	4.73	4.64	7.51	4.80	7.65	3.78	7.80
2/9/93	11:00		2.98 A	3.70	3.74	3.83	7.60	4.07	7.91	3.62	7.40
2/9/93	12:30		4.22	2.87	2.78	2.99	7.56	3.12	7.62	3.16	7.77
3/3/93	09:45										
3/4/93	11:15		5.20	3.41	3.62	3.56	7.03	3.78	7.12	3.40	7.38

A - Water levels affected by development or sampling.
MP - Measuring Point

JOBS\307601\Table1.wk1

Table 2 - Soil Chemical Analytical Results
Exploratory Borings

Monitoring Well Boring Number	Depth in Feet	Concentration in mg/kg						
				Volatile Aromatic Hydrocarbons (EPA Method 8020)				
		WTPH-D	WTPH-G	B	T	E	X	Total Lead
MW-2R	14	ND	ND	ND	ND	ND	ND	3.6
MW-8	7.5	ND	ND	ND	ND	ND	ND	3
MW-9	10	ND	ND	ND	ND	ND	ND	3.4
MTCA Method A Cleanup levels		200	200	0.005	0.04	0.02	0.02	250

NOTES:
Chemical Analysis conducted by Analytical Technologies, Inc. Laboratory certificates are presented in Appendix B.
MTCA = Washington State Model Toxics Control Act.

JOBS\307601\Table2.wk1

Table 3 - Groundwater Quality Summary
Monitoring Wells

Monitoring Well No.	Date Sampled	Sampled by	Concentration in mg/L						
					Volatile Aromatic Hydrocarbons(2)				Total
			WTPH-D	WTPH-G	B	T	E	X	Lead
MTCA Method A Cleanup Level			1.0	1.0	0.005	0.04	0.02	0.02	0.005
MW-1	6/13/90	RZA	NA	ND(1)	0.006	ND	ND	ND	
	8/15/90	HCI	ND(1)	ND(1)	0.0028	nd	nd	0.0008	
	11/16/90	HCI	ND(1)	ND(1)	0.005	ND	ND	ND	
	1/8/91	HCI	ND(1)	ND(1)	0.0038	ND	ND	ND	
	3/20/91	HCI	ND(1)	ND(1)	0.0024	ND	ND	ND	
	3/3/92	HCI	ND(1)	ND(1)	0.0054	ND	ND	ND	
	6/17/92	HCI	ND	ND	0.0012	ND	ND	ND	
	2/9/93	HCI	ND	ND	ND	ND	ND	ND	0.0044
MW-2	6/13/90	RZA	NA	ND(1)	0.100	0.004	0.120	0.922	
	6/22/90	RZA	NA	ND(1)	0.249	0.002	0.127	0.555	
	8/15/90	HCI	ND(1)	ND(1)	0.081	0.0019	0.032	0.120	
dup	8/15/90	HCI	ND(1)	2 (1)	0.130	ND	0.056	0.180	
	11/16/90	HCI	NS	NS	NS	NS	NS	NS	
MW-2R	2/9/93	HCI	ND	ND	0.019	ND	ND	0.0005	0.025
dup	2/9/93	HCI	ND	ND	0.019	ND	ND	ND	0.025
MW-3	6/13/90	RZA	NA	ND(1)	ND	ND	ND	0.006	
	8/15/90	HCI	ND(1)	ND(1)	ND	ND	0.0007	0.0007	
	11/16/90	HCI	ND(1)	ND(1)	ND	0.0002	0.0007	ND	
	1/8/91	HCI	ND(1)	ND(1)	ND	ND	0.0011	ND	
	3/20/91	HCI	ND(1)	ND(1)	ND	ND	0.0035	0.0012	
	3/3/92		ND(1)	0.12	ND	0.00050	ND	0.00050	
	6/17/92	HCI	ND(1)	0.12	ND	ND	ND	ND	
MW-3R	2/9/93	HCI	2.9	0.79	ND	ND	0.0031	0.0020	0.036
MW-4	7/18/90	RZA	NA	ND	0.085	ND	0.003	0.007	
	8/15/90	HCI	ND(1)	ND(1)	0.190	ND	0.003	0.007	
	11/16/90	HCI	ND(1)	22(1)	ND	1.600	0.510	2.300	
	1/8/91	HCI	3(1)	16(1)	0.079	0.160	0.960	2.000	
	3/20/91	HCI	ND(1)	3(1)	0.0110	0.0057	0.1700	0.2400	
	7/23/91	HCI	2.9	2.4	0.0077	ND	0.170	0.130	
	3/3/92	HCI	1.7	12.0	0.0012	0.310	1.000	3.200	
	4/23/92	HCI	NA	NA	ND	0.0067	0.350	0.350	
	6/17/92	HCI	0.24	0.71	ND	ND	0.018	0.0020	
dup	6/17/92	HCI	ND	0.62	ND	ND	0.017	0.0019	
MW-4R	2/9/93	HCI	ND	ND	0.039	ND	ND	0.0025	0.024

Table 3 – Groundwater Quality Summary
Monitoring Wells

Monitoring Well No.	Date Sampled	Sampled by	Concentration in mg/L						
					Volatile Aromatic Hydrocarbons(2)				Total
			WTPH-D	WTPH-G	B	T	E	X	Lead
MTCA Method A Cleanup Level			1.0	1.0	0.005	0.04	0.02	0.02	0.005
MW-5	7/18/90	RZA	NA	ND	0.010	ND	ND	ND	
	8/15/90	HCI	ND(1)	ND(1)	0.053	ND	0.0018	0.0053	
	11/16/90	HCI	ND(1)	ND(1)	0.200	ND	0.0037	0.001	
	1/8/91	HCI	ND(1)	ND(1)	0.0042	ND	ND	ND	
	3/20/91	HCI	ND(1)	ND(1)	0.0012	ND	ND	ND	
	7/23/91	HCI	ND	0.046	0.00062	ND	0.0034	0.010	
	3/3/92	HCI	ND	0.094	ND	ND	ND	0.00054	
	6/17/92	HCI	0.23	0.43	ND	ND	0.015	0.048	
Destroyed	9/92	–	–	–	–	–	–	–	–
MW-6	7/30/90	RZA	NA	ND(1)	0.173	ND	ND	0.015	
	8/15/90	HCI	ND(1)	ND(1)	0.150	0.0006	0.0015	0.017	
	11/16/90	HCI	ND(1)	5(1)	0.130	ND	0.069	0.500	
dup	11/16/90	HCI	ND(1)	6(1)	0.100	nd	nd	0.440	
	1/8/91	HCI	ND(1)	ND(1)	0.041	ND	0.0037	0.011	
dup	1/8/91	HCI	ND(1)	ND(1)	0.052	ND	0.0046	0.011	
	3/20/91	HCI	ND(1)	ND(1)	0.054	ND	0.0012	ND	
dup	3/20/91	HCI	ND(1)	ND(1)	0.058	ND	0.0017	ND	
	7/23/91		ND	0.13	0.035	ND	ND	ND	
	3/3/92		ND	0.060	0.0092	ND	0.0015	0.0044	
	3/3/92		ND	0.043	0.0098	ND	ND	0.00063	
	6/17/92	HCI	ND	ND	0.0024	ND	ND	ND	
	2/9/93		NS	NS	NS	NS	NS	NS	NS
MW-7	7/30/90	RZA	NA	ND	ND	ND	ND	ND	
	8/15/90	HCI	ND(1)	ND(1)	0.0007	ND	ND	ND	
	11/16/90	HCI	ND(1)	ND(1)	0.011	ND	ND	ND	
	1/8/91	HCI	ND(1)	ND(1)	0.0019	ND	0.0005	0.0026	
	3/20/91	HCI	ND(1)	ND(1)	0.0005	ND	0.0006	ND	
	7/23/91	HCI	ND(1)	ND	ND	ND	ND	ND	
	3/3/92	HCI	ND(1)	ND	ND	ND	ND	ND	
	6/17/92	HCI	ND	ND	ND	ND	ND	ND	
	2/9/93	HCI	ND	ND	ND	ND	ND	ND	0.04

Table 1 - Waste Characterization Analyses Conducted

Sample Media (Sample ID)	Analyte (Method)											
	TCLP As, Cd, Cr, Pb (EPA 1131)	TCLP Benzene (EPA 1311, 8240)	Total Organic Halides (TOX) (EPA 9020)	TPH (EPA 418.1)	Total As, Cd, Cr, Pb (EPA 6010, 7060, 7421)	Benzene (EPA 8020)	PCBs (EPA 8080)	Flashpoint (EPA 101)	BTEX (WTPH-G) (EPA 8020)	Semivolatiles (EPA 8270)	Volatiles (EPA 8240)	Hydrocarbon Identification (QWAC GC-FID)
Waste Oil UST Liquid (PRO-1)							X	X		X		X
Waste Oil UST Solids (WOT-Sludge)	X	X	X	X								
Waste Oil UST Rinse Water (WOT-Rinse)			X	X	X	X						
Diesel UST Liquids (Diesel Prod.)			X		X		X	X	X			
Diesel UST Rinse Water (Diesel Rinse)			X		X		X	X	X			

TABLE 1
SOIL SAMPLES ANALYTICAL RESULTS
UNDOCUMENTED UST

Former Chevron Service Station 9-3099
East Marginal Way South and Pacific Highway South
Seattle, Washington

Sample I.D.	Date	Depth in Feet	TPH-Gasoline (ppm)	TPH-Diesel (ppm)	TPH-Oil (ppm)	Benzene (ppm)	Toluene (ppm)	Ethyl-benzene (ppm)	Xylenes (ppm)
WOB-4.5	07/26/96	4.5	30.8	1,360	7,600	ND	ND	ND	ND
NSW-3	07/26/96	3	139	5,210	23,800	ND	ND	ND	ND
SSW-3	07/26/96	3	543	6,390	28,700	ND	1.63	1.56	15.5
MTCA Method A Cleanup Levels:			100	200	200	0.5	40	20	20
Laboratory Reporting Limits:			**5-100**	**210-420**	**525-1050**	**0.05-1.0**	**0.05-1.0**	**0.05-1.0**	**0.1-2.0**

Concentrations in ppm (mg/L)
ND - Not Detected
Certified analytical results are included in Attachment B
TPH as Gasoline - Analysis by Washington DOE Method WTPH-G
TPH as Diesel/TPH-Oil - Analysis by Washington Method WTPH-D + Extended
BTEX Compounds - Analysis by EPA Method 8020A

TABLE 1
GROUNDWATER ELEVATION DATA

Chevron Service Station 9-3099
10805 East Marginal Way South
Seattle, Washington

Well Number	Top of Casing Elevation (feet)	Depth to Groundwater (feet)	Groundwater Elevation (feet)	Separate-Phase Hydrocarbons (yes/no)
MW-10	99.21	15.10	84.11	No
MW-11	98.15	14.59	83.56	No
MW-12	97.49	13.75	83.74	No

Elevations, in feet, are based on an arbitrary project datum of 100.00 feet assigned to the SE corner of the concrete pad housing the air/water service.
Depth to groundwater measured on 9/5/97.

TABLE 2
SOIL ANALYTICAL RESULTS

Chevron Service Station 9-3099
10805 East Marginal Way South
Seattle, Washington

Sample I.D.	Date	Depth (feet)	Benzene (ppm)	Toluene (ppm)	Ethyl-benzene (ppm)	Xylenes (ppm)	TPH-Gasoline (ppm)	TPH-Diesel (ppm)	TPH-Oil (ppm)	Total Lead (ppm)
MW10-13	09/03/97	13	ND	ND	ND	ND	ND	ND	NA	NA
MW11-6	09/03/97	6.0	ND	ND	ND	ND	ND	ND	NA	NA
MW12-6	09/03/97	6.0	ND	ND	ND	ND	ND	ND	ND	NA
MW12-11	09/03/97	11.0	ND	ND	ND	ND	ND	ND	35.1	NA
Stockpile	09/03/97	-	ND	ND	ND	ND	ND	ND	ND	ND
MTCA Method A Cleanup Levels:			0.5	40	20	20	100	200	200	250
Laboratory Reporting Limits:			0.050	0.050	0.050	0.10	5.0	10.0	25.0	10.0

Concentrations reported as parts per million (mg/kg)
Certified analytical results are included in Attachment C
ND - Not Detected at or above the laboratory reporting limit
TPH as Gasoline - Analysis by Washington Method WTPH-G
TPH as Diesel and Oil - Analysis by Washington Method WTPH-D plus extended
BTEX Compounds - Analysis by EPA Method 8020A
Total Lead - Analysis by EPA 6000/7000 Series Methods

TABLE 3
GROUNDWATER ANALYTICAL RESULTS

Chevron Service Station 9-3099
10805 East Marginal Way South
Seattle, Washington

Sample I.D.	Date	Benzene (ppb)	Toluene (ppb)	Ethyl-benzene (ppb)	Xylenes (ppb)	TPH-Gasoline (ppb)	TPH-Diesel (ppb)	TPH-Oil (ppb)
MW-10	09/05/97	ND	ND	ND	ND	ND	ND	ND
MW-11	09/05/97	ND	ND	ND	ND	77.2	376	ND
MW-12	09/05/97	ND	ND	ND	ND	ND	366	ND
TB	09/05/97	ND	ND	ND	ND	ND	NA	NA
MTCA Method A Cleanup Levels:		5	40	30	20	1,000	1,000	5.0
Laboratory Reporting Limits:		0.50	0.50	0.50	1.0	50	250	750

Concentrations reported as parts per billion (ug/L)
Certified analytical results are included in Attachment C
ND - Not Detected at or above the laboratory reporting limit
TPH as Gasoline - Analysis by Washington Method WTPH-G
TPH as Diesel - Analysis by Washington Method WTPH-D (extended)
BTEX Compounds - Analysis by EPA Method 8020A

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Groundwater Monitoring Data and Analytical Results

Chevron Service Station #9-3099
10805 East Marginal Way South
Tukwila, Washington

WELL ID/ TOC*(ft.)	DATE	DTP (ft.)	DTW (ft.)	SPHT (ft.)	GWE (ft.)	TPH-D (ppb)	TPH-O (ppb)	TPH-G (ppb)	B (ppb)	T (ppb)	E (ppb)	X (ppb)	MTBE (ppb)
MW-1													
17.97	06/13/90	--	--	--	--	--	--	ND	6.0	ND	ND	ND	--
	08/15/90	--	--	--	--	ND	--	ND	2.8	ND	ND	0.8	--
	11/16/90	--	--	--	--	ND	--	ND	5.0	ND	ND	ND	--
	01/08/91	--	--	--	--	ND	--	ND	3.8	ND	ND	ND	--
	03/20/91	--	--	--	--	ND	--	ND	2.4	ND	ND	ND	--
	03/03/92	--	--	--	--	ND	--	ND	5.4	ND	ND	ND	--
	06/17/92	--	--	--	--	ND	--	ND	1.2	ND	ND	ND	--
	02/09/93[1]	--	--	--	--	ND	--	ND	ND	ND	ND	ND	--
	04/12/93[1,2]	--	--	--	--	ND	--	ND	ND	ND	ND	ND	--
	06/24/93	--	13.30	--	4.67	ND	--	ND	ND	ND	ND	ND	--
	09/28/93	--	14.30	--	3.67	ND	--	ND	1.6	3.0	ND	2.3	--
	12/20/93	--	12.91	--	5.06	ND	--	ND	ND	ND	ND	ND	--
	06/02/94	--	12.89	--	5.08	ND	--	ND	ND	ND	ND	ND	--
	12/20/94	--	10.99	--	6.98	ND	--	ND	ND	ND	ND	ND	--
	ABANDONED												
MW-2	06/13/90	--	--	--	--	--	--	ND	100	4.0	120	922	--
	06/22/90	--	--	--	--	--	--	ND	249	2.0	127	555	--
	08/15/90	--	--	--	--	ND	--	ND	81	1.9	32	120	--
	(D) 08/15/90	--	--	--	--	ND	--	2.0	130	ND	56	180	--
	11/16/90	--	--	--	--	--	--	--	--	--	--	--	--
	ABANDONED												
MW-2R													
17.51	02/09/93[3]	--	--	--	--	ND	--	ND	19	ND	ND	0.5	--
	(D) 02/09/93[3]	--	--	--	--	ND	--	ND	19	ND	ND	ND	--
	04/12/93[2,3]	--	--	--	--	300	--	ND	16	ND	ND	ND	--
	(D) 04/12/93[2,3]	--	--	--	--	300	--	ND	17	ND	ND	ND	--
	06/24/93	--	14.33	--	3.18	300	--	ND	2.6	ND	ND	ND	--

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Groundwater Monitoring Data and Analytical Results
Chevron Service Station #9-3099
10805 East Marginal Way South
Tukwila, Washington

WELL ID/ TOC*(ft.)	DATE	DTP (ft.)	DTW (ft.)	SPHT (ft.)	GWE (ft.)	TPH-D (ppb)	TPH-O (ppb)	TPH-G (ppb)	B (ppb)	T (ppb)	E (ppb)	X (ppb)	MTBE (ppb)
MW-2R	09/28/93	--	15.66	--	1.85	ND	--	ND	ND	ND	ND	ND	--
(cont)	12/20/93	--	13.82	--	3.69	ND	--	ND	3.3	ND	ND	ND	--
	06/02/94	--	16.08	--	1.43	ND	--	ND	ND	ND	ND	ND	--
	12/20/94	--	12.15	--	5.36	ND	--	ND	ND	ND	ND	ND	--
	ABANDONED												
MW-3	06/13/90	--	--	--	--	--	--	ND	ND	ND	ND	6.0	--
	08/15/90	--	--	--	--	ND	--	ND	ND	ND	0.7	0.7	--
	11/16/90	--	--	--	--	ND	--	ND	ND	0.2	0.7	ND	--
	01/08/91	--	--	--	--	ND	--	ND	ND	ND	1.1	ND	--
	03/20/91	--	--	--	--	ND	--	ND	ND	ND	3.5	1.2	--
	03/03/92	--	--	--	--	ND	--	120	ND	0.5	ND	0.5	--
	06/17/92	--	--	--	--	ND	--	120	ND	ND	ND	ND	--
	ABANDONED												
MW-3R													
17.68	02/09/93[4]	--	--	--	--	2,900	--	790	ND	ND	3.1	2.0	--
	04/12/93[2,4]	--	--	--	--	ND	--	380	ND	ND	0.7	0.7	--
	06/24/93	--	14.40	--	3.28	300	--	160	ND	ND	ND	ND	--
	09/28/93	--	15.98	--	1.70	ND	--	ND	ND	ND	ND	ND	--
	12/20/93	--	13.73	--	3.95	ND	--	ND	ND	ND	ND	ND	--
	06/02/94	--	16.43	--	1.25	ND	--	160	ND	ND	ND	ND	--
	12/20/94	--	12.06	--	5.62	ND	--	130	ND	ND	ND	ND	--
	09/28/95[5]	--	12.76	--	4.92	320	--	ND	ND	ND	ND	ND	--
	12/08/95[5]	--	12.60	--	5.08	550	--	260	ND	ND	ND	ND	--
	03/18/96[6]	--	11.53	--	6.15	0.32	ND	940	ND	ND	1.6	ND	--
	DESTROYED												

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Groundwater Monitoring Data and Analytical Results
Chevron Service Station #9-3099
10805 East Marginal Way South
Tukwila, Washington

WELL ID/ TOC*(ft.)	DATE	DTP (ft.)	DTW (ft.)	SPHT (ft.)	GWE (ft.)	TPH-D (ppb)	TPH-O (ppb)	TPH-G (ppb)	B (ppb)	T (ppb)	E (ppb)	X (ppb)	MTBE (ppb)
MW-4	07/18/90	--	--	--	--	--	--	ND	85	ND	3.0	7.0	--
	08/15/90	--	--	--	--	ND	--	ND	190	ND	3.0	7.0	--
	11/16/90	--	--	--	--	ND	--	22,000	ND	1,600	510	2,300	--
	01/08/91	--	--	--	--	3,000	--	16,000	79	160	960	2,000	--
	03/20/91	--	--	--	--	ND	--	3,000	11	5.7	170	240	--
	07/23/91	--	--	--	--	2,900	--	2,400	8.0	ND	170	130	--
	03/03/92	--	--	--	--	1,700	--	12,000	1.0	310	1,000	3,200	--
	04/23/92	--	--	--	--	--	--	--	ND	6.7	350	350	--
	06/17/92	--	--	--	--	240	--	710	ND	ND	18	2.0	--
(D)	06/17/92	--	--	--	--	ND	--	620	ND	ND	17	1.9	--
	ABANDONED												
MW-4R													
18.14	02/09/93[7]	--	--	--	--	ND	--	ND	39	ND	ND	2.5	--
	04/12/93[2,7]	--	--	--	--	ND	--	ND	52	ND	ND	6.6	--
(D)	04/12/93	--	--	--	--	ND	--	ND	53	ND	0.5	7.3	--
	06/24/93	--	--	--	3.59	ND	--	130	41	0.6	3.7	19	--
	09/28/93	--	--	--	1.80	ND	--	200	18	0.6	3.7	24	--
(D)	09/28/93	--	--	--	--	ND	--	190	16	0.7	2.9	21	--
	12/20/93	--	--	--	3.85	ND	--	ND	16	ND	0.7	11	--
(D)	12/20/93	--	--	--	--	ND	--	ND	16	ND	0.7	12	--
	06/02/94	--	--	--	1.50	ND	--	160	7.0	ND	ND	1.9	--
(D)	06/02/94	--	--	--	--	ND	--	110	7.3	ND	ND	2.1	--
	12/20/94	--	--	--	6.21	ND	--	ND	0.6	ND	ND	ND	--
(D)	12/20/94	--	--	--	--	ND	--	110	0.5	ND	ND	ND	--
	09/28/95[5]	--	13.61	--	4.53	290	--	ND	ND	ND	ND	ND	--
	12/08/95[8]	--	10.60	--	7.54	340	--	ND	ND	ND	ND	ND	--
	03/18/96[8]	--	10.65	--	7.49	ND	ND	ND	ND	ND	ND	ND	--
	DESTROYED												

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Groundwater Monitoring Data and Analytical Results
Chevron Service Station #9-3099
10805 East Marginal Way South
Tukwila, Washington

WELL ID/ TOC*(ft.)	DATE	DTP (ft.)	DTW (ft.)	SPHT (ft.)	GWE (ft.)	TPH-D (ppb)	TPH-O (ppb)	TPH-G (ppb)	B (ppb)	T (ppb)	E (ppb)	X (ppb)	MTBE (ppb)
MW-5	07/18/90	--	--	--	--	--	--	ND	10	ND	ND	ND	--
	08/15/90	--	--	--	--	ND	--	ND	53	ND	1.8	5.3	--
	11/16/90	--	--	--	--	ND	--	ND	200	ND	3.7	1.0	--
	01/08/91	--	--	--	--	ND	--	ND	4.2	ND	ND	ND	--
	03/20/91	--	--	--	--	ND	--	ND	1.2	ND	ND	ND	--
	07/23/91	--	--	--	--	ND	--	46	0.6	ND	3.4	10	--
	03/03/92	--	--	--	--	ND	--	94	ND	ND	ND	0.5	--
	06/17/92	--	--	--	--	230	--	430	ND	ND	15	48	--
	DESTROYED												
MW-6	07/30/90	--	--	--	--	--	--	ND	173	ND	ND	15	--
	08/15/90	--	--	--	--	ND	--	ND	150	0.6	1.5	17	--
	11/16/90	--	--	--	--	ND	--	500	130	ND	69	500	--
(D)	11/16/90	--	--	--	--	ND	--	600	100	ND	ND	440	--
	01/08/91	--	--	--	--	ND	--	ND	41	ND	3.7	11	--
(D)	01/08/91	--	--	--	--	ND	--	ND	52	ND	4.6	11	--
	03/20/91	--	--	--	--	ND	--	ND	54	ND	1.2	ND	--
(D)	03/20/91	--	--	--	--	ND	--	ND	58	ND	1.7	ND	--
	07/23/91	--	--	--	--	ND	--	130	35	ND	ND	ND	--
	03/03/92	--	--	--	--	ND	--	60	9.2	ND	1.5	4.4	--
(D)	03/03/92	--	--	--	--	ND	--	43	9.8	ND	ND	0.6	--
	06/17/92	--	--	--	--	ND	--	ND	2.4	ND	ND	ND	--
	DESTROYED												
MW-7													
17.91	07/30/90	--	--	--	--	--	--	ND	ND	ND	ND	ND	--
	08/15/90	--	--	--	--	ND	--	ND	0.7	ND	ND	ND	--
	11/16/90	--	--	--	--	ND	--	ND	11	ND	ND	ND	--
	01/08/91	--	--	--	--	ND	--	ND	1.9	ND	0.5	2.6	--
	03/20/91	--	--	--	--	ND	--	ND	0.5	ND	0.6	ND	--

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Groundwater Monitoring Data and Analytical Results
Chevron Service Station #9-3099
10805 East Marginal Way South
Tukwila, Washington

WELL ID/ TOC*(ft.)	DATE	DTP (ft.)	DTW (ft.)	SPHT (ft.)	GWE (ft.)	TPH-D (ppb)	TPH-O (ppb)	TPH-G (ppb)	B (ppb)	T (ppb)	E (ppb)	X (ppb)	MTBE (ppb)
MW-7	07/23/91	--	--	--	--	ND	--	ND	ND	ND	ND	ND	--
(cont)	03/03/92	--	--	--	--	ND	--	ND	ND	ND	ND	ND	--
	06/17/92	--	--	--	--	ND	--	ND	ND	ND	ND	ND	--
	02/09/93[9]	--	--	--	--	ND	--	ND	ND	ND	ND	ND	--
	04/12/93[9,10]	--	--	--	--	ND	--	ND	ND	ND	ND	ND	--
	06/24/93	--	11.93	--	5.98	ND	--	ND	ND	ND	ND	ND	--
	09/28/93	--	11.80	--	6.11	ND	--	ND	ND	ND	ND	ND	--
	12/20/93	--	10.43	--	7.48	ND	--	ND	ND	ND	ND	ND	--
	06/20/94	--	11.09	--	6.82	ND	--	ND	ND	ND	ND	ND	--
	12/20/94	--	10.08	--	7.83	ND	--	ND	ND	ND	ND	ND	--
	ABANDONED												
MW-8													
16.93	02/09/93[11]	--	--	--	--	ND	--	ND	ND	ND	ND	ND	--
	04/12/93[2,11]	--	--	--	--	300	--	ND	ND	ND	ND	ND	--
	06/24/93	--	--	--	--	ND	--	ND	ND	ND	ND	ND	--
	09/28/93	--	--	--	--	ND	--	ND	ND	ND	ND	ND	--
	12/20/93	--	--	--	--	ND	--	ND	ND	ND	ND	ND	--
	06/02/94	--	--	--	--	ND	--	ND	ND	ND	ND	ND	--
	12/20/94	--	--	--	--	ND	--	ND	ND	ND	ND	ND	--
	ABANDONED												
MW-8A													
16.84	02/09/93[12]	--	--	--	--	ND	--	ND	ND	ND	ND	ND	--
	04/12/93[2,12]	--	--	--	--	ND	--	ND	ND	ND	ND	ND	--
	06/24/93	--	9.75	--	7.09	ND	--	ND	ND	0.6	ND	ND	--
	09/28/93	--	10.87	--	5.97	ND	--	ND	3.0	6.1	0.7	3.3	--
	12/20/93	--	9.78	--	7.06	ND	--	ND	ND	ND	ND	ND	--

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Groundwater Monitoring Data and Analytical Results
Chevron Service Station #9-3099
10805 East Marginal Way South
Tukwila, Washington

WELL ID/ TOC*(ft.)	DATE	DTP (ft.)	DTW (ft.)	SPHT (ft.)	GWE (ft.)	TPH-D (ppb)	TPH-O (ppb)	TPH-G (ppb)	B (ppb)	T (ppb)	E (ppb)	X (ppb)	MTBE (ppb)
MW-8A	06/02/94	--	9.84	--	7.00	ND	--	ND	ND	ND	ND	ND	--
(cont)	12/20/94	--	9.11	--	7.73	ND	--	ND	ND	ND	ND	ND	--
	ABANDONED												
MW-9													
16.72	02/09/93[13]	--	--	--	--	ND	--	ND	ND	ND	ND	ND	--
	04/12/93[14]	--	--	--	--	ND	--	ND	ND	ND	ND	ND	--
	06/24/93	--	13.57	--	3.15	ND	--	ND	ND	ND	ND	ND	--
	09/28/93	--	14.50	--	2.22	ND	--	ND	ND	ND	ND	ND	--
	12/20/93	--	13.02	--	3.70	ND	--	ND	ND	ND	ND	ND	--
	06/02/94	--	14.89	--	1.83	ND	--	ND	ND	ND	ND	ND	--
	12/20/94	--	11.23	--	5.49	ND	--	ND	ND	ND	ND	ND	--
	ABANDONED												
MW-9A													
16.68	02/09/93[15]	--	--	--	--	ND	--	ND	ND	ND	0.8	0.5	--
	04/12/93[2,15]	--	--	--	--	300	--	ND	ND	ND	ND	ND	--
	06/24/93	--	9.27	--	7.41	390	--	ND	ND	ND	ND	ND	--
	09/28/93	--	10.23	--	6.45	ND	--	ND	ND	ND	ND	ND	--
	12/20/93	--	8.69	--	7.99	280	--	ND	ND	ND	ND	ND	--
	06/02/94	--	9.38	--	7.30	260	--	ND	ND	ND	ND	ND	--
	12/20/94	--	8.30	--	8.38	ND	--	ND	ND	ND	ND	ND	--
	ABANDONED												
MW-10													
99.21	09/05/97	--	15.10	--	84.11	ND	ND	ND	ND	ND	ND	ND	--
	03/18/98	--	15.68	--	83.53	ND	ND	ND	3.86	ND	ND	ND	--
	06/19/98[16]	--	15.75	--	83.46	ND	--	ND	3.88	ND	ND	ND	29.7
	09/02/98	--	16.46	--	82.75	ND	--	ND	ND	ND	ND	ND	22.6

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Groundwater Monitoring Data and Analytical Results
Chevron Service Station #9-3099
10805 East Marginal Way South
Tukwila, Washington

WELL ID/ TOC*(ft.)	DATE	DTP (ft.)	DTW (ft.)	SPHT (ft.)	GWE (ft.)	TPH-D (ppb)	TPH-O (ppb)	TPH-G (ppb)	B (ppb)	T (ppb)	E (ppb)	X (ppb)	MTBE (ppb)
MW-10	11/24/98	--	10.49	--	88.72	ND	--	ND	0.714	ND	ND	ND	8.08
(cont)	03/24/99	--	10.81	0.00	88.40	--[19]	--	ND	ND	0.553	ND	ND	ND
	05/29/99	--	13.42	0.00	85.79	301	--	ND	0.839	ND	ND	ND	9.93[20]
	09/04/99[21]	--	15.26	0.00	83.95	339	--	ND	2.05	ND	ND	ND	15.9[23]
	11/16/99[25]	--	12.10	0.00	87.11	ND[24]	--	ND	ND[24]	ND	ND	ND	19.5/13.3[26]
	10/2/00[25]	--	14.48	0.00	84.73	ND	--	ND	37.2	3.25	ND	ND	31.7/23.4[28]
	12/17/00[27]	--	13.74	0.00	85.47	ND	--	62.6	87.5	7.24	ND	1.67	46.6/41.9[28]
	03/25/01[25]	--	14.01	0.00	85.20	377	--	ND[24]	79.6	6.72	ND[24]	5.24	40.6/43.0[26]
	06/10/01[25]	--	13.35	0.00	85.86	435	--	<50.0	73.0	4.70	<0.500	4.62	36.4/39[26]
REPORTED: 05.30.03	09/09/01[25]	--	14.58	0.00	84.63	NOT SAMPLED DUE TO OBSTRUCTION[30]				--	--	--	--
	11/30/01	--	11.48	0.00	87.73	554	<500	254	90.4	15.2	2.46	16.3	42.3/37.7[26]
	02/20/02	--	13.52	0.00	85.69	<250[32]	--	<50	22	3.1	0.51	3.1	18/17[26]
	05/22/02	--	15.59	0.00	83.62	NOT SAMPLED DUE TO OBSTRUCTION				--	--	--	--
	NP 11/24/02	--	14.15	0.00	85.06	<250[32]	<250[32]	550	180	2.3	28	120	27/23[26]
	NP 05/05-07/03	--	13.32	0.00	85.89	<250[32]	<250[32]	1,300	78	41	43	190	20/20[26]
	NP 11/13/03	--	14.08	0.00	85.13	250[32]	<250[32]	1,100	82	31	38	140	21/18[26]
MW-11													
98.15	09/05/97	--	14.59	--	83.56	376	ND	77.2	ND	ND	ND	ND	--
	03/18/98	--	11.06	--	87.09	390	ND	ND	ND	ND	ND	ND	--
	06/19/98[17]	--	13.56	--	84.59	297	--	ND	ND	ND	ND	ND	6.79
	09/02/98	--	10.88	--	87.27	ND	--	ND	31.2	ND	ND	ND	44.3
	11/24/98	--	11.93	--	86.22	ND	--	ND	13.5	0.546	ND	2.91	16.7
	03/24/99	--	10.43	0.00	87.72	ND	--	ND	3.97	ND	ND	ND	11.2
	05/29/99[21]	--	9.92	0.00	88.23	ND	--	ND	ND	ND	ND	ND	32.7[20]
	09/04/99	--	10.95	0.00	87.20	ND	--	ND	ND	ND	ND	ND	48.2[23]
	11/16/99[25]	--	8.31	0.00	89.84	369	--	ND	ND	ND	ND	ND	44.8/33.9[26]
	10/02/00[27]	--	15.05	0.00	83.10	252	--	ND	ND	ND	ND	ND	31.6/35.0[28]
	12/17/00	--	12.99	0.00	85.16	435	--	ND	ND	ND	ND	ND	9.11/8.93[28]
	03/25/01[25]	--	12.16	0.00	85.99	912	--	ND	ND	0.640	ND	1.51	5.01/5.12[26]
	06/10/01[25]	--	12.11	0.00	86.04	790	--	<50.0	<0.500	<0.500	<0.500	<1.00	6.64/7.3[26]

Table

Groundwater Monitoring Data and Analytical Results
Chevron Service Station #9-3099
10805 East Marginal Way South
Tukwila, Washington

WELL ID/ TOC*(ft.)	DATE	DTP (ft.)	DTW (ft.)	SPHT (ft.)	GWE (ft.)	TPH-D (ppb)	TPH-O (ppb)	TPH-G (ppb)	B (ppb)	T (ppb)	E (ppb)	X (ppb)	MTBE (ppb)
MW-11	09/09/01[25]	--	14.58	0.00	83.57	494	<500	<50.0	<0.500	<0.500	<0.500	<1.00	27.8/27.8[26]
(cont)	11/30/01	--	9.81	0.00	88.34	293[31]	<500	<50.0	<0.500	<0.500	<0.500	<1.00	<1.00/<0.500[26]
	02/20/02	--	9.22	0.00	88.93	<250[32]	--	<50	<0.50	<0.50	<0.50	<1.5	<2.5
	NP 05/22/02	--	10.72	0.00	87.43	500[32]	<750[32]	72	<0.50	0.87	<0.50	<1.5	<2.5
	NP 11/24/02	--	13.79	0.00	84.36	<250[32]	<250[32]	50	0.83	0.57	<0.50	<1.5	30/20[26]
	05/05-07/03	11.00	14.50	3.50	86.45***	NOT SAMPLED DUE TO THE PRESENCE OF SPH				--	--	--	--
	11/13/03	12.34	16.50	4.16	84.98**	NOT SAMPLED DUE TO THE PRESENCE OF SPH				--	--	--	--
MW-12													
98.49	09/05/97	--	13.75	--	84.74	366	ND	ND	ND	ND	ND	ND	--
	03/18/98	--	13.40	--	85.09	ND	ND	ND	9.52	ND	ND	ND	--
	06/19/98[18]	--	14.09	--	84.40	653	--	ND	11.3	0.909	ND	ND	47
	09/02/98	--	14.94	--	83.55	ND	--	ND	66.2	ND	ND	1.65	146
	11/24/98	--	11.29	--	87.20	ND	--	ND	6.05	ND	ND	ND	22.4
	03/24/99	--	11.46	0.00	87.03	ND	--	ND	10.3	1.20	ND	1.13	17.1
	05/29/99[21]	--	12.80	0.00	85.69	ND	--	ND	30.9	0.646	ND	3.69	51.3[20]
	09/04/99	--	11.21	0.00	87.28	ND	--	ND[24]	168	15.4	3.46	37.3	132[23]
	11/16/99[25]	--	7.80	0.00	90.69	4,650	--	1,410	442	360	6.05	123	70.1/70.7[26]
	10/02/00[27]	--	10.97	0.00	87.52	2,430[29]	--	347	286	49.4	3.91	58.4	49.7/49.8[28]
	12/17/00	--	9.25	0.00	89.24	252	--	284	190	13.9	3.43	31.3	26.0/22.6[28]
	03/25/01	--	10.11	0.00	88.38	779	--	74.1	24.7	0.995	0.936	5.19	15.3/18.2[26]
	06/10/01	--	9.73	0.00	88.76	759	--	<50.0	24.3	5.33	0.540	4.05	16.0/17[26]
	09/09/01	--	10.03	0.00	88.46	653	<500	78.5	15.7	5.04	0.947	9.18	15.4/13.6[26]
	11/30/01	--	8.43	0.00	90.06	311	<500	<50.0	5.11	<0.500	<0.500	1.27	4.95/3.93[26]
	02/20/02	--	8.22	0.00	90.27	<250[32]	--	<50	<0.50	<0.50	<0.50	<1.5	<2.5
	NP 05/22/02	--	8.95	0.00	89.54	<250[32]	<750[32]	110	<0.50	0.71	<0.50	<1.5	<2.5
	NP 11/24/02	--	9.86	0.00	88.63	<250[32]	<250[32]	1,200	98	5.5	47	150	12/10[26]
	NP 05/05-07/03	--	8.72	0.00	89.77	<250[32]	450[32]	<50	<0.5	<0.5	<0.5	<1.5	<2.5
	NP 11/13/03	--	9.74	0.00	88.75	<250[32]	<250[32]	<50	<0.5	<0.5	<0.5	<1.5	6.2/5[26]

Table
Groundwater Monitoring Data and Analytical Results
Chevron Service Station #9-3099
10805 East Marginal Way South
Tukwila, Washington

WELL ID/ TOC*(ft.)	DATE	DTP (ft.)	DTW (ft.)	SPHT (ft.)	GWE (ft.)	TPH-D (ppb)	TPH-O (ppb)	TPH-G (ppb)	B (ppb)	T (ppb)	E (ppb)	X (ppb)	MTBE (ppb)
Trip Blank													
TB-LB	09/02/98	--	--	--	--	--	--	ND	ND	ND	ND	ND	ND
	11/24/98	--	--	--	--	--	--	ND	ND	ND	ND	ND	ND
	03/24/99	--	--	--	--	--	--	ND	ND	ND	ND	ND	ND
	05/29/99[22]	--	--	--	--	--	--	--	--	--	--	--	--
	09/04/99	--	--	--	--	--	--	ND	ND	ND	0.525	3.36	ND
	11/16/99	--	--	--	--	--	--	ND	ND	ND	ND	ND	ND
	10/02/00	--	--	--	--	--	--	ND	ND	ND	ND	ND	ND
	12/17/00	--	--	--	--	--	--	ND	ND	ND	ND	ND	ND
	03/25/01	--	--	--	--	--	--	ND	ND	ND	ND	ND	ND
	06/10/01	--	--	--	--	--	--	<50.0	<0.500	<0.500	<0.500	<1.00	<1.00
	09/09/01	--	--	--	--	--	--	<50.0	<0.500	<0.500	<0.500	<1.00	<1.00
	11/30/01	--	--	--	--	--	--	<50.0	<0.500	<0.500	<0.500	<1.00	<1.00
	02/20/02	--	--	--	--	--	--	<50	<0.50	<0.50	<0.50	<1.5	<2.5
	05/22/02	--	--	--	--	--	--	<50	<0.50	<0.50	<0.50	<1.5	<2.5
	11/24/02	--	--	--	--	--	--	<50	<0.50	<0.50	<0.50	<1.5	<2.5
	05/05-07/03	--	--	--	--	--	--	<50	<0.5	<0.5	<0.5	<1.5	<2.5
	11/13/03	--	--	--	--	--	--	<50	<0.5	<0.5	<0.5	<1.5	<2.5

	TPH-D	TPH-O	TPH-G	B	T	E	X	MTBE
Standard Laboratory Reporting Limits:	250	250	50	0.5	0.5	0.5	1.5	2.5
MTCA Method A Cleanup Levels:	500	500	800/1,000	5	1,000	700	1,000	20
Current Method:	NWTPH-D + Extended		NWTPH-G and EPA 8021B					

Table

Groundwater Monitoring Data and Analytical Results

Chevron Service Station #9-3099
10805 East Marginal Way South
Tukwila, Washington

EXPLANATIONS:

Groundwater monitoring data and laboratory analytical results prior to November 24, 1998, were compiled from reports prepared by Pacific Environmental Group, Inc.

TOC = Top of Casing
(ft.) = Feet
DTP = Depth to Product
DTW = Depth to Water
GWE = Groundwater Elevation
SPHT = Separate Phase Hydrocarbon Thickness
TPH-D = Total Petroleum Hydrocarbons as Diesel

TPH-O = Total Petroleum Hydrocarbons as Oil
TPH-G = Total Petroleum Hydrocarbons as Gasoline
B = Benzene
T = Toluene
E = Ethylbenzene
X = Xylenes
MTBE = Methyl tertiary butyl ether

ND = Not Detected
(ppb) = Parts per billion
-- = Not Measured/Not Analyzed
(D) = Duplicate
NP = No purge
MTCA = Model Toxics Control Act Cleanup Regulations [WAC 173-340-720(2)(a)(I), as amended 02/01]

* TOC elevations are referenced in feet relative to an arbitrary datum.

** GWE has been corrected for the presence of SPH; correction factor: [(TOC - DTW) + (SPHT x 0.80)].

*** GWE has been corrected for the presence of SPH; correction factor: [(TOC - DTP - SPHT) + (SPHT x 0.80)]; Historical data has been altered to correct error in original reporting of depth to product as depth to water.

1 Total Lead was 4.4 ppb on 02/09/93 and 3.5 ppb on 04/12/93.
2 Dissolved Lead was ND.
3 Total Lead was 25 ppb on 02/09/93 and on 04/12/93 Total Lead was 31 ppb and the duplicate sample was 30 ppb.
4 Total Lead was 36 ppb on 02/09/93 and 56 ppb on 04/12/93.
5 Total Lead was ND.
6 Total Lead was 12 ppb.
7 Total Lead was 24 ppb on 02/09/93 and 53 ppb on 04/12/93.
8 Total Lead was 20 ppb on 12/08/95 and 4.8 ppb on 03/18/96.
9 Total Lead was 40 ppb on 02/09/93 and 27 ppb on 04/12/93.
10 Dissolved Lead was 3.9 ppb.
11 Total Lead was 25 ppb on 02/09/93 and 33 ppb on 04/12/93.
12 Total Lead was 18 ppb on 02/09/93 and 74 ppb on 04/12/93.
13 Total Lead was 23 ppb.
14 Total Lead was 42 ppb and Dissolved lead was 3.1 ppb.
15 Total Lead was 75 ppb on 02/09/93 and 120 ppb on 04/12/93.
16 Total Lead was 21.2 ppb.
17 Total Lead was 2.89 ppb.
18 Total Lead was 1.53 ppb.
19 Laboratory lost sample during the extraction process and therefore, was unable to analyze for TPH-D.

Tabl

Groundwater Monitoring Data and Analytical Results
Chevron Service Station #9-3099
10805 East Marginal Way South
Tukwila, Washington

EXPLANATIONS: (cont)

20 MTBE results were below 200 ppb and were not confirmed by 8260.

21 ORC installed in well.

22 Laboratory data was not available.

23 MTBE confirmed by EPA Method 8260.

24 Detection limit raised. Refer to analytical reports.

25 ORC present in well.

26 MTBE by EPA Method 8260.

27 ORC replaced in well.

28 Laboratory report indicates MTBE by EPA Method 8260 was analyzed outside the recommended holding time.

29 Laboratory report indicates the hydrocarbon concentration result in this sample is partially due to one or more individual peaks eluting in the diesel/heavy oil range.

30 ORC stuck in well; unable to remove for sampling.

31 Laboratory report indicates results in the diesel organics range are primarily due to overlap from a heavy oil range product.

32 TPH-D and TPH-O analysis with silica gel cleanup.

Table 2

Dissolved Oxygen Concentrations
Chevron Service Station #9-3099
10805 East Marginal Way South
Tukwila, Washington

WELL ID	DATE	BEFORE PURGE *(mg/L)*	AFTER PURGE *(mg/L)*
MW-10	05/29/99	--	0.18
	09/04/99[1]	--	--
MW-11	05/29/99[1]	--	0.11
	09/04/99[1]	--	--
MW-12	05/29/99[1]	--	0.23
	09/04/99[1]	--	--

EXPLANATIONS:

(mg/L) = Milligrams per liter
-- = Not Measured

[1] ORC installed in well.

Tab

Groundwater Analytical Results - Oxygenate Compounds
Chevron Service Station #9-3099
10805 East Marginal Way South
Tukwila, Washington

WELL ID	DATE	METHANOL (ppm)	ETHANOL (ppb)	TBA (ppb)	MTBE (ppb)	DIPE (ppb)	ETBE (ppb)	TAME (ppb)
MW-10	03/25/01	ND	ND[1]	174	43.0	ND[1]	ND[1]	ND[1]
	06/10/01	<10.0	<500	190	39	<2.0	<2.0	<2.0
	09/09/01	NOT SAMPLED DUE TO OBSTRUCTION[2]			--	--	--	--
	11/30/01	<10.0	<500	120	37.7	<1.00	<1.00	<1.00
	02/20/02	--	--	--	17	--	--	--
	11/24/02	--	--	--	23	--	--	--
	05/05-07/03	--	--	--	20	--	--	--
	11/13/03	--	--	--	18	--	--	--
MW-11	03/25/01	ND	ND	ND	5.12	ND	ND	ND
	06/10/01	<10.0	<500	<20	7.3	<2.0	<2.0	<2.0
	09/09/01[3]	<10.0	<1,000	<250	27.8	<2.00	<2.00	<2.00
	11/30/01	<10.0	<500	<50.0	<0.500	<1.00	<1.00	<1.00
	11/24/02	--	--	--	20	--	--	--
MW-12	03/25/01	ND	ND[1]	173	18.2	ND[1]	ND[1]	ND[1]
	06/10/01	<10.0	<500	180	17	<2.0	<2.0	<2.0
	09/09/01[3]	<10.0	<1,000	<250	13.6	<2.00	<2.00	<2.00
	11/30/01	<10.0	<500	<50.0	3.93	<1.00	<1.00	<1.00
	11/24/02	--	--	--	10	--	--	--
	11/13/03	--	--	--	5	--	--	--

Tabl.
Groundwater Analytical Results - Oxygenate Compounds
Chevron Service Station #9-3099
10805 East Marginal Way South
Tukwila, Washington

EXPLANATIONS:

TBA = Tertiary butyl alcohol
MTBE = Methyl tertiary butyl ether
DIPE = Di-isopropyl ether
ETBE = Ethyl tertiary butyl ether
TAME = Tertiary amyl methyl ether
(ppm) = Parts per million
(ppb) = Parts per billion
ND = Not Detected
-- = Not Analyzed

[1] Detection limit raised. Refer to analytical reports.
[2] ORC stuck in well; unable to remove for sampling.
[3] Though not requested, laboratory provided analysis for both 1,2-Dibromoethane and 1,2-Dichloroethane. The results were <2.00 ppb.

ANALYTICAL METHODS:

EPA Method 8015 for Methanol
EPA Method 8260 for Oxygenate Compounds

Table 4
Separate Phase Hydrocarbon Thickness/Removal Data
Chevron Service Station #9-3099
10805 East Marginal Way South
Tukwila, Washington

WELL ID	DATE	DTP *(ft.)*	DTW *(ft.)*	SPH THICKNESS *(ft.)*	AMOUNT BAILED (SPH + WATER) *(gallons)*
MW-11	05/05-07/03	11.00	14.50	3.50	0.00
	11/13/03	12.34	16.50	4.16	0.00

EXPLANATIONS:

DTP = Depth to Product
DTW = Depth to Water
(ft.) = Feet
SPH = Separate Phase Hydrocarbons

Note: Historical data has been altered to correct error in original reporting of depth to product as depth to water.

TABLE 1
SOIL SAMPLE ANALYTICAL RESULTS
Boeing Field Chevron
10805 East Marginal Way South
Tukwila, Washington
February 27, 2004

Sample Name	Sample Depth	Location	TPH-G	B	T	E	X
S-B1-15	15	West Planter	<5.00	0.181	0.0587	0.0717	0.286
S-B2-15	15	West Planter	38.4	3.83	5.25	1.49	5.67
S-B3-14	14	West Planter	101	0.0463	<0.0500	0.508	0.439
S-B4-15	15	West Side, North Planter	<5.00	<0.0300	<0.0500	<0.0500	<0.100
S-B5-15	15	West Side, North Planter	<5.00	<0.0300	<0.0500	<0.0500	<0.100
S-B6-10	10	North Side, North Planter	<5.00	<0.0300	<0.0500	<0.0500	<0.100
S-B7-11	11	East Side, North Planter	<5.00	<0.0300	<0.0500	<0.0500	<0.100
S-B8-10	10	East Side, North Planter	<5.00	<0.0300	<0.0500	<0.0500	<0.100
S-B9-10	10	South Parking Area	<5.00	<0.0300	<0.0500	<0.0500	<0.100
S-B10-10	10	Southwest Planter	<5.00	<0.0300	<0.0500	<0.0500	<0.100
MTCA Method A Cleanup Levels (Soil)			30/100*	0.03	7	6	9

EXPLANATION:

Soil concentrations are in mg/kg (ppm).
Depth of samples are in feet below ground surface.
TPH-G = Total Petroleum Hydrocarbons as Gasoline by Ecology Method NWTPH-Gx
B = Benzene; T = Toluene; E = Ethylbenzene; X = Total Xylenes
BTEX = Aromatic compounds by EPA Method 8021B
< = Less than the stated laboratory reporting limit
NA = Not applicable
* = TPH-G soil cleanup level is 30 ppm, unless benzene is not detected in the sample, or if toluene, ethylbenzene, and total xylenes consitute less than 1% of the TPH-G present in the sample. If these conditions are met, the cleanup level for TPH-G may be elevated to 100 ppm.
Shaded values equal or exceed MTCA Method A Cleanup Levels.

TABLE 2
WATER SAMPLE ANALYTICAL RESULTS
Boeing Field Chevron
10805 East Marginal Way South
Tukwila, Washington
February 27, 2004

Sample Name	Location	TPH-G	B	T	E	X
B1	West Planter	7,920	1,290	1,110	118	524
B2	West Planter	114,000	5,930	38,600	2,580	13,000
B3	West Planter	3,380	3.28	12.2	15.6	20.3
B4	West Side, North Planter	610	57.4	20.6	1.31	3.60
B5	West Side, North Planter	50.6	<0.500	0.589	<0.500	1.38
B6	North Side, North Planter	<50.0	<0.500	<0.500	<0.500	<1.00
B7	East Side, North Planter	89.4	<0.500	<0.500	<0.500	<1.00
B8	East Side, North Planter	<50.0	<0.500	<0.500	<0.500	<1.00
B9	South Parking Area	<50.0	<0.500	<0.500	<0.500	<1.00
B10	Southwest Planter	<50.0	<0.500	<0.500	<0.500	<1.00
MTCA Method A Cleanup Levels (Water)		800/1,000*	5.0	1,000	700	1,000

EXPLANATION:

Water concentrations are in µg/L (ppb).

Depth of samples are in feet below ground surface.

TPH-G = Total Petroleum Hydrocarbons as Gasoline by Ecology Method NWTPH-Gx

B = Benzene; T = Toluene; E = Ethylbenzene; X = Total Xylenes

BTEX = Aromatic compounds by EPA Method 8021B

< = Less than the stated laboratory reporting limit

NA = Not applicable

* = TPH-G cleanup level for groundwater is 800 ppb if benzene is present. TPH-G cleanup level is 1,000 ppb if benzene is not present.

Shaded values equal or exceed MTCA Method A Cleanup Levels.

TABLE 1
SOIL SAMPLE ANALYTICAL RESULTS
Boeing Field Chevron
10805 East Marginal Way South
Tukwila, Washington
July 16, 2004

Sample Name	Sample Depth	Location	TPH-G	B	T	E	X
S-B1-5	5	West Planter	<5.00	<0.0300	0.0576	<0.0500	0.100
S-B2-10	10	West Planter	510	0.179	0.616	3.48	3.28
MTCA Method A Cleanup Levels (Soil)			30/100*	0.03	7	6	9

EXPLANATION:

Soil concentrations are in mg/kg (ppm).

Depth of samples are in feet below ground surface.

TPH-G = Total Petroleum Hydrocarbons as Gasoline by Ecology Method NWTPH-Gx

B = Benzene; T = Toluene; E = Ethylbenzene; X = Total Xylenes

BTEX = Aromatic compounds by EPA Method 8021B

< = Less than the stated laboratory reporting limit

NA = Not applicable

* = TPH-G soil cleanup level is 30 ppm, unless benzene is not detected in the sample, or if toluene, ethylbenzene, and total xylenes constitute less than 1% of the TPH-G present in the sample. If these conditions are met, the cleanup level for TPH-G may be elevated to 100 ppm.

Shaded values equal or exceed MTCA Method A Cleanup Levels.

TABLE 2
GROUNDWATER ANALYTICAL RESULTS
Boeing Field Chevron
10805 East Marginal Way South
Tukwila, Washington

Well	Sample Date	DTW	GW Elev.	TPH-G	B	T	E	X
MW10 99.18	08/16/04	15.80	83.38	**6,710**	**191**	555	130	626
MW11 98.12	08/16/04	16.15	81.97	**79,000**	**3,340**	**11,600**	**2,010**	**10,600**
MW12 97.48	08/16/04	9.90	87.58	<50.0	<0.500	0.935	<0.500	1.84
MW13 97.23	08/16/04	16.71	80.52	**14,400**	**3,850**	138	332	**1,150**
MW14 98.07	08/16/04	17.90	80.17	**175,000**	**8,820**	**31,700**	**4,010**	**21,300**
MTCA Method A Cleanup Levels (Water)				800/1,000*	5.0	1,000	700	1,000

EXPLANATION:
Concentrations are in µg/L (ppb).
DTW = Depth to water in feet below top of casing
GW Elev. = Groundwater elevation relative to top of casing elevations
TPH-G = Total Petroleum Hydrocarbons as Gasoline by Ecology Method NWTPH-Gx
B = Benzene; T = Toluene; E = Ethylbenzene; X = Total Xylenes
BTEX = Aromatic compounds by EPA Method 8021B
< = Less than the stated laboratory reporting limit
NA = Not applicable
* = TPH-G cleanup level for groundwater is 800 ppb if benzene is present. TPH-G cleanup level is 1,000 ppb if benzene is not present.
Shaded values equal or exceed MTCA Method A Cleanup Levels.

TABLE 3
WELLHEAD ELEVATION SURVEY RESULTS
Boeing Field Chevron
10805 East Marginal Way South
Tukwila, Washington
August 16, 2004

Location	HI	FS	BS	Elev	Difference	Notes	Computed Wellhead Elevations	
Benchmark	104.945		4.945	100.000		Start First Set		
MW10		5.770		99.175				
MW11		6.822		98.123				
MW12		7.468		97.477				
MW13		7.712		97.233				
MW14		6.872		98.073				
Benchmark	104.945		4.945	100.000		End First Set		
Benchmark	104.950		4.950	100.000		Start Second Set		
MW10		5.775		99.175	+0.000		**MW10 =**	**99.175**
MW11		6.830		98.120	-0.003		**MW11 =**	**98.122**
MW12		7.477		97.473	-0.004		**MW12 =**	**97.475**
MW13		7.720		97.230	-0.003		**MW13 =**	**97.232**
MW14		6.879		98.071	-0.002		**MW14 =**	**98.072**
Benchmark	105.190		5.190	100.000		End Second Set		

EXPLANATION:
Elevations are in feet above sea level.
Measurements are in feet.
HI = Height of Instrument
FS = Foreshot
BS = Backshot
Elev = Elevation
All final elevations were calculated by taking the average of two elevations that were confirmed to within 0.005 feet.
Elevations were measured from north side of the casing rim, except where noted, using optical level and graduated rod.
Elevations are relative to an arbitrary datum of 100.000, assigned to a benchmark located
on the northern side of the northwestern driveway entrance, marked on 8/16/04 by ERI with white paint.

TABLE 1
SOIL AND GROUNDWATER SAMPLE ANALYTICAL RESULTS
Boeing Field Chevron
10805 East Marginal Way South
Tukwila, Washington
March 1, 2005

Sample Name	Sample Depth	TPH-G	TPH-D	TPH-O	B	T	E	X
SOIL SAMPLE								
S-10-B11	10	<3.83	<10.0	<25.0	<0.0230	<0.0383	<0.0383	<0.0766
GROUNDWATER SAMPLE								
B11	NA	<50.0	500	<500	<0.500	<0.500	<0.500	<1.00
MTCA Method A Cleanup Levels (Soil)		30/100*	2,000	2,000	0.03	7	6	9
MTCA Method A Cleanup Levels (Groundwater)		800/1,000*	500	500	5	1,000	700	1,000

EXPLANATION:
Soil concentrations are in mg/kg (ppm).
Groundwater concentrations are in µg/L (ppb).
Depth of soil samples are in feet below ground surface.
TPH-G = Total Petroleum Hydrocarbons as Gasoline by Ecology Method NWTPH-Gx
TPH-D and TPH-O = Total Petroleum Hydrocarbons as Diesel and as Oil by Ecology Method NWTPH-Dx
B = Benzene; T = Toluene; E = Ethylbenzene; X = Total Xylenes
BTEX = Aromatic compounds by EPA Method 8021B
< = Less than the stated laboratory reporting limit
NA = Not applicable
* = TPH-G cleanup level is the lower stated value, unless benzene is not detected in the sample, or if toluene, ethylbenzene, and total xylenes consitute less than 1% of the TPH-G present in the sample. If these conditions are met, the cleanup level for TPH-G may be elevated to the second stated value.
Shaded values equal or exceed MTCA Method A Cleanup Levels.

TABLE 1

Well Construction Data and Recent Groundwater Elevations
Boeing Field Chevron

Well Designation	Well Installation Date	Elevation Top of PVC Casing (ft.)*	Depth to Top of Screen (ft.)	Depth to Bottom of Screen (ft.)	Well Diam. (in.)	Date Measured	Comment	Depth to Water (ft.)	Calculated GW Elevations (ft.)
MW-10	9/3/97	100.08	8	20	2	04/18/08	Outgoing Tide	11.25	88.83
						04/25/08	Incoming Tide	11.41	88.67
MW-11	9/3/97	99.01	8	20	2	04/18/08	Outgoing Tide	14.11	84.90
						04/25/08	Incoming Tide	13.42	85.59
MW-12	9/3/97	98.38	8	20	2	04/18/08	Outgoing Tide	9.31	89.07
						04/25/08	Incoming Tide	9.70	88.68
MW-13	7/16/04	99.14	4	24	2	04/18/08	Outgoing Tide	14.38	84.76
						04/25/08	Incoming Tide	13.68	85.46
MW-14	7/16/04	99.96	4	24	2	04/18/08	Absorbent Present	16.66	83.30
MW-15	8/26/05	99.79	10	25	2	04/18/08	Absorbent Present	16.37	83.42
MW-16	8/26/05	100.22	10	25	2	04/18/08	Outgoing Tide	10.43	89.79
						04/25/08	Incoming Tide	10.57	89.65
MW-17	8/26/05	99.90	10	25	2	04/10/08	--	10.37	89.53
MW-18	4/16/08	97.26	11	16	1	04/18/08	Outgoing Tide	9.02	88.24
						04/25/08	Incoming Tide	9.13	88.13
MW-19	4/16/08	97.07	15	20	1	04/18/08	Outgoing Tide	10.40	86.67
						04/25/08	Incoming Tide	10.75	86.32
MW-20	4/16/08	97.72	15	20	1	04/18/08	Outgoing Tide	13.45	84.27
						04/25/08	Incoming Tide	12.31	85.41
MW-21	4/16/08	97.28	17	22	1	04/18/08	non-vertical well	14.52	82.76
						04/25/08	non-vertical	11.90	85.38
IP-3	4/19/06	99.31	18	24	2	03/27/08	--	13.74	85.57
IP-4	4/26/06	99.52	8	14	3	03/27/08	Absorbent Present	10.82	88.70
IP-5	4/26/06	100.10	18	24	2	04/18/08	Outgoing Tide	15.61	84.49
						04/25/08	Incoming Tide	14.81	85.29
IP-6	8/4/06	99.29	18	24	2	04/18/08	Absorbent Present	15.20	84.09
IP-7	8/4/06	99.35	18	24	2	04/18/08	Absorbent Present	16.03	83.32
EW-1	3/17/08	100.01	8	23	2	03/27/08	--	14.70	85.31
EW-2	3/17/08	100.25	8	23	2	03/27/08	--	15.01	85.24
EW-3	3/17/08	99.90	8	23	2	04/18/08	Outgoing Tide	15.52	84.38
						04/25/08	Incoming Tide	14.57	85.33
EW-4	3/17/08	99.90	8	23	2	03/27/08	--	14.88	85.02
EW-5	3/17/08	99.92	8	23	2	03/27/08	--	15.00	84.92
EW-6	3/18/08	99.95	8	23	2	03/27/08	--	15.32	84.63
EW-7	3/18/08	99.57	8	23	2	03/27/08	--	14.94	84.63
EW-8	3/18/08	99.68	8	23	2	03/27/08	--	15.08	84.60
EW-9	3/18/08	99.46	8	23	2	03/27/08	--	14.82	84.64
						04/18/08	Outgoing Tide	14.97	84.49
						04/25/08	Incoming Tide	13.12	86.34
EX-N	2004	99.40	1	15	6	04/10/08	--	10.85	88.55
EX-S	2004	98.94	1	15	4	04/18/08	Outgoing Tide	10.30	88.64
						04/25/08	Incoming Tide	10.41	88.53

Notes:

* Elevations based on an arbitrary elevation of 100.00 feet on the sidewalk curb near the north corner of 309 Cedar Street (Figure 2).

-- Not Applicable.

For wells with "outgoing" and "incoming" tides, See Figure XX for approximately elevation contours.

Tides for 4/18/08: high at 0430, low at 1107, GW levels at 0840 to 0930

Tides for 4/25/08: low at 0316, high at 0728, GW levels at 0715 to 0740

Table 2

Product Thickness Measurements
Boeing Field Chevron
Seattle, Washington

Well	TOC Elevation	Date	Depth Measurement (in feet) Water	Product	Product Thickness (feet)	Potentiometric Surface Elevation (ft)	Comments
MW-10	100.08	8/22/2006	14.90	nm	0.00	85.18	
		1/4/2007	11.09	nm	0.00	88.99	
		1/25/2007	11.20	nm	0.00	88.88	
		3/27/2008	11.88	nm	0.00	88.20	
		4/18/2008	11.25	nm	0.00	88.83	
MW-11	99.01	7/14/2005	13.61	nm	0.00	85.40	
		7/19/2005	14.75	nm	0.01	84.27	
		1/20/2006	7.60	nm	0.00	91.41	
		1/31/2006	8.38	nm	0.00	90.63	
		4/3/2006	10.06	nm	0.00	88.95	
		5/2/2006	9.86	nm	0.00	89.15	
		8/22/2006	15.95	nm	0.00	83.06	
		10/13/2006	13.82	nm	0.00	85.19	
		1/4/2007	9.51	nm	0.00	89.50	
		1/25/2007	11.93	nm	0.00	87.08	
		2/22/2007	12.31	nm	0.00	86.70	
		3/27/2008	12.75	nm	0.00	86.26	
		4/9/2008	15.52	nm	0.00	83.49	
		4/18/2008	14.11	nm	0.00	84.90	9:12 AM
		4/18/2008	15.24	nm	0.00	83.77	12:20 PM
MW-12	98.38	8/22/2006	9.91	nm	0.00	88.47	
		3/27/2008	8.14	nm	0.00	90.24	
MW-13	99.14	7/14/2005	15.10	nm	0.00	84.04	
		7/19/2005	16.30	nm	0.00	82.84	
		1/20/2006	11.10	nm	0.00	88.04	
		1/31/2006	11.15	nm	0.00	87.99	
		5/2/2006	13.80	nm	0.00	85.34	
		5/8/2006	14.91	nm	0.00	84.23	
		8/22/2006	16.50	nm	0.00	82.64	
		1/4/2007	10.91	nm	0.00	88.23	
		1/25/2007	12.93	nm	0.00	86.21	
		3/27/2008	13.48	nm	0.00	85.66	
MW-14	99.96	7/1/2005	18.90	nm	2.45	82.87	
		7/14/2005	17.70	nm	2.19	83.88	
		7/19/2005	17.00	nm	0.85	83.59	
		10/26/2005	16.72	nm	0.82	83.85	
		11/9/2005	15.81	nm	0.33	84.39	
		11/30/2005	15.04	nm	0.26	85.11	
		12/7/2005	14.25	nm	0.31	85.94	
		12/14/2005	14.23	nm	0.34	85.98	
		1/20/2006	12.30	nm	0.46	88.00	
		1/31/2006	12.11	nm	0.01	87.86	
		4/3/2006	14.48	nm	2.25	87.14	
		5/2/2006	14.80	nm	0.59	85.60	
		5/8/2006	16.19	nm	0.56	84.18	
		8/22/2006	17.51	nm	0.02	82.46	Brown Product, not transparent
		10/13/2006	16.40	14.51	1.89	84.96	
		1/4/2007	12.20	11.29	0.91	88.43	
		1/25/2007	16.59	13.02	3.57	86.01	
		2/22/2007	13.99	13.95	0.04	86.00	
		3/7/2007	15.43	15.38	0.05	84.57	
		5/1/2007	15.07	nm	0.00	84.89	
		10/1/2007	16.07	13.79	2.28	85.57	
		10/23/2007	17.17	14.65	2.52	84.65	
		2/20/2008	?	14.84	0.20	85.47	Interface measurement approximate
		2/21/2008	14.705	14.70	0.01	85.26	Measured after removing absorbent
		2/25/2008	16.43	16.39	0.04	83.56	Measured after removing absorbent

Table 2

Product Thickness Measurements
Boeing Field Chevron
Seattle, Washington

Well	TOC Elevation	Date	Depth Measurement (in feet) Water	Product	Product Thickness (feet)	Potentiometric Surface Elevation (ft)	Comments
		2/26/2008	14.43	14.43	0.00	85.53	Trace product
		2/28/2008	14.15	14.15	0.00	85.81	Trace product
MW-14 Continued		3/4/2008	15.10	14.93	0.17	84.99	Measured after removing absorbent
		3/12/2008	16.10	15.6	0.50	84.23	Measured after removing absorbent
		3/13/2008	14.45	14.32	0.13	85.61	Measured after removing absorbent
		3/21/2008	No product measured after removing absorbent				
		3/27/2008	15.55	nm	0.00	84.41	Measured after removing absorbent
		4/2/2008	15.33	15.33	0.00	84.63	Trace product
		4/7/2008	17.10	nm	0.00	82.86	Measured after removing absorbent
		4/9/2008	16.74	nm	0.00	83.22	Measured after removing absorbent
		4/11/2008	No product measured after removing absorbent				
		4/15/2008	No product measured after removing absorbent				
		4/18/2008	16.66	nm	0.00	83.30	Measured after removing absorbent
		4/22/2008	16.53	nm	0.00	83.43	Measured after removing absorbent
MW-15	99.79	11/30/2005	16.84	nm	3.05	85.20	
		12/7/2005	15.91	nm	2.81	85.96	
		12/14/2005	16.18	nm	3.22	85.99	
		1/20/2006	12.05	nm	0.65	88.22	
		1/31/2006	12.41	nm	0.86	88.02	
		4/3/2006	17.30	nm	2.70	84.49	
		5/2/2006	16.59	nm	3.30	85.64	
		5/8/2006	15.60	nm	0.00	84.19	
		6/13/2006	16.97	nm	0.10	82.89	
		6/19/2006	15.16	nm	0.00	84.63	
		8/22/2006	17.22	nm	0.01	82.58	
		10/13/2006	15.04	14.96	0.08	84.81	
		1/4/2007	11.51	11.50	0.01	88.29	
		1/25/2007	13.63	13.60	0.03	86.18	
		2/9/2007	13.94	13.89	0.05	85.89	
		2/22/2007	14.01	14.00	0.01	85.79	
		3/7/2007	15.19	15.07	0.12	84.69	
		5/1/2007	15.80	14.52	1.28	84.94	
		10/1/2007	15.33	13.89	1.44	85.52	
		2/20/2008	14.36	13.90	0.46	85.77	
		2/21/2008	no product measured after removing absorbent				
		2/25/2008	16.05	16.02	0.03	83.76	Measured after removing absorbent
		2/26/2008	15.02	15.02	0.00	84.77	Trace product
		2/28/2008	13.99	nm	0.00	85.80	Measured after removing absorbent
		3/4/2008	14.72	14.71	0.01	85.08	Trace after removing absorbent
		3/12/2008	15.28	15.28	0.00	84.51	Trace after removing absorbent
		3/21/2008	No product measured after removing absorbent				
		4/15/2008	No product measured after removing absorbent				
		4/18/2008	16.37	nm	0.00	83.42	Measured after removing absorbent
		4/22/2008	16.38	nm	0.00	83.41	Measured after removing absorbent
MW-16	100.22	1/20/2006	11.93	nm	0.00	88.29	
		1/31/2006	12.15	nm	0.00	88.07	
		4/3/2006	12.60	nm	0.00	87.62	
		8/22/2006	17.74	nm	0.00	82.48	
		10/13/2006	14.95	nm	0.00	85.27	
		1/4/2007	12.01	nm	0.00	88.21	
		1/25/2007	14.37	nm	0.00	85.85	
		3/27/2008	9.88	nm	0.00	90.34	
		4/18/2008	10.43	nm	0.00	89.79	
MW-17	99.90	1/20/2006	11.25	nm	0.00	-	
		4/10/2008	10.37	nm	0.00		
IP-3	99.31	5/2/2006	13.74	nm	0.00	85.57	
		5/8/2006	15.10	nm	0.00	84.21	
		6/13/2006	16.16	nm	0.00	83.15	

Table 2

Product Thickness Measurements
Boeing Field Chevron
Seattle, Washington

Well	TOC Elevation	Date	Depth Measurement (in feet) Water	Product	Product Thickness (feet)	Potentiometric Surface Elevation (ft)	Comments
		6/19/2006	14.65	nm	0.00	84.66	
		8/22/2006	16.73	nm	0.00	82.58	
		10/13/2006	14.55	nm	0.00	84.76	
IP-3 Continued		1/4/2007	11.11	nm	0.00	88.20	
		2/22/2007	13.45	nm	0.00	85.86	
		5/1/2007	14.22	nm	0.00	85.09	
		10/1/2007	13.82	nm	0.00	85.49	
		2/25/2008	15.59	15.59	0.00	83.72	
		2/26/2008	14.49	nm	0.00	84.82	
		2/28/2008	13.63	nm	0.00	85.68	
		3/27/2008	13.74	nm	0.00	85.57	
		4/18/2008	15.95	nm	0.00	83.36	
		4/22/2008	15.96	nm	0.00	83.35	
IP-4	99.52	5/2/2006	10.29	nm	0.07	89.28	
		5/8/2006	10.32	nm	0.00	89.20	
		6/13/2006	10.35	nm	0.00	89.17	
		6/19/2006	10.48	nm	0.00	89.04	
		10/13/2006	13.91	11.69	2.22	87.25	
		1/4/2007	9.65	nm	0.00	89.87	
		1/25/2007	9.97	nm	0.00	89.55	
		2/22/2007	10.12	nm	0.00	89.40	
		3/7/2007	10.13	nm	0.00	89.39	
		5/1/2007	10.71	nm	0.00	88.81	
		10/1/2007	11.64	nm	0.00	87.88	
		2/25/2008	10.40	10.40	0.00	89.12	Measured less than 0.005' product
		2/26/2008	10.28	nm	0.00	89.24	
		2/28/2008	10.27	nm	0.00	89.25	
		3/27/2008	10.82	nm	0.00	88.70	Measured after removing absorbent
		4/9/2008	10.93	nm	0.00	88.59	Measured after removing absorbent
		4/18/2008	10.97	nm	0.00	88.55	Measured after removing absorbent
		4/22/2008	11.02	nm	0.00	88.50	Absorbent saturated to 2", left in
IP-5	100.10	5/2/2006	14.54	nm	0.00	85.56	
		5/8/2006	15.83	nm	0.00	84.27	
		6/13/2006	17.03	nm	0.00	83.07	
		6/19/2006	15.48	nm	0.00	84.62	
		8/22/2006	17.57	nm	0.00	82.53	
		10/13/2006	15.25	nm	0.00	84.85	
		1/4/2007	11.93	nm	0.00	88.17	
		1/25/2007	13.97	nm	0.00	86.13	
		2/9/2007	12.65	nm	0.00	87.45	
		2/22/2007	14.33	nm	0.00	85.77	
		5/1/2007	15.06	nm	0.00	85.04	
		10/1/2007	14.54	nm	0.00	85.56	
		10/23/2007	15.51	nm	0.00	84.59	
		2/20/2008	14.41	nm	0.00	85.69	
		3/27/2008	15.01	nm	0.00	85.09	
		4/18/2008	15.61	nm	0.00	84.49	
IP-6	99.29	8/22/2006	16.93	nm	0.16	82.48	
		10/13/2006	14.70	14.52	0.18	84.72	
		1/4/2007	11.05	10.85	0.20	88.39	
		1/25/2007	13.36	13.19	0.17	86.06	
		2/22/2007	13.47	nm	0.00	85.82	
		3/7/2007	14.91	14.90	0.01	84.39	
		5/1/2007	15.12	14.77	0.35	84.43	
		10/1/2007	15.84	13.31	2.53	85.32	
		10/23/2007	16.75	14.15	2.60	84.46	
		2/20/2008	14.61	14.21	0.40	84.98	
		2/21/2008	No product measured after removing absorbent				

Table 2

Product Thickness Measurements
Boeing Field Chevron
Seattle, Washington

Well	TOC Elevation	Date	Depth Measurement (in feet) Water	Product	Product Thickness (feet)	Potentiometric Surface Elevation (ft)	Comments
		2/25/2008	15.93	15.92	0.01	83.37	Measured after removing absorbent
		2/26/2008	14.41	nm	0.00	84.88	Measured after removing absorbent
		2/28/2008	13.75	nm	0.00	85.54	Measured after removing absorbent
		3/4/2008	14.59	14.58	0.01	84.71	Measured after removing absorbent
		3/12/2008	No product measured after removing absorbent				
IP-6 Continued		3/21/2008	No product measured after removing absorbent				
		3/27/2008	15.08	nm	0.00	84.21	Measured after removing absorbent
		4/2/2008	14.88	nm	0.00	84.41	Measured after removing absorbent
		4/7/2008	16.61	nm	0.00	82.68	Measured after removing absorbent
		4/9/2008	16.22	nm	0.00	83.07	Measured after removing absorbent
		4/11/2008	No product measured after removing absorbent				
		4/15/2008	No product measured after removing absorbent				
		4/18/2008	15.20	nm	0.00	84.09	Measured after removing absorbent
		4/22/2008	15.82	nm	0.00	83.47	Measured after removing absorbent
IP-7	99.35	8/22/2006	16.93	nm	0.01	82.43	
		10/13/2006	16.51	14.09	2.42	84.63	
		1/4/2007	13.89	9.98	3.91	88.35	
		1/25/2007	16.39	12.40	3.99	85.91	Measured at 13:00. Low tide at 14:48, 0.0 tide
		2/9/2007	15.96	12.09	3.87	86.25	
		2/22/2007	13.48	13.20	0.28	86.08	
		3/7/2007	15.29	14.62	0.67	84.56	
		5/1/2007	15.61	14.20	1.41	84.78	
		10/1/2007	13.87	13.75	0.12	85.57	
		10/23/2007	15.61	14.20	1.41	84.78	
		2/20/2008	14.41	13.71	0.70	85.46	
		2/21/2008	14.10	14.07	0.03	85.27	Measured after removing absorbent
		2/25/2008	15.85	15.74	0.11	83.58	Measured after removing absorbent
		2/26/2008	14.34	nm	0.00	85.01	Measured after removing absorbent
		2/28/2008	13.53	13.53	0.00	85.82	Trace product
		3/4/2008	14.72	14.26	0.46	84.97	Measured after removing absorbent
		3/12/2008	15.70	14.82	0.88	84.30	Measured after removing absorbent
		3/13/2008	14.00	13.52	0.48	85.70	Measured after removing absorbent
		3/21/2008	No product measured after removing absorbent				
		3/27/2008	14.85	nm	0.00	84.50	Measured after removing absorbent
		4/2/2008	14.72	14.72	0.00	84.63	Trace product
		4/7/2008	16.42	nm	0.00	82.93	Measured after removing absorbent
		4/9/2008	15.95	nm	0.00	83.40	Measured after removing absorbent
		4/11/2008	No product measured after removing absorbent				
		4/15/2008	No product measured after removing absorbent				
		4/18/2008	16.03	nm	0.00	83.32	Measured after removing absorbent
		4/22/2008	15.55	nm	0.00	83.80	Measured after removing absorbent
EX-N*	99.4	1/20/2006	7.92	nm	0.00		
		1/31/2006	8.78	nm	0.00		
		4/3/2006	9.80	nm	0.00		
		5/2/2006	9.90	nm	0.00		
		3/7/2007	10.29	nm	0.00		
		10/23/2007	11.28	nm	0.00		
		2/21/2008	10.21	nm	0.00		
		4/10/2008	10.85	nm	0.00		
EX-S*	98.94	1/20/2006	7.65	nm	0.00		
		1/31/2006	8.00	nm	0.00		
		4/3/2006	8.92	nm	0.00		
		5/2/2006	9.24	nm	0.00		
		10/13/2006	11.53	11.30	0.23		
		3/7/2007	9.50	nm	0.00		
		10/23/2007	10.63	nm	0.00		
		2/21/2008	9.46	nm	0.00		
		4/10/2008	10.18	nm	0.00		

Table 2

Product Thickness Measurements
Boeing Field Chevron
Seattle, Washington

Well	TOC Elevation	Date	Depth Measurement (in feet) Water	Product	Product Thickness (feet)	Potentiometric Surface Elevation (ft)	Comments
		4/18/2008	10.30	nm	0.00		
EW-1	100.01	3/27/2008	14.70	nm	0.00		No product present
		4/2/2008	14.88	nm	0.00		No product present
		4/22/2008	16.52	nm	0.00		No product present
EW-2	100.25	3/27/2008	15.01	nm	0.00		No product present
		4/2/2008	15.25	nm	0.00		No product present
		4/22/2008	15.25	15.25	0.00		Possible sheen detected
EW-3	99.9	3/27/2008	15.09	nm	0.00		No product present
		4/2/2008	14.94	nm	0.00		No product present
		4/18/2008	15.52	nm	0.00		No product present
		4/22/2008	16.51	nm	0.00		No product present
EW-4	99.9	3/27/2008	14.88	nm	0.00		No product present
		4/2/2008	14.73	nm	0.00		No product present
		4/22/2008	16.30	nm	0.00		No product present
EW-5	99.92	3/27/2008	15.00	nm	0.00		No product present
		4/2/2008	14.86	14.86	0.00		Trace product
		4/9/2008	16.82	nm	0.00		No product present
		4/10/2008	14.47	nm	0.00		No product present
		4/11/2008	15.25	15.25	0.00		Trace, installed absorbent socks
		4/22/2008	16.50	nm	0.00		Bottom sock saturated, replaced
EW-6	99.95	3/27/2008	15.32	nm	0.00		No product present
		4/2/2008	15.27	nm	0.00		No product present
		4/9/2008	16.80	nm	0.00		No product present
		4/11/2008	16.24	nm	0.00		No product present
		4/22/2008	16.13	nm	0.00		No product present
EW-7	99.57	3/27/2008	14.94	nm	0.00		No product present
		4/2/2008	14.90	nm	0.00		No product present
		4/9/2008	16.38	nm	0.00		No product present
		4/11/2008	15.66	15.66	0.00		Trace, installed absorbent socks
		4/22/2008	15.68	15.68	0.00		Trace, Sock 1/3 saturated, left in
EW-8	99.68	3/27/2008	15.08	nm	0.00		No product present
		4/9/2008	16.54	nm	0.00		No product present
		4/11/2008	16.15	nm	0.00		No product present
		4/22/2008	15.94	nm	0.00		No product present
EW-9	99.46	3/27/2008	14.82	nm	0.00		No product present
		4/2/2008	14.77	nm	0.00		No product present
		4/9/2008	16.26	nm	0.00		No product present
		4/11/2008	15.64	nm	0.00		No product present
		4/18/2008	14.97	nm	0.00		No product present
		4/22/2008	15.61	nm	0.00		No product present

Notes: Enhanced Fluid Recovery event conducted 1/26/06.
Approximately 3,000 gallons gasoline-impacted water removed from MW-14 and MW-15.
First Peroxide Event conducted near MW-15 (IP-3, IP-4, IP-5, MW-15) on 5/2/06
Second Peroxide Event conducted near MW-15 on 6/13/06 at low tide after product measurements.
Third peroxide event conducted at IP6 & IP7 (330-gal 17% each) and 330-gal split amongst IP3, IP4, and IP5, 8/11/06
Fourth Peroxide event to IP6, IP4, and IP3 (1320 Gallons 17%) on 12/28 and 12/29/06
Fifth Peroxide event 2/9/07 using 11% (1,700 liters into IP-6, 1,000 liters into IP-7, 900L into MW-14)
FPR Extraction Wells EW-1 through EW-9 installed on 3/17/08 and 3/18/08.
* - Extraction well names assigned by G-Logics
Specific Gravity of Gasoline, SG = 0.739
nm = product was absent so no measurement available

TABLE 3

Soil Sample Analysis, TPH and BTEX (1), Units in mg/kg

Samples Collected 2006 (Urban Redevelopment) & 2008 (G-Logics)

Boeing Field Chevron

Boring	Sample Name	Sample Date	Depth (feet)	NWTPH-Gx (Gasoline-range)	Benzene	Toluene	Ethyl-benzene	Xylenes
P-4	P4 12.5-13	4-25-06	13	2,800	NA	NA	NA	NA
P-6	P6 11.5-12	4-25-06	12	5	NA	NA	NA	NA
	P6 18.5-19	4-25-06	19	370	NA	NA	NA	NA
P-8	P8 18.5-19	4-25-06	19	2,800	NA	NA	NA	NA
EW-1	EW1-10	3-17-08	10	10	0.32	0.12	0.33	0.75
	EW1-15	3-17-08	15	nd	nd	nd	nd	nd
	EW1-20	3-17-08	20	nd	1.06	0.62	0.16	0.76
	EW1-24	3-17-08	24	15	1.34	1.28	0.31	1.86
EW-2	EW-2-10	3-17-08	10	nd	nd	nd	nd	nd
	EW2-14	3-17-08	14	nd	nd	nd	0.059	0.26
	EW2-20	3-17-08	20	19	0.51	0.88	0.50	2.51
	EW2-24	3-17-08	24	13	0.80	1.32	0.31	1.36
EW-3	EW-3-10	3-17-08	10	nd	nd	nd	nd	nd
	EW3-15	3-17-08	15	nd	0.31	0.14	0.38	1.33
	EW3-15(DUP)	3-17-08	15	10	0.35	0.084	0.47	1.31
	EW3-20	3-17-08	20	31	1.66	3.76	0.55	3.27
EW-4	EW-4-10	3-17-08	10	nd	nd	nd	nd	nd
	EW4-15	3-17-08	15	nd	nd	nd	nd	nd
	EW4-20	3-17-08	20	21	0.63	2.39	0.44	2.19
EW-5	EW-5-15	3-17-08	15	nd	nd	nd	nd	nd
	EW5-20	3-17-08	20	14	1.01	1.04	0.34	1.12
	EW5-23	3-17-08	23	33	0.70	2.18	0.81	3.83
	EW5-23(DUP)	3-17-08	23	34	0.70	2.26	0.85	4.02
EW-6	EW-6-10	3-18/08	10	nd	nd	nd	nd	nd
	EW6-15	3-18-08	15	nd	nd	nd	nd	nd
	EW6-20	3-18-08	20	37	1.14	3.42	5.03	2.43
	EW6-23	3-18-08	23	nd	0.11	0.20	0.092	0.25
EW-7	EW-7-10	3-18/08	10	nd	nd	nd	nd	nd
	EW7-15	3-18-08	15	nd	nd	nd	nd	nd
	EW7-15(DUP)	3-18-08	15	nd	nd	nd	nd	nd
	EW7-20	3-18-08	20	nd	nd	nd	nd	nd
	EW7-25	3-18-08	25	nd	nd	nd	nd	nd

TABLE 3

Soil Sample Analysis, TPH and BTEX (1), Units in mg/kg

Samples Collected 2006 (Urban Redevelopment) & 2008 (G-Logics)

Boeing Field Chevron

Boring	Sample Name	Sample Date	Depth (feet)	NWTPH-Gx (Gasoline-range)	Benzene	Toluene	Ethyl-benzene	Xylenes
EW-8	EW-8-10	3-18/08	10	**97**	**0.24**	1.00	1.29	2.02
	EW8-15	3-18-08	15	**293**	**1.23**	2.61	4.37	3.21
	EW8-20	3-18-08	20	14	**0.22**	1.47	0.46	1.37
	EW8-25	3-18-08	25	nd	**0.092**	0.54	0.23	0.84
EW-9	EW-9-10	3-18/08	10	nd	nd	nd	nd	nd
	EW-9-15	3-18-08	15	**4,320**	**37.4**	**201**	100	**317**
	EW-9-20	3-18-08	20	**379**	**2.41**	**17.4**	**9.16**	**28.5**
	EW-9-25	3-18-08	25	nd	nd	nd	nd	nd
MW-18	MW-18-15	4-16-08	15	nd	nd	nd	nd	nd
MW-19	MW19-20	4-16-08	20	nd	nd	nd	nd	nd
MW-20	MW-20-20	4-16-08	20	nd	nd	nd	nd	nd
MW-21	MW-21-17	4-16-08	17	nd	nd	nd	nd	nd
	MW-21-17(DUF	4-18-08	17	nd	nd	nd	nd	nd
MTCA Method A Cleanup Level (2)				**100(a)**	**0.03**	**7.0**	**6.0**	**9.0**

Notes:

(1) TPH by NWTPH-Gx Methods, BETX by Method 8021B.

(2) Method A Soil Cleanup Levels (mg/kg), Unrestricted Land Use, Amendments Adopted August 2001, Most Conservative Cleanup Level.*

* Exceeding These Levels Do Not Necessarily Trigger Requirements For Cleanup Action Under MTCA.

(a) Soil Cleanup Level For Gasoline With Detectable Benzene is 30 mg/kg.

DUP Duplicate Sample For QA/QC Purpose.

nd Concentration Less Than The Laboratory Method Detection Limit.

NA Not Analyzed

27 Bold Number(s) Indicates Concentration Detected.

250 Bold Number(s) and Shading Indicates Concentration Exceeds MTCA Method A Cleanup Level.

TABLE 4

Groundwater Sample Analysis, TPH and BTEX (1), Units in ug/L

March-April 2008

Boeing Field Chevron

Sample ID	Sample Date	NWTPH-Gx (Gasoline-range)	Benzene	Toluene	Ethyl-benzene	Xylenes
MW-10	3-27-08	nd	nd	nd	nd	nd
MW-11	3-27-08	**10,600**	**96**	97	167	985
MW-12	3-27-08	nd	nd	nd	nd	nd
MW-12 Dup	3-27-08	nd	nd	nd	nd	nd
MW-13	3-27-08	nd	**29**	3.3	nd	3.9
MW-16	3-27-08	nd	nd	nd	nd	nd
IP-3	3-27-08	**62,900**	**6,120**	**8,450**	**968**	**4,420**
IP-4	3-27-08	**84,400**	**14,600**	**22,100**	**4,920**	**17,600**
IP-5	3-27-08	**13,300**	**711**	**1,260**	363	**1,370**
EW-1	4-4-08	**11,000**	**436**	493	276	920
EW-4	4-4-08	130	**26**	nd	nd	5.6
EW-6	4-4-08	nd	**15**	2.6	1.8	7.1
EW-7	4-4-08	**2,460**	**17**	99	nd	270
EW-7 Dup	4-4-08	**2,510**	**16**	94	nd	255
MW-17	4-11-08	nd	nd	nd	nd	nd
EW-5	4-11'08	**1,420**	**130**	3.6	74	173
EW-5 Dup	4-11-08	**1,420**	**120**	3.5	83	166
MW-18	4-18-08	nd	nd	nd	nd	nd
MW-19	4-18-08	nd	nd	nd	nd	nd
MW-20	4-18-08	nd	nd	nd	nd	nd
MW-21	4-18-08	nd	nd	nd	nd	nd
MW-21 Dup	4-18-08	nd	nd	nd	nd	nd
MTCA Method A Cleanup Level (2)		**1,000(a)**	**5.0**	**1,000**	**700**	**1,000**

Notes:

See Figure 4 for Samples Collected by G-Logics in 2006

(1) TPH by NWTPH-Gx Methods, BETX by Method 8021B.

(2) Method A Groundwater Cleanup Levels (ug/L), MTCA, Amendments Adopted August 2001.*

* Exceeding These Levels Do Not Necessarily Trigger Requirements For Cleanup Action Under MTCA

(a) Groundwater Cleanup Level For Gasoline With Detectable Benzene is 800 ug/L.

DUP Lab Duplicate Sample For QA/QC Purpose.

nd Concentration Less Than The Laboratory Method Detection Limit.

27 Bold Number(s) Indicates Concentration Detected.

250 Bold Number(s) and Shading Indicates Concentration Exceeds MTCA Method A Cleanup Level.

Monitoring Well and Sample Date	Depth to Water Level	Groundwater Elevation	Gasoline-range TPH (ug/L)	Diesel-range TPH (ug/L)	Oil-range TPH (ug/L)	Benzene (ug/L)	Toluene (ug/L)	Ethylbenzene (ug/L)	Total Xylenes (ug/L)	Total Lead (ug/L)	Methyl Tutiary Butyl Ether (ug/L)
MW-1 TOC 101.44 (17.97)											
Adandoned											
12/20/1997	10.99	6.98	ND (<50)	ND (<250)	---	ND (<0.5)	ND (<0.5)	ND (<0.5)	ND (<1.5)	---	---
6/2/1994	12.89	5.08	ND (<50)	ND (<250)	---	ND (<0.5)	ND (<0.5)	ND (<0.5)	ND (<1.5)	---	---
12/20/1993	12.91	5.06	ND (<50)	ND (<250)	---	ND (<0.5)	ND (<0.5)	ND (<0.5)	ND (<1.5)	---	---
9/28/1993	14.3	3.67	ND (<50)	ND (<250)	---	1.6	3	ND (<0.5)	2.3	---	---
6/24/1993	13.3	4.67	ND (<50)	ND (<250)	---	ND (<0.5)	ND (<0.5)	ND (<0.5)	ND (<1.5)	---	---
4/12/1993	NR	NR	ND (<50)	ND (<250)	---	ND (<0.5)	ND (<0.5)	ND (<0.5)	ND (<1.5)	3.5	---
2/9/1993	NR	NR	ND (<100)	ND (<500)	---	ND (<0.5)	ND (<0.5)	ND (<0.5)	ND (<0.5)	4.4	---
6/17/1992	NR	NR	ND	ND	---	1.2	ND	ND	ND	---	---
3/3/1992	NR	NR	ND (<1,000)	ND (<1,000)	---	**5.4**	ND	ND	ND	---	---
3/20/1991	NR	NR	ND (<1,000)	ND (<1,000)	---	2.4	ND	ND	ND	---	---
1/8/1991	NR	NR	ND (<1,000)	ND (<1,000)	---	3.8	ND	ND	ND	---	---
11/16/1990	12.06	5.91	ND (<1,000)	ND (<1,000)	---	**5**	ND (<0.5)	ND (<0.5)	ND (<0.5)	---	---
8/15/1990	15.29	2.68	ND (<1,000)	ND (<1,000)	---	2.8	ND (<0.5)	ND (<0.5)	0.8	---	---
8/3/1990	15.4	2.57	---	---	---	---	---	---	---	---	---
7/30/1990	14.9	3.07	---	---	---	---	---	---	---	---	---
6/27/1990	13.82	4.15	---	---	---	---	---	---	---	---	---
6/13/1990	14.65	3.32	ND (<10,000)	---	---	6	ND (<1)	ND (<1)	ND (<1)	---	---
MW-2 TOC 100.52											
Replaced with MW-2R 2/5/1993											
11/16/1990	NR	NR	NS	NS	NS	NS	NS	NS	NS	NS	NS
8/15/1990 [1]	---	---	**2,000**	ND (<1,000)	---	**130**	ND (<0.5)	56	180	---	---
8/15/1990		4.97	ND (<1,000)	ND (<1,000)	---	**81**	1.9	32	120	---	---
8/3/1990	12.00	88.52	---	---	---	---	---	---	---	---	---
7/30/1990	11.41	89.11	---	---	---	---	---	---	---	---	---
6/27/1990	10.69	89.83	---	---	---	---	---	---	---	---	---
6/22/1990	NR	NR	ND (<10,000)	---	---	**249**	2	127	555	---	---
6/13/1990	9.85	90.67	ND (<10,000)	---	---	**100**	4	120	922	---	---
MW-2R TOC 17.51											
Adandoned											
12/20/1994	12.15	5.36	ND (<50)	ND (<250)	---	ND (<0.5)	ND (<0.5)	ND (<0.5)	ND (<1.5)	---	---
6/2/1994	16.08	1.43	ND (<50)	ND (<250)	---	ND (<0.5)	ND (<0.5)	ND (<0.5)	ND (<1.5)	---	---
12/20/1993	13.82	3.69	ND (<50)	ND (<250)	---	3.3	ND (<0.5)	ND (<0.5)	ND (<1.5)	---	---
9/28/1993	15.66	1.85	ND (<50)	ND (<250)	---	ND (<0.5)	ND (<0.5)	ND (<0.5)	ND (<1.5)	---	---
6/24/1993	14.33	3.18	ND (<50)	300	---	2.6	ND (<0.5)	ND (<0.5)	ND (<1.5)	---	---
4/12/1993 [1]	NR	NR	ND (<50)	300	---	**17**	ND (<0.5)	ND (<0.5)	ND (<1.5)	**30**	---
4/12/1993	NR	NR	ND (<50)	300	---	**16**	ND (<0.5)	ND (<0.5)	ND (<1.5)	**31**	---
2/9/1993 [1]	NR	NR	ND (<100)	ND (<500)	---	**19**	ND (<0.5)	ND (<0.5)	ND (<0.5)	**25**	---
2/9/1993	NR	NR	ND (<100)	ND (<500)	---	**19**	ND (<0.5)	ND (<0.5)	0.5	**25**	---

Table 1
Product Thickness Measurements
Boeing Field Chevron

Well	Date	Product Thickness (feet)	Depth to GW (TOC)
MW-11	7/14/2005	None	13.61
	7/19/2005	Trace	14.75
	1/20/2006	None	7.60
	1/31/2006	None	8.38
MW-13	7/14/2005	None	15.10
	7/19/2005	None	16.30
	1/20/2006	None	11.10
	1/31/2006	None	11.15
MW-14	7/1/2005	2.45	18.90
	7/14/2005	2.19	17.70
	7/19/2005	0.85	17.00
	10/26/2005	0.82	16.72
	11/9/2005	0.33	15.81
	11/30/2005	0.26	15.04
	12/7/2005	0.31	14.25
	12/14/2005	0.34	14.23
	1/20/2006	0.46	12.30
	1/31/2006	0.01	12.11
MW-15	11/30/2005	3.05	16.84
	12/7/2005	2.81	15.91
	12/14/2005	3.22	16.18
	1/20/2006	0.65	12.05
	1/31/2006	0.86	12.41
MW-16	1/20/2006	None	11.93
	1/31/2006	None	12.15
MW-17	1/20/2006	None	11.25
EX-N*	1/20/2006	None	7.92
	1/31/2006	None	8.78
EX-S*	1/20/2006	None	7.65
	1/31/2006	None	8.00

Notes: EFR event conducted 1/26/06.
Approximately 3,000 gallons gasoline-impacted water removed from MW-14 and MW-15.
No free product was found in tank truck 3 days following removal.
Measurements for 2005 by ERI, 2006 by G-Logics
* - Extraction well names assigned by G-Logics

Table 1

Product Thickness Measurements
Boeing Field Chevron
Seattle, Washington

Well	Rim Elevation	Date	Depth Measurement (in feet) Water	Product	Product Thickness (feet)	Potentiometric Surface Elevation (ft)	Comments
MW-10	100.08	8/22/2006	14.90	nm	0	85.18	
		1/4/2007	11.09	nm	0	88.99	
		1/25/2007	11.20	nm	0	88.88	
MW-11	99.01	7/14/2005	13.61	nm	0	85.40	
		7/19/2005	14.75	nm	0.01	84.27	
		1/20/2006	7.60	nm	0	91.41	
		1/31/2006	8.38	nm	0	90.63	
		4/3/2006	10.06	nm	0	88.95	
		5/2/2006	9.86	nm	0	89.15	
		8/22/2006	15.95	nm	0	83.06	
		10/13/2006	13.82	nm	0	85.19	
		1/4/2007	9.51	nm	0	89.50	
		1/25/2007	11.93	nm	0	87.08	
		2/22/2007	12.31	nm	0	86.70	
MW-12	98.38	8/22/2006	9.91	nm	0	88.47	
MW-13	99.14	7/14/2005	15.10	nm	0	84.04	
		7/19/2005	16.30	nm	0	82.84	
		1/20/2006	11.10	nm	0	88.04	
		1/31/2006	11.15	nm	0	87.99	
		5/2/2006	13.80	nm	0	85.34	
		5/8/2006	14.91	nm	0	84.23	
		8/22/2006	16.50	nm	0	82.64	
		1/4/2007	10.91	nm	0	88.23	
		1/25/2007	12.93	nm	0	86.21	
MW-14	99.96	7/1/2005	18.90	nm	2.45	82.87	
		7/14/2005	17.70	nm	2.19	83.88	
		7/19/2005	17.00	nm	0.85	83.59	
		10/26/2005	16.72	nm	0.82	83.85	
		11/9/2005	15.81	nm	0.33	84.39	
		11/30/2005	15.04	nm	0.26	85.11	
		12/7/2005	14.25	nm	0.31	85.94	
		12/14/2005	14.23	nm	0.34	85.98	
		1/20/2006	12.30	nm	0.46	88.00	
		1/31/2006	12.11	nm	0.01	87.86	
		4/3/2006	14.48	nm	2.25	87.14	
		5/2/2006	14.80	nm	0.59	85.60	
		5/8/2006	16.19	nm	0.56	84.18	
		8/22/2006	17.51	nm	0.02	82.46	Brown Product, not transparent
		10/13/2006	16.40	14.51	1.89	84.96	
		1/4/2007	12.20	11.29	0.91	88.43	
		1/25/2007	16.59	13.02	3.57	86.01	
		2/22/2007	13.99	13.95	0.04	86.00	
		5/1/2007	15.07	nm	0.00	84.89	
		10/1/2007	16.07	13.79	2.28	85.57	
		10/23/2007	17.17	14.65	2.52	84.65	
		2/20/2008	?	14.84	0.20	85.47	Interface measurement approximate
		2/21/2008	14.705	14.70	0.005	85.26	measured after removing absorbent
		2/25/2008	16.43	16.39	0.04	83.56	measured after removing absorbent
		2/26/2008	14.43	14.43	0.00	85.53	Trace product
		2/28/2008	14.15	14.15	0.00	85.81	Trace product

Table 1

Product Thickness Measurements

Boeing Field Chevron

Seattle, Washington

Well	Rim Elevation	Date	Depth Measurement (in feet) Water	Product	Product Thickness (feet)	Potentiometric Surface Elevation (ft)	Comments
MW-15	99.79	11/30/2005	16.84	nm	3.05	85.20	
		12/7/2005	15.91	nm	2.81	85.96	
		12/14/2005	16.18	nm	3.22	85.99	
		1/20/2006	12.05	nm	0.65	88.22	
		1/31/2006	12.41	nm	0.86	88.02	
		4/3/2006	17.30	nm	2.70	84.49	
		5/2/2006	16.59	nm	3.30	85.64	
		5/8/2006	15.60	nm	0	84.19	
		6/13/2006	16.97	nm	0.10	82.89	
		6/19/2006	15.16	nm	0.00	84.63	
		8/22/2006	17.22	nm	0.01	82.58	
		10/13/2006	15.04	14.96	0.08	84.81	
		1/4/2007	11.51	11.50	0.01	88.29	
		1/25/2007	13.63	13.60	0.03	86.18	
		2/9/2007	13.94	13.89	0.05	85.89	
		2/22/2007	14.01	14.00	0.01	85.79	
		5/1/2007	15.80	14.52	1.28	84.94	
		10/1/2007	15.33	13.89	1.44	85.52	
		2/20/2008	14.36	13.90	0.46	85.77	
		2/21/2008	no product measured after removing absorbent				
		2/25/2008	16.05	16.02	0.03	83.76	Measured after removing absorbent
		2/26/2008	15.02	15.02	0.00	84.77	Trace product
		2/28/2008	13.99	nm	0.00	85.80	Measured after removing absorbent
MW-16	100.22	1/20/2006	11.93	nm	0	88.29	
		1/31/2006	12.15	nm	0	88.07	
		4/3/2006	12.60	nm	0	87.62	
		8/22/2006	17.74	nm	0	82.48	
		10/13/2006	14.95	nm	0	85.27	
		1/4/2007	12.01	nm	0	88.21	
		1/25/2007	14.37	nm	0	85.85	
MW-17	-	1/20/2006	11.25	nm	0	-	
IP-3	99.31	5/2/2006	13.74	nm	0	85.57	
		5/8/2006	15.10	nm	0	84.21	
		6/13/2006	16.16	nm	0	83.15	
		6/19/2006	14.65	nm	0	84.66	
		8/22/2006	16.73	nm	0	82.58	
		10/13/2006	14.55	nm	0	84.76	
		1/4/2007	11.11	nm	0	88.20	
		2/22/2007	13.45	nm	0	85.86	
		5/1/2007	14.22	nm	0	85.09	
		10/1/2007	13.82	nm	0	85.49	
		2/25/2008	15.59	15.59	0	83.72	
		2/26/2008	14.49	nm	0	84.82	
		2/28/2008	13.63	nm	0	85.68	
IP-4	99.52	5/2/2006	10.29	nm	0.07	89.28	
		5/8/2006	10.32	nm	0	89.20	
		6/13/2006	10.35	nm	0	89.17	
		6/19/2006	10.48	nm	0	89.04	
		10/13/2006	13.91	11.69	2.22	87.25	
		1/4/2007	9.65	nm	0	89.87	
		1/25/2007	9.97	nm	0	89.55	
		2/22/2007	10.12	nm	0	89.40	
		5/1/2007	10.71	nm	0	88.81	
		10/1/2007	11.64	nm	0	87.88	
		2/25/2008	10.40	10.40	0	89.12	Measured less than 0.05' product
		2/26/2008	10.28	nm	0	89.24	
		2/28/2008	10.27	nm	0	89.25	

Table 1

Product Thickness Measurements

Boeing Field Chevron

Seattle, Washington

Well	Rim Elevation	Date	Depth Measurement (in feet) Water	Product	Product Thickness (feet)	Potentiometric Surface Elevation (ft)	Comments
IP-5	100.10	5/2/2006	14.54	nm	0	85.56	
		5/8/2006	15.83	nm	0	84.27	
		6/13/2006	17.03	nm	0	83.07	
		6/19/2006	15.48	nm	0	84.62	
		8/22/2006	17.57	nm	0	82.53	
		10/13/2006	15.25	nm	0	84.85	
		1/4/2007	11.93	nm	0	88.17	
		1/25/2007	13.97	nm	0	86.13	
		2/9/2007	12.65	nm	0	87.45	
		2/22/2007	14.33	nm	0	85.77	
		5/1/2007	15.06	nm	0	85.04	
		10/1/2007	14.54	nm	0	85.56	
		10/23/2007	15.51	nm	0	84.59	
		2/20/2008	14.41	nm	0	85.69	
IP-6	99.29	8/22/2006	16.93	nm	0.16	82.46	
		10/13/2006	14.70	14.52	0.18	84.72	
		1/4/2007	11.05	10.85	0.20	88.39	
		1/25/2007	13.36	13.19	0.17	86.06	
		2/22/2007	13.47	nm	0	85.82	
		5/1/2007	15.12	14.77	0.35	84.43	
		10/1/2007	15.84	13.31	2.53	85.32	
		10/23/2007	16.75	14.15	2.60	84.46	
		2/20/2008	14.61	14.21	0.40	84.98	
		2/21/2008	No product measured after removing absorbent				
		2/25/2008	15.93	15.92	0.01	83.37	Measured after removing absorbent
		2/26/2008	14.41	nm	0.00	84.88	Measured after removing absorbent
		2/28/2008	13.75	nm	0.00	85.54	Measured after removing absorbent
IP-7	99.35	8/22/2006	16.93	nm	0.01	82.43	
		10/13/2006	16.51	14.09	2.42	84.63	
		1/4/2007	13.89	9.98	3.91	88.35	
		1/25/2007	16.39	12.40	3.99	85.91	Measured at 13:00. Low tide at 14:48, 0.0 tide
		2/9/2007	15.96	12.09	3.87	86.25	
		2/22/2007	13.48	13.20	0.28	86.08	
		5/1/2007	15.61	14.20	1.41	84.78	
		10/1/2007	13.87	13.75	0.12	85.57	
		10/23/2007	15.61	14.20	1.41	84.78	
		2/20/2008	14.41	13.71	0.70	85.46	
		2/21/2008	14.10	14.07	0.03	85.27	Measured after removing absorbent
		2/25/2008	15.85	15.74	0.11	83.58	Measured after removing absorbent
		2/26/2008	14.34	nm	0.00	85.01	Measured after removing absorbent
		2/28/2008	13.53	13.53	0.00	85.82	Trace product
EX-N*		1/20/2006	7.92	nm	0		
		1/31/2006	8.78	nm	0		
		4/3/2006	9.80	nm	0		
		5/2/2006	9.90	nm	0		
		10/23/2007	11.28	nm	0		
		2/21/2008	10.21	nm	0		
EX-S*		1/20/2006	7.65	nm	0		
		1/31/2006	8.00	nm	0		
		4/3/2006	8.92	nm	0		
		5/2/2006	9.24	nm	0		
		10/13/2006	11.53	11.30	0.23		
		10/23/2007	10.63	nm	0		
		2/21/2008	9.46	nm	0		

Notes: Enhanced Fluid Recovery event conducted 1/26/06.

Approximately 3,000 gallons gasoline-impacted water removed from MW-14 and MW-15.

First Peroxide Event conducted near MW-15 (IP-3, IP-4, IP-5, MW-15) on 5/2/06

Second Peroxide Event conducted near MW-15 on 6/13/06 at low tide after product measurements.

Third peroxide event conducted at IP6 & IP7 (330-gal 17% each) and 330-gal split amongst IP3, IP4, and IP5, 8/11/06

Fourth Peroxide event to IP6, IP4, and IP3 (1320 Gallons 17%) on 12/28 and 12/29/06

Fifth Peroxide event 2/9/07 using 11% (1,700 liters into IP-5, 1,000 liters into IP-7, 900L into MW-14)

* - Extraction well names assigned by G-Logics

Specific Gravity of Gasoline, SG =

nm = product was absent so no measurer 0.739

TABLE 2

Approximate Free-Product Recovery Rates in Wells IP-6, IP-7, MW-14, and MW-15
Boeing Chevron, Seattle, Washington

Well ID	Date	Product Removed Ounces	Product Remaining Ounces	Elapsed Time Days	Production Rate Oz/Day
IP-6	2/21/2008	7.0	0.0	1.0	7.0
	2/25/2008	7.0	1.5	4.0	2.1
	2/26/2008	2.0	0.0	1.0	2.0
	2/27/2008	1.0	0.0	1.0	1.0
	2/28/2008	1.0	0.0	1.0	1.0
IP-7	2/21/2008	7.0	6.0	1.0	13.0
	2/25/2008	7.0	17.0	4.0	6.0
	2/26/2008	7.0	0.0	1.0	7.0
	2/27/2008	6.7	0.0	1.0	6.7
	2/28/2008	3.5	0.0	1.0	3.5
MW-14	2/21/2008	7.0	1.0	1.0	8.0
	2/25/2008	7.0	1.0	4.0	2.0
	2/26/2008	2.1	0.0	1.0	2.1
	2/27/2008	0.7	0.0	1.0	0.7
	2/28/2008	0.7	0.0	1.0	0.7
MW-15	2/21/2008	4.6	0.0	1.0	4.6
	2/25/2008	7.0	6.0	4.0	3.3
	2/26/2008	2.1	0.0	1.0	2.1
	2/27/2008	1.4	0.0	1.0	1.4
	2/28/2008	0.7	0.0	1.0	0.7

Note Refer to figures for well locations.

Product removal calculations use the following:

As per manufacturer, a full 1.5" x 18" absorbent will hold 7 ounces of petroleum.

The sand pack in a 2" dia. well has 30% porosity and a pore volume of 150 ounces per foot of well depth.

A 2" dia. well has a volume of 21 ounces per foot of well depth.

TABLE 1

Water Levels and Product Thickness Measurements

Boeing Field Chevron Station

Well Designation	Well Installation Date	Elevation Top of Casing (ft.)*	Depth to Top of Screen (ft.)	Depth to Bottom of Screen (ft.)	Well Diam. (in.)	Date Measured	Depth to Product (ft.)	Depth to Water (ft.)	Calculated Free Product (ft.)
MW-14	---	99.96	---	---	2	03/24/11	---	12.62	---
						06/08/11	---	16.27	---
						08/02/11	---	16.04	---
						09/26/11	---	16.80	---
						11/29/11	---	13.62	---
						02/01/12	---	12.93	---
						03/28/12	---	13.40	---
MW-15	---	99.79	---	---	2	03/24/11	12.89	12.91	**0.02**
						06/08/11	---	---	---
						08/02/11	---	12.38	---
						09/26/11	---	10.20	---
						11/29/11	---	10.27	---
						02/01/12	---	9.67	---
						03/28/12	---	9.32	---
EW-1	3/17/08	---	6	24	2	03/24/11	---	9.37	---
						06/08/11	---	12.23	---
						08/02/11	---	11.05	---
						09/26/11	---	11.58	---
						11/29/11	---	10.68	---
						02/01/12	---	10.10	---
						03/28/12	---	9.85	---
EW-2	3/17/08	---	8	24	2	03/24/11	---	9.51	---
						06/08/11	---	13.01	---
						08/02/11	---	13.33	---
						09/26/11	---	11.69	---
						11/29/11	---	10.76	---
						02/01/12	---	10.40	---
						03/28/12	---	9.89	---

TABLE 1

Water Levels and Product Thickness Measurements

Boeing Field Chevron Station

Well Designation	Well Installation Date	Elevation Top of Casing (ft.)*	Depth to Top of Screen (ft.)	Depth to Bottom of Screen (ft.)	Well Diam. (in.)	Date Measured	Depth to Product (ft.)	Depth to Water (ft.)	Calculated Free Product (ft.)
EW-6	3/18/08	--	8	24	2	03/24/11	--	9.95	--
						06/08/11	--	12.15	--
						08/02/11	--	12.45	--
						09/26/11	--	11.53	--
						11/29/11	--	11.46	--
						02/01/12	--	11.97	--
						03/28/12	--	11.34	--
EW-7	3/18/08	--	8	22	2	03/24/11	--	12.41	--
						06/08/11	--	16.34	--
						08/02/11	--	15.42	--
						09/26/11	--	16.51	--
						11/29/11	--	13.29	--
						02/01/12	--	12.63	--
						03/28/12	--	13.12	--
EW-9	3/18/08	--	8	23	2	03/24/11	--	12.32	--
						06/08/11	--	16.19	--
						08/02/11	15.25	15.99	**0.74**
						09/26/11	16.28	17.14	**0.86**
						11/29/11	13.00	13.98	**0.98**
						02/01/12	12.53	12.63	**0.10**
						03/28/12	--	13.01	--

TABLE 1

Water Levels and Product Thickness Measurements
Boeing Field Chevron Station

Well Designation	Well Installation Date	Elevation Top of Casing (ft.)*	Depth to Top of Screen (ft.)	Depth to Bottom of Screen (ft.)	Well Diam. (in.)	Date Measured	Depth to Product (ft.)	Depth to Water (ft.)	Calculated Free Product (ft.)
IP-7	8/4/06	99.35	17	23	2	03/24/11	11.68	14.33	**2.65**
						06/08/11	15.10	15.82	**0.72**
						08/02/11	14.82	16.95	**2.13**
						09/26/11	16.09	17.04	**0.95**
						11/29/11	12.39	14.87	**2.48**
						02/01/12	11.75	14.68	**2.93**
						03/28/12	12.71	14.22	**1.51**

Notes:

* Elevations based on an arbitrary elevation of 100'

--- No Free Product Detected.

Monitoring Well and Sample Date	Depth to Water Level	Groundwater Elevation	Gasoline-range TPH (ug/L)	Diesel-range TPH (ug/L)	Oil-range TPH (ug/L)	Benzene (ug/L)	Toluene (ug/L)	Ethylbenzene (ug/L)	Total Xylenes (ug/L)	Total Lead (ug/L)	Methyl Tutiary Butyl Ether (ug/L)
MW-3 TOC 101.44											
Replaced with MW-3R on 2/4/1993											
6/17/1992	NR	NR	120	ND (<1,000)	---	ND (<0.5)	ND (<0.5)	ND (<0.5)	ND	---	---
3/3/1992	NR	NR	120	ND (<1,000)	---	ND (<0.5)	0.5	ND (<0.5)	0.5	---	---
3/20/1991	NR	NR	ND (<1,000)	ND (<1,000)	---	ND (<0.5)	ND (<0.5)	3.5	1.2	---	---
1/8/1991	NR	NR	ND (<1,000)	ND (<1,000)	---	ND (<0.5)	ND (<0.5)	1.1	ND	---	---
11/16/1990		4.23	ND (<1,000)	ND (<1,000)	---	ND (<0.5)	2	0.7	ND (<0.5)	---	---
8/15/1990		0.2	ND (<1,000)	ND (<1,000)	---	ND (<0.5)	ND (<0.5)	0.7	0.7	---	---
8/3/1990	18	83.44	---	---	---	---	---	---	---	---	---
7/30/1990	17.24	84.2	---	---	---	---	---	---	---	---	---
6/27/1990	15.07	86.37	---	---	---	---	---	---	---	---	---
6/13/1990	15.25	86.19	ND (<10,000)	---	---	ND (<1)	ND (<1)	ND (<1)	6	---	---
MW-3R TOC 17.68											
Destroyed											
3/18/1996	11.53	6.15	940	0.32	ND (<250)	ND (<0.5)	ND (<0.5)	1.6	ND	12	---
12/8/1995	12.6	5.08	260	**550**	---	ND (<0.5)	ND (<0.5)	ND (<0.5)	ND	ND	---
9/28/1995	12.76	4.92	ND (<50)	320	---	ND (<0.5)	ND (<0.5)	ND (<0.5)	ND	ND	---
12/20/1994	12.06	5.62	130	ND (<250)	---	ND (<0.5)	ND (<0.5)	ND (<0.5)	ND	---	---
6/2/1994	16.43	1.25	160	ND (<250)	---	ND (<0.5)	ND (<0.5)	ND (<0.5)	ND	---	---
12/20/1993	13.73	3.95	ND (<50)	ND (<250)	---	ND (<0.5)	ND (<0.5)	ND (<0.5)	ND	---	---
9/28/1993	15.98	1.7	ND (<50)	ND (<250)	---	ND (<0.5)	ND (<0.5)	ND (<0.5)	ND	---	---
6/24/1993	14.4	3.28	160	300	---	ND (<0.5)	ND (<0.5)	ND (<0.5)	ND	---	---
4/12/1993	NR	NR	380	ND (<250)	---	ND (<0.5)	ND (<0.5)	0.7	0.7	**56**	---
2/9/1993	NR	NR	790	**2,900**	---	ND (<0.5)	ND (<0.5)	3.1	2	**36**	---
MW-4 TOC 101.03											
Replaced 2/4/1993											
6/17/1992 [1]	NR	NR	620	ND	---	ND	ND	17	1.9	---	---
6/17/1992	NR	NR	710	240	---	ND	ND	18	2	---	---
4/23/1992	NR	NR	---	---	---	ND	6.7	350	350	---	---
3/3/1992	NR	NR	**12,000**	**1,700**	---	1.2	310	**1,000**	**3,200**	---	---
7/23/1991	NR	NR	**2,400**	**2,900**	---	**8.0**	ND	170	130	---	---
3/20/1991	NR	NR	**3,000**	ND (<1,000)	---	**11**	5.7	170	240	---	---
1/8/1991	NR	NR	**16,000**	**3,000**	---	**79**	160	**960**	**2,000**	---	---
11/16/1990		8.21	**22,000**	ND (<1,000)	---	ND (<250)	**1,600**	510	**2,300**	---	---
8/15/1990		6.83	ND (<1,000)	ND (<1,000)	---	**190**	ND (< 1)	3	7	---	---
8/3/1990	10.5	90.53	---	---	---	---	---	---	---	---	---
7/30/1990	10.48	90.55	---	---	---	---	---	---	---	---	---
7/18/1990	NR	NR	ND (<10,000)	---	---	**85**	ND (<1)	3	7	---	---
6/27/1990	10.1	90.93	---	---	---	---	---	---	---	---	---
6/13/1990	9.95	91.08	---	---	---	---	---	---	---	---	---

Monitoring Well and Sample Date	Depth to Water Level	Groundwater Elevation	Gasoline-range TPH (ug/L)	Diesel-range TPH (ug/L)	Oil-range TPH (ug/L)	Benzene (ug/L)	Toluene (ug/L)	Ethylbenzene (ug/L)	Total Xylenes (ug/L)	Total Lead (ug/L)	Methyl Tutiary Butyl Ether (ug/L)
MW-4R TOC 18.14											
Destroyed											
3/18/1996	10.65	7.49	ND (<50)	ND (<250)	ND (<250)	ND (<0.5)	ND (<0.5)	ND (<0.5)	ND (<1.5)	4.8	---
12/8/1995	10.60	7.54	ND (<50)	340	---	ND (<0.5)	ND (<0.5)	ND (<0.5)	ND (<1.5)	**20**	---
9/28/1995	13.61	4.53	ND (<50)	290	---	ND (<0.5)	ND (<0.5)	ND (<0.5)	ND (<1.5)	ND	---
12/20/1994 [1]	NR	NR	110	ND (<250)	---	0.5	ND (<0.5)	ND (<0.5)	ND (<1.5)	---	---
12/20/1994	11.93	6.21	ND (<50)	ND (<250)	---	0.6	ND (<0.5)	ND (<0.5)	ND (<1.5)	---	---
6/2/1994 [1]	NR	NR	110	ND (<250)	---	**7.3**	ND (<0.5)	ND (<0.5)	2.1	---	---
6/2/1994	16.64	1.5	160	ND (<250)	---	**7**	ND (<0.5)	ND (<0.5)	1.9	---	---
12/20/1993 [1]	NR	NR	ND (<50)	ND (<250)	---	**16**	ND (<0.5)	0.7	12	---	---
12/20/1993	14.29	3.85	ND (<50)	ND (<250)	---	**16**	ND (<0.5)	0.7	11	---	---
9/28/1993 [1]	NR	NR	190	ND (<250)	---	**16**	0.7	2.9	21	---	---
9/28/1993	16.34	1.8	200	ND (<250)	---	**18**	0.6	3.7	24	---	---
6/24/1993	14.55	3.59	130	ND (<250)	---	**41**	0.5	3.7	19	---	---
4/12/1993 [1]	NR	NR	ND (<50)	ND (<250)	---	**53**	ND (<0.5)	0.5	7.3	---	---
4/12/1993	NR	NR	ND (<50)	ND (<250)	---	**52**	ND (<0.5)	ND (<0.5)	6.6	**53**	---
2/9/1993	NR	NR	ND (<100)	ND (<500)	---	**39**	ND (<0.5)	ND (<0.5)	2.5	**24**	---
MW-5 TOC 101.07											
Destroyed 9/1992											
6/17/1992	NR	NR	430	230	---	ND (<0.5)	ND (<0.5)	15	48	---	---
3/3/1992	NR	NR	94	ND (<250)	---	ND (<0.5)	ND (<0.5)	ND (<0.5)	0.54	---	---
7/23/1991	NR	NR	46	ND (<250)	---	0.62	ND (<0.5)	3.4	10	---	---
3/20/1991	NR	NR	ND (<1,000)	ND (<1,000)	---	1.2	ND (<0.5)	ND (<0.5)	ND (<1.5)	---	---
1/8/1991	NR	NR	ND (<1,000)	ND (<1,000)	---	4.2	ND (<0.5)	ND (<0.5)	ND (<1.5)	---	---
11/16/1990		8.43	ND (<1,000)	ND (<1,000)	---	**200**	ND (<0.5)	3.7	1	---	---
8/15/1990		6.97	ND (<1,000)	ND (<1,000)	---	**53**	ND (<0.5)	1.8	5.3	---	---
8/3/1990	10.17	90.9	---	---	---	---	---	---	---	---	---
7/30/1990	10.16	90.91	---	---	---	---	---	---	---	---	---
7/18/1990	NR	NR	ND (<10,000)	---	---	**10**	ND (<1)	ND (<1)	ND (<1)	---	---
6/27/1990	10.1	90.97	---	---	---	---	---	---	---	---	---
6/13/1990	10	91.07	---	---	---	---	---	---	---	---	---
MW-6 TOC 100.91											
Destroyed											
6/17/1992	NR	NR	ND (<50)	ND (<250)	---	2.4	ND (<0.5)	ND (<0.5)	ND (<1.5)	---	---
3/3/1992	NR	NR	43	ND (<250)	---	**9.8**	ND (<0.5)	ND (<0.5)	0.6	---	---
3/3/1992	NR	NR	60	ND (<250)	---	**9.2**	ND (<0.5)	1.5	4.4	---	---
7/23/1991	NR	NR	130	ND (<250)	---	**35**	ND (<0.5)	ND (<0.5)	ND (<1.5)	---	---
3/20/1991 [1]	NR	NR	ND (<1,000)	ND (<1,000)	---	**58**	ND (<0.5)	1.7	ND (<1.5)	---	---
3/20/1991	NR	NR	ND (<1,000)	ND (<1,000)	---	**54**	ND (<0.5)	1.2	ND (<1.5)	---	---
1/8/1991 [1]	NR	NR	ND (<1,000)	ND (<1,000)	---	**52**	ND (<0.5)	4.6	11	---	---
1/8/1991	NR	NR	ND (<1,000)	ND (<1,000)	---	**41**	ND (<0.5)	3.7	11	---	---
11/16/1990 [1]	NR	NR	600	ND (<1,000)	---	**100**	ND (<25)	ND (<25)	440	---	---
11/16/1990		8.21	500	ND (<1,000)	---	**130**	ND (<25)	69	500	---	---
8/15/1990		6.71	ND (<1,000)	ND (<1,000)	---	**150**	0.6	1.5	17	---	---
8/3/1990	10.65	90.26	---	---	---	---	---	---	---	---	---
7/30/1990	10.56	90.35	ND (<10,000)	---	---	**173**	ND (<1)	ND (<1)	15	---	---

Monitoring Well and Sample Date	Depth to Water Level	Groundwater Elevation	Gasoline-range TPH (ug/L)	Diesel-range TPH (ug/L)	Oil-range TPH (ug/L)	Benzene (ug/L)	Toluene (ug/L)	Ethylbenzene (ug/L)	Total Xylenes (ug/L)	Total Lead (ug/L)	Methyl Tutiary Butyl Ether (ug/L)
MW-7 TOC 100.86 (17.91)											
Abandoned											
12/20/1994	10.08	7.83	ND (<50)	ND (<250)	---	ND (<0.5)	ND (<0.5)	ND (<0.5)	ND (<1.5)	---	---
6/20/1994	11.09	6.82	ND (<50)	ND (<250)	---	ND (<0.5)	ND (<0.5)	ND (<0.5)	ND (<1.5)	---	---
12/20/1993	10.43	7.48	ND (<50)	ND (<250)	---	ND (<0.5)	ND (<0.5)	ND (<0.5)	ND (<1.5)	---	---
9/28/1993	11.80	6.11	ND (<50)	ND (<250)	---	ND (<0.5)	ND (<0.5)	ND (<0.5)	ND (<1.5)	---	---
6/24/1993	11.93	5.98	ND (<50)	ND (<250)	---	ND (<0.5)	ND (<0.5)	ND (<0.5)	ND (<1.5)	---	---
4/12/1993	NR	NR	ND (<50)	ND (<250)	---	ND (<0.5)	ND (<0.5)	ND (<0.5)	ND (<1.5)	**27**	---
2/9/1993	NR	NR	ND (<100)	ND (<500)	---	ND (<0.5)	ND (<0.5)	ND (<0.5)	ND (<0.5)	**40**	---
6/17/1992	NR	NR	ND	ND	---	ND	ND	ND	ND	---	---
3/3/1992	NR	NR	ND	ND (<1,000)	---	ND	ND	ND	ND	---	---
7/23/1991	NR	NR	ND	ND (<1,000)	---	ND	ND	ND	ND	---	---
3/20/1991	NR	NR	ND (<1,000)	ND (<1,000)	---	0.5	ND	0.6	ND	---	---
1/8/1991	NR	NR	ND (<1,000)	ND (<1,000)	---	1.9	ND	0.5	2.6	---	---
11/16/1990	10.12	7.79	ND (<1,000)	ND (<1,000)	---	**11**	ND (<0.5)	ND (<0.5)	ND (<0.5)	---	---
8/15/1990	11.29	6.62	ND (<1,000)	ND (<1,000)	---	0.7	ND (<0.5)	ND (<0.5)	ND (<0.5)	---	---
8/3/1990	10.69	7.22	---	---	---	---	---	---	---	---	---
7/30/1990	10.51	7.4	ND (<10,000)	---	---	ND (<1)	ND (<1)	ND (<1)	ND (<1)	---	---
MW-8 TOC 16.93											
Abandoned	NR	NR	ND (<50)	ND (<250)	---	ND (<0.5)	ND (<0.5)	ND (<0.5)	ND (<1.5)	---	---
12/20/1994	NR	NR	ND (<50)	ND (<250)	---	ND (<0.5)	ND (<0.5)	ND (<0.5)	ND (<1.5)	---	---
6/2/1994	NR	NR	ND (<50)	ND (<250)	---	ND (<0.5)	ND (<0.5)	ND (<0.5)	ND (<1.5)	---	---
12/20/1993	NR	NR	ND (<50)	ND (<250)	---	ND (<0.5)	ND (<0.5)	ND (<0.5)	ND (<1.5)	---	---
9/28/1993	NR	NR	ND (<50)	ND (<250)	---	ND (<0.5)	ND (<0.5)	ND (<0.5)	ND (<1.5)	---	---
6/24/1993	NR	NR	ND (<50)	ND (<250)	---	ND (<0.5)	ND (<0.5)	ND (<0.5)	ND (<1.5)	---	---
4/12/1993	NR	NR	ND (<50)	300	---	ND (<0.5)	ND (<0.5)	ND (<0.5)	ND (<1.5)	**33**	---
2/9/1993	NR	NR	ND (<100)	ND (<500)	---	ND (<0.5)	ND (<0.5)	ND (<0.5)	ND (<0.5)	**25**	---
MW-8A TOC 16.84											
Abandoned											
12/20/1994	9.11	7.73	ND (<50)	ND (<250)	---	ND (<0.5)	ND (<0.5)	ND (<0.5)	ND (<1.5)	---	---
6/2/1994	9.84	7	ND (<50)	ND (<250)	---	ND (<0.5)	ND (<0.5)	ND (<0.5)	ND (<1.5)	---	---
12/20/1993	9.78	7.06	ND (<50)	ND (<250)	---	ND (<0.5)	ND (<0.5)	ND (<0.5)	ND (<1.5)	---	---
9/28/1993	10.87	5.97	ND (<50)	ND (<250)	---	3	6.1	0.7	3.3	---	---
6/24/1993	9.75	7.09	ND (<50)	ND (<250)	---	ND (<0.5)	0.6	ND (<0.5)	ND (<1.5)	---	---
4/12/1993	NR	NR	ND (<50)	ND (<250)	---	ND (<0.5)	ND (<0.5)	ND (<0.5)	ND (<1.5)	**74**	---
2/9/1993	NR	NR	ND (<100)	ND (<500)	---	ND (<0.5)	ND (<0.5)	ND (<0.5)	ND (<0.5)	**18**	---
MW-9 TOC 16.72											
Adandoned											
12/20/1994	11.23	5.49	ND (<50)	ND (<250)	---	ND (<0.5)	ND (<0.5)	ND (<0.5)	ND (<1.5)	---	---
6/2/1994	14.89	1.83	ND (<50)	ND (<250)	---	ND (<0.5)	ND (<0.5)	ND (<0.5)	ND (<1.5)	---	---
12/20/1993	13.02	3.70	ND (<50)	ND (<250)	---	ND (<0.5)	ND (<0.5)	ND (<0.5)	ND (<1.5)	---	---
9/28/1993	14.50	2.22	ND (<50)	ND (<250)	---	ND (<0.5)	ND (<0.5)	ND (<0.5)	ND (<1.5)	---	---
6/24/1993	13.57	3.15	ND (<50)	ND (<250)	---	ND (<0.5)	ND (<0.5)	ND (<0.5)	ND (<1.5)	---	---
4/12/1993	NR	NR	ND (<50)	ND (<250)	---	ND (<0.5)	ND (<0.5)	ND (<0.5)	ND (<1.5)	**42**	---
2/9/1993	NR	NR	ND (<100)	ND (<500)	---	ND (<0.5)	ND (<0.5)	ND (<0.5)	ND (<0.5)	**23**	---

Monitoring Well and Sample Date	Depth to Water Level	Groundwater Elevation	Gasoline-range TPH (ug/L)	Diesel-range TPH (ug/L)	Oil-range TPH (ug/L)	Benzene (ug/L)	Toluene (ug/L)	Ethylbenzene (ug/L)	Total Xylenes (ug/L)	Total Lead (ug/L)	Methyl Tutiary Butyl Ether (ug/L)
MW-9A TOC 16.68											
Adandoned											
12/20/1994	8.3	8.38	ND (<50)	ND (<250)	---	ND (<0.5)	ND (<0.5)	ND (<0.5)	ND (<1.5)	---	---
6/2/1994	9.38	7.3	ND (<50)	260	---	ND (<0.5)	ND (<0.5)	ND (<0.5)	ND (<1.5)	---	---
12/20/1993	8.69	7.99	ND (<50)	280	---	ND (<0.5)	ND (<0.5)	ND (<0.5)	ND (<1.5)	---	---
9/28/1993	10.23	6.45	ND (<50)	ND (<250)	---	ND (<0.5)	ND (<0.5)	ND (<0.5)	ND (<1.5)	---	---
6/24/1993	9.27	7.41	ND (<50)	390	---	ND (<0.5)	ND (<0.5)	ND (<0.5)	ND (<1.5)	---	---
4/12/1993	NR	NR	ND (<50)	300	---	ND (<0.5)	ND (<0.5)	ND (<0.5)	ND (<1.5)	**120**	---
2/9/1993	NR	NR	ND (<100)	ND (<500)	---	ND (<0.5)	ND (<0.5)	0.8	0.5	**75**	---
MW-10 TOC 99.21											
3/27/2008	NR	NR	ND	---	---	ND	ND	ND	ND	---	---
8/16/2004	15.8	83.38	**6,710**	---	---	**191**	555	130	626	---	---
11/13/2003	14.08	85.13	**1,100**	250	<250	**82**	31	38	140	---	21/18
05/05-07/03	13.32	85.89	**1,300**	<250	<250	**78**	41	43	190	---	**20/20**
11/24/2002	14.15	85.06	550	<250	<250	**180**	2.3	28	120	---	**27/23**
5/22/2002	15.59	83.62	---	---	---	---	---	---	---	---	---
2/20/2002	13.52	85.69	<50	<250	---	**22**	3.1	0.51	3.1	---	18/17
11/30/2001	11.48	87.73	254	**554**	<500	**90.4**	15.2	2.46	16.3	---	**42.3/37.7**
9/9/2001	14.58	84.63	---	---	---	---	---	---	---	---	---
6/10/2001	13.35	85.86	<50	435	---	**73**	4.7	<0.5	4.62	---	**36.4/39**
3/25/2001	14.01	85.2	ND (<50)	377	---	**79.6**	6.72	ND (<0.5)	5.24	---	**40.6/43.0**
12/17/2000	13.74	85.47	62.6	ND (<250)	---	**87.5**	7.24	ND (<0.5)	1.67	---	**46.6/41.9**
10/2/2000	14.48	84.73	ND (<50)	ND (<250)	---	**37.2**	3.25	ND (<0.5)	ND (<1.5)	---	**31.7/23.4**
11/16/1999	12.1	87.11	ND (<50)	ND (<250)	---	ND (<0.5)	ND (<0.5)	ND (<0.5)	ND (<1.5)	---	19.5/13.3
9/4/1999	15.26	83.95	ND (<50)	339	---	2.05	ND (<0.5)	ND (<0.5)	ND (<1.5)	---	15.9
5/29/1999	13.42	85.79	ND (<50)	301	---	0.839	ND (<0.5)	ND (<0.5)	ND (<1.5)	---	9.93
3/24/1999	10.81	88.4	ND (<50)	---	---	ND (<0.5)	0.553	ND (<0.5)	ND (<1.5)	---	ND (<2.5)
11/24/1998	10.49	88.72	ND (<50)	ND (<250)	---	0.714	ND (<0.5)	ND (<0.5)	ND (<1.5)	---	8.08
9/2/1998	16.46	82.75	ND (<50)	ND (<250)	---	ND (<0.5)	ND (<0.5)	ND (<0.5)	ND (<1.5)	---	**22.6**
6/19/1998	15.75	83.46	ND (<50)	ND (<250)	---	3.88	ND (<0.5)	ND (<0.5)	ND (<1.5)	**21.2**	**29.7**
3/18/1998	15.68	83.53	ND (<50)	ND (<250)	ND (<250)	3.86	ND (<0.5)	ND (<0.5)	ND (<1.5)	---	---
9/5/1997	15.1	84.11	ND (<50)	ND (<250)	ND (<750)	ND (<0.5)	ND (<0.5)	ND (<0.5)	ND (<1)	---	---

Monitoring Well and Sample Date	Depth to Water Level	Groundwater Elevation	Gasoline-range TPH (ug/L)	Diesel-range TPH (ug/L)	Oil-range TPH (ug/L)	Benzene (ug/L)	Toluene (ug/L)	Ethylbenzene (ug/L)	Total Xylenes (ug/L)	Total Lead (ug/L)	Methyl Tutiary Butyl Ether (ug/L)
MW-11 TOC 98.15											
3/27/2008	NR	NR	**10,600**	---	---	**96.2**	97.3	167	985	---	---
11/16/2005	NR	NR	**61,800**	---	---	**1,710**	---	---	---	---	---
8/16/2004	16.15	81.97	**79,000**	---	---	**3,340**	**11,600**	**2,010**	**10,600**	---	---
11/13/2003	16.5	84.98	---	---	---	---	---	---	---	---	---
05/05-07-03	14.5	86.45	---	---	---	---	---	---	---	---	---
11/24/2002	13.79	84.36	50	<250	<250	0.83	0.57	<0.5	<1.5	---	**30/20**
5/22/2002	10.72	87.43	72	**500**	<750	<0.5	0.87	<0.5	<1.5	---	<2.5
2/20/2002	9.22	88.93	<50	<250	---	<0.5	<0.5	<0.5	<1.5	---	<2.5
11/30/2001	9.81	88.34	<50	293	<500	<0.5	<0.5	<0.5	<1.0	---	<1.0/<0.5
9/9/2001	14.58	83.57	<50	494	<500	<0.5	<0.5	<0.5	<1.0	---	**27.8/27.8**
6/10/2001	12.11	86.04	<50	**790**	---	<0.5	<0.5	<0.5	<1.0	---	6.64/7.3
3/25/2001	12.16	85.99	ND (<50)	**912**	---	ND (<0.5)	0.64	ND (<0.5)	1.51	---	5.01/5.12
12/17/2000	12.99	85.16	ND (<50)	435	---	ND (<0.5)	ND (<0.5)	ND (<0.5)	ND (<1.5)	---	9.11/8.93
10/2/2000	15.05	83.1	ND (<50)	252	---	ND (<0.5)	ND (<0.5)	ND (<0.5)	ND (<1.5)	---	**31.6/35.0**
11/16/1999	8.31	89.84	ND (<50)	369	---	ND (<0.5)	ND (<0.5)	ND (<0.5)	ND (<1.5)	---	**44.8/33.9**
9/4/1999	10.95	87.2	ND (<50)	ND (<250)	---	ND (<0.5)	ND (<0.5)	ND (<0.5)	ND (<1.5)	---	**48.2**
5/29/1999	9.92	88.23	ND (<50)	ND (<250)	---	ND (<0.5)	ND (<0.5)	ND (<0.5)	ND (<1.5)	---	**32.7**
3/24/1999	10.43	87.72	ND (<50)	ND (<250)	---	3.97	ND (<0.5)	ND (<0.5)	ND (<1.5)	---	11.2
11/24/1998	11.93	86.22	ND (<50)	ND (<250)	---	**13.5**	0.546	ND (<0.5)	2.91	---	16.7
9/2/1998	10.88	87.27	ND (<50)	ND (<250)	---	**31.2**	ND (<0.5)	ND (<0.5)	ND (<1.5)	---	**44.3**
6/19/1998	13.56	84.59	ND (<50)	297	---	ND (<0.5)	ND (<0.5)	ND (<0.5)	ND (<1.5)	---	6.79
3/18/1998	11.06	87.09	ND (<50)	390	ND (<750)	ND (<0.5)	ND (<0.5)	ND (<0.5)	ND (<1.5)	---	---
9/5/1997	14.59	83.56	77.2	376	ND (<750)	ND (<0.5)	ND (<0.5)	ND (<0.5)	ND (<1)	---	---

Monitoring Well and Sample Date	Depth to Water Level	Groundwater Elevation	Gasoline-range TPH (ug/L)	Diesel-range TPH (ug/L)	Oil-range TPH (ug/L)	Benzene (ug/L)	Toluene (ug/L)	Ethylbenzene (ug/L)	Total Xylenes (ug/L)	Total Lead (ug/L)	Methyl Tutiary Butyl Ether (ug/L)
MW-12 TOC 97.49											
3/27/2008 D	NR	NR	ND	---	---	ND	ND	ND	ND	---	---
3/27/2008	NR	NR	ND	---	---	ND	ND	ND	ND	---	---
11/16/2005	NR	NR	ND (<50)	---	---	ND (<0.50)	---	---	---	---	---
8/16/2004	9.9	87.58	ND (<50)	---	---	ND (<0.50)	0.935	ND (<0.50)	1.84	---	---
11/13/2003	9.74	88.75	<50	<250	<250	<0.50	<0.50	<0.50	<1.5	---	<2.5/5
05/05-07/03	8.72	89.77	<50	<250	450	<0.50	<0.50	<0.50	<1.5	---	<2.5
11/24/2002	9.86	88.63	**1,200**	<250	<250	**98**	5.5	47	150	---	12/10
5/22/2002	8.95	89.54	110	<250	<750	<0.50	0.71	<0.50	<1.5	---	<2.5
2/20/2002	8.22	90.27	<50	<250	---	<0.50	<0.50	<0.50	<1.5	---	<2.5
11/30/2001	8.43	90.06	<50	311	<500	**5.11**	<0.50	<0.50	1.27	---	4.95/3.93
9/9/2001	10.03	88.46	78.5	653	<500	**15.7**	5.04	0.947	9.18	---	15.4/13.6
6/10/2001	9.73	88.76	<50	**759**	---	**24.3**	5.33	0.54	4.05	---	16/17
3/25/2001	10.11	88.38	74.1	**779**	---	**24.7**	0.998	0.936	5.19	---	15.3/18.2
12/17/2000	9.25	89.24	284	252	---	**190**	13.9	3.43	31.3	---	**26.0/22.6**
10/2/2000	10.97	87.52	347	**2430**	---	**286**	49.4	3.91	58.4	---	**49.7/49.8**
11/16/1999	7.8	90.69	**1,410**	**4,650**	---	**442**	360	6.05	123	---	**70.1/70.7**
9/4/1999	11.21	87.28	ND (<50)	ND (<250)	---	**168**	15.4	3.46	37.3	---	**132**
5/29/1999	12.8	85.69	ND (<50)	ND (<250)	---	**30.9**	0.646	ND (<0.5)	3.69	---	**51.3**
3/24/1999	11.46	87.03	ND (<50)	ND (<250)	---	**10.3**	1.2	ND (<0.5)	1.13	---	17.1
11/24/1998	11.29	87.2	ND (<50)	ND (<250)	---	**6.05**	ND (<0.5)	ND (<0.5)	ND (<1.5)	---	**22.4**
9/2/1998	14.94	83.55	ND (<50)	ND (<250)	---	**66.2**	ND (<0.5)	ND (<0.5)	1.65	---	**146**
6/19/1998	14.09	84.4	ND (<50)	**653**	---	**11.3**	0.909	ND (<0.5)	ND (<1.5)	1.53	**47**
3/18/1998	13.4	85.09	ND (<50)	ND (<250)	ND (<250)	**9.52**	ND (<0.5)	ND (<0.5)	ND (<1.5)	---	---
9/5/1997	13.75	83.74	ND (<50)	366	ND (<750)	ND (<0.5)	ND (<0.5)	ND (<0.5)	ND (<1)	---	---
MW-13 TOC 97.23											
3/27/2008	NR	NR	ND	---	---	**28.5**	3.3	ND	3.9	---	---
5/8/2006	NR	NR	ND	---	---	ND	ND	ND	3.3	---	---
11/16/2005	NR	NR	**12,600**	---	---	**3,360**	---	---	---	---	---
8/16/2004	16.71	80.52	**14,400**	---	---	**3,850**	138	332	**1,150**	---	---
MW-14 TOC 98.07											
8/16/2004	17.9	80.17	**175,000**	---	---	**8,820**	**31,700**	**4,010**	**21,300**	---	---
MW-15											
5/8/2006	NR	NR	28	---	---	**1,600**	**7,900**	**1,300**	**7,000**		
MW-16											
3/27/2008	NR	NR	ND	---	---	ND	ND	ND	ND	---	---
11/6/2005	NR	NR	ND (<50)	---	---	0.741	---	---	---	---	---
MW-17											
4/11/2008	NR	NR	ND (<100)	---	---	ND (<1)	ND (<2)	ND (<1)	ND (<3)	---	---
11/16/2005	NR	NR	ND (<50)	---	---	1.5	---	---	---	---	---
MW-18											
4/18/2008	NR	NR	ND (<100)	---	---	ND (<1)	ND (<2)	ND (<1)	ND (<3)	---	---
MW-19											
4/18/2008	NR	NR	ND (<100)	---	---	ND (<1)	ND (<2)	ND (<1)	ND (<3)	---	---

Monitoring Well and Sample Date	Depth to Water Level	Groundwater Elevation	Gasoline-range TPH (ug/L)	Diesel-range TPH (ug/L)	Oil-range TPH (ug/L)	Benzene (ug/L)	Toluene (ug/L)	Ethylbenzene (ug/L)	Total Xylenes (ug/L)	Total Lead (ug/L)	Methyl Tutiary Butyl Ether (ug/L)
MW-20											
4/18/2008	NR	NR	ND (<100)	---	---	ND (<1)	ND (<2)	ND (<1)	ND (<3)	---	---
MW-21											
4/18/2008 D	NR	NR	ND (<100)	---	---	ND (<1)	ND (<2)	ND (<1)	ND (<3)	---	---
4/18/2008	NR	NR	ND (<100)	---	---	ND (<1)	ND (<2)	ND (<1)	ND (<3)	---	---
B-11											
3/1/2005	NR	NR	ND (<50)	---	---	ND (0.50)				---	---
IP-3											
3/27/2008	NR	NR	**62,900**	---	---	**6,120**	**8,850**	**968**	**4,420**	---	---
5/8/2006	NR	NR	28	---	---	**1,800**	**13,000**	**1,000**	**8,300**	---	---
IP-4											
3/27/2008	NR	NR	**84,400**	---	---	**14,600**	**22,100**	**4,920**	**17,600**	---	---
5/8/2006	NR	NR	110	---	---	**15,000**	**48,000**	**3,700**	**23,000**	---	---
IP-5											
3/27/2008	NR	NR	**13,300**	---	---	**711**	**1,260**	363	**1,370**	---	---
5/9/2006	NR	NR	48	---	---	**2,100**	**18,000**	**3,500**	**20,000**	---	---
EW-1											
4/4/2008	NR	NR	11,000	---	---	435	493	276	920	---	---
EW-4											
4/4/2008	NR	NR	130	---	---	26.3	ND	ND	5.6	---	---
EW-5											
4/11/2008 D	NR	NR	1,420	---	---	129	3.5	83.2	166	---	---
4/11/2008	NR	NR	1,420	---	---	130	3.6	74	173	---	---
EW-6											
4/4/2008	NR	NR	ND	---	---	14.8	2.6	1.8	7.1	---	---
EW-7											
4/4/2008 D	NR	NR	2,510	---	---	16.3	93.6	ND	255	---	---
4/4/2008	NR	NR	2,460	---	---	16.8	98.8	ND	270	---	---

Notes: Results above the respective Model Toxics Control Act Method A cleanup levels, if any, are in **bold**.
ug/L = micrograms per Liter (equivalent to parts per billion).
ND = non detect.
--- = not sampled.
NR = Not Reported
TPH = Total Petroleum Hydrocarbons.
[1] A duplicate sample was collected for quality control measures.

APPENDIX C

Summary of Data Gaps Identified To-Date

Boeing Chevron Data Gaps

Gap #1: Free-Phase Hydrocarbons in Groundwater

- April 2012 Free-Product Recovery Update is most recent report of groundwater/free product recovery conditions at the site
  - Product present in EW-9 (up to 0.98 feet thick in Nov 2011 & IP-7 (up to 2.93 feet thick in Feb 2012)
  - Socks used in EW-7, EW-9, IP-7 & MW-15
  - Product thickness greater during low groundwater levels
  - 10 gallons of product recovered between 9/2011 & 4/2012
  - Total 74.4 gal recovered since May 2008
- Ecology has not received a 2013 Free Product Recovery Update
- Most recent groundwater sampling event reported is from Nov 13, 2003 – Gettler-Ryan, Inc report to Chevron dated 12/15/2003
  - Wells MW-10, -11 & -12 sampled quarterly in 1999 – February 2002, semi annually May 2002 through November 2003
  - Free-phase hydrocarbon first identified May 2003 at MW-11 (approx 3.5 feet thick) and again at MW-11 in November 2003 (approx 4.16 feet thick)
  - ORC was applied on several occasions at wells MW-10, -11 & -12 between May 1999 September 2001
  - During 2002, sampling results at MW-10 reported concentrations of benzene and MTBE exceeding MTCA Method A cleanup levels during at least one sampling event (MTBE also detected above 20 ppb in November 2003). During 2002 at MW-11, diesel range hydrocarbons were detected in groundwater at a concentration of 500 ppb (equal to MTCA Method A cleanup level) during one sampling event. At MW-12, gasoline and benzene were reported at concentrations exceeding the MTCA Method A cleanup levels in November 2002.

Gap #2: Lateral Extent of Groundwater Impacts – Perched Unit

- Monitoring wells (still existing) installed only in perched unit: MW18
- Most wells are installed across both groundwater units: MW10 through MW17, and extraction wells EW1 through EW8
- Last groundwater sampling event reported was Spring 2008 (Gasoline and BTEX data only)
- Overall perimeter of groundwater impacts not constrained, particularly to the east, west and south
- MTBE in groundwater above MTCA Method A cleanup levels historically at wells MW10 and MW11. No MTBE in groundwater data since 2003.
- Diesel reported in B11 grab GW sample (2005) at 500 ppb (equal to MTCA Method A CUL). Diesel reported in MW11 (5/2002) at 500 ppb. No diesel groundwater data for wells MW13 through MW21.

Gap #3: Lateral Extent of Groundwater Impacts – Semi-Confined Unit

- Monitoring wells (still existing) installed only in the deep/semi-confined unit: MW-19, MW-20, MW-21
- Most wells are installed across both groundwater units: MW10 through MW17, and extraction wells EW1 through EW8
- Last groundwater sampling event reported was Spring 2008 (Gasoline and BTEX data only)

- Overall perimeter of groundwater impacts not constrained, particularly to the east, west and south
- MTBE in groundwater above MTCA Method A cleanup levels historically at wells MW10 and MW11. No MTBE in groundwater data since 2003.
- Diesel reported in MW11 (5/2002) at 500 ppb. No diesel groundwater data for wells MW19 through MW21.

Gap #4: Lateral and Vertical Extent of Soil Impacts

- The lateral extent of soil impacted by gasoline and/or BTEX constituents has not been fully delineated.
    - Benzene has been detected above the MTCA Method A (unrestricted) cleanup level of 0.03 mg/kg in soil samples collected at depths of 20 and 25' bgs at MW17, located west of the site in the right-of-way.
    - The line of soil borings/monitoring wells/extraction wells located in the planter box adjacent to the western property line (EW-6 to the north to EW-1 to the south) all contain one or more samples with concentrations of gasoline and/or BTEX constituents in soil above corresponding MTCA Method A cleanup levels. The western extent of soil impacts has not been constrained, particularly beyond the utility corridor
    - The northern/northeastern extent of soil impacts can be approximated somewhat based on analytical findings at MW16, EW-7, MW11, and MW12. *Note: MW11 and MW12 were installed and soil samples collected prior to identification of the 3rd release at the site.*
    - The eastern and southern extent of soil impacts has not been fully defined, particularly beneath and surrounding the current pump islands and south/southwest of MW13.
- The vertical extent of soil impacted by gasoline and/or BTEX constituents is not fully defined or understood (from south to north, western property line)
    - A soil sample was collected at a depth of 15 feet near MW13, approximately 5 months prior to drilling and installation of MW13. That boring reported a concentration of Benzene (0.181 mg/kg) exceeding MTCA Method A at a depth of 15'. A soil sample collected from the borehole where MW13 was installed, at a depth of 10' did not contain gasoline or benzene. (G/BTEX>MTCA A for GW at MW13)
    - Soil samples from the perched groundwater unit contained gasoline and/or BTEX constituents above MTCA Method A cleanup levels at MW14, MW15 and EW1
    - Soil samples from the lower, semi-confined groundwater unit contained concentrations of gasoline and/or BTEX constituents above MTCA Method A cleanup levels at EW5 (up to 23' bgs), EW3 and EW4 (up to 20' bgs, and EW2 and EW1 (up to 25' bgs). No soil samples were collected from locations EW1 through EW5 at depths greater than those identified above.
    - Soils samples collected near the base of the confining layer separating the two groundwater units contained gasoline and/or BTEX above MTCA Method A cleanup levels at EW3, MW15, and MW13, while samples from comparable depths at EW5 and EW1 contained concentrations below the cleanup levels.

- Existing soil sampling data does not include any data within the upper ten feet of soils, thus the upper extent of impacted soils has not been clearly identified.

Gap #5: Thickness of Lower (semi-confined) Hydrogeologic Unit

- Lower (semi-confined) hydrogeologic unit is most commonly logged as SP fine to medium-grained dark gray sand.
- Many boring logs show the top of this unit first occurring at approximately 15' below ground surface, however the base of the unit has not been encountered
- Deepest boreholes approximately 25' bgs – MW16, MW15

Gap #6: Contamination (soil and/or groundwater) May be Present In or Beneath the Underground Utility Corridor

- Underground utility corridor is located nearly coincident with the western property line – reportedly a storm drain, water line, and electrical conduit run parallel to Pacific Highway South
- Soil and groundwater impacted above MTCA Method A is located adjacent, to the east, of the utility corridor and data strongly suggests contamination is present in fill materials (if they extent to depths of 10-15' below ground surface) or beneath underground utility feathers.
- Depending on the actual depth of the utility trench/corridor, the corridor may be serving as a preferential, lower permeability pathway to convey impacted groundwater north-south along Tukwila International Blvd, perpendicular to the expected hydraulic gradient.

Appendix D

Final Quality Assurance Project Plan

Section 1: Introduction

The purpose of this Quality Assurance Project Plan (QAPP) is to identify the quality assurance and quality control (QA/QC) protocols necessary to achieve the project-specific data quality objectives for sample collection and analysis during the RI at the Boeing Field Chevron Site. The objectives for the RI as well as the background, project description, project organization and schedule, and sampling procedures are described in the Agency Review Draft Work Plan for RI (Work Plan).

Section 2: Quality Objectives

The data quality objectives (DQOs) for this project are to describe and implement field and laboratory procedures that ensure: 1) data will be representative of actual environmental conditions, and 2) data are of known and acceptable quality. Measurements will be made to yield accurate and precise results representative of the media and conditions measure. Concentrations will be calculated by the analytical laboratory and reported in units consistent with those used by regulatory agencies to allow for comparability of data.

Accuracy, precision, completeness, representativeness, comparability, and sensitivity are terms used to describe the quality of analytical data. Routine procedures for measuring precision and accuracy include use of quality control samples (i.e., replicate analyses, check or laboratory control samples, matrix spikes, and procedural blanks). These indictors of data quality are discussed below.

2.1 Precision

Precision is an appraisal of the reproducibility of a set of measurements. Precision can be better defined as the variability of a group of measurements compared to their average value. Variability for environmental monitoring programs contains both an analytical component and a field component.

Analytical precision will be evaluated by the analyses of matrix spike duplicate and laboratory duplicate samples, which can be mathematically expressed as the relative percent difference (RPD) between duplicate samples analyses. RPD is calculated using the following equation:

$$\boldsymbol{RPD = \frac{C1 - C2}{C} x\ 100}$$

Where:

C1 = First concentration value or recovery value measured for a variable

C2 = Second concentration value or recovery value measured for a variable

The frequency of the performance of matrix spike duplicate and laboratory duplicate samples, where applicable, is usually one per batch (which typically consists of up to 20 samples) for each sample matrix received.

Field duplicate samples will be submitted blind to the laboratory as a means to determine field variability. Frequency of field duplicate samples id discussed in Section 4.2.

Precision quantities will be calculated for analyses with method reporting limits of the same order of magnitude and with detection concentrations greater than or equal to five times the method reporting limits. In instances where no criteria have been established (e.g., field duplicates), relative percent difference project goals will be 50 percent for well-homogenized soil samples and 30 percent for water samples.

2.2 Bias and Accuracy

Bias is the systematic or persistent distortion of a measurement process that causes error in one direction. Accuracy refers to how close a measurement is to the true value. Bias and accuracy will be evaluated by the analysis of matrix spike samples and laboratory control samples and can be mathematically expressed as the percent recovery of an analyte that has been used to fortify a field sample or clean laboratory matrix sample at a known concentration prior to analysis. The percent recovery (R) for a matrix spike sample is calculated as follows:

$$R = \frac{SSR - SR}{SA} x\, 100$$

Where:

SSR = Spiked sample result

SR = Sample result

SA = Spike added.

The following calculation is used to determine R for a laboratory control sample or reference material:

$$R = \frac{RM}{RC} x\ 100$$

Where:

RM = Reference material result

RC = Known reference concentration

Results of matrix spike and laboratory control samples will be evaluated to the laboratory's control limits. Control limits are defined as the mean recovery, plus or minus three standard deviations, of the 20 data points, with the warning limits set as the mean, plus or minus two standard deviations. The laboratory will review the QC samples and surrogate standard recoveries for each analysis to ensure that internal QC data lie within the limits of acceptability. The laboratory will investigate any suspect trends and take appropriate corrective actions.

Field blank samples and method blank samples will also be used to evaluate bias of the data. Results for field and method blanks can reflect systematic bias that results from contamination of samples during collection or analysis. Analytes detected in field or method blank samples will be evaluated as potential indicators of bias.

2.3 Representativeness

Representativeness concerns the degree to which sample data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, or an environmental condition. Where appropriate, sampling locations will be selected on both systematic (to provide adequate coverage) and biased (in areas most likely to have adverse effects) samples bases in an attempt to spatially cover the study area. Sampling locations and methods for selection of these sampling locations are presented in the Work Plan.

2.4 Completeness

Completeness is a measure of the amount of valid data obtained from a measurement system. Completeness will be measured for each set of data received by dividing the number of valid measurements actually obtained by the number of valid measurements that were planned. Although 100 percent is the goal for completeness, 90 percent is the minimum acceptable level (EPA 2008).

2.5 Comparability

Comparability is a qualitative QA criterion that expresses the confidence in the ability to compare one data set with another. Comparability among data sets is achieved through the use of similar sampling procedures and analytical methods. Sampling procedures will be performed as specified in the Work Plan. Analytical procedures will be conducted according to the methods discussed in this QAPP.

2.6 Sensitivity

Sensitivity is the capability of a method or instrument to discriminate between measurement responses representing different levels of the variable of interest. The method detection limit (MDL) is defined as the statistically calculated minimum amount that can be measured with 99 percent confidence that the report value is greater than zero. MDLs are specified in the individual methods and are developed by the laboratory for each analyte of interest representing the aqueous and solid matrices within the capability of an analytical method.

The method reporting limit (MRL) or practical quantitation limit (PQL) is the lowest value to which the laboratory will report an unqualified quantitative result for an analyte. The PQL is always greater than the statistically determined MDL. The PQLs required for this project are such that data can be compared to the lowest possible applicable, relevant, and appropriate requirements (ARARs) suitable for the site. PQLs are discussed in greater detail in Section 3.

Section 3: Analytical Procedures

The analytical laboratory(s) selected to analyze samples for this project will be certified by Washington State Department of Ecology (Ecology) for all the analytical methods required for the project. The analytical methods for the analyses, applicable sample containers, and holding times are summarized in Table D-1. Target PQLs are summarized in Table D-2.

Terracon shall submit a summary of analytical methods, PQLs and MDLs from their selected laboratories to Ecology for review and approval prior to the start of field sampling activities.

Analysis of the soil and ground water samples will be performed using the following methods:

- Method NWTPH-Gx: Gasoline-range organics by GC/FID (Ecology 1997).
- Method NWTPH-Dx: Diesel-range organics and heavy oil-range organics by GC/FID (Ecology 1997).
- Extractable Petroleum Hydrocarbons Method: EPH by NWEPH.

- Volatile Petroleum Hydrocarbons Method: VPH by NWVPH.

- Method 8020: Benzene, toluene, ethyl benzene, total xylenes (BTEX) compounds, methyl tertiary butyl ether (MTBE), 1, 2-dichloroethane (EDC), 1,2-dibromoethane (EDB), and/or n-hexane.

- Method 8270 SIM: PAHs including naphthalenes and cPAHs[3].

- Method 6010a: total lead in soils and catch basin solids

- Method 200.8: total and dissolved lead in ground water and stormwater

Field parameters will be measured during ground water sampling as outlined in the Work Plan.

Section 4: Quality Control

QC samples will be assessed for both field and laboratory operations to evaluate overall precision/bias and accuracy throughout the project. Field QC samples will include field duplicate and blank samples. The types and frequency for QC samples are discussed below.

4.1 Laboratory Quality Control

Laboratory QC parameters, criteria, and frequency will be performed in accordance with the analytical methods referenced in Section 3. Comparison of QC sample results against established criteria is performed during the data validation process as described in Section 6.3. Laboratory QC data may include:

- Laboratory control and laboratory duplicate samples

- Matrix spikes and matrix spike duplicate samples

- Laboratory duplicates

- Surrogate standards

- Internal standards

- Method and instrument blanks

[3] As discussed above, cPAH analyses will be performed on only select soil sample(s).

- Post-digestion spikes

The frequency of analysis for laboratory control samples, matrix spike samples, matrix spike duplicate samples, laboratory duplicate samples, and method blank samples will be one for every 20 samples or one per batch, where applicable, or as specified in the analytical methods. Surrogate spikes and internal standards will be added to samples as required by the methods. Laboratory control limits and performance-based criteria presented in the methods will be used to establish the acceptability of the data or the need for re-analysis of a sample. Analytical data will be evaluated by the laboratory based on the following criteria, where applicable:

- Performance of analytical method tests
    - Holding times
    - Matrix spike and matrix spike duplicate results
    - Calibration data using check compound and system performance check with compound analysis results
    - Laboratory blank sample analysis results
    - Interference check samples analysis results
    - Laboratory check sample analysis results
    - Comparison of calibration and sample analysis
    - Linearity of response and linear range.
- Analytical results of internal standards and the calculation of percent recoveries
- Reporting limits obtained
- Accuracy and precision of matrix spike/matrix spike duplicate analysis
- Comparison of the percentage of missing or undetected substances among duplicate samples.

During data validation, analytical results will be evaluated against the performance criteria noted in the QAPP and the individual analytical methods.

4.2 Field Quality Control Samples

Field duplicate samples are designed to monitor overall sampling and analytical precision. In general, duplicate samples will be collected at a frequency of approximately one duplicate sample per 20 samples or one duplicate sample per batch of samples if less than 20 samples are collected.

For duplicate water samples, sample containers will be alternately filled. The locations for duplicate sample collection will be approximately every 10th sample collected, but will ultimately be determined in the field. Duplicate samples will be treated as separate samples from the originals (assigned unique sample numbers), and not identified to the laboratory as duplicate samples. Field duplicate samples will be documented on the daily field report, in the field logbook, or other appropriate field form.

Trip blank samples will also be collected. Volatile organic samples are susceptible to contamination by diffusion of organic contaminants through the sample vials. Therefore, trip blank samples will be submitted to monitor for possible sampling contamination during shipment if VOC analyses are performed. Trip blank samples will be prepared by the analytical laboratory by filling volatile organic analysis (VOA) vials with organic-free water and shipping the blank samples with the clean sample containers. Trip blank samples will accompany the sample containers through collection and shipment to the laboratory and will be stored with the samples.

Section 5: Data Management

5.1 Documentation and Records

Records will be maintained documenting activities performed and data generated during implementation of the Work Plan. The types of documents that will be generated during implementation of the Work Plan are discussed below.

5.1.1. Field Documentation

Field personnel will document their field activities on either a daily field log or in a field logbook and complete other field forms applicable to the field activities being performed. The daily field logs and field logbooks will document information regarding who was present during field activities (field personnel, subcontractors, visitors), weather conditions, work conducted that day, problems encountered and corrective actions, if any, etc. Field logs will be filed in the project files.

Field logbooks and other types of field forms (e.g., ground water purge and sample forms, boring log/well construction logs using the Unified Soil Classification System, test pit excavation logs) will be used to record data obtained during various field activities. The individual field personnel will be responsible for maintaining these forms. Field daily logs, field logbooks, and other field forms will then be archived in the project files and provided to Ecology in monthly progress reports as well as the RI report.

5.1.2. Laboratory Documentation

Records related to sample analysis will be documented by the laboratory. The laboratory will be required to submit data that are supported by sufficient backup information and QC results to enable reviewers to determine the quality of the data. The laboratory will submit the data in electronic and paper format. The paper format (i.e., hard copy) data packages from the laboratory will consist of the following information, where applicable:

- A cover letter for each sample batch will include a summary of any QC, sample, shipment, or analytical problems, and will document internal decision. Problems will be outlined and final solutions documented. A copy of the signed chain-of-custody form for each batch of samples will be included in the deliverable.
- Sample concentrations will be reported on standard data sheets in proper units and to the appropriate number of significant figures. For undetected values, the lower limit of detection for each compound will be reported separately for each sample. Dates of sample extraction or preparation and analysis will be included.
- Method blank results.
- Surrogate percent recoveries.
- Laboratory duplicate results, where applicable.
- Laboratory control sample results, where applicable, with percent recoveries and spiking concentrations.
- Matrix spike/matrix spike duplicate percent recoveries, with spiking concentrations and calculated relative percent differences.
- A list of the detection limits calculated for laboratory instruments for all analytes.
- Laboratory data qualifier codes appended to analyte concentrations, as appropriate, and a summary of code definitions.

Sample holding times will be calculated by comparing the data of sample collection (shown on the chain-of-custody form) with the date of sample extraction/analysis. Analytical laboratory deliverables will be validated.

The analytical laboratory will routinely archive raw laboratory data, including initial and continuing calibration data, chromatograms, and quantitation reports for at least 5 years.

5.2 Instrument/Equipment Calibration and Frequency

Field instruments will be operated, calibrated, and maintained by qualified personnel, according to manufacturer's guidelines and recommendations. At a minimum, instruments will be calibrated before use each day or more frequently as necessary. Calibration records will be recorded in the daily field log, field logbook, or other appropriate forms.

Laboratory instruments will be calibrated and maintained in accordance with the requirements of analytical methods and normal operating standards associated with good laboratory practices. Calibration requirements are specified in each laboratory's QA manual. Calibration records are documented in laboratory logbooks.

5.3 Instrument/Equipment Testing, Inspection, and Maintenance

Sampling equipment that will be used during field activities is discussed in the Work Plan. Preventive maintenance of equipment is essential if project resources are to provide accurate results and are to be used cost-effectively. Preventive maintenance will take two forms: 1) implementation of a schedule of preventive maintenance activities to reduce downtime and maintain accuracy of measurement systems and 2) availability of critical spare parts and backup systems and equipment.

Qualified operators will perform routine inspections and maintenance for field instruments in accordance with manufacturers' recommendations. Field equipment will be inspected prior to the start of sampling activities. Maintenance activities, if performed, will be documented in the daily field log or field logbook. As most types of field equipment that will be used for this project are standard (i.e., used frequently in environmental samples), replacement parts are readily available. The field personnel will be responsible for maintaining the field equipment.

The laboratory's QA manual discusses preventive maintenance for laboratory equipment and instruments. Maintenance and inspection records are documented in laboratory logbooks.

Section 6: Audits and Reports

6.1 Performance Evaluation Audits

Performance evaluation audits are an independent means of establishing the quality of measurement data by analysis of samples provided specifically for the evaluation.

During a performance evaluation audit, the performance of the laboratory technicians and the instrumentation or analytical systems on which they work are evaluated. A performance evaluation audit is accomplished by providing performance evaluation samples containing specific pollutants (in appropriate matrices) whose identities and/or concentrations are unknown to the technician. Laboratories participate in both internal and external performance testing to examine the overall laboratory performance as well as to qualify for various federal, state, and independent certification programs.

The laboratory will be responsible for implementing corrective action for analytical procedures. Corrective action procedures are described in the laboratory's QA manual. If QC data are unacceptable, the cause will be determined and corrected. Corrective actions that affect the integrity of the project analytical data will require re-analysis of the affected sample or qualifying of these data in the final data report. If corrective actions are warranted by a laboratory, the laboratory will document and forward the corrective action(s).

6.2 System and Technical Laboratory Audits

System and technical audits are performed by the laboratory QA Manager according to a predetermined schedule and when requested by laboratory management. An independent audit may be conducted should corrective actions be needed during implementation of the Work Plan (e.g., a laboratory repeatedly does not meet QC criteria, or overall performance of the laboratory is questionable). This audit will be project-specific and will focus only on the performance of the laboratory for this project. A laboratory audit report will be prepared, if necessary.

6.3 Field Operations

A readiness review will be conducted prior to initiation of each field task requiring sampling to verify that the necessary preparations have been made for efficient and effective completion of the task-related field activities. The Project Manager will verify that the necessary field equipment has been assembled for the field activity and that the applicable subcontractors, if necessary, have been scheduled. Any deficiencies noted during this readiness review will be corrected prior to initiation of field activities.

Field personnel are required to maintain continual communication with project members during the duration of field activities. Thereby, should issues arise during field activities, corrective actions can be implemented.

Section 7: Data Tracking, Reduction, and Validation

7.1 Sample Data Tracking System

During field activities, field personnel will be responsible for overseeing field measurements and data recording. Information on field forms will be verified by the Terracon Project Manager that the following conditions have been met:

- Samples are properly documented in daily field logs, field logbooks and/or other field forms appropriate to the field activities being conducted.
- Chain-of-custody forms are complete and accurate.
- Samples collected are properly documented and field forms are completed.
- Samples and analyses specified in the Work Plan have been collected.
- Correct number of field QC samples was collected.

In addition, upon receipt of samples at the laboratory, it will be verified by the analytical laboratory that samples were received at the appropriate temperature and in good condition (i.e., no excessive headspace, broken sample containers, etc.). If a sample does not arrive at the laboratory at the appropriate temperature or the integrity of the sample is in question, the potential implication of the anomaly will be evaluated and a course of action will be determined based on the nature of the anomaly.

7.2 Data Reduction

Both field and laboratory data will be collected during implementation of the Work Plan. Data obtained during sample collection will be manually entered onto daily field logs, field logs book, and other field forms.

The laboratory will provide analytical data in electronic and/or paper form. Electronic data will be loaded into project databases and verified with the paper copy. Initial lab EDDs will be submitted to Ecology with the laboratory analytical reports.

Some data from the field logs, field log books, sampling forms, and analytical data (such as sample location name and coordinates, water levels, and field parameters) may also be manually entered into project databases or various programs such as computer-aided drafting and design (CADD). Manually entered data will be reviewed by a second individual.

The central data management tool for the laboratory is the laboratory information management system (LIMS). The LIMS is used for sample processing, including sample log-in and tracking, instrument data storage and processing, generating data reports, and verifying results. Data collected from each laboratory instrument, either manually or electronically, are reviewed and confirmed by the analyst prior to reporting. Laboratory records including chain-of-custody forms, bench sheets, and analytical results, whether in electronic or hard copy format, are stored chronologically by batch or project.

7.3 Data Review, Verification, and Validation

Field and laboratory data generated during implementation of the Work Plan will be reviewed, verified, and validated. Field data entered into databases will be verified. Error identified during the verification of data will be corrected prior to release of the final data.

The laboratory is responsible for verifying analytical results prior to the submittal of the final laboratory data report. Initially, all analytical data generated by the laboratory are verified by the laboratory. During the analysis process, the analyst and the laboratory QA Manager verify that the results have met various performance-based control limits (e.g., surrogate recoveries and continuing calibration). Non-conformance of various method QC requirements and control limits warrants the re-analysis and/or re-extraction of a sample.

Finally, the data will be verified and validated based on the quality objectives specified in this QAPP and performance-based criteria specified in the analytical methods in accordance with applicable portions of EPA's Contract Laboratory Program National Functional Guidelines for Organic and Inorganic Data Review (EPA 2004; 2008). If data do not meet required criteria, they will be flagged with data qualifiers as specified under the action portion of each requirement of the functional guidelines (EPA 2004; 2008).

Data verification and validation will be conducted to assess the laboratory's performance in meeting the quality objectives identified in the QAPP (e.g., reporting limits and control limits) and performance-based criteria specified in the analytical methods. The components to be evaluated during the data validation process are summarized below:

- Holding times
- Method blank results
- Surrogate recovery results for organic analyses
- Laboratory control sample results

- Field duplicate results
- Field blank results
- Laboratory duplicate results, where applicable
- Matrix spike/matrix spike duplicate (MS/MSD) results for all relevant analyses
- Completeness
- Reported detection limits for analyses

If data do not meet the quality objectives and required criteria, they will be flagged with data qualifiers as specified under the action portion of each requirement of the functional guidelines (EPA 2014). Typical data qualifiers include, but are not limited to, “J,” used to indicate an estimated value, “B,” used to indicate blank contamination, and “R,” used to indicate a rejected value. The findings of the data validation will be presented in the RI report. Limitations to the usability of the data will also be discussed in the report. Formal validation reports will not be prepared.

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APPENDIX E

Field Standard Operating Procedures

STANDARD OPERATING PROCEDURE

E.2000
GROUNDWATER SAMPLING – LOW FLOW GROUNDWATER SAMPLING

Last Revision or Review: June 2010

Objective
To collect a representative groundwater sample from the sampling point for chemical analysis. This procedure should be used when attempting to minimize stress to the aquifer due to monitoring well sampling. This procedure includes the documentation of sampling methods, sampling supplies and protocol to reduce potential for alteration and or cross-contamination during the sampling event.

Equipment
- Groundwater Elevation Data form;
- laboratory Chain-of-Custody form;
- laboratory sample labels;
- field logbook;
- indelible ink pen;
- pH, temperature, and specific conductance meter;
- turbidity meter;
- sample containers and packing material;
- cooler with ice pack and packing media;
- well purging equipment – disposable bailers and string;
- sampling device – low-flow peristaltic pump;
- mobile, secure shed to protect equipment during sampling (insulated during colder weather);
- keys for locking cap on well and secure shed;
- deionized (DI) water; and
- site map.

Procedures

Preparation - Meet with Project Manager;
- obtain the sample containers, forms, and equipment necessary to complete the sampling event;
- calibrate all field equipment i.e., temperature, pH, specific conductance meter and turbidity meter;

- document equipment calibration in field logbook; and
- establish sampling sequence.

Monitoring Well Purging

- document all field activities in field logbook and field forms
- water levels - collect and record water levels
- purge monitoring wells
    - using bailers, remove three (3) well casing volumes of water from each well (or until well goes dry)
    - collect purge water in a bucket and dispose of on site away from the well to minimize potential vertical migration along the annular well space
- return to site after stabilization period of two (2) days
- contamination minimization
    - use plastic sheet as an apron to isolate the wellhead by splitting sufficiently to pass the well protector and slide over wellhead onto ground.

Sampling

- use a low-flow sampling pump
- determine proper depth of purging device, approximately half the distance of the water column or approximate middle of the well screen
- attach new section of pump tubing to pump
- lower pump suction tubing slowly (to minimize disturbance) into well to midpoint of sampling zone
- start pump at its lowest setting and slowly increase speed until discharge occurs.
- check water level and adjust pump speed to maintain drawdown at less than four (4) inches and pump no faster than 0.1 L/min
- stabilization parameters
    - record turbidity, temperature, pH, and specific conductance at regular intervals

- transfer the groundwater sample directly to the laboratory prepared sample containers
    - fill sample containers by allowing pump discharge to flow gently down the side of the container with minimal disturbance
    - do not over-fill sample containers which contain a preservative
    - place samples in cooler with ice

Data Documentation

- record all pertinent sampling information on the sampling container label, sampling information form, chain-of-custody, and shipping form.
- pertinent data will vary based on the parameter and the form; however, the following data must be recorded - time, date, job number, project name, sampling location, samplers name,

sampling methodology, parameters to be analyzed, stabilization data, and general observations.

- make appropriate entries in the chain-of-custody form at time of sample collection - ensure that the chain-of-custody protocol required for the project is maintained

ATTACHED SUPPORTING REFERENCES

Low Stress (Low Flow) Purging and Sampling Procedure for the Collection of Ground Water Samples from Monitoring Wells, EPA Region 1, July 30, 1996, Revision 2.

STANDARD OPERATING PROCEDURE FOR LOW-STRESS (Low Flow) / MINIMAL DRAWDOWN GROUND-WATER SAMPLE COLLECTION

INTRODUCTION

The collection of "representative" water samples from wells is neither straightforward nor easily accomplished. Ground-water sample collection can be a source of variability through differences in sample personnel and their individual sampling procedures, the equipment used, and ambient temporal variability in subsurface and environmental conditions. Many site inspections and remedial investigations require the sampling at ground-water monitoring wells within a defined criterion of data confidence or data quality, which necessitates that the personnel collecting the samples are trained and aware of proper sample-collection procedures.

The purpose of this standard operating procedure (SOP) is to provide a method which minimize the amount of impact the purging process has on the ground water chemistry during sample collection and to minimize the volume of water that is being purged and disposed. This will take place by placing the pump intake within the screen interval and by keeping the drawdown at a minimal level (0.33 feet) (Puls and Barcelona, 1996) until the water quality parameters have stabilized and sample collection is complete. The flow rate at which the pump will be operating will be depended upon both hydraulic conductivity of the aquifer and the drawdown with the goal of minimizing the drawdown. The flow rate from the pump during purging and sampling will be at a rate that will not compromise the integrity of the analyte that is being sampled. This sampling procedure may or may not provide a discrete ground water sample at the location of the pump intake. The flow of ground-water to the pump intake will be dependent on the distribution of the hydraulic conductivity (K) of the aquifer within the screen interval. In order to minimize the drawdown in the monitoring well a low-flow rate must be utilized. Low-flow refers to the velocity with which water enters the pump intake from the surrounding formation in the immediate vicinity of the well screen. It does not necessarily refer to the flow rate of water discharged at the surface, which can be affected by flow regulators or restrictions (Puls and Barcelona, 1996). This SOP was developed by the Superfund/RCRA Ground Water Forum and draws from an USEPA's Ground Water Issue Paper, Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedure, by Robert W. Puls and Michael J. Barcelona. Also, available USEPA Regional SOPs regarding Low-Stress(Low Flow)Purging and Sampling were used for this SOP.

SCOPE AND APPLICATION

This SOP should be used primarily at monitoring wells which have a screen or an open interval with a length of ten feet or less and can accept a sampling device which minimizes the disturbance to the aquifer or the water column in the well casing. The screen or open interval should have been optimally located to intercept an existing contaminant plume(s) or along flowpaths of potential contaminant releases. Knowledge of the contaminant distribution within the screen interval is highly recommended and is essential for the success of this sampling procedure. The ground-water samples which are collected using this procedure are acceptable for the analyses of ground-water contaminants which may be found at Superfund and RCRA contamination sites. The analytes may be volatile, semi-volatile organic compounds, pesticides, PCBs, metals and other inorganic compounds. The screened interval should be located within the contaminant plume(s) and the pump intake should be placed at or near the known source of the contamination within the screened interval. It is critical to place the pump intake in the exact location or depth for each sampling event. This argues for the use of dedicated, permanently installed sampling devices whenever possible. If this is not possible then the placement of the pump intake should be positioned with a calibrated sampling pump hose sounded with a weighted-tape or using a pre-measured hose. The pump intake should not be placed near the bottom of the screened interval to avoid disturbing any sediment that may have settled at the bottom of the well.

Water-quality indicator parameters and water levels must be measured during purging, prior to sample collection. Stabilization of the water quality parameters as well as monitoring water levels are a prerequisite to sample collection. The water-quality indicator parameters which are recommended include the following: specific electrical conductance, dissolved oxygen, turbidity, oxidation-reduction potential, pH, and temperature. The latter two parameters are useful data, but are generally insensitive as purging parameters. Oxidation-reduction potential may not always be appropriate stabilization parameter, and will depend on site-specific conditions. However, readings should be recorded because of its value as a double check for oxidation conditions, and for fate and transport issues. Also, when samples are collected for metals, semi-volatile organic compounds, and pesticides every effort must be made to reduce turbidity to 10 NTUs or less (not just the stabilization of turbidity) prior to the collection of the water sample. In addition to the measurement of the above parameters, depth to water must be measured during purging (U.S. Environmental Protection Agency, 1995).

Proper well construction, development and maintenance are essential for any ground-water sampling procedure. Prior to conducting the field work, information on the construction of the well and well development should be obtained and that information factored into the site specific sampling procedure. The attached Sampling Checklist is an example of the type of information that is useful.

Stabilization of the water-quality indicator parameters is the criterion for sample collection. But if stabilization is not occurring and the procedure has been strictly followed, then sample collection can take place once three (minimum) to six (maximum) casing volumes have been removed (Schuller et al., 1981 and U.S. Environmental Protection Agency., 1986; Wilde et al., 1998; Gibs and Imbrigiotta., 1990). The specific information on what took place during purging must be recorded in the field notebook or in the ground-water sampling log.

This SOP is not to be used where non-aqueous phase liquids (immiscible fluids) are present in the monitoring well.

EQUIPMENT

- Depth-to-water measuring device - An electronic water-level indicator or steel tape and chalk, with marked intervals of

0.01 foot. Interface probe for determination of liquid products (NAPL) presence, if needed.

- Steel tape and weight - Used for measuring total depth of well. Lead weight should not be used.
- Sampling pump - Submersible or bladder pumps with adjustable rate controls are preferred. Pumps are to be constructed of inert materials, such as stainless steel and teflon®. Pump types that are acceptable include gear and helical driven, centrifugal (low-flow type) and air-activated piston. Adjustable rate, peristaltic pump can be used when the depth to water is 20 feet or less.
- Tubing - Teflon® or Teflon® lined polyethylene tubing is preferred when sampling for organic compounds. Polyethylene tubing can be used when sampling inorganics.
- Power Source - If a combustion type (gasoline or diesel-driven) generator is used, it must be placed downwind of the sampling area.
- Flow measurement supplies - flow meter, graduated cylinder and a stop watch.
- Multi-Parameter meter with flow-through-cell - This can be one instrument or more contained in a flow-through cell. The water-quality indicator parameters which must be monitored are pH, ORP/EH, dissolved oxygen (DO), turbidity, specific conductance, and temperature. Turbidity readings must be collected before the flow cell because of the potential for sediment buildup which can bias the turbidity measurements. Calibration fluids for all instruments should be NIST-traceable and there should be enough for daily calibration through-out the sampling event. The inlet of the flow cell must be located near the bottom of the flow cell and the outlet near the top. The size of the flow cell should be kept to a minimum and a closed cell is preferred. The flow cell must not contain any air or gas bubbles when monitoring for the water-quality indicator parameters.
- Decontamination Supplies - Including a reliable and documented source of distilled water and any solvents (if used). Pressure sprayers, buckets or decontamination tubes for pumps, brushes and non-phosphate soap will also be needed.
- Sample bottles, sample preservation supplies, sample tags or labels and chain of custody forms.
- Approved Field Sampling and Quality Assurance Project Plan.
- Well construction data, field and water quality data from the previous sampling event.
- Well keys and map of well locations.

- Field notebook, ground-water sampling logs and calculator. A suggested field data sheet (ground-water sampling record or ground-water sampling log) are provided in the attachment.
- Filtration equipment, if needed. An in-line disposable filter is recommended.
- Polyethylene sheeting which will be placed on ground around the well head.
- Personal protective equipment specified in the site Health and Safety Plan.
- Air monitoring equipment as specified in the Site Health and Safety Plan.
- Tool box -All needed tools for all site equipment used.
- A 55-gallon drum or container to contain the purged water.

Materials of construction of the sampling equipment (bladders, pumps, tubing, and other equipment that comes in contact with the sample) should be limited to stainless steel, Teflon®, glass and other inert material. This will reduce the chance of the sampling materials to alter the ground-water where concentrations of the site contaminants are expected to be near the detection limits. The sample tubing diameter thickness should be maximized and the tubing length should be minimized so that the loss of contaminants into and through the tubing walls may be reduced and the rate of stabilization of ground-water parameters is maximized. The tendency of organics to sorb into and out of material makes the appropriate selection of sample tubing material critical for trace analyses (Pohlmann and Alduino, 1992; Parker and Ranney, 1998).

PURGING AND SAMPLING PROCEDURES

The following describes the purging and sampling procedures for the Low-Stress (Low Flow)/ Minimal Drawdown method for the collection of ground-water samples. These procedures also describe steps for dedicated and non-dedicated systems.

<u>Pre-Sampling Activities</u> (Non-dedicated and dedicated system)

1. Sampling locations must begin at the monitoring well with the least contamination, generally up-gradient or furthest from the site or suspected source. Then proceed systematically to the monitoring wells with the most contaminated ground water.

2. Check and record the condition of the monitoring well for damage or evidence of tampering. Lay out polyethylene sheeting around the well to minimize the likelihood of contamination of sampling/purging equipment from the soil. Place monitoring, purging and sampling equipment on the sheeting.

3. Unlock well head. Record location, time, date and appropriate information in a field logbook or on the ground-water sampling log (See attached ground-water sampling record and ground-water sampling log as examples).

4. Remove inner casing cap.

5. Monitor the headspace of the monitoring well at the rim of the casing for volatile organic compounds (VOC) with a Photo-ionization detector (PID) or Flame ionization detector (FID), and record in the logbook. If the existing monitoring well has a history of positive readings of the headspace, then the sampling must be conducted in accordance with the Health and Safety Plan.

6. Measure the depth to water (water level must be measured to nearest 0.01 feet) relative to a reference measuring point on the well casing with an electronic water level indicator or steel tape and record in logbook or ground-water sampling log. If no reference point is found, measure relative to the top of the inner casing, then mark that reference point and note that location in the field logbook. Record information on depth to ground water in the field logbook or ground water sampling log. Measure the depth to water a second time to confirm initial measurement; measurement should agree within 0.01 feet or re-measure.

7. Check the available well information or field information for the total depth of the monitoring well. Use the information from the depth of water in step six and the total depth of the monitoring well to calculate the volume of the water in the monitoring well or the volume of one casing. Record information in field logbook or ground-water sampling log.

Purging and Sampling Activities

8A. Non-dedicated system - Place the pump and support equipment at the wellhead and slowly lower the pump and tubing down into the monitoring well until the location of the pump intake is set at a pre-determined location within the screen interval. The placement of the pump intake should be positioned with a calibrated sampling pump hose, sounded with a weighted-tape, or using a pre-measured hose. Refer to the available monitoring well information to determine the depth and length of the screen interval. Measure the depth of the pump intake while lowering the pump into location. Record pump location in field logbook or groundwater sampling log.

8B. Dedicated system - Pump has already been installed, refer to the available monitoring well information and record the depth of the pump intake in the field logbook or ground-water sampling log.

9. Non-dedicated system and dedicated system - Measure the water level (water level must be measured to nearest 0.01 feet) and record information on the ground-water sampling log, leave water level indicator probe in the monitoring well.

10. Non-dedicated and dedicated system - Connect the discharge line from the pump to a flow-through cell. A “T” connection is needed prior to the flow cell to allow for the collection of water for the turbidity measurements. The discharge line from the flow-through cell must be directed to a container to contain the purge water during the purging and sampling of the monitoring well.

11. Non-dedicated and dedicated system - Start pumping the well at a low flow rate (0.2 to 0.5 liter per minute) and slowly increase the speed. Check water level. Maintain a steady flow rate while maintaining a drawdown of less than 0.33 feet (Puls and Barcelona, 1996). If drawdown is greater than 0.33 feet lower the flow rate. 0.33 feet is a goal to help guide with the flow rate adjustment. It should be noted that this goal may be difficult to achieve under some circumstances due to geologic heterogeneities within the screened interval, and may require adjustment based on site-specific conditions and personal experience (Puls and Barcelona, 1996).

12. Non-dedicated and dedicated system - Measure the discharge rate of the pump with a graduated cylinder and a stop watch. Also, measure the water level and record both flow rate and water level on the groundwater sampling log. Continue purging, monitor and record water level and pump rate every three to five minutes during purging. Pumping rates should be kept at minimal flow to

ensure minimal drawdown in the monitoring well.

13. Non-dedicated and dedicated system - During the purging, a minimum of one tubing volume (including the volume of water in the pump and flow cell) must be purged prior to recording the water-quality indicator parameters. Then monitor and record the water-quality indicator parameters every three to five minutes. The water-quality indicator field parameters are turbidity, dissolved oxygen, specific electrical conductance, pH, redox-potential and temperature. Oxidation-reduction potential may not always be an appropriate stabilization parameter, and will depend on site-specific conditions. However, readings should be recorded because of its value as a double check for oxidizing conditions. Also, for the final dissolved oxygen measurement, if the readings are less than 1 milligram per liter, it should be collected and analyze with the spectrophotometric method (Wilde et al., 1998 Wilkin et al., 2001), colorimetric or Winkler titration (Wilkin et al., 2001). The stabilization criterion is based on three successive readings of the water quality field parameters; the following are the criteria which must be used:

Parameter	**Stabilization Criteria**	**Reference**
pH	± 0.1 pH units	Puls and Barcelona, 1996; Wilde et al.,
Specific electrical conductance (SEC)	± 3% FS/cm	Puls and Barcelona, 1996
oxidation-reduction potential (ORP)	± 10 millivolts	Puls and Barcelona 1996
turbidity	± 10 % NTUs (when turbidity is greater than 10 NTUs)	Puls and Barcelona, 1996 Wilde et al., 1998
dissolved oxygen	± 0.3 milligrams per liter	Wilde et al., 1998

Once the criteria have been successfully met indicating that the water quality indicator parameters have stabilized, then sample collection can take place.

14. If a stabilized drawdown in the well can’t be maintained at 0.33 feet and the water level is approaching the top of the screened interval, reduce the flow rate or turn the pump off (for 15 minutes) and allow for recovery. It should be noted whether or not the pump has a check valve. A check valve is required if the pump is shut off. Under no circumstances should the well be

pumped dry. Begin pumping at a lower flow rate, if the water draws-down to the top of the screened interval again turn pump off and allow for recovery. If two tubing volumes (including the volume of water in the pump and flow cell) have been removed during purging then sampling can proceed next time the pump is turned on. This information should be noted in the field notebook or ground-water sampling log with a recommendation for a different purging and sampling procedure.

15. Non-dedicated and dedicated system - Maintain the same pumping rate or reduce slightly for sampling (0.2 to 0.5 liter per minute) in order to minimize disturbance of the water column. Samples should be collected directly from the discharge port of the pump tubing prior to passing through the flow-through cell. Disconnect the pump's tubing from the flow-through-cell so that the samples are collected from the pump's discharge tubing. For samples collected for dissolved gases or Volatile Organic Compounds (VOCs) analyses, the pump's tubing needs to be completely full of ground water to prevent the ground water from being aerated as the ground water flows through the tubing. The sequence of the samples is immaterial unless filtered (dissolved) samples are collected and they must be collected last (Puls and Barcelona, 1996). All sample containers should be filled with minimal turbulence by allowing the ground water to flow from the tubing gently down the inside of the container. When filling the VOC samples a meniscus must be formed over the mouth of the vial to eliminate the formation of air bubbles and head space prior to capping. In the event that the ground water is turbid,(greater then 10 NTUs), a filtered metal (dissolved) sample also should be collected.

If filtered metal sample is to be collected, then an in-line filter is fitted at the end of the discharge tubing and the sample is collected after the filter. The in-line filter must be pre-rinsed following manufacturer's recommendations and if there are no recommendations for rinsing, a minimum of 0.5 to 1 liter of ground water from the monitoring well must pass through the filter prior to sampling.

16A. Non-dedicated system - Remove the pump from the monitoring well. Decontaminate the pump and dispose of the tubing if it is non-dedicated.

16B Dedicated system - Disconnect the tubing that extends from the plate at the wellhead (or cap) and discard after use.

17. Non-dedicated system - Before locking the monitoring well, measure and record the well depth (to 0.1 feet).
Measure the total depth a second time to confirm initial measurement; measurement should agree within 0.01 feet or re-measure.

18. Non-dedicated and dedicated system - Close and lock the well.

DECONTAMINATION PROCEDURES

Decontamination procedures for the water level meter and the water quality field parameter sensors.
The electronic water level indicator probe/steel tape and the water-quality field parameter sensors will be decontaminated by the following procedures:
1. The water level meter will be hand washed with phosphate free detergent and a scrubber, then thoroughly rinsed with distilled water.

2. Water quality field parameter sensors and flow-through cell will be rinsed with distilled water between sampling locations. No other decontamination procedures are necessary or recommended for these probes since they are sensitive. After the sampling event, the flow cell and sensors must be cleaned and maintained per the manufacturer's requirements.

Decontamination Procedure for the Sampling Pump

Upon completion of the ground water sample collection the sampling pump must be properly decontaminated between monitoring wells. The pump and discharge line including support cable and electrical wires which were in contact with the ground water in the well casing must be decontaminated by the following procedure:

1. The outside of the pump, tubing, support cable and electrical wires must be pressured sprayed with soapy water, tap water and distilled water. Spray outside of tubing and pump until water is flowing off of tubing after each rinse. Use bristle brush to help remove visible dirt and contaminants.
2. Place the sampling pump in a bucket or in a short PVC casing (4-in. diameter) with one end capped. The pump placed in this device must be completely submerged in the water. A small amount of phosphate free detergent must be added to the potable water

(tap water).
3. Remove the pump from the bucket or 4-in. casing and scrub the outside of the pump housing and cable.
4. Place pump and discharge line back in the 4-in. casing or bucket, start pump and re-circulate this soapy water for 2 minutes (wash).
5. Re-direct discharge line to a 55-gallon drum, continue to add 5 gallons of potable water (tap water)or until soapy water is no longer visible.
6. Turn pump off and place pump into a second bucket or 4-in. Casing which contains tap water, continue to add 5-gallons of tap water (rinse).
7. Turn pump off and place pump into a third bucket or 4-in. casing which contains distilled/deionized water, continue to add three to five gallons of distilled/deionized water (final rinse).
8. If a hydrophobic contaminant is present (such as separate phase, high levels of PCB's, etc.) An additional decon step, or steps, may be added. For example, an organic solvent, such as reagent-grade isopropanol alcool may be added as a first spraying/bucket prior to the soapy water rinse/bucket.

FIELD QUALITY CONTROL

Quality control (QC) samples must be collected to verify that sample collection and handling procedures were performed adequately and that they have not compromised the quality of the ground water samples. The appropriate EPA program guidance must be consulted in preparing the field QC sample requirements for the site-specific Quality Assurance Project Plan (QAPP).

There are five primary areas of concern for quality assurance (QA) in the collection of representative ground-water samples:

1. Obtaining a ground-water sample that is representative of the aquifer or zone of interest in the aquifer. Verification is based on the field log documenting that the field water-quality parameters stabilized during the purging of the well, prior to sample collection.
2. Ensuring that the purging and sampling devices are made of materials, and utilized in a manner, which will not interact with or alter the analyses.
3. Ensuring that results generated by these procedures are reproducible; therefore, the sampling scheme should incorporate co-located samples (duplicates).

4. Preventing cross-contamination. Sampling should proceed from least to most contaminated wells, if known. Field equipment blanks should be incorporated for all sampling and purging equipment, and decontamination of the equipment is therefore required.
5. Properly preserving, packaging, and shipping samples.

All field quality control samples must be prepared the same as regular investigation samples with regard to sample volume, containers, and preservation. The chain of custody procedures for the QC samples will be identical to the field ground water samples. The following are quality control samples which must be collected during the sampling event:

Sample Type	Frequency
• Field duplicates	1 per 20 samples
• Matrix spike	1 per 20 samples
• Matrix spike duplicate	1 per 20 samples
• Equipment blank	Per Regional requirements or policy
• Trip blank (VOCs)	1 per sample cooler
• Temperature blank	1 per sample cooler

HEALTH AND SAFETY CONSIDERATIONS

Depending on the site-specific contaminants, various protective programs must be implemented prior to sampling the first well. The site Health and Safety Plan should be reviewed with specific emphasis placed on the protection program planned for the sampling tasks. Standard safe operating practices should be followed, such as minimizing contact with potential contaminants in both the liquid and vapor phase through the use of appropriate personal protective equipment.

Depending on the type of contaminants expected or determined in previous sampling efforts, the following safe work practices will be employed:

<u>Particulate or metals contaminants</u>

1. Avoid skin contact with, and incidental ingestion of, purge water.
2. Use protective gloves and splash protection.

<u>Volatile organic contaminants</u>

1. Avoid breathing constituents venting from well.
2. Pre-survey the well head space with an appropriate device as specified in the Site Health and Safety Plan.
3. If monitoring results indicate elevated organic constituents, sampling activities may be conducted in level C protection. At a minimum, skin protection will be afforded by disposable protective clothing, such as Tyvek®.

General, common practices should include avoiding skin contact with water from preserved sample bottles, as this water will have pH less than 2 or greater than 10. Also, when filling pre-acidified VOA bottles, hydrochloric acid fumes may be released and should not be inhaled.

POST-SAMPLING ACTIVITIES

Several activities need to be completed and documented once ground-water sampling has been completed. These activities include, but are not limited to:

1. Ensure that all field equipment has been decontaminated and returned to proper storage location. Once the individual field equipment has been decontaminated, tag it with date of cleaning, site name, and name of individual responsible.
2. All sample paperwork should be processed, including copies provided to the Regional Laboratory, Sample Management Office, or other appropriate sample handling and tracking facility.
3. All field data should be complied for site records.
4. All analytical data when processed by the analytical laboratory, should be verified against field sheets to ensure all data has been returned to sampler.

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SAMPLING CHECKLIST

Well Identification:________________________

Map of Site Included: Y or N
Wells Clearly Identified w/ Roads: Y or N
Well Construction Diagram Attached: Y or N

Well Construction:

Diameter of Borehole:________ Diameter of Casing:__________
Casing Material:____________ Screen Material:______________

Screen Length:______________ Total Depth:_______________

Approximate Depth to Water:______________
Maximum Well Development Pumping Rate:__________________
Date of Last Well Development:______________

Previous Sampling Information:

Was the Well Sampled Previously: Y or N
(If Sampled, Fill Out Table Below)

Table of Previous Sampling Information

Parameter	Previously Sampled	Number of Times Sampled	Maximum Concentration	Notes (include previous purge rates)

Ground-Water Sampling Log

Site Name: **Well #:** **Date:**

Well Depth(Ft-BTOC[1]): **Screen Interval**(Ft):

Well Dia.: **Casing Material:** **Sampling Device:**

Pump placement(Ft from TOC[2]):

Measuring Point: **Water level (static)**(Ft):

Water level (pumping)(Ft): **Pump rate**(Liter/min):

Sampling Personnel:

Other info: (such as sample numbers, weather conditions and field notes)

Water Quality Indicator Parameters

Time	Pumping rates (L/min)	Water level (ft)	DO (mg/l)	ORP (mv)	Turb. (NTU)	SEC[3] (FS/cm)	pH	Temp. (C°)	Volume pumped (L)

Type of Sample collected:

1-casing volume was:

Total volume purged prior to sample collection:

<u>Stabilization Criteria</u>

DO	±	0.3 mg/l
Turb.	±	10%
SEC	±	3%
ORP	±	10 mv
pH	±	0.1 unit

[1]**BTOC-Below Top of Casing**
[2]**TOC-Top of Casing**
[3]**Specific electrical conductance**

STANDARD OPERATING PROCEDURE

E.1500
BORING ABANDONMENT – COMMERCIAL SEALANT

Last Review or Revision: June 2010

Objective and Application

To permanently close soil borings consistent with industry practice and close the soil boring to prevent its serving as a vertical conduit for movement of environmental impacts through soils. Soil borings of 2-inch diameter or greater are considered borings within the definition of this TSOP.

Equipment

Hand tools appropriate to the job.

Commercially-available sealant materials for well abandonment. Terracon preference for non-slurry fill will be chipped Benseal®, high yield Wyoming bentonite or equivalent.

Procedures

Backfill the soil boring with a mixture of soil cuttings and bentonite or other sealant material as required by state law (i.e. backfill with hydrated bentonite to near surface and cemtn the upper two feet). When specified by the project manager, attempt to place soil cuttings back in the borehole in the order that the soil was removed so that soil is returned to the approximate depth from which it originated.

Attached Supporting Documents

- Volume of Soil Boring, Annulus around 2" and 4" Casings, and Grout Mixtures
- Brainard Kilman Field Facts

Other Supporting Documents

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

VOLUME OF SOIL BORING

CUBIC FEET PER LINEAR FOOT

LENGTH (ft.)	DIAMETER OF SOIL BORING 2	4	6	INSIDE DIAMETER OF HOLLOW STEM AUGER 3.25 / 7.25	4.25 / 8.25	6.25 / 10.25
1	0.028	0.088	0.201	0.29	0.37	0.57
2	0.06	0.18	0.4	0.6	0.7	1.1
3	0.08	0.26	0.6	0.9	1.1	1.7
4	0.11	0.35	0.8	1.2	1.5	2.3
5	0.14	0.44	1.0	1.5	1.9	2.9
6	0.17	0.53	1.2	1.7	2.2	3.4
7	0.20	0.62	1.4	2.0	2.6	4.0
8	0.22	0.70	1.6	2.3	3.0	4.6
9	0.25	0.79	1.8	2.6	3.3	5.1
10	0.28	0.88	2.0	2.9	3.7	5.7
11	0.31	0.97	2.2	3.2	4.1	6.3
12	0.34	1.06	2.4	3.5	4.4	6.8
13	0.36	1.14	2.6	3.8	4.8	7.4
14	0.39	1.23	2.8	4.1	5.2	8.0
15	0.42	1.32	3.0	4.4	5.6	8.6
16	0.45	1.41	3.2	4.6	5.9	9.1
17	0.48	1.50	3.4	4.9	6.3	9.7
18	0.50	1.58	3.6	5.2	6.7	10.3
19	0.53	1.67	3.8	5.5	7.0	10.8
20	0.56	1.76	4.0	5.8	7.4	11.4
22	0.62	1.94	4.4	6.4	8.1	12.5
24	0.67	2.11	4.8	7.0	8.9	13.7
25	0.70	2.20	5.0	7.3	9.3	14.3
26	0.73	2.29	5.2	7.5	9.6	14.8
28	0.78	2.46	5.6	8.1	10.4	16.0
30	0.84	2.64	6.0	8.7	11.1	17.1
32	0.90	2.82	6.4	9.3	11.8	18.2
34	0.95	2.99	6.8	9.9	12.6	19.4
35	0.98	3.08	7.0	10.2	13.0	20.0
36	1.01	3.17	7.2	10.4	13.3	20.5
38	1.06	3.34	7.6	11.0	14.1	21.7
40	1.12	3.52	8.0	11.6	14.8	22.8
45	1.3	4.0	9.0	13.1	16.7	25.7
50	1.4	4.4	10.1	14.5	18.5	28.5
55	1.5	4.8	11.1	16.0	20.4	31.4
60	1.7	5.3	12.1	17.4	22.2	34.2
65	1.8	5.7	13.1	18.9	24.1	37.1
70	2.0	6.2	14.1	20.3	25.9	39.9
75	2.1	6.6	15.1	21.8	27.8	42.8
80	2.2	7.0	16.1	23.2	29.6	45.6
85	2.4	7.5	17.1	24.7	31.5	48.5
90	2.5	7.9	18.1	26.1	33.3	51.3
95	2.7	8.4	19.1	27.6	35.2	54.2
100	2.8	8.8	20.1	29.0	37.0	57.0
125	3.5	11.0	25.1	36.3	46.3	71.3
150	4.2	13.2	30.2	43.5	55.5	85.5
175	4.9	15.4	35.2	50.8	64.8	99.8
200	5.6	17.6	40.2	58.0	74.0	114.0

GALLONS PER LINEAR FOOT

LENGTH (ft.)	DIAMETER OF SOIL BORING 2	4	6	INSIDE DIAMETER OF HOLLOW STEM AUGER 3.25 / 7.25	4.25 / 8.25	6.25 / 10.25
1	0.17	0.66	1.5	2.14	2.78	4.29
2	0.3	1.3	3.0	4.3	5.6	8.6
3	0.5	2.0	4.5	6.4	8.3	12.9
4	0.7	2.6	6.0	8.6	11.1	17.2
5	0.9	3.3	7.5	10.7	13.9	21.5
6	1.0	4.0	9.0	12.8	16.7	25.7
7	1.2	4.6	10.5	15.0	19.5	30.0
8	1.4	5.3	12.0	17.1	22.2	34.3
9	1.5	5.9	13.5	19.3	25.0	38.6
10	1.7	6.6	15.0	21.4	27.8	42.9
11	1.9	7.3	16.5	23.5	30.6	47.2
12	2.0	7.9	18.0	25.7	33.4	51.5
13	2.2	8.6	19.5	27.8	36.1	55.8
14	2.4	9.2	21.0	30.0	38.9	60.1
15	2.6	9.9	22.5	32.1	41.7	64.4
16	2.7	10.6	24.0	34.2	44.5	68.6
17	2.9	11.2	25.5	36.4	47.3	72.9
18	3.1	11.9	27.0	38.5	50.0	77.2
19	3.2	12.5	28.5	40.7	52.8	81.5
20	3.4	13.2	30.0	42.8	55.6	85.8
22	3.7	14.5	33.0	47.1	61.2	94.4
24	4.1	15.8	36.0	51.4	66.7	103.0
25	4.3	16.5	37.5	53.5	69.5	107.3
26	4.4	17.2	39.0	55.6	72.3	111.5
28	4.8	18.5	42.0	59.9	77.8	120.1
30	5.1	19.8	45.0	64.2	83.4	128.7
32	5.4	21.1	48.0	68.5	89.0	137.3
34	5.8	22.4	51.0	72.8	94.5	145.9
35	6.0	23.1	52.5	74.9	97.3	150.2
36	6.1	23.8	54.0	77.0	100.1	154.4
38	6.5	25.1	57.0	81.3	105.6	163.0
40	6.8	26.4	60.0	85.6	111.2	171.6
45	7.7	29.7	67.5	96.3	125.1	193.1
50	8.5	33.0	75.0	107.0	139.0	214.5
55	9.4	36.3	82.5	117.7	152.9	236.0
60	10.2	39.6	90.0	128.4	166.8	257.4
65	11.1	42.9	97.5	139.1	180.7	278.9
70	11.9	46.2	105.0	149.8	194.6	300.3
75	12.8	49.5	112.5	160.5	208.5	321.8
80	13.6	52.8	120.0	171.2	222.4	343.2
85	14.5	56.1	127.5	181.9	236.3	364.7
90	15.3	59.4	135.0	192.6	250.2	386.1
95	16.2	62.7	142.5	203.3	264.1	407.6
100	17.0	66.0	150.0	214.0	278.0	429.0
125	21.3	82.5	187.5	267.5	347.5	536.3
150	25.5	99.0	225.0	321.0	417.0	643.5
175	29.8	115.5	262.5	374.5	486.5	750.8
200	34.0	132.0	300.0	428.0	556.0	858.0

VOLUME OF ANNULUS AROUND 2" CASING

CUBIC FEET PER LINEAR FOOT

LENGTH (ft.)	DIAMETER OF SOIL BORING					
				INSIDE DIAMETER OF HOLLOW STEM AUGER		
				3.25	4.25	6.25
	2	4	6	7.25	8.25	10.25
1	0	0.065	0.178	0.26	0.34	0.54
2	0	0.13	0.4	0.5	0.7	1.1
3	0	0.20	0.5	0.8	1.0	1.6
4	0	0.26	0.7	1.0	1.4	2.2
5	0	0.33	0.9	1.3	1.7	2.7
6	0	0.39	1.1	1.6	2.0	3.2
7	0	0.46	1.2	1.8	2.4	3.8
8	0	0.52	1.4	2.1	2.7	4.3
9	0	0.59	1.6	2.3	3.1	4.9
10	0	0.65	1.8	2.6	3.4	5.4
11	0	0.72	2.0	2.9	3.7	5.9
12	0	0.78	2.1	3.1	4.1	6.5
13	0	0.85	2.3	3.4	4.4	7.0
14	0	0.91	2.5	3.6	4.8	7.6
15	0	0.98	2.7	3.9	5.1	8.1
16	0	1.04	2.8	4.2	5.4	8.6
17	0	1.11	3.0	4.4	5.8	9.2
18	0	1.17	3.2	4.7	6.1	9.7
19	0	1.24	3.4	4.9	6.5	10.3
20	0	1.30	3.6	5.2	6.8	10.8
22	0	1.43	3.9	5.7	7.5	11.9
24	0	1.56	4.3	6.2	8.2	13.0
25	0	1.63	4.5	6.5	8.5	13.5
26	0	1.69	4.6	6.8	8.8	14.0
28	0	1.82	5.0	7.3	9.5	15.1
30	0	1.95	5.3	7.8	10.2	16.2
32	0	2.08	5.7	8.3	10.9	17.3
34	0	2.21	6.1	8.8	11.6	18.4
35	0	2.28	6.2	9.1	11.9	18.9
36	0	2.34	6.4	9.4	12.2	19.4
38	0	2.47	6.8	9.9	12.9	20.5
40	0	2.60	7.1	10.4	13.6	21.6
45	0	2.9	8.0	11.7	15.3	24.3
50	0	3.3	8.9	13.0	17.0	27.0
55	0	3.6	9.8	14.3	18.7	29.7
60	0	3.9	10.7	15.6	20.4	32.4
65	0	4.2	11.6	16.9	22.1	35.1
70	0	4.6	12.5	18.2	23.8	37.8
75	0	4.9	13.4	19.5	25.5	40.5
80	0	5.2	14.2	20.8	27.2	43.2
85	0	5.5	15.1	22.1	28.9	45.9
90	0	5.9	16.0	23.4	30.6	48.6
95	0	6.2	16.9	24.7	32.3	51.3
100	0	6.5	17.8	26.0	34.0	54.0
125	0	8.1	22.3	32.5	42.5	67.5
150	0	9.8	26.7	39.0	51.0	81.0
175	0	11.4	31.2	45.5	59.5	94.5
200	0	13.0	35.6	52.0	68.0	108.0

GALLONS PER LINEAR FOOT

LENGTH (ft.)	DIAMETER OF SOIL BORING					
				INSIDE DIAMETER OF HOLLOW STEM AUGER		
				3.25	4.25	6.25
	2	4	6	7.25	8.25	10.25
1	0	0.491	1.33	1.91	2.55	4.06
2	0	1.0	2.7	3.8	5.1	8.1
3	0	1.5	4.0	5.7	7.7	12.2
4	0	2.0	5.3	7.6	10.2	16.2
5	0	2.5	6.7	9.6	12.8	20.3
6	0	2.9	8.0	11.5	15.3	24.4
7	0	3.4	9.3	13.4	17.9	28.4
8	0	3.9	10.6	15.3	20.4	32.5
9	0	4.4	12.0	17.2	23.0	36.5
10	0	4.9	13.3	19.1	25.5	40.6
11	0	5.4	14.6	21.0	28.1	44.7
12	0	5.9	16.0	22.9	30.6	48.7
13	0	6.4	17.3	24.8	33.2	52.8
14	0	6.9	18.6	26.7	35.7	56.8
15	0	7.4	20.0	28.7	38.3	60.9
16	0	7.9	21.3	30.6	40.8	65.0
17	0	8.3	22.6	32.5	43.4	69.0
18	0	8.8	23.9	34.4	45.9	73.1
19	0	9.3	25.3	36.3	48.5	77.1
20	0	9.8	26.6	38.2	51.0	81.2
22	0	10.8	29.3	42.0	56.1	89.3
24	0	11.8	31.9	45.8	61.2	97.4
25	0	12.3	33.3	47.8	63.8	101.5
26	0	12.8	34.6	49.7	66.3	105.6
28	0	13.7	37.2	53.5	71.4	113.7
30	0	14.7	39.9	57.3	76.5	121.8
32	0	15.7	42.6	61.1	81.6	129.9
34	0	16.7	45.2	64.9	86.7	138.0
35	0	17.2	46.6	66.9	89.3	142.1
36	0	17.7	47.9	68.8	91.8	146.2
38	0	18.7	50.5	72.6	96.9	154.3
40	0	19.6	53.2	76.4	102.0	162.4
45	0	22.1	59.9	86.0	114.8	182.7
50	0	24.6	66.5	95.5	127.5	203.0
55	0	27.0	73.2	105.1	140.3	223.3
60	0	29.5	79.8	114.6	153.0	243.6
65	0	31.9	86.5	124.2	165.8	263.9
70	0	34.4	93.1	133.7	178.5	284.2
75	0	36.8	99.8	143.3	191.3	304.5
80	0	39.3	106.4	152.8	204.0	324.8
85	0	41.7	113.1	162.4	216.8	345.1
90	0	44.2	119.7	171.9	229.5	365.4
95	0	46.6	126.4	181.5	242.3	385.7
100	0	49.1	133.0	191.0	255.0	406.0
125	0	61.4	166.3	238.8	318.8	507.5
150	0	73.7	199.5	286.5	382.5	609.0
175	0	85.9	232.8	334.3	446.3	710.5
200	0	98.2	266.0	382.0	510.0	812.0

VOLUME OF ANNULUS AROUND 4" CASING

CUBIC FEET PER LINEAR FOOT

	DIAMETER OF SOIL BORING					
				INSIDE DIAMETER OF HOLLOW STEM AUGER		
				3.25	4.25	6.25
LENGTH (ft.)	2	4	6	7.25	8.25	10.25
1	0	0	0.11	0.2	0.26	0.46
2	0	0	0.2	0.4	0.5	0.9
3	0	0	0.3	0.6	0.8	1.4
4	0	0	0.4	0.8	1.0	1.8
5	0	0	0.6	1.0	1.3	2.3
6	0	0	0.7	1.2	1.6	2.8
7	0	0	0.8	1.4	1.8	3.2
8	0	0	0.9	1.6	2.1	3.7
9	0	0	1.0	1.8	2.3	4.1
10	0	0	1.1	2.0	2.6	4.6
11	0	0	1.2	2.2	2.9	5.1
12	0	0	1.3	2.4	3.1	5.5
13	0	0	1.4	2.6	3.4	6.0
14	0	0	1.5	2.8	3.6	6.4
15	0	0	1.7	3.0	3.9	6.9
16	0	0	1.8	3.2	4.2	7.4
17	0	0	1.9	3.4	4.4	7.8
18	0	0	2.0	3.6	4.7	8.3
19	0	0	2.1	3.8	4.9	8.7
20	0	0	2.2	4.0	5.2	9.2
22	0	0	2.4	4.4	5.7	10.1
24	0	0	2.6	4.8	6.2	11.0
25	0	0	2.8	5.0	6.5	11.5
26	0	0	2.9	5.2	6.8	12.0
28	0	0	3.1	5.6	7.3	12.9
30	0	0	3.3	6.0	7.8	13.8
32	0	0	3.5	6.4	8.3	14.7
34	0	0	3.7	6.8	8.8	15.6
35	0	0	3.9	7.0	9.1	16.1
36	0	0	4.0	7.2	9.4	16.6
38	0	0	4.2	7.6	9.9	17.5
40	0	0	4.4	8.0	10.4	18.4
45	0	0	5.0	9.0	11.7	20.7
50	0	0	5.5	10.0	13.0	23.0
55	0	0	6.1	11.0	14.3	25.3
60	0	0	6.6	12.0	15.6	27.6
65	0	0	7.2	13.0	16.9	29.9
70	0	0	7.7	14.0	18.2	32.2
75	0	0	8.3	15.0	19.5	34.5
80	0	0	8.8	16.0	20.8	36.8
85	0	0	9.4	17.0	22.1	39.1
90	0	0	9.9	18.0	23.4	41.4
95	0	0	10.5	19.0	24.7	43.7
100	0	0	11.0	20.0	26.0	46.0
125	0	0	13.8	25.0	32.5	57.5
150	0	0	16.5	30.0	39.0	69.0
175	0	0	19.3	35.0	45.5	80.5
200	0	0	22.0	40.0	52.0	92.0

GALLONS PER LINEAR FOOT

	DIAMETER OF SOIL BORING					
				INSIDE DIAMETER OF HOLLOW STEM AUGER		
				3.25	4.25	6.25
LENGTH (ft.)	2	4	6	7.25	8.25	10.25
1	0	0	0.84	1.48	1.95	3.46
2	0	0	1.7	3.0	3.9	6.9
3	0	0	2.5	4.4	5.9	10.4
4	0	0	3.4	5.9	7.8	13.8
5	0	0	4.2	7.4	9.8	17.3
6	0	0	5.0	8.9	11.7	20.8
7	0	0	5.9	10.4	13.7	24.2
8	0	0	6.7	11.8	15.6	27.7
9	0	0	7.6	13.3	17.6	31.1
10	0	0	8.4	14.8	19.5	34.6
11	0	0	9.2	16.3	21.5	38.1
12	0	0	10.1	17.8	23.4	41.5
13	0	0	10.9	19.2	25.4	45.0
14	0	0	11.8	20.7	27.3	48.4
15	0	0	12.6	22.2	29.3	51.9
16	0	0	13.4	23.7	31.2	55.4
17	0	0	14.3	25.2	33.2	58.8
18	0	0	15.1	26.6	35.1	62.3
19	0	0	16.0	28.1	37.1	65.7
20	0	0	16.8	29.6	39.0	69.2
22	0	0	18.5	32.6	42.9	76.1
24	0	0	20.2	35.5	46.8	83.0
25	0	0	21.0	37.0	48.8	86.5
26	0	0	21.8	38.5	50.7	90.0
28	0	0	23.5	41.4	54.6	96.9
30	0	0	25.2	44.4	58.5	103.8
32	0	0	26.9	47.4	62.4	110.7
34	0	0	28.6	50.3	66.3	117.6
35	0	0	29.4	51.8	68.3	121.1
36	0	0	30.2	53.3	70.2	124.6
38	0	0	31.9	56.2	74.1	131.5
40	0	0	33.6	59.2	78.0	138.4
45	0	0	37.8	66.6	87.8	155.7
50	0	0	42.0	74.0	97.5	173.0
55	0	0	46.2	81.4	107.3	190.3
60	0	0	50.4	88.8	117.0	207.6
65	0	0	54.6	96.2	126.8	224.9
70	0	0	58.8	103.6	136.5	242.2
75	0	0	63.0	111.0	146.3	259.5
80	0	0	67.2	118.4	156.0	276.8
85	0	0	71.4	125.8	165.8	294.1
90	0	0	75.6	133.2	175.5	311.4
95	0	0	79.8	140.6	185.3	328.7
100	0	0	84.0	148.0	195.0	346.0
125	0	0	105.0	185.0	243.8	432.5
150	0	0	126.0	222.0	292.5	519.0
175	0	0	147.0	259.0	341.3	605.5
200	0	0	168.0	296.0	390.0	692.0

GROUT MIXTURES

PORTLAND CEMENT GROUT

CUBIC FEET	CEMENT 94 lb. sack	BENTONITE lbs.	WATER gallons
1	0.6339	3.17	5.07
1.577	1.0	5.0	8.0
2	1.27	6.3	10.1
3	1.90	9.5	15.2
4	2.54	12.7	20.3
5	3.17	15.9	25.4
6	3.80	19.0	30.4
7	4.44	22.2	35.5
8	5.07	25.4	40.6
9	5.71	28.5	45.6
10	6.34	31.7	50.7
11	6.97	34.9	55.8
12	7.61	38.0	60.8
13	8.24	41.2	65.9
14	8.87	44.4	71.0
15	9.51	47.6	76.1
16	10.14	50.7	81.1
17	10.78	53.9	86.2
18	11.41	57.1	91.3
19	12.04	60.2	96.3
20	12.68	63.4	101.4
22	13.95	69.7	111.5
24	15.21	76.1	121.7
25	15.85	79.3	126.8
26	16.48	82.4	131.8
28	17.75	88.8	142.0
30	19.02	95.1	152.1
32	20.28	101.4	162.2
34	21.55	107.8	172.4
35	22.19	111.0	177.5
36	22.82	114.1	182.5
38	24.09	120.5	192.7
40	25.36	126.8	202.8
45	28.5	142.7	228.2
50	31.7	158.5	253.5
55	34.9	174.4	278.9
60	38.0	190.2	304.2
65	41.2	206.1	329.6
70	44.4	221.9	354.9
75	47.5	237.8	380.3
80	50.7	253.6	405.6
85	53.9	269.5	431.0
90	57.1	285.3	456.3
95	60.2	301.2	481.7
100	63.4	317.0	507.0
125	79.2	396.3	633.8
150	95.1	475.5	760.5
175	110.9	554.8	887.3
200	126.8	634.0	1014.0

BENTONITE GROUT

CUBIC FEET	BENTONITE 50 lb sack	WATER gallons
1	0.444	6.22
2	0.9	12.4
2.25	1	14
3	1.3	18.7
4	1.8	24.9
5	2.2	31.1
6	2.7	37.3
7	3.1	43.5
8	3.6	49.8
9	4.0	56.0
10	4.4	62.2
11	4.9	68.4
12	5.3	74.6
13	5.8	80.9
14	6.2	87.1
15	6.7	93.3
16	7.1	99.5
17	7.5	105.7
18	8.0	112.0
19	8.4	118.2
20	8.9	124.4
22	9.8	136.8
24	10.7	149.3
25	11.1	155.5
26	11.5	161.7
28	12.4	174.2
30	13.3	186.6
32	14.2	199.0
34	15.1	211.5
35	15.5	217.7
36	16.0	223.9
38	16.9	236.4
40	17.8	248.8
45	20.0	279.9
50	22.2	311.0
55	24.4	342.1
60	26.6	373.2
65	28.9	404.3
70	31.1	435.4
75	33.3	466.5
80	35.5	497.6
85	37.7	528.7
90	40.0	559.8
95	42.2	590.9
100	44.4	622.0
125	55.5	777.5
150	66.6	933.0
175	77.7	1088.5
200	88.8	1244.0

STANDARD OPERATING PROCEDURE

E.470
SAMPLE HANDLING – GROUNDWATER (LEVEL D)

Last Review or Revision: June 2010

OBJECTIVE

To collect a representative groundwater sample from the sampling point for chemical analysis. This includes the documentation of sampling methods, sampling supplies, and protocol to reduce potential for alteration and or cross-contamination during the sampling event.

EQUIPMENT

- Monitoring equipment specified by project manager;
- Electronic water level indicator, phase level indicator, etc.;
- Decontamination equipment;
- Proper forms, labels and indelible ink pen;
- pH, temperature, and specific conductance meter;
- Sample containers and packing material, tape, and labels;
- Filtration device and filters (and fixing agents as appropriate);
- Cooler with ice pack and packing media;
- Bucket (calibrated in gallons or liters)
- Sampling device
- Bailers, pumps, etc.
- Keys for locking cap on well;
- Rope - steel, nylon, teflon, or polypropylene;
- Deionized (DI) water;
- Chemical-resistant gloves
- Knife; and
- Site map.

PROCEDURES

a) Preparation

- Meet with Project Manager;
- Obtain the bottles, forms, and equipment necessary to complete the sampling event;
- Calibrate all field equipment i.e., pH and conductivity meters;
- Establish sampling well sequence (generally least impacted to most impacted).

b) Field Activities

- Water levels - collect and record water levels (and well depth, if requested by P.M.)

c) Contamination minimization

- Use plastic sheet if necessary
- Use proper bailing techniques (hand over hand) to prevent rope from touching the ground or low flow sampling techniques with dedicated disposable tubing

d) Sample Collection

1) Preservation

- Use containers with proper preservative if necessary.
- Routine preservatives are listed in the attached documentation (Check with Project Manager and/or lab).

2) Filtration

- Metals only - (Do not filter samples for VOC analyses).
- Field filter samples collected for dissolved metals analyses immediately after collecting the sample (if required and/or allowed by local or state regulations).
- Filter the sample prior to adding preservative or transferring to sample container containing a preservative(if required and/or allowed by local or state regulations).
- Discard the filter, tubing and transfer container.

3) Collection

- Minimize disturbances that may aerate the sample (i.e., lower bailer slowly into water, pour slowly into sample container, use low flow sampling procedures, etc.).

- Pour water from the top of the bailer or insert the bottom emptying device for sample transfer.

- Transfer the groundwater sample directly to the laboratory prepared sample container or the filter cup.

- Samples collected for VOCs should always be collected from a recently filled bailer full of water as soon as it is brought to the surface.

- Collect samples for VOCs by forming a positive meniscus on the sample vial and capping immediately.

- VOC samples must be free of air bubbles.

- Do not over-fill sample containers which contain a preservative.

- Place samples in cooler with ice or blue-ice.

4) Filtration Procedures

- Set up filtering apparatus according to the manufacturer's directions.

- Use a 0.45 micron membrane filter (may need a pre-filter to prevent clogging if the sample is turbid).

- Flush a minimum of 250 ml of D.I. water (or larger volume if recommended by manufacturer specifications) through the filtering apparatus and filter prior to filtering the sample.

- Pump the sample through the filter and discard the initial 100-200 ml (if you have sufficient volume).

- Collect and transfer the remaining sample volume to the sample container.

5) Data Documentation

- Record all pertinent sampling information on the sampling container label, sampling information form, chain-of-custody, and shipping form.

- Pertinent data will vary based on the parameter and the form; however, the following data must be recorded. Time, date, job number, project name, sampling location, samplers name, sampling methodology, parameters to be analyzed, stabilization data, and general observations.

- Make all entries in the chain-of-custody form prior to leaving the site. Ensure that the chain-of-custody protocol required for the project is maintained.

- If samples must be shipped, the chain-of-custody form must be enclosed with the samples and the container sealed with Terracon security labels. Obtain a post office receipt, bill of lading or similar document from the shipper to be included as part of the chain-of-custody documentation. Return one copy of the chain-of-custody documentation to the project manager.

6) Equipment Cleaning

- Clean all equipment used as specified by the Project Manager and according to cleaning procedures prior to collecting a sample from the next sample location.

7) Sample Packaging and Shipment

- Carefully package the samples in a cooler with ice. Take care to wrap the sample containers in packing materials and place in sealed Zip top bags.

- Ship the samples via overnight courier as specified by the Project Manager. Be sure to secure all address labels with clear packing tape.

Attached Supporting Documents

- **Typical Chemical Analysis Methods and Preservatives**.

Other Supporting Documents

- **ASTM D4448-85a** *Standard Guide for Sampling Groundwater Monitoring Wells*.

Typical Chemical Analysis Methods and Preservatives

Analytical Test Method	Pilot Chemical Group	Sample Matrix			Sample Quantity (Minimum)											Preservative			Holding Time (Days)	Container Type
					Field Recovery Quantity			Laboratory Quantity												
		Soil	Water	Gas/Vapor	1500 grams	200 milliliters	2 Liters	400 milligrams	4 oz.	16 oz.	40 milliliters	200 milliliters	250 milliliters	500 milliliters	1 Liter	Cool $4^{o}C$, dark	pH<2, w/HNO_3	pH<2 w/HCL		
EPA 8260B	VOCs	X			X				X							X			14*	8 oz. CWM
			X				X				X							X	14*	40 mL GV
EPA 8270C	SVOCs	X			X				X							X			7**	8 oz. CWM
			X												X	X			7**	2 Liter AWM
EPA 8082	PCBs	X			X				X							X			7**	8 oz. CWM
			X				X								X	X			7**	2 Liter AWM
EPA 6010	Metals	X			X				X							X			180	4 oz. CWM
			X				X							X			X		180	500 mL HDPE
NIOSH 1501	Benzene, Toluene			X		X		X								X			14	Carbon Filter
EPA 9040A	pH	X			X				X							X			14*	4 oz. CWM
			X				X						X			X			14*	250 mL HDPE

* = Preserve within 2 days then analyze within 14 days
** = Extraction to occur within 7 days and analysis within 40 days after extraction
CWM = clear wide mouth
HDPE = High-density polyethylene bottles
GV = Glass vial
AWM = Amber wide mouth
AJ = Amber Jug

E.2420
CLEANING – HIGH-PRESSURE, HOT-WATER WASHING

Objective

To prepare the equipment for field activities in a manner which minimizes the potential for obtaining biased or erroneous data due to contaminant transfer. Decontamination is performed as a quality assurance measure and a safety precaution. It minimizes cross-contaminants between samples and also helps to maintain a clean working environment.

Equipment

- As determined by the project manager
- High pressure hot/cold water washing device or steam cleaner
- Expendable supplies:
- Surgical gloves
- Chem-wipes
- Garbage bags
- Detergent (Alconox or TSP)
- Containers for collections of waste liquids, if necessary D.I. water
- Dilute acid, methanol, ethanol or other cleaning fluid
- Wash rack facility
- Cleaning containers with brushes (plastic, steel or stainless steel buckets)
- Aluminum foil
- Safety monitoring devices as specified in the safety plan.

Procedures

Decontamination procedures will vary considerably based on the equipment, type of contaminant, type of sample and detection levels. Initial decontamination should take place at the site prior to demobilizing. This will minimize the spread of contamination. The extent of on-site decontamination will vary based on specific conditions; however, an attempt should be made to decontaminate as thoroughly as possible on site. The more care one applies on keeping the equipment clean, the less energy will be required on decontamination.

All field equipment must be prepared at the laboratory/office prior to use. This will include additional decontamination, inspection, and maintenance.

Equipment such as hand trowels, bailers, mixing bowls, hand augers, etc., should be cleaned and wrapped in aluminum foil (with shiny side out) prior to mobilization.

Decontamination of larger objects, such as the working end of the drill rig or the downhole tools is accomplished using a high pressure wash.

Sampling and monitoring equipment is normally cleaned by washing and rinsing with liquids such a soap or detergent solutions, tap water, D.I. water, methanol, or a dilute acid.

The extent and type of contaminant will determine the degree of decontamination. If the level of contamination cannot be readily determined, cleaning should be based on the assumption that the equipment is highly contaminated.

Listed below is a decontamination procedure which may be employed for field equipment such as a water level indicator at a monitoring well which contains dissolved petroleum hydrocarbons. If different or more elaborate procedures are required, they should be specified by the project manager during the project initiation meeting.

- Remove gross contamination from the equipment using a chem-wipe or brush.
- Wash with a soap or detergent solution
- Rinse with D.I. water
- Rinse with methanol (if method requires)
- Rinse with D.I. water
- Repeat the entire procedure or any part of the procedure as necessary.

Waste products produced by the decontamination procedures such as waste liquids, solids, gloves, chem-wipes, etc., should be collected and disposed of based on the nature of the contaminant. Specific details for the handling of these wastes should be addressed by the project manager.

STANDARD OPERATING PROCEDURE

E.550
Field Surface Screening – Soil / Photoionization Detector

Last Review or Revision: June 2010

Objective

To provide a qualitative and limited quantitative field screening of soil samples to aid in the evaluation of soil for the presence of volatile or semi-volatile organic chemicals.

The procedure is premised on the physical property of volatile compounds to move from the soil matrix of a freshly obtained soil sample (e.g., split spoon sample, grab sample) to the airborne state as vapor. The measurement of ambient air in close proximity to the surface of the soil will produce an indication of contaminants moving from the soil matrix to air. The relative strength of contaminants in ambient air around the sample will be considered an indication of the relative concentration of chemicals in the soil sample.

The procedure is semi-quantitative but valid only for the most preliminary qualitative decision-making. The procedure is highly susceptible to external air changes in wind velocity, ambient dilution by moving air and ambient influence by contaminants in moving air. The rate and degree of volatilization is susceptible to smearing of the exterior of the sample by the sampler wall in clay soils.

Measurements cannot be used as the sole indicator of soil contamination or in lieu of prescribed laboratory chemical testing for purposes of regulatory compliance. This procedure is only to be used for sites involving volatile or semi-volatile organic compounds, including tetrachloroethylene (perchloroethylene or PCE). This procedure is not to be used for purposes of health and safety monitoring.

Equipment

- Calibration gas from manufacturer
- Photoionization detector equipped with 10.0 eV lamp or greater.
- Forms and indelible ink pen
- Disposable chemical-resistant gloves

Procedures

On a daily basis, the unit should be gas calibrated to a manufacturer's gas standard and the results recorded in the field logbook. If the unit does not calibrate, return it to the local Terracon equipment evaluation for evaluation and, if necessary, repair.

Immediately prior to making a field measurement the unit should be operated for approximately 1 minute and any background concentrations noted or zeroed out relative to measurements.

The opened sampler should be placed on disposable plastic material or a surface that can be cleaned between tests to avoid inadvertent contribution of ionizable vapor from previous tests.

Using a clean stainless steel knife or other cutting tool, slice through the sample to expose fresh soil material not smeared by the sampler or excavating equipment. Immediately begin the test procedure as follows.

- Place the tip of the PID probe between ½ and 1 inches from the surface of the exposed soil.
- Maintaining the proper and constant distance of the probe tip from the sample move the probe very slowly over the surface of sample material, giving good coverage to all portions of the sample.
- Total test time should be in excess of 1 minute for volatile chemicals of concern and in excess of 3 minutes for semi-volatile chemicals of concern.
- Record the highest reading obtained as parts per million (ppm) calibration gas equivalents (i.e., TEI580 calibrated to isobutylene would be expressed as ppmi). Record unusual fluctuations and any noticeable physical correlation to the sample (i.e., "highest readings at ½-1 feet below ground surface over a sand seam in the split spoon sample").

Sample Disposal

Soil samples should be returned to the site and included in auger soil or excavation soil for proper disposal.

Documentation

Record the highest reading in calibration gas equivalents on forms provided by the Project Manager or in the field log book. Pertinent data will vary based on the parameter and the form; however, the following data must be recorded; date, job number, project name, sampling location, sample interval (if appropriate) sample identification, samplers name, and general observations.

Attached Supporting Documents

- **Thermo Environmental Instruments, Inc.** *OVM/Datalogger Model 580B Operating Manual*

E.50
Sampling – Environmental Representativeness

LAST REVIEW OR REVISION: June 2010

OBJECTIVE AND INTENT:

The information value of data depends heavily upon the interaction among sampling and analytical designs in relation to the intended use of the data, the site-specific context surrounding that intended use, and the associated quality control. The environmental condition of the site will be determined by the chemical data from samples collected in the field.

A Quick Look – USEPA CLU-IN 2001

Data quality is the function of the data's information content and its ability to represent the true state of a site.

Data representativeness is the measure of the degree to which samples can be used to estimate the characteristics of the true state of a hazardous waste site.

Brownfields are considered an application in which data quality and representativness will play an important role.

The term "representative data" means that there is some stability in the samples and assurance of a reasonable data density for the site being sampled. “Reasonable” data density varies depending on the intended use of the information. Project decisions which are very general in nature or used only for preliminary decision-making may have a very limited data density to represent the site, but the decisions which can be made from the data are also limited. Project decisions made from data for enforcement or litigation are much more concerned with sampling density and how well the information represents the site.

The procedures, handling and documentation by Terracon staff should routinely and consistently be as uniform as is practicable so that any sample from any media best represents the environmental condition.

This procedure is provided as supporting guidance and direction to Terracon field and design staff to provide quality samples representative of the intended project decision.

APPLICATION

Sampling is the selection of a representative portion of a larger population, universe or body. Through examination of a sample, the characteristics of the larger body can be inferred. The characteristics to be inferred will directly affect the method and procedure to select a representative sample.

Technical information derived from soil and groundwater samples differ greatly for purposes of geotechnical and environmental engineering, although the physical procedures of sample collection or measurement are often the same. The proper application of any one or more physical procedures to collect the sample will be dependent on the characteristic condition the sample is intended to represent. Environmental and geotechnical characteristics can often be determined from the same sample, other times they cannot. Combined use must be carefully considered by the Terracon Project Manager before application.

In general, any representative environmental sample is intended to reflect the in-situ, or undisturbed, chemically-impacted condition measured relative to the project decision and must consider;

- The media of the sample and it's physical properties
- The contaminant of concern and it's physical properties
- The contaminant of concern and it's chemical properties
- The spatial boundaries to be represented by the sample

EQUIPMENT

Equipment will be as specified by the Project Manager, specific to the requisite Terracon Standard Operating Procedure (TSOP).

PROCEDURES

Procedures will be as specified by the Project Manager, specific to the requisite Terracon Standard Operating Procedure (TSOP).

However, Terracon personnel shall be cognizant of and maintain the following general "rules of thumb" when reviewing TSOPs provided by Managers and when field procedures raise changed conditions which require communication of the new conditions back to the Project Manager;

- Volatile chemicals of concern dictate the least amount of disturbance and handling to preserve the representative characteristic; the lower the concentration of concern in the sampled body the more important the issue of disturbance becomes.

- Non-volatile chemicals of concern dictate a greater amount of disturbance and handling to preserve the representative characteristic; this may allow more extensive methods to physically select a representative sample and may allow the construction of composite samples in some regulatory programs.

- A decreasing sensitivity to disturbance is generally associated with sampled media as follows;

    - Water
    - Granular soils or other materials
    - Bedrock or other consolidated materials
    - Clay soils or other materials with high clay or organic contents

- Samples taken by mechanical samplers should represent both the vertical and horizontal spatial boundaries of the media collected.

- Samples taken by mechanical samplers should represent the media that is least influenced by the sampling method. For example, in a split spoon sampler the interior of the sample recovered is more representative than the exterior edge which contacted and is disturbed by the steel split spoon shell during penetration.

DOCUMENTATION

Documentation will be as specified by the Project Manager, specific to the requisite TSOP.

ATTACHED SUPPORTING DOCUMENTS

SOP 2001, Rev 0.0	EPA ERT GENERAL FIELD SAMPLING GUIDELINES

OTHER SUPPORTING DOCUMENTS

TSOP E.30	Chain-of-Custody Documentation
TSOP E.100	Surface & Near Surface Soil Sampling – Grab
TSOP E.100 Series	Surface/Near Surface Sampling Terracon Procedures
TSOP E.300 Series	Drilling Terracon Procedures
TSOP E.400 Series	Subsurface Sampling Terracon Procedures

E.2120
SOIL GAS SAMPLING – SUBSLAB PIN METHOD
(Replaces former E.2100)

Last Revision/Review: March 2014
Reviewer/Office: DEK/Corporate

Objective

The objective of subslab or subfloor soil gas/vapor sampling is to provide an estimate of the concentration of vapors that may be released by subsurface soils and potentially enter pathways that could produce airborne exposures to receptors in buildings or structures. The purpose of this document is to provide guidance and recommended standard practices for conducting sub-slab soil gas sampling to Terracon personnel.

Many states have vapor encroachment, vapor intrusion and/or soil gas sampling guidance documents with specific requirements or recommended procedures for soil gas sampling. State-specific requirements and guidance supersede this guidance document and Terracon personnel should adhere to the most current state-specific guidance when conducting soil gas investigations. If state-specific requirements are less stringent than the procedures recommended in this guidance, it is recommended that the procedures in this guidance be utilized.

For states where specific vapor encroachment, vapor intrusion and/or soil gas sampling regulations or guidance are not in place, Terracon personnel should consult this guidance document and the recommended standard practices herein.

This application involves effects on indoor air quality (i.e., borings are beneath an occupied or potentially occupied structure), sampling requires the participation / review of a Terracon industrial hygienist (IH) in selecting methods and scoping work. Engaging an IH is encouraged in addressing any airborne contaminants. For direction to local or regional technical assistance, contact the Chair of the Industrial Hygiene Practice Resource Group on the Environmental Services Terranet webpage. Click here if viewing electronically.

Implementation

The *Guidance Document* provides basic guidelines and field procedures for conducting subslab or subfloor soil gas vapor sampling. Subslab soil gas data from samples collected under the building slab and within the advective envelope of the building-driven pressurization or depressurization indicates whether contaminants have accumulated directly under the building.

This is Terracon's preferred method for soil gas evaluation for sites with existing buildings with foundations above the water table.

Procedures

Since 2013, Terracon addresses all soil gas and subslab soil vapor sampling through special guidance prepared by the Vapor Encroachment/Intrusion Committee. Staff should use Terracon's *Soil Gas Investigation Guidance Document (Version 1.0, August 7, 2013)*, or most current version. This document is available on the Environmental Services Terranet webpage. Click here if viewing electronically.

Procedures shall be as specified in *4.0 SUBSLAB SOIL GAS SAMPLING PROTOCOL* of the *Guidance Document*.

Quality assurance and quality control procedures should be incorporated into property-specific sampling and analysis plans from 5.0 LEAK DETECTION AND QA/QC of the *Guidance Document*.

The *Guidance Document* must be attached to this TSOP for field use.

Other Supporting References

- *Final Guidance For Assessing And Mitigating The Vapor Intrusion Pathway From Subsurface Sources To Indoor Air (Draft)*, U.S. Environmental Protection Agency Office of Solid Waste and Emergency Response, April 2013.

STANDARD OPERATING PROCEDURE

E.468
SAMPLE HANDLING - SOIL (LEVEL D)

Last Review or Revision: June 2010

1. OBJECTIVE

   To obtain a representative soil or sediment sample for chemical analysis. This includes the documentation of sampling methods, and protocols used for sample collection, processing, handling and shipment.

2. EQUIPMENT

   - Monitoring equipment (HNU, OVA, OVM, TGI, TIP, FID color metric detector tubes) as specified by Project Manager;
   - Sampling Device (split barrel sampler, hand auger, hand trowel, shovel, posthole digger, tube sampler, or other appropriate sampling device);
   - Decontamination Equipment;
   - Laboratory prepared sample containers;
   - Forms including "Soil Sampling Information Sheet", chain-of-custody, etc;
   - Indelible ink pen;
   - Stainless steel bowl;
   - Plastic sheet;
   - Site map;
   - Measuring wheel;
   - Engineers tape marked in units of feet, tenths of a foot (0.1 ft.), and hundredths of a foot (0.01 ft.);
   - Tool box;
   - Disposable chemical-resistant gloves; and
   - Chem-wipes.

3. PROCEDURES.

a) Surficial soil/sampling

- Determine sample location (set grid, if necessary)
- Determine the proper sampling device based on soil type, depth, sample type, etc.
- Collect each sample at the specified depth consistently for each sample.

b) Direct Sampling

- Transfer sample directly from the sampling device to the sample container.
- If evaluating for organic vapors, transfer half of sample to glass mason jar or plastic bag (zip top) for field testing. The sample should be split so as to obtain a sample for screening that is representative of the sample for testing. This can be accomplished by slicing the sample (if cohesive) lengthwise or by using other mechanical means. Care should be taken so as not to over-agitate the sample, especially if volatile organic compound testing is required.
- Document visual and physical characteristics

c) Composite sampling (non-volatile only)

- Decreases analytical cost but also decreases ability to detect low level contamination
- Transfer equal volume/weight of sample from each location/depth to a stainless steel mixing bowl
- Use a hand trowel or spoon to mix the soil sample
- If the sample size is very large, composite on a large sheet of clean plastic or stainless steel cookie sheet pan, or mix equal volumes from numerous composite samples.
- If soils are cohesive, break up clumps.
- Spread soil uniformly on plastic sheet or in bottom of stainless steel bowl or stainless steel tray and divide into quarters.
- Obtain equal quantity of soil from each sample for transfer to sample container (without mixing or break up).

d) Decontamination

- Decontamination procedures should be specified by the project manager.

- Decontamination procedures for UST sites includes an Alconox® detergent scrub followed by a clean water rinse.

- Decontamination fluids are to be replaced between sample locations (each boring) to reduce the potential for cross contamination.

e) Sample preservation - store in cooler with ice.

f) Sample documentation

- Complete the "Soil Sampling Information Sheet" and chain-of-custody form. Date to be recorded includes sampling location, methodology, depth, visual and physical characteristics, time and date.

4. ATTACHED SUPPORTING DOCUMENTATION

a) ASTM D4220 *Practice For Preserving and Transporting Soil Samples*

5. OTHER REFERENCES

a) Laboratory- or program-specific requirements for handling, preservation, and transport of samples for chemical analyses.

EXAMPLE SOIL SAMPLING INFORMATION SHEET

PROJECT NAME ______________________________ PROJECT NO. ______________

PROJECT LOCATION ____

SAMPLE POINT ______________ DATE ____________ TIME __________________
SAMPLE POINT DESCRIPTION ____
SAMPLE METHOD ____
SAMPLE INTERVAL ____
SAMPLE DESCRIPTION ____
SAMPLE APPEARANCE ____
ORGANIC VAPOR READING ____
SAMPLING PROBLEMS ____
CLEANING PERFORMED IN FIELD ____
COMMENTS ____

SAMPLE POINT ______________ DATE ____________ TIME __________________
SAMPLE POINT DESCRIPTION ____
SAMPLE METHOD ____
SAMPLE INTERVAL ____
SAMPLE DESCRIPTION ____
SAMPLE APPEARANCE ____
ORGANIC VAPOR READING ____
SAMPLING PROBLEMS ____
CLEANING PERFORMED IN FIELD ____
COMMENTS ____

FORM COMPLETED BY: __________________________ DATE ______________________

EPA 832-B-09-003

Industrial Stormwater Monitoring and Sampling Guide

March 2009

Final Draft

Acknowledgements

All photos are courtesy of Tetra Tech, Inc. Sampling illustrations in Section 2 are courtesy of Washington Department of Ecology's guide on *How To Do Stormwater Sampling: A guide for industrial facilities* (available at http://www.ecy.wa.gov/pubs/0210071.pdf)

Final Draft
Prepublication Copy

A formatted version of this guide will be available in April, 2009.

Industrial Stormwater Monitoring and Sampling Guide

The Industrial Stormwater Monitoring and Sampling Guide ("guide") is a how-to primer for industrial facility operators on how to conduct visual and analytical monitoring of stormwater discharges. The target audience is operators of facilities subject to the U.S. Environmental Protection Agency's (EPA) 2008 Multi-Sector General Permit (2008 MSGP) or a similar State-issued industrial stormwater permit. The information presented will also be useful to anyone interested in industrial stormwater monitoring. The procedures presented in this guide, specifically related to monitoring methodology and quality assurance, will help ensure that stormwater samples yield usable information.

The 2008 MSGP covers specific industrial activities (see Appendix D of the 2008 MSGP, available at www.epa.gov/npdes/msgp) in States, territories, and Indian Country lands where EPA is the National Pollutant Discharge Elimination System (NPDES) permitting authority (i.e., in those States or territories not authorized to issue NPDES permits themselves – see Appendix C of the 2008 MSGP).

This guide does not impose any new legally binding requirements on EPA, States, or the regulated community, and does not confer legal rights or impose legal obligations upon any member of the public. In the event of a conflict between the discussion in this document and any statute, regulation, or permit, this document would not be controlling.

Monitoring vs. Sampling. **In this guide, "sampling" refers to the actual, physical collection and analysis of stormwater samples. The term "monitoring" refers to both sampling and visual observations of stormwater discharges, including the related preparation and documentation tasks.**

Interested parties are free to raise questions and objections about the substance of this guide and the appropriateness of the application of this guide to a particular situation. EPA and other decision makers retain the discretion to adopt approaches on a case-by-case basis that differ from those described in this guide where appropriate.

1. Introduction to Stormwater Monitoring and Sampling

Most industrial stormwater permits require installation and implementation of control measures to minimize or eliminate pollutants in stormwater runoff from your facility. The control measures you choose for your facility must be documented in your facility-specific Stormwater Pollution Prevention Plan (SWPPP). The results of your stormwater monitoring will help you determine the effectiveness of your control measures, and overall stormwater management program. Evaluation of your stormwater management program will include inspections, visual assessments, and monitoring (i.e., sampling) of specified stormwater discharges. Regular stormwater inspections and visual assessments provide qualitative information on whether there are unaddressed potential pollutant sources at your site, and whether existing control measures are effective or need to be reevaluated. Stormwater sampling provides quantitative (i.e., numeric) data to determine pollutant concentrations in runoff and, in turn, the degree to which your control measures are effectively minimizing contact between stormwater and pollutant sources, and the success of your stormwater control approach in meeting applicable discharge requirements or effluent limits.

The following are the types of industrial stormwater monitoring requirements typically included in industrial general permits:

- **Visual Assessments of Discharges.** Permittees are required to regularly and frequently (e.g., quarterly under the 2008 MSGP) take a grab sample during a rain event and assess key visual indicators of stormwater pollution – color, odor, clarity, floating solids, settled solids, suspended solids, foam, oil sheen, and other qualitative markers of pollution. The findings of these assessments are used to trigger further facility inspections and corrective actions to modify problems found at the site.

- **Indicator or Benchmark Sampling**. Stormwater samples are collected from a site's discharge points (or outfalls) for laboratory analysis and the results are compared with benchmark pollutant concentrations as an indicator of the performance of stormwater control measures. A benchmark pollutant concentration is a level above which a stormwater discharge could adversely affect receiving water quality (and control measures must be evaluated) and, if below, the facility is not expected to have an impact on receiving water quality. This type of monitoring differs from "compliance monitoring" (see below) in that exceedances of the indicator or benchmark levels are not considered violations, but rather "red flags" that could point to a problem at the site with exposed pollutant sources or control measures that are not working correctly. For instance, the 2008 MSGP includes "benchmarks" that are based to a large degree on EPA's aquatic life criteria. Where the average of samples taken over four consecutive quarters exceed the applicable benchmark concentration of a particular pollutant, the permittee is required to investigate whether the higher pollutant levels can be attributed to some pollutant source or faulty control measure(s), and to address such problems through corrective action and possibly further monitoring.

- **Compliance Sampling.** Where a facility is subject to one of the Federal effluent limitation guidelines (ELGs) addressing limits on stormwater runoff, sampling is required to determine compliance with those limits. Table 1 provides a list of the current applicable effluent limitation guidelines.

Table 1. Applicable Effluent Limitations Guidelines (2008 MSGP Part 2.1.3)

Regulated Activity	40 CFR Part/Subpart
Discharges resulting from spray down or intentional wetting of logs at wet deck storage areas	Part 429, Subpart I
Runoff from phosphate fertilizer manufacturing facilities that comes into contact with any raw materials, finished product, by-products or waste products (SIC 2874)	Part 418, Subpart A
Runoff from asphalt emulsion facilities	Part 443, Subpart A
Runoff from material storage piles at cement manufacturing facilities	Part 411, Subpart C
Mine dewatering discharges at crushed stone, construction sand and gravel, or industrial sand mining facilities	Part 436, Subparts B, C, or D
Runoff from hazardous waste landfills	Part 445, Subpart A
Runoff from non-hazardous waste landfills	Part 445, Subpart B
Runoff from coal storage piles at steam electric generating facilities	Part 423

These limits are required to be included in all general industrial permits. Typically, permits require corrective action and further sampling when an effluent limitation is exceeded. An exceedance of an applicable effluent limitation guideline constitutes a violation of the permit.

- **Monitoring Requirements for Discharges to Impaired Waters** - General industrial permits may have special monitoring requirements for facilities that discharge pollutants of concern into impaired waters.

For an explanation of these monitoring requirements in the 2008 MSGP see Part 6.2. Part 8 of the 2008 MSGP includes the benchmark and effluent limitation guideline monitoring requirements for each of the industrial sectors affected by such requirements.

2. Preparation for Monitoring

This section describes the information you will need before monitoring. While this guide is meant to be a general primer for anyone interested in industrial stormwater monitoring, Section 2 follows the organization of the 2008 MSGP. Many State general permits are very similar to the 2008 MSGP. It is EPA's hope that this format will be of use to permittees in most states. However, if you are subject to a State industrial general permit, you should compare your permit's monitoring requirements to the requirements reflected in this guide to ensure that you are following all applicable State requirements.

In general, preparation is critical to make sure that industrial stormwater monitoring is conducted properly and in a timely manner. Most of this information should have been collected previously for the purposes of submitting your permit application or Notice of Intent (NOI), and in developing the monitoring procedures section of your stormwater pollution prevention plan (SWPPP). However, this guide reviews some of the steps necessary to develop this information, such as the site map component of the SWPPP, in case facilities have not already done so. If you have already completed any of these steps in this section, you can skip to the next application section or subsection in this guide. For more information on how to develop a SWPPP, refer to EPA's guide *Developing Your Stormwater Pollution Prevention Plan: A Guide for Industrial Operators*, available on EPA's website at www.epa.gov/npdes/stormwater/msgp.

If you have already submitted your NOI, the following documents will serve as good resources for information that you will need prior to monitoring:

- A copy of your NOI or application submitted to EPA or a State, and your assigned permit registration number.

- A copy of the EPA/State response to your NOI/permit application submission if it includes specific details pertaining to your monitoring (e.g., pollutants required to be monitored, frequency of monitoring, benchmark or compliance sampling requirements, etc.).

- A copy of your applicable permit, including the accompanying fact sheet.

- A complete copy of your SWPPP, which must include a detailed site map of your facility with locations of all stormwater monitoring points, and a description of the procedures you or your stormwater pollution prevention team will follow when conducting monitoring and visual assessments.

2.1 Determine Where Stormwater Is Discharged From Your Property

If you have not already done so, walk the grounds and perimeter of your facility during a storm event to identify where runoff discharges from the site (known as "outfalls"). Outfalls are locations where stormwater exits the facility property, including pipes, ditches, swales, and other structures that transport stormwater. If possible, walk outside the boundary of your facility to identify outfalls that may not be apparent from within your site.

Stormwater discharges to the slot drain and is conveyed offsite through a valved pipe.

You should note where:

- Concentrated stormwater exits your facility (e.g., through a pipe, ditch or similar conveyance). These outlets are usually good sampling points.
- Dispersed runoff (i.e. sheet flow) flows offsite (e.g., through a grassy area or across a parking lot). Note whether concentrated flows commingle with the sheet flow.
- Storm drain inlets or catch basins are located. Try to determine where the storm drains send your runoff (e.g., to your municipal separate storm sewer system [MS4], to a combined sewer system, to the separated sanitary sewer, or directly to a nearby waterbody).

- Authorized non-stormwater discharges commingle with stormwater prior to discharge (such commingled discharges may be covered under your permit).

- Areas where stormwater might enter your facility from neighboring facilities and commingle with your stormwater discharges.

Terms to Know:

Combined Sewer System: Combined sewer systems are sewers that are designed to collect rainwater runoff, domestic sewage, and industrial wastewater in the same pipe. Most of the time, combined sewer systems transport all of their wastewater to a sewage treatment plant, where it is treated and then discharged to a water body. During periods of heavy rainfall or snowmelt, however, the wastewater volume in a combined sewer system can exceed the capacity of the sewer system or treatment plant. For this reason, combined sewer systems are designed to overflow occasionally and discharge excess wastewater directly to nearby streams, rivers, or other water bodies.

MS4: A conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains) which are owned and operated by a … public body (created by or pursuant to State law) having jurisdiction over disposal of sewage, industrial wastes, stormwater, or other wastes … that discharges to waters of the United States; designed or used for collecting or conveying stormwater; which is not a combined sewer; and which is not part of a publicly owned treatment works (POTW). [40 CFR 122.26(b)(8)].

Mark these locations on your facility site map, which will be included as part of your SWPPP, and label each outfall location with unique identifiers to differentiate them. For example, you may decide to name the different outfalls according to where the stormwater is being discharged, such as MS4-1, MS4-2, etc. for outfalls discharging to the MS4 or ST-1, ST-2, etc. for outfalls discharging directly to an adjacent stream. Using unique identifiers will help you to coordinate monitoring requirements.

In addition to marking the outfalls on the map, you will need to determine the drainage area for each discharge point. If your facility is large and has significant changes in elevation, a topographic map may be necessary. However, if your facility is small and relatively flat, the best way to define the drainage area for each outfall is an on-the-ground visual assessment, preferably during a rain event. Sketch the basic drainage areas on the map for each outfall. Knowing the drainage area for each outfall is helpful when your sampling indicates problems at that outfall. You can focus your efforts on the industrial materials and activities in that drainage area, instead of the entire site, to identify what may be causing the problem.

2.2 Determine Where You Will Collect Samples

Now that you have determined the different points of discharge from your site, you will need to select the exact locations from which you will be collecting your stormwater samples. Note that Part 5.1.5.2 of the 2008 MSGP requires industrial operators to document in their SWPPPs the location where samples will be collected. Generally, industrial stormwater permits require that you sample stormwater discharges prior to the stormwater leaving your facility, and at a location downstream from all of your industrial materials and activities. The reason behind requiring such a location is so that the sample is representative of your facility's discharge, taking into account the types of pollutants that may be contained in runoff from the property.

Appropriate sample locations include:

- Underground pipes that collect stormwater from drop inlets and convey stormwater to an offsite location (e.g., street, curb or MS4). Be sure you collect only the stormwater discharging from your facility and not the baseflow in the pipes that is being discharged from facilities upstream. Do not enter underground locations to collect samples. Use a pole with a sampling container attached at the end to collect the sample.

- Open ditches, gutters or swales that carry stormwater from your facility to an offsite location. If these conveyances contain runoff from another facility, it is important to note that in your SWPPP;

- Facility driveways and other street access points; and

- Outlets discharging offsite from onsite stormwater detention ponds or other types of structural control measures. It is important to sample at the OUTLET of your structural control measures, as opposed to the INLET of such structures, in order to determine the quality of the water after treatment.

Where to Sample When There Are Multiple Discharge Points

You are required to monitor all outfalls that receive stormwater discharges from your industrial activity. See Part 6.1.1 of the 2008 MSGP. If you have multiple stormwater discharge points at your facility, you need to identify which outfalls are associated with industrial materials and activities, and monitor those outfalls. Understanding the hydrologic connection between your outfalls and the parts of your facility that drain to those points, and the pollutants associated with the industrial activities in these areas, will assist you in designing a monitoring program that is representative of the pollutants being discharged from your site. Developing such an understanding will also help later on when you begin to assess your sampling results and determine where improvements could be made to your stormwater control measures. The site map you prepare (see Part 5.1.2 of the 2008 MSGP) will help you understand the correlation between your areas of potential pollutant sources, the direction of stormwater flow from those areas, and the discharge points.

Note that you are not required to monitor at outfall locations that receive stormwater flow only from unregulated areas of your site (i.e., there are no industrial materials or activities in the drainage area). For instance, a hypothetical facility may have two outfalls, one that receives discharges from an area where industrial materials are handled and stored, and a second outfall that receives discharges from an unregulated parking lot used by employees. In this scenario, the industrial permittee would only collect samples from the first outfall because it discharges stormwater associated with industrial activity. Alternatively, if the site's second outfall (e.g., the outfall receiving runoff from the parking lot) also drains areas of the facility with regulated industrial activities, then this outfall would also need to be sampled. In this situation, sampling for this outfall should be done at a location prior to where the two flows commingle so that you are capturing the industrial portion of the flow. See Part 6.1.2 of the 2008 MSGP.

Where to Sample if Outfalls Are Substantially Identical

If your facility has two or more outfalls whose discharges are "substantially identical," some industrial stormwater permits, including the 2008 MSGP, allow you to monitor the discharge at just one representative outfall and apply the results to the other substantially identical outfalls. EPA defines "substantially identical" in the 2008 MSGP as follows:

> "… two or more outfalls that you believe discharge substantially identical effluents, based on the similarities of the general industrial activities and control measures, exposed materials that may significantly contribute pollutants to stormwater, and runoff coefficients of their drainage areas …." See Part 6.1.1 of the 2008 MSGP.

The flexibility provided to permittees to sample at just one location, which is considered representative of all substantially identical outfalls, is an exception to the rule stated above that samples must be taken from all outfalls at a facility. Note that this exception does not apply to compliance monitoring (effluent limitation guideline monitoring), which must be conducted at each outfall to which the effluent guideline applies.

In choosing which of the substantially identical outfalls from which to sample, you should select the outfall that has been observed to have the most consistent flow. To use the substantially identical outfall exception, you must document in your SWPPP how the two or more outfalls are substantially identical, based on the above definition. You will need to document the following information:

- The locations of the outfalls;
- Estimated size of the drainage area (in square feet) for each outfall;
- General industrial activities conducted in the drainage area of each outfall;
- Control measures being implemented in the drainage area of each outfall;
- Why the outfalls are expected to discharge similar stormwater; and
- An estimate of the runoff coefficient of the drainage areas (0.0 no runoff potential to 1.0 all precipitation runs off).

The runoff coefficient is the ratio of excess runoff to the amount of precipitation for a given time over a given area, with a 0 (zero) runoff coefficient meaning no runoff potential and 1.0 (one) meaning a completely impervious surface and all stormwater runs off. The runoff coefficient is related to the amount of impervious surfaces (buildings, pavement, sidewalks, etc.) versus pervious surfaces (grass, graveled areas, etc.) at the site. The more impervious surface a facility has, the larger the runoff coefficient. Light industrial facilities typically have a runoff coefficient between 0.50 and 0.80 and heavy industrial facilities typically have a runoff coefficient between 0.60 and 0.90.

Here is an example where a facility could take advantage of the “substantially identical outfalls” exception: a metal recycling facility with a large scrap metal pile has three separate outfalls that are each connected by their own drainage ditch to different portions of the same pile, and the runoff that is discharged is managed using the same type of control measure in each drainage area. In this scenario, the facility’s operator can use the “substantially identical outfall” exception because the industrial activities at the site are all the same, the runoff flows through exposed areas that presumably contribute the same type of pollutants, and the drainage area has the same or similar runoff coefficients. Note that the substantially identical outfall exception could not be used if there were in fact differences in any of the required components defined above.

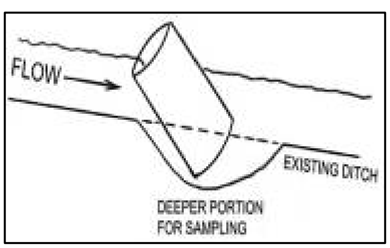
If your permit does allow you to use a substantially identical outfall exception, make sure you carefully review the type of monitoring for which this exception applies. For instance, while the 2008 MSGP allows permittees to use the substantially identical outfall exception for benchmark and visual assessment samples, the permit prohibits use of this exception for compliance monitoring (e.g., for use in showing compliance with numeric effluent limitation guidelines). Therefore, if a facility permitted under the 2008 MSGP is subject to a numeric limit based on an EPA effluent limitation guideline, it would have to monitor all outfalls at the site receiving flows from the applicable industrial activities. See Part 6.2.2.2 of the 2008 MSGP.

Where to collect a sample

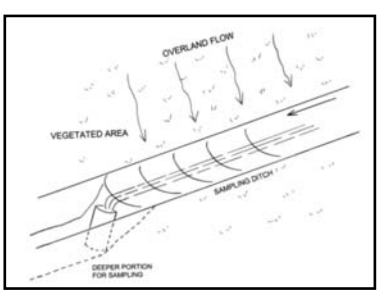
Sampling Sheet Flow

In some areas of your facility it may be difficult to obtain a sample because the runoff drains as sheet flow before it becomes concentrated enough for sampling. If the flow is too shallow to directly fill a collection bottle, you can overcome this by:

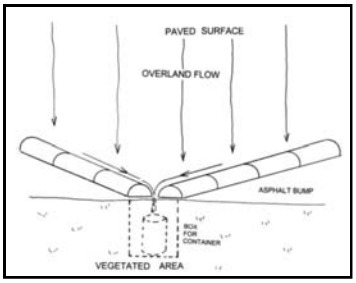
- Concentrating the sheet flow by excavating a small depression in an existing ditch or other location where stormwater runoff flows.



- Installing a trough, gutter or ditch to intercept and concentrate stormwater flow.



- Installing “speed” bumps to convey and concentrate a large area of sheet flow.



Collecting a sheet flow stormwater sample.

You should make these modifications during a period when rain is not forecast so any pollutants generated can be cleaned up before a storm hits. Also, if you dig a ditch or disturb the earth in some way, line the disturbance with concrete or plastic so that you do not contaminate your stormwater samples with sediment or other pollutants.

Sampling from a Pipe

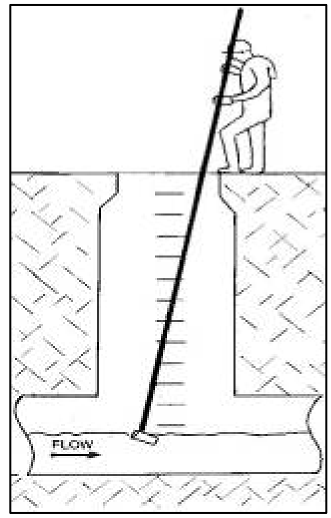
For runoff flowing through a pipe into a ditch or receiving water, you should sample the outflow directly from the pipe. For hard-to-reach pipes, it may be necessary to fasten a collection bottle to a pole (see Sampling from a Manhole in Table 2 below).

When collecting any type of stormwater sample it is imperative that the sample is collected before the stormwater reaches the receiving water.

Sampling From a Drainage Ditch or Swale

If your stormwater is discharged via a drainage ditch or vegetated swale, take a grab sample from a consistently flowing part of the ditch / swale. If the ditch / swale is too small or shallow, install a barrier device in the channel or deepen a small area so you are able to sample directly into the bottles. Allow sufficient time to pass after disturbing the bottom so that any solids stirred up do not contaminate your sample.

Sampling From a Stormwater Detention / Retention Basin or Other Treatment Device



If it is necessary for you to sample from a detention or retention basin, do so at the outfall of the structure. Collecting samples from stagnant or slowly moving water inside a pond will not yield a representative sample as the pollutants might not be adequately mixed. Stormwater basins may hold stormwater for long periods of time. Collect your sample within 30 minutes from when the pond begins to discharge.

Potential Sampling Issues

Depending on the location of your monitoring points, you may encounter additional challenges beyond deciding which sampling technique to employ at each site. Table 2 identifies some stormwater sampling problems common to industrial facilities and guidance for how EPA suggests you address them if they occur at your site.

Table 2. Solutions to Typical Stormwater Sampling Problems

Problem	Solution
Run-on from Neighboring Properties	Ideally, your stormwater samples will contain only runoff from your site. However, stormwater from a neighboring facility can "run on" and commingle with your own regulated discharge, possibly adding contaminants not found at your facility. You are responsible for any and all pollutants discharged from your site irrespective of the pollutants' origin and whether the other facility has permit coverage. This responsibility includes run-on discharges from neighboring properties if this discharge commingles with your own regulated discharge. To accommodate stormwater run-on, EPA requires as part of the SWPPP site description that you document the locations and sources of run-on. As part of this documentation, if you collect and analyze samples of the run-on, you will need to report all such findings in your SWPPP.
Stormwater from industrial areas commingles with stormwater discharges from non-industrial areas or areas not regulated under the MSGP before it reaches the surface water body or MS4.	Attempt to sample the industrial stormwater discharge before it mixes with stormwater from non-industrial areas.
Adverse Weather Conditions	High tides and high flow or flood conditions can cause stormwater conveyances to reach maximum capacity, pipes to become clogged or submerged, and other unrepresentative flow situations. High flows could also be dangerous, so you should use your best professional judgment when selecting sampling locations. In some cases you may need to sample at a point before the intended outfall location.
There are numerous stormwater outfalls in one area.	Construct an impound channel or join together flows by building a weir or digging a ditch to collect discharge at a low point for sampling purposes. This artificial collection point should be lined with plastic to prevent infiltration and the introduction of

Problem	Solution
	sediment. Or, alternatively, sample at several locations to represent total site runoff.
The outfall is inaccessible (examples include underwater discharges or unreachable discharges such as a pipe discharging out of a cliff).	Go upstream of the discharge until a sample can be taken (i.e., to the nearest manhole or inspection point). You may need to sample at several locations to best represent runoff from this discharge point if you cannot access an upstream location.
A facility has many sampling locations making it difficult to collect all of the samples during the first 30 minutes of discharge, as required by the 2008 MSGP.	Have a sampling crew ready when storms are forecast so that all outfalls can be sampled during the first 30 minutes. Also, automatic samplers may be used to collect samples within the first 30 minutes, triggered by the amount of rainfall, the depth of flow, flow volume or time.
A stormwater sample location is beneath a manhole.	For accessibility and safety, use a sampling pole to collect samples from a manhole. Before a person can enter a manhole to collect a sample, they must be trained in confined space entry.
Stormwater from more than one industry type is commingled.	You must comply with monitoring requirements for all applicable sectors and SIC codes.

2.3 Determine Which Types of Monitoring Requirements Apply At Each Outfall

The next step in preparing for monitoring at your site is to determine the type of monitoring requirements that correspond to each outfall. The type of monitoring requirements to which you are subject will differ according to your permit. Different monitoring requirements may also apply to individual outfalls on your property based on the type of industrial activity discharging to that point, and even the receiving water to which you are discharging. Using your permit, determine the type of monitoring requirements to which your specific facility is subject, and document in your SWPPP the specific monitoring requirements that applies to each outfall, including the frequency of monitoring and the specific parameters that must be monitored.

Recall that it is not necessary to monitor an outfall if it does not have any industrial activity associated with it (e.g., discharge from an employee parking lot that does not commingle with stormwater runoff from an area of industrial activity) or if the outfall does not drain to a surface water (i.e. the outfall drains to a sanitary sewer or combined sewer system).

The following applies to the types of monitoring required under the 2008 MSGP. If you are not subject to the 2008 MSGP, consult your State permit to determine your monitoring requirements.

- ***Visual Assessments*** (Part 4.2 of the 2008 MSGP) – All 2008 MSGP permittees are required to collect samples of their stormwater discharge for visual inspection. The following qualitative characteristics must be assessed:

  - color;
  - odor;
  - clarity;
  - floating solids;
  - settled solids;
  - suspended solids;
  - foam;
  - oil sheen; and

- other obvious indicators of stormwater pollution.

Visual assessments must be conducted at all outfalls, although if several outfalls are "substantially identical" then only one visual assessment must be conducted on the set of outfalls. The sampling frequency for visual assessments under the 2008 MSGP is quarterly. The monitoring quarters are: January 1 – March 31, April 1 – June 30, July 1 – September 30, and October 1 – December 31.

- ***Benchmark Monitoring*** (Part 6.2.1 of the 2008 MSGP) – This type of analytic monitoring applies to certain industrial sectors regulated under the 2008 MSGP. Permittees subject to these requirements must take periodic grab samples of their stormwater discharge to compare the concentrations of key indicator pollutants to their corresponding benchmark concentrations. The benchmark values are based in large part on EPA's aquatic life water quality criteria and are meant to serve as indicators of how well a facility's stormwater control efforts are working. If a particular benchmark is exceeded, this indicates to a permittee that there may be a problem at the site, such as a spill, exposed pollutant source, or a faulty control measure, and triggers a required review of the potential problem to determine what corrective actions are necessary. For example, a total suspended solids (TSS) concentration found in a benchmark sample of greater than 100 mg/L, which is the applicable benchmark concentration for TSS, would require a facility to re-evaluate and potentially revise control measures implemented to control dust, soil erosion, or other sources of suspended solids. Note that the exceedance of the benchmark is not a violation (because benchmarks are typically not enforceable limits), but the failure to conduct the follow-up investigation and applicable corrective actions would be a violation of the permit.

Be sure to update your SWPPP and site map whenever you change or add new control measures. Control measure maintenance activities must be documented (preferably in a log), and such records must be kept with your SWPPP and stormwater file.

Determine whether you are subject to any benchmark monitoring requirements based on your particular industrial sector or subsector. The benchmark monitoring requirements differ based on the sector or subsector under which a particular facility falls. Note that not all sectors are subject to this type of monitoring. Appendix D in the 2008 MSGP provides the Standard Industrial Classification (SIC) code and activity codes categorized by sectors and subsectors. Use Appendix D to link your industrial activities with their associated SIC code sectors / subsectors. Your facility will have a primary industrial activity and associated SIC or activity code (which is the major determinant of your permit requirements), and, possibly, additional secondary sectors / subsectors with additional requirements for which you must comply. Next, using Part 8 of the 2008 MSGP, under your particular sector or subsector, determine whether you are subject to any benchmark monitoring requirements, and the corresponding benchmark that applies. Consider the following example: if you operate a gold mine (subsector G2) you are subject in Part 8.G.8.2 to the following benchmark monitoring requirements:

Table 3. Subsector G-2.		
Subsector (Discharges may be subject to requirements for more than one sector/subsector)	**Parameter**	**Benchmark Monitoring Cutoff Concentration**
Subsector G2. Iron Ores; Copper Ores; Lead and Zinc Ores; Gold and Silver Ores; Ferroalloy Ores, Except Vanadium; and Miscellaneous Metal Ores (SIC Codes 1011, 1021, 1031, 1041, 1044, 1061, 1081, 1094, 1099) (Note: when analyzing hardness for a suite of metals, it is more cost effective to add analysis of calcium and magnesium, and have hardness calculated than to require hardness analysis separately)	Total Suspended Solids (TSS)	100 mg/L
	Turbidity	50 NTU
	pH	6.0-9.0 s.u.
	Hardness (as $CaCO_3$; calc. from Ca, Mg)[1]	no benchmark value
	Total Antimony	0.64 mg/L
	Total Arsenic	0.15 mg/ L
	Total Beryllium	0.13 mg/L
	Total Cadmium[1]	Hardness Dependent
	Total Copper[1]	Hardness Dependent
	Total Iron	1.0 mg/L
	Total Lead[1]	Hardness Dependent
	Total Mercury	0.0014 mg/L
	Total Nickel[1]	Hardness Dependent
	Total Selenium	0.005 mg/L
	Total Silver[1]	Hardness Dependent
	Total Zinc[1]	Hardness Dependent

Based on this table, you then know the pollutant parameter for which you must conduct benchmark monitoring, and the corresponding benchmark concentration against which you will compare each individual grab sample. Each sector or subsector subject to benchmark monitoring requirements includes a similar table in Part 8 of the 2008 MSGP.

After you have determined which (if any) benchmark sampling requirements apply, document in your SWPPP which outfalls are subject to such requirements, the frequency of monitoring, and the parameters that must be analyzed. If your facility has multiple outfalls, be aware that there may be different requirements for different outfalls depending on the type of industrial activity conducted in the drainage area of each outfall. You are only required to conduct benchmark monitoring for those outfalls with discharges from the specific sectors / subsectors that are affected by such requirements. Where an outfall includes no discharges from those sectors or subsectors for which benchmark monitoring requirements apply, then no benchmark samples need to be taken at that outfall.

The required benchmark monitoring frequency under the 2008 MSGP is quarterly. The monitoring quarters, beginning with the first quarter on April 1, 2009 are: April 1 – June 30, July 1 – September 30, October 1 – December 31 and January 1 – March 31.

Exceptions for Inactive and Unstaffed Sites (Part 6.2.1.3 of the 2008 MSG) – The requirement for benchmark monitoring does not apply to inactive and unstaffed facilities, providing there are no industrial materials or activities exposed to stormwater. This exception only applies to benchmark monitoring requirements and not to the other types of monitoring described above.

To claim this special exemption, you must note on the next quarterly benchmark monitoring report that your facility is inactive and unstaffed, and you must keep an inactive and unstaffed certification onsite (see Part 4.2.1.3). The requirement for conducting a quarterly visual assessment also does not apply inactive and unstaffed sites, as long as there are no industrial materials or activities exposed to stormwater. If you are invoking the exception for inactive and unstaffed sites, maintain a signed and certified statement onsite with your SWPPP stating that the site is inactive and unstaffed, and that there are no industrial materials or activities exposed to stormwater.

Hardness-Dependent Benchmarks (Appendix J of the 2008 MSGP) **–** The benchmark values of some metals are dependent on the level of hardness in your receiving waters (see 2008 MSGP, Appendix J). Hardness is a characteristic of water that results from the presence of dissolved salts, especially calcium sulfate or bicarbonate, and is usually reported as carbonate, noncarbonate or calcium + magnesium (Ca + Mg). If you are required to monitor for a hardness-dependent pollutant, you must first determine the hardness of your receiving water before you can establish the corresponding benchmark concentration.

- ***Effluent Limitations Monitoring*** (Part 6.2.2 of the 2008 MSGP) – Eight of the 2008 MSGP's 29 industrial sectors are required to monitor to determine if they comply with EPA-defined effluent limitation guidelines. These monitoring requirements are included in Part 8 of the 2008 MSGP. Effluent limitation guidelines are legally enforceable limitations that must not be exceeded in stormwater discharges.

  Similar to the benchmark monitoring requirements, samples only need to be taken at those outfalls with discharges from the specific activities that are subject to effluent limitation guidelines; otherwise these requirements do not apply. As stated previously, permittees subject to these monitoring requirements must take samples at all applicable outfalls, and no exceptions are given for substantially identical outfalls. However, if you are required to monitor a pollutant both for benchmark and effluent limitation guideline purposes, you only need to take one sample for both requirements.

When monitoring requirements overlap, e.g., TSS once per year for an effluent limit and once per quarter for benchmark monitoring, you may use a single sample to satisfy both monitoring requirements (i.e., one of your four quarterly benchmark samples would be used for your yearly effluent limit sample).

Table 4 identifies the industrial activities that are subject to effluent limitation guideline monitoring requirements and the associated sampling parameters. Effluent limitation guideline samples must be taken once per year (see Part 8 of the 2008 MSGP for the numerical values of each effluent limit).

Table 4. Required Monitoring for Effluent Limitations Guidelines

Regulated Activity	Where in 2008 MSGP	Sector	Effluent Limit Parameters
Discharges resulting from spray down or intentional wetting of logs at wet deck storage areas	Part 8.A.7	A	debris, pH
Runoff from phosphate fertilizer manufacturing facilities	Part 8.C.4	C	total P, fluoride

Regulated Activity	Where in 2008 MSGP	Sector	Effluent Limit Parameters
Runoff from asphalt paving and roofing emulsion facilities	Part 8.D.4	D	total suspended solids (TSS), oil and grease, pH
Runoff from material storage piles at cement manufacturing facilities	Part 8.E.5	E	TSS, pH
Mine dewatering discharges at crushed stone, construction sand and gravel, or industrial sand mining facilities	Part 8.J.9	J	TSS, pH
Runoff from hazardous waste landfills	Part 8.K.6	K	biochemical oxygen demand (BOD_5), TSS, ammonia, alpha terpineol, benzoic acid, p-cresol, phenol, total recoverable zinc, pH, aniline, naphthalene, pyridine, total recoverable chromium,
Runoff from non-hazardous waste landfills	Part 8.L.10	L	biochemical oxygen demand (BOD_5), TSS, ammonia, alpha terpineol, benzoic acid, p-cresol, phenol, total recoverable zinc, pH
Discharges from coal storage piles	Part 8.O.8	O	TSS, pH

Determine whether you are subject to any effluent limitation guideline monitoring requirements. Document in your SWPPP which outfalls are subject to such requirements, the frequency of monitoring, and the parameters that must be analyzed.

- ***Impaired Waters Monitoring*** (Part 6.2.4 of the 2008 MSGP) – The 2008 MSGP requires facilities to monitor, at least in the first year of permit coverage (and yearly thereafter depending on the sample results in the first year), for the presence of any pollutant causing an impairment to their receiving water. This requirement is triggered regardless of whether the particular pollutant is used or stored at the industrial site; however the facility may be able to discontinue monitoring after the first year if the pollutant is not present in the sample and is not expected to be present in any discharge. In advance of conducting this monitoring, you should already have a good idea of whether the pollutant will be found in your discharge. When you developed your SWPPP, you conducted a complete inventory of your site to determine what pollutants or pollutant constituents could be discharged in stormwater runoff. See Section 3.1 of EPA's guide, *Developing Your Stormwater Pollution Prevention Plan: A Guide for Industrial Operators*, particularly the discussion about conducting an "Inventory of Materials and Pollutants". Using this inventory from your SWPPP, you will be able to determine if any materials stored or used at your facility could contribute to impairment of your receiving water.

  The next section of this guide includes specific steps to help you determine if you are subject to impaired waters monitoring requirements. After following those steps, document in your SWPPP which outfalls are subject to impaired waters monitoring requirements, the frequency of sampling, and the parameters that must be monitored.

- ***State / Tribal Monitoring Requirements*** (Part 6.2.3 of the 2008 MSGP) – The 2008 MSGP includes a number of additional monitoring requirements that are unique to individual States and/or Indian Country lands. These requirements are set out in Part 9 of the permit. These requirements may include additional or more frequent benchmark monitoring requirements, alternative benchmark thresholds, or additional parameters that must be monitored to establish compliance with applicable water quality standards.

Based on the State or Indian Country land in which they are located, each 2008 MSGP permittee must consult the applicable Part 9 section to determine what, if any, additional monitoring requirements apply. If you are subject to such requirements, you must document in your SWPPP which outfalls are subject to these provisions, the frequency of applicable sampling, and the parameters that must be monitored

- ***Additional Monitoring Required by EPA –*** It is possible EPA may require additional monitoring (see 2008 MSGP Part 6.2.5). You will be notified by the Agency if additional monitoring is required.

2.4 Determine if Your Facility is Subject to Impaired Waters Monitoring Requirements

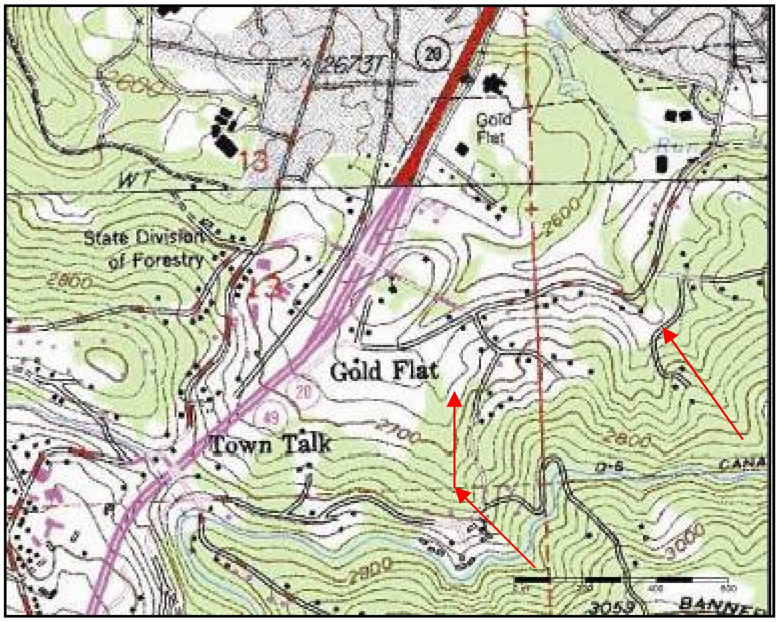
If you are required by your industrial stormwater permit to monitor for pollutants that cause impairment to your receiving water, you must first identify the receiving waters (e.g. ditch, creek, intermittent stream, lake, arroyo, etc.) into which your facility discharges stormwater and mark them on your site map. Note that you will have already identified your receiving waters if you filed an NOI to be covered by the 2008 MSGP.

A. Identify Your Receiving Water(s)

Do these monitoring requirements apply to me if I discharge into a dry ditch?
Yes, if the ditch eventually conveys the runoff to a waters of the United States.

There are several ways to identify your receiving waters. Your receiving water may be a lake, stream, river, ocean, wetland or other waterbody, and may or may not be located adjacent to your facility. Your facility might discharge directly into its receiving water, or indirectly to the receiving water by discharging first through an MS4, ditch, or other conveyance.

If the discharge from your facility does not discharge into an underground storm sewer system, you can use your site map and local topographic maps to pinpoint the closest waterways. Using the contours on the topographic map and your facility's outfall locations, determine the direction stormwater runoff flows from your facility. Once you know the direction of flow, you should be able to identify the receiving waters into which you discharge.



Sample section of a U.S.G.S. quadrangle map, with arrows showing direction of flow.

After identifying where your stormwater enters a waterbody, identify any additional interconnected waters for at least one linear mile downstream from the entrance point of your discharge (in case there are concerns about impacts to these downstream waters).

Resources to help you identify receiving waters:

- EPA's Water Locator Tool (available at www.epa.gov/npdes/stormwater/msgp) allows you to locate nearby receiving waters and impaired waterbodies within a 10 mile radius of your facility.

- EPA's Enviromapper (www.epa.gov/enviro/emef) enables you to find nearby waterbodies by entering your facility's zip code, address, facility name or identification number, EPA Region, watershed, or latitude/longitude data. Additional information on the location of impaired waterbodies can also be obtained.

- Topographic maps, which can be obtained from the U.S. Geological Survey (USGS) at http://topomaps.usgs.gov/ordering_maps.html, or through a retailer.

If your stormwater drains into an MS4, you will likely need to contact the operator of the system (e.g., the local public works department, the highway department, etc.) to identify the first receiving water your stormwater is released to after entering the MS4. Some MS4s have their storm sewer infrastructure maps available online.

Remember, the MS4 into which your facility's stormwater discharges is NOT your receiving water. The first waterbody that the MS4 discharges to after receiving your stormwater is the receiving water for your facility.

B. Determine if Your Receiving Water is Impaired and Whether a TMDL Has Been Completed

Once you have identified your receiving water(s), you will need to find out if the waterbody is impaired, and, if so, whether a total maximum daily load (TMDL) has been approved or established.

- **Water quality impairment status.** You need to determine whether your facility's receiving water is listed by your State as impaired and/or has an approved or established Total Maximum Daily Load (TMDL). EPA's Water Locator Tool (available at www.epa.gov/npdes/stormwater/msgp) will help find impaired waters within a 10 mile radius of your facility. Another place to check is EPA's website on Water Quality Assessment and TMDL information (www.epa.gov/waters/ir) or you can also contact your State water agency (cfpub2.epa.gov/npdes/contacts.cfm?program_id=6&type=STATE).

"Impaired waters" are streams, rivers, and lakes that do not currently meet their applicable designated uses and water quality standards. States, territories, and authorized tribes are required under the Clean Water Act to compile lists of known impaired waters, called 303(d) lists. Stormwater discharges to impaired waters may trigger additional control measures and monitoring requirements. For facilities subject to EPA's 2008 MSGP, see Part 2.2 for a more detailed discussion of water quality-based effluent limitations and conditions for discharging to impaired waters.

If your receiving water is impaired, use EPA's Water Locator Tool or Water Quality Assessment and TMDL website, or a State agency to help you determine:

- For what pollutant(s) is the water impaired? Make a separate list of all pollutants that have caused your waterbody to be impaired.

- Has an approved TMDL been completed for each of the pollutants? Some TMDL documents include information suggesting the type of monitoring that should be conducted to improve the understanding of the impairment or to demonstrate achievement of applicable wasteload allocations (WLAs).

C. Determine What Monitoring Requirements Apply

Having determined the pollutants that cause the impairment, you should now consult your permit to determine the type of monitoring that must be conducted, the frequency of monitoring, and whether any exceptions apply to certain pollutants. As discussed in Section 2.3 above, this must all be documented in your SWPPP so that it is clear which requirements apply to which outfall.

The 2008 MSGP lists several exceptions to and clarifications of the requirement to monitor for each impairment pollutant. In Part 6.2.4.1 of the 2008 MSGP, the permit clarifies that no monitoring is required when a waterbody's biological communities are impaired but no pollutant is specified as causing the impairment, or when a waterbody's impairment is related to hydrologic modification, impaired hydrology, or temperature. The permit also clarifies that monitoring is only required for pollutants for which a standard analytical method exists as defined in 40 CFR Part 136. In addition, certain exceptions exist that enable the permittee to be excused from sampling after the first year if it is found either that:

- The pollutant for which the waterbody is impaired is not detected above natural background levels in the discharge, and it is documented that the pollutant is not expected to be present above natural background discharges; or

- The pollutant for which the waterbody is impaired is not present and not expected to be present in the discharge.

Both the parameters that must be sampled and the frequency of monitoring for impairment pollutants may be subject to State- or Indian Country land-specific requirements. Therefore, each 2008 MSGP permittee must also consult Part 9 of the permit when determining which impaired waters sampling requirements apply.

2.5 What Type of Storm Events Qualify for Monitoring

In addition to understanding which monitoring requirements apply and where, it is also critical to develop an understanding of what type of discharge event you will be sampling. Under the 2008 MSGP, two preconditions must be met before a storm or snowmelt event is considered adequate to be monitored (see Part 6.1.3 of the 2008 MSGP).

- The storm / snowmelt event must create an actual discharge from your site ("measurable storm event"). This storm event will vary based on numerous factors at your site, the most obvious being the actual size and duration of the storm event. However, the amount of impervious surface at your facility will impact this as well. If your facility is covered mostly by grass or another type of vegetation with only a small amount of paved surfaces or roofs, it will take a larger storm to create a discharge from your site than it would at a facility that is entirely paved. Another factor affecting whether and how frequently you have a measurable storm event will be how frequently rain occurs at your facility and the size of the most recent storms. Saturated soil will generate a stormwater discharge more quickly than dry soil; however, VERY dry soil can also become compacted and become nearly impervious to rain, thereby converting precipitation to runoff quickly as well. You will need to pay attention to your facility's particular characteristics to develop an understanding of what type of rain events or snowmelt results in a discharge.

- At least 72 hours must have elapsed since the previous measurable storm event (unless you are able to document that less than a 72-hour interval is representative for local storm events during the sampling period, or if you are monitoring snowmelt consistent with Part 4.2.1 [quarterly visual assessments] or Part 6.2.1 [benchmark monitoring] of the 2008 MSGP).

In order to properly characterize rain events at your facility, it is a good idea to begin by documenting each event as part of your facility's routine maintenance activities. You can purchase a simple rain gauge and keep a notebook handy in order to document the dates on which rain occurred and the amount of rain that fell. You should also consider documenting whether or not an actual discharge from your facility occurred for each rain event. Tracking rainfall amounts and discharge information will help you to better predict which storm events will be measureable and result in a discharge.

In order to be prepared to take advantage of storms that will result in a "measurable storm event":

- Be familiar with local precipitation trends, storm patterns, and seasonal variations.

- Check weather forecasts so you can prepare to sample upcoming precipitation events.

- In addition to your local television news and the Weather Channel, you can get weather information online from http://www.wrh.noaa.gov (National Weather Service) and http://www.weather.com.

Note: You should try to collect both benchmark samples and visual monitoring samples concurrently so you can compare visual observations with the laboratory results, and reduce your field activities burden.

What To Do If You Are Unable To Sample – EPA acknowledges there may be times you are unable to complete required monitoring. The following are guidelines on how you should deal with such times.

- *Areas with Intermittent Stormwater Runoff* **–** If your facility experiences limited rainfall for extended periods of the year (i.e., in arid or semi-arid climates), or freezing conditions that often prevent runoff from occurring, then the quarterly monitoring events may be distributed during seasons when discharging does occur. If you are unable to collect four samples in one year because of insufficient runoff, document this fact in your SWPPP and continue quarterly monitoring until you have collected four samples.

- *Snowmelt Sampling* – If you are located where appreciable snow is common, one of your samples must include the capture of snowmelt discharge. If, however, you experience prolonged subfreezing temperatures, you may only be able to acquire a sample once over two quarters. You will then have to complete the monitoring requirements as above.

- *Adverse Weather Conditions* **–** When adverse weather prevents sampling per your monitoring schedule, you must sample during the next qualifying storm event. Adverse conditions are those that are dangerous or create inaccessibility for personnel, caused by such things as flooding, high winds, electrical storms or situations that otherwise make sampling impractical (e.g., drought or extended frozen conditions).

2.6 Select the Monitoring Team

Identify the members of your facility's pollution prevention team (which you identified in your SWPPP) who will collect samples and conduct visual assessments of discharges. To be considered as a member of the monitoring team, applicable staff must be familiar with the SWPPP, especially the site plan, the layout of the facility, potential pollutant sources, and the monitoring and reporting program. They also need to possess the knowledge and skills to assess conditions and activities that could impact stormwater quality at your facility, and to be able to evaluate the effectiveness of control measures. Typically, monitoring staff are based near the site to enable them to be available on short notice to sample storm events.

Ideally, the pollution prevention team consists of at least one individual from each shift so that a team member is always present during normal operating hours.

It is also important that monitoring staff understand and follow all quality assurance quality control (QAQC) techniques and procedures to ensure that the data is good. You should discuss these techniques with your laboratory prior to taking samples and properly train all sampling staff.

2.7 Select a Laboratory to Analyze the Samples

Your stormwater samples will need to be analyzed for the parameters you identified in section 2.3 by a qualified laboratory. Labs must use the approved methodologies found at 40 CFR Part 136 and return a report with chemical concentrations including data quality assurance information.

EPA recommends that you select a laboratory that is a participant in the EPA's Discharge Monitoring Report - Quality Assurance (DMRQA) Program, and, if possible, be approved by the National Environmental Laboratory Accreditation Program (NELAP). NOTE: for ELG compliance monitoring, participation in DMRQA is a minimum requirement.

Things to discuss with the laboratory

- What type and size of bottle will be provided for each test?
- How full do I fill the bottle?
- Are there any safety concerns with materials provided by the lab?
- What is the best way to preserve the samples?
- What kind of labels will be supplied and how should I fill them out?
- Will the lab deliver the supplies or do I need to pick them up?
- What are the maximum holding times for each water quality parameter to be sampled?
- Will the lab provide pH paper? Samples need to be tested for pH within 15 minutes of collection to be valid, typically in the field.
- Will the lab pick up the samples from my facility or do I need to deliver them?
- Can you walk me through filling out the chain-of-custody forms?
- Is the quantitation limit for each parameter less than the benchmark or effluent limitation concentration?*

* The quantitation limit is the minimum concentration of a parameter that the lab can accurately report using a particular method.

- A comprehensive list of NELAP-approved laboratories can be found at www.nelac-institute.org/accred-labs.php

- To ensure your chosen laboratory is eligible and reliable, you may want to request documentation showing they are certified to analyze environmental samples, and evidence they participate in DMRQA or other performance evaluation testing results.

You should ask the laboratory about any additional services and products they offer. Such as:

- pre-labeled bottles and pre-printed chain-of-custody forms;

- training on sample collection, documentation and data interpretation;

- sampling and courier services; and

- complete sampling kits which include bottles, packing materials, bottle labels, coolers and chain-of-custody forms; many laboratories provide free sampling kits.

2.8 Document Monitoring Procedures in Your SWPPP

Ensure your monitoring procedures are correctly documented in your SWPPP (see 2008 MSGP Part 5.1.5.2). The required information includes:

- The monitoring requirements that specifically apply to your facility.
- Information related to the substantially identical outfall exception, if you will use it.
- Your sampling procedures.
- Your procedures for performing quarterly visual assessments of stormwater discharges. This SWPPP element includes the routine facility inspections and comprehensive site inspections required by the 2008 MSGP (see 2008 MSGP Part 4.1 and 4.3, respectively).

Figure 1 is an example of a completed MSGP Industrial Stormwater/Snowmelt Monitoring Summary Form. You should fill out this form (Appendix A) with the sampling locations and monitoring requirements that apply to your facility and include a copy in your SWPPP.

Benchmark Levels and ELGs					
			ELG		
Industry Sector	Pollutant	Benchmark Level	Daily Max	Monthly Average	Instant Min/Max
D	TSS	100	23	15	
D	Oil and Grease		15	10	
D	pH				6 - 9
E2	Iron	1			
E2	TSS	100	50		
E2	pH				6 - 9

Sample Summary								
Outfall Identifier	Industry Sector (SIC)	Basis	Frequency	Timing	Total Suspended Solids (SM 2540D)	pH	Oil and Grease (EPA Method 1664A)	Iron (EPA Method 200.9)
e.g. 001-A	Sector D (SIC 2951)	Benchmark	1/Quarter	1st wk of month	✓	✓	✓	
e.g. 001-A	Sector D (SIC 2951)	ELG	1/year	January	✓			
e.g. 001-B	Subsector E2 (SIC 3271)	Benchmark	1/Quarter	1st wk of month	✓			✓
e.g. 001-B	Subsector E2 (SIC 3271)	ELG	1/Year	January	✓	✓		

Figure 1. Example MSGP Industrial Stormwater/Snowmelt Monitoring Summary Form with monitoring requirements, sampling locations and industry sectors.

3. Conduct Monitoring

This section describes sampling preparation, choosing the right storm event to monitor, how to collect stormwater samples, how to conduct quarterly visual assessments, quality control considerations, and how to report the results.

The information contained in this section is not specific to monitoring for the 2008 MSGP or any particular general industrial permit.

3.1 What to Have In Place Prior to Collecting Stormwater Samples

Preparation is essential, especially if you are in a climate where measureable storm events are infrequent.

- ***In-Office Preparations*** – Your in-office preparations should include the following:
    - Contacting the lab well ahead of time so that you have the sample bottles before a measurable storm event.
    - Paying attention to weather forecasts so that you are tracking patterns that are likely to result in a measurable storm event.
    - Knowing who your monitoring personnel are and how to contact them when a measurable storm event is expected.
    - Having sampling gear assembled and checked for readiness.
    - Preparing sample bottle labels using waterproof ink with the following information (if not already done by the lab):
        - Facility name and address
        - Sample location identifier (e.g., Outfall 001)
        - Name or initials of sampling personnel
        - Parameter and associated analytical method (e.g., TSS, Method # 0160.2; consult with your contract laboratory for analytical method numbers)
        - Sample type (generally will be "grab" samples)
        - Sample preservation notes
        - Date and time after completing sampling event
    - Having chain-of-custody forms ready for use.

The chain of custody form is a document that travels with the sample from collection through analysis. Each individual that handles the sample will place their name, date, and time on the chain-of-custody form. The form is used to maintain the integrity of the sample by providing documentation of the control, transfer, and analysis of samples (see Section 3.4 below for a more detailed discussion of chain-of-custody).

- ***Sampling Supplies*** – Collect the following supplies and keep them ready for quick use:

  - Clean, sterilized sample bottles, sized appropriately for the parameter to be analyzed (many labs provide the appropriate bottles or will tell you what size to get). Glass must be used for oil and grease samples; plastic containers can be used for other parameters. Use Teflon or aluminum-lined caps.

    For rinsing sample bottles, use only distilled water

  - If bottles are new but not pre-cleaned, they must be pre-conditioned before use by filling with water for several days (the duration can be reduced by using a dilute solution of hydrochloric acid).

  - Additional glass or clear plastic bottles suitable for visual assessments.

  - Visual monitoring forms (see example in Appendix B).

  - Clipboard and site-specific monitoring checklist.

  - If needed, a pole (sold at field supply stores) on which to attach sample bottles and attachment clips or strapping tape to secure the bottle to the pole.

  - Safety equipment, including first aid kit.

  - Hand sanitizer solution.

  - Carrying case for sampling equipment or backpack for carrying equipment to remote locations.

  - Powder-free disposable nitrile or latex gloves (sold by medical and laboratory suppliers or may be provided by your contract laboratory). Do *not* use powdered gloves as they may contaminate your samples.

  - Indelible pens / markers that can write on wet surfaces.

  - Foul-weather gear including footwear appropriate for the conditions at your sampling locations (e.g., non-slip boots).

  - Sturdy cooler and ice or ice packs for stowing and preserving your samples en route to the lab (the lab may provide an appropriate container).

  - Field notebook or field forms for your sampling records (waterproof notebooks are available at office supply stores).

  - pH paper and appropriate chemical preservatives for adding to sample bottles (obtain from your laboratory).

Preparing sampling supplies.

- ***Optional or as-needed supplies:***
  - Sodium bicarbonate (for safety reasons if using acid preservative additives)
  - A graduated stick to measure water depth for determining safe / wade-able sampling access locations (if a sampling pole will be used, you can modify it with depth markings)
  - Mosquito repellent
  - Flashlight in case of sudden loss of light or darkness under storm conditions
  - Flagging tape for marking access to remote or overgrown locations
  - Camera, used for:
    - Recording evidence of potential pollutants or sampling conditions.
    - Especially useful if different people will do the sampling throughout the permit term.
    - Pictures of sample appearance along with the visual inspection records can help “normalize” visual assessments.
    - Pictures of the sampling location can help you find the same spot for subsequent sampling events.

Develop a stormwater sampling checklist to ensure consistency and continuity across sampling events. Since stormwater sampling is not a regular part of a facility's workload, a checklist of things to have prepared before sampling, sampling activities, and sampling locations will help you remember from quarter to quarter. You can make the checklist by noting the things you did for the first sampling event to remember for future sampling events. Keep the checklist updated as you gain experience with sampling.

3.2 Collect Stormwater Samples

Contact the lab prior to collecting stormwater samples so they know to expect the samples and have adequate staff available to conduct the analyses within the applicable holding times (the lab may offer courier service). Inform them of the pollutant parameters for which your samples will be analyzed.

A stormwater grab sample is collected directly into the sample container.

Follow the protocol below to obtain an accurate grab or manual sample. A grab sample is a single sample "grabbed" by filling up a container, either by hand or attached to a pole. Obtaining accurate data is vital to your ability to assess how your stormwater control measures are performing.

- Wear disposable powder-free gloves for sampling; never touch the inside of the lid or bottle.
- For oil and grease: fill the glass sample bottle directly from the discharge; never collect in a container first and then transfer to the sample bottle because oily residue will collect along the inside of the first collection bottle and make the sample inaccurate.

Remember, oil and grease must be collected directly into the glass sample bottle.

- If you have problems accessing the stormwater discharge point (e.g., access is too far or dangerous), use a pole or other appropriate sampling apparatus.

- Sample only stormwater discharging from your facility (i.e., do not sample from puddles, ponds or retention basins).

- Sample from a turbulent section in the central part of the flow; avoid touching the bottom or sides of the stormwater conveyance.

- Fill the sample bottle nearly to the top (meniscus almost at the rim) by holding the opening into the flow of water; do not rinse or overfill the bottles.

Sample bottles labeled with location, date, time, sample collector, analysis, and preservative type.

While stormwater samples are typically grab samples, in some situations the use of an automatic sampler may be appropriate. Automatic samplers are mechanical devices that monitor site conditions and collect a sample when needed. The automatic sampler can be set up well in advance of a storm, or set up as a permanent installation, and the technician can retrieve the sample after the storm when conditions are favorable. Advantages of automatic samplers include low labor costs, convenience, and safety – personnel are not out in the storm trying to collect one or more samples. The major disadvantage is cost; automatic samplers are expensive. Secondarily, the automatic sampler cannot collect visual observations, and they cannot be used for collection of certain measurements.

After the samples have been collected:

- Place the samples in a sturdy cooler partially filled with ice. As a general rule, samples should be kept at approximately 39°F (4°C) until the cooler is delivered to the lab.

- Put a completed chain-of-custody form enclosed in a re-sealable plastic bag inside the cooler. If you have several

pH has a 15 minute holding time; therefore, the sample must be analyzed within 15 minutes of collection.

coolers complete a separate chain of custody form for each cooler.

- Deliver the samples to the lab (e.g. drive, arrange same-day pick-up by the lab, or use an express / overnight service) as soon as possible, bearing in mind the holding times for each parameter sampled.

Stormwater samples packed for delivery to the lab, note the chain of custody forms attached to the lid.

3.3 Record Information for Each Monitoring Event

For each individual sample collected, you should note the following information:

- The sample / outfall identifier.
- The duration between the storm event you sampled and the end of the previous storm event that resulted in a discharge of stormwater from your site (i.e., a "measurable storm event").
- The date and duration of the storm event sampled.
- Rainfall measurement or estimate (in inches).
- Estimate of the total volume of the discharge sampled from the outfall.

You should record this information on a Stormwater Collection Form (see appendix C for an example).

3.4 Quality Assurance Considerations

The following actions must be followed explicitly. Quality assurance (QA) helps maintain the accuracy and integrity / legal defensibility of your monitoring results by documenting the stewardship of your samples, by minimizing biases in sampling and lab procedures, and by helping to assess the accuracy and precision of the lab's analyses.

Holding Times and Sample Preservation

Samples that cannot be delivered to the lab on the same day may need to be preserved, often by cooling to 4°C (i.e., in an ice bath) and/or with added chemical preservatives (laboratory-supplied bottles may already include preservatives). If your samples need to be analyzed for more than one parameter you may need to bottle more than one sample at an outfall using different preservatives. In addition, you should be aware of the maximum holding time allowed for a particular parameter before which the sample must be analyzed. Following is a table with typical preservation and holding requirements for benchmark parameters and additional potential pollutants of concern (the latter will not have a numeric value in parentheses). Work with your laboratory service providers to develop a list of containers to optimize "sharing" of containers across different parameters. Not all laboratories provide the same container types for the different parameters. Laboratories frequently provide pre-completed custody records and seals, and will provide pre-labeled sample bottles for ease of use in the field as part of their routine "value-added" services. Pre-completed custody records and labels require only time, date, and samplers' initials in order to complete this critical documentation. Your laboratory may also have additional sampling, sample handling, or shipping instructions helpful to your sample collection personnel. NOTE: Whenever possible, minimize the amount of lead time sample containers / kits are outside of the laboratory. Extended storage of pre-preserved containers for some analytes may present opportunity for blank contamination, even under ideal storage conditions.

Table 5. Sample Preservation and Hold Times

Parameter (Benchmark Level, mg/l or as specified)	Preservation		Maximum Holding Time	Sample Container
	Cool to 4º C?	Additional		
Aluminum, Total Recoverable (0.75)	N	HNO_3 (nitric acid) to pH <2	6 months	500 mL HDPE
Ammonia (2.14)	Y	H_2SO_4 (sulfuric acid) to pH <2	28 days	500 mL HDPE
Antimony, Total Recoverable (0.64)	N	HNO_3 to pH <2	6 months	500 mL HDPE
Arsenic, Total Recoverable (0.15)	N	HNO_3 to pH <2	6 months	500 mL HDPE
Beryllium, Total Recoverable (0.13)	N	HNO_3 to pH <2	6 months	500 mL HDPE
Biological Oxygen Demand, BOD_5 (30)	Y	None	48 hours	1L HDPE or glass
Cadmium, Total Recoverable (0.0005 – 0.0053)*	N	HNO_3 to pH <2	6 months	500 mL HDPE
Chemical Oxygen Demand, COD (120.0)	Y	H_2SO_4 to pH <2	28 days	100 mL HDPE or glass
Chromium (0.58 – 3.82)*	N	HNO_3 to pH <2	6 months	500 mL HDPE

Parameter (Benchmark Level, mg/l or as specified)	Preservation		Maximum Holding Time	Sample Container
	Cool to 4º C?	Additional		
Copper, Total Recoverable (0.0038 – 0.0332)*	N	HNO_3 to pH <2	6 months	500 mL HDPE
Cyanide, Total (0.022)	Y	NaOH (sodium hydroxide) to pH >12, refrigerate in dark	14 days; 24 hours if sulfide present	1 L HDPE
Fluoride		None	28 days	100 mL HDPE
Hardness (as CaCO3)		HNO_3 or $H_2SO_4$to pH <2 (method dependent)	6 months	100 mL HDPE
Iron, Total Recoverable (1.0)	N	HNO_3 to pH <2	6 months	500 mL HDPE
Lead, Total Recoverable (0.014 – 0.262)*	N	HNO_3 to pH <2	6 months	500 mL HDPE
Magnesium, Total Recoverable (0.064)	N	HNO_3 to pH <2	6 months	500 mL HDPE
Mercury, Total Recoverable (0.0014)	N	HNO_3 to pH <2	28 days	500 mL HDPE
Nickel, Total Recoverable (0.15 – 1.02)*	N	HNO_3 to pH <2	6 months	500 mL HDPE
Nitrate + Nitrite Nitrogen (0.68)	Y	H_2SO_4 to pH <2	28 days	200 mL HDPE
Oil and Grease	Y	HCl or H_2SO_4 to pH <2	28 days	1L Boston round glass
pH (6.0 – 9.0 s.u.)	N	None	15 min (Field test)	50 mL
Phenols, Total Recoverable	Y	H_2SO_4 to pH <2	28 days	500 mL HDPE
Phosphorous, Total (2.0)	Y	H_2SO_4 to pH <2	28 days	500 mL HDPE
Radium, Total Recoverable		HNO_3 to pH <2	6 months	1L HDPE
Radium, dissolved		Field-filtered HNO_3 to pH <2; if not field filtered - none	Field filtered, preserved 6months; if not field filtered, filter on receipt, preserve to pH <2 6 months	1L HDPE
Selenium, Total Recoverable (0.005)	N	HNO_3 to pH <2	6 months	500 mL HDPE
Silver, Total Recoverable (0.0007 – 0.0183)*	N	HNO_3 to pH <2	6 months	500 mL HDPE
Total Suspended Solids, TSS (100)	Y	None	7 days	200 mL HDPE
Turbidity (50 NTU)	Y	store in the dark	48 hrs	100 mL HDPE
Uranium		HNO_3 to pH <2	6 months	500mL HDPE
Zinc, Total Recoverable (0.04 – 0.26)*	N	HNO_3 to pH <2	6 months	500 mL HDPE
Landfill Parameters				
Alpha Terpineol	Y	NA	7 days to extraction 40 days to analysis	1L Amber glass
Aniline	Y	NA	7 days to extraction 40 days to analysis	1L Amber glass
Benzoic Acid	Y	NA	7 days to extraction 40 days to analysis	1L Amber glass
Napthalene	Y	NA	7 days to extraction	1L Amber glass

Parameter (Benchmark Level, mg/l or as specified)	Preservation		Maximum Holding Time	Sample Container
	Cool to 4º C?	Additional		
			40 days to analysis	
p-Cresol	Y	NA	7 days to extraction 40 days to analysis	1L Amber glass
Pyridine	Y	NA	7 days to extraction 40 days to analysis	1L Amber glass

*These values are hardness dependent.

Field Blanks

Field blanks are distilled or de-ionized water samples prepared when you are collecting stormwater samples. Field blanks are prepared, in the field, after cleaning the sampling equipment but before collection of water quality samples. Blanks are prepared by pouring distilled de-ionized water into each scoop, dipper, etc. used for sample collection and then into sample bottles as if they were actual field samples. The field blanks are processed and analyzed in an identical manner as the stormwater samples. If the lab detects any contamination in the blanks, your sampling results could be considered tainted (either from contamination or errors in sampling or analysis). Collection and analysis of field blanks is not required by the 2008 MSGP; however, field blanks are used for quality control to assess whether contamination was introduced during sampling, and may prove useful in interpretation of results.

Chain of Custody Forms and Procedures

Samples must be traceable from the point of collection until the sampling results are reported. To do this, document who is in possession of the samples using the chain of custody procedures below. One person should be responsible for the care and custody of the samples, and for generating the chain of custody record until the samples are properly transferred or relinquished to the laboratory. Chain of custody tasks include:

- Ensure that the sample labels are properly filled in.
- Complete the chain of custody form with the date, time, parameter and sample locations for each sample, and sign the form.
- During the transfer of custody of the samples, both the persons relinquishing and receiving the cooler (including lab personnel) must record the date and time on the chain of custody form and sign it.
- Record the shipping method, courier name(s), and other pertinent information as remarks on the chain of custody form.
- The original chain of custody form remains with the samples and a copy must be provided to the facility for inclusion in project records.

Chain of custody records are critical to ensure that no tampering occurs between sample collection and analysis. Your analytical service provider may provide training or written instructions to assist in your completion of accurate custody records. This is another key area where many laboratories invite the opportunity to work with their clients as part of their value-added services.

3.5 Conducting Visual Assessments of Stormwater Discharges

All facilities covered by the 2008 MSGP must perform quarterly visual assessments, irrespective of benchmark monitoring.

Visually inspecting stormwater samples from a measurable discharge at your sampling outfalls is an inexpensive way of assessing the performance of your control measures. The sample should be collected and analyzed in a colorless glass or plastic bottle. It is recommended that you take photographs of the discharges at the time of observation in case more than one person is doing the assessments and because photos can be helpful in determining the effectiveness of your control measures and any need to make changes to control measures.

Assess the general appearance, as an indicator of contaminants, of your discharges for these characteristics:

- ***Color*** – If the discharge has an unusual color, such as reddish, brown, or yellow hue, this may indicate pollutants or suspended sediment.
- ***Odor*** – If the discharge has a noticeable odor, for instance if it smells like gasoline fumes, rotten eggs, raw sewage, or solvents odor, or has a sour smell, this could be indicative of pollutants in the discharge.
- ***Clarity*** – If the discharge is not clear, but is instead cloudy or opaque, this could indicate elevated levels of pollutants in the discharge.
- ***Floating solids*** – If you observe materials floating at or near the top of the bottle, take note of what the materials appear to be.
- ***Settled solids*** – You should wait about a half hour after collection, then note the type and size of materials that are settled at the bottom of the bottle.
- ***Suspended solids*** – Particles suspended in the water will affect its clarity, and color and could be attributable to pollutant sources at your facility.
- ***Oil sheen*** – You should check the surface of the water for a rainbow color or sheen; this would indicate the presence of oil or other hydrocarbons in the discharge.
- ***Foam*** – You should gently shake the bottle and note whether there is any foam.
- ***Other obvious indicators of stormwater pollution.***

To record your visual monitoring results you can use the optional “Quarterly Visual Monitoring Form” in Appendix B (or a comparable one of your own).

4. Evaluate Monitoring Results

The primary purpose of any industrial stormwater monitoring program, consisting of analytic chemical monitoring and visual assessments, is to provide feedback on the performance of your selection and implementation of control measures. Visual evidence of pollution in a stormwater sample, a spike in the concentration of a benchmark pollutant, or the exceedance of a numeric effluent limitation provides an indicator that modifications or additions to the site's control measures need to be considered to improve the effectiveness of your stormwater program.

The following will aid you in interpreting your monitoring results and revising your control measures, if necessary.

4.1 Evaluating Quarterly Visual Assessment Results

For anything but colorless and odorless stormwater in your discharge, you should investigate what area of your site or what specific pollutant sources are contributing to the contamination of your site's runoff. To search for the source of pollutants, you should move upstream from the discharge point. You should scrutinize your exposed industrial materials and activities (material handling equipment, industrial machinery, raw materials, finished product, wastes, or products that are stored, used or created onsite, etc.). Examine where material handling activities occur, such as: storage, loading and unloading, and material transporting. Be aware, the source could be from an ongoing activity or the result of a spill or other infrequent occurrence. In looking at your samples, consider the following:

- When there is a distinct color or odor, are the abnormalities associated with any raw materials, chemicals or other materials used at the site?
- Muddiness or sediment may have been picked up from areas where there is disturbed earth or other unpaved areas lacking adequate control measures.
- Foam or oil sheen may be the result of a leak or spill of materials.
- Cloudiness indicates suspended solids such as dust, ash, powdered chemicals, and ground up materials. Determine whether you use any of these materials and whether they are exposed to stormwater.

Clean up all sources of potential contamination, make changes to your control measures, and update your SWPPP, as necessary.

4.2 Evaluating Benchmark Monitoring Results

The analysis of your benchmark monitoring results can yield valuable information about the characteristics of your runoff and how well your control measures are working. Once you have received your lab results for your benchmark samples, compare these concentrations to the benchmark values that apply to your facility. The 2008 MSGP requires that you conduct four benchmark samples in your first year, and then compare the average value to the applicable benchmark. If the average concentration of your samples exceeds the benchmark, then you are required under the permit to evaluate whether changes to your control measures are necessary. See Parts 6.2.1.2 and 3.2. However, prior to the completion of the four samples, if one or more sample results makes an exceedance of the benchmark mathematically certain, you are required to conduct this evaluation without waiting for the results of the remaining benchmark samples.

Table 6 will help you decide a course of action depending on the results of your benchmark samples.

Table 6. Evaluation of Benchmark Monitoring Results

<table>
<tr><td colspan="2">Does the average of your four quarterly benchmark samples for any pollutant exceed the applicable benchmark concentration? OR
<u>If you have not yet completed your four quarterly benchmark samples, does the total value of your samples already make an exceedance of the benchmark mathematically certain (e.g., the sum of the concentration of your samples exceeds four times (4X) the benchmark concentration)?</u></td></tr>
<tr><td>YES</td><td>NO</td></tr>
<tr><td>You must evaluate whether modifications to the stormwater control measures used at your site are necessary. You will need to consider whether there is a problem in the selection, design, installation, and/or operation of applicable control measures. Follow the evaluation and corrective action process in Parts 3.2, 3.3, and 3.4.

An exceedance of a benchmark does not necessarily mean that your control measures are insufficient. Continue reading below for additional items to consider as you proceed.</td><td>Sample results below benchmark limits provide an indication that your control measures are working as intended to minimize the discharge of pollutants.

Although your samples indicate properly functioning control measures, you should continue to note changes to your site that may affect the quality of stormwater runoff, and to link such changes to your future monitoring results.

You are still required to meet all requirements in the permit affecting the implementation and maintenance of your control measures, despite the good results of your benchmark monitoring.</td></tr>
</table>

If benchmarks were exceeded:

- Did you sample correctly?
    - Did you start with clean sample collection jars and were the samples preserved and submitted to the lab within the allotted time frame?
    - Did you properly sample the discharge flowing from the site or did you collect the sample from a low spot or stagnant pool?

- Was anything atypical going on at the site prior to or during the storm? Atypical activities could include:

    - A leak or spill that was not adequately cleaned up.
    - Construction, painting and paving activities.
    - Having a large amount of material (raw materials, wastes or products) recently delivered or being prepared for shipment.

- Did you observe anything during visual inspections that may have indicated that stormwater runoff would have been exposed to pollutants? If so, are control measures in place to address the pollutant sources?

The more the benchmark was exceeded, the greater your facility's problems may be, necessitating a more robust response. For example, if your results for TSS were over the benchmark value by a relatively small amount (e.g., TSS values of 110 to 150 mg/L, compared to the 100 mg/l benchmark level assigned to TSS), then simply performing additional housekeeping measures (e.g., frequent sweeping) may reduce the values below the benchmark of 100 mg/l by the next storm. However, an exceedance above 150 mg/l may warrant new or supplementary control measures (assuming your control measures are performing as designed) that more effectively reduce the potential for sediment in discharges (e.g., installing storm inlet filters, seeding / stabilizing disturbed areas, implementing dust and debris controlling procedures). TSS values exceeding benchmarks by orders of magnitude indicate a serious problem, and may require structural control measures (e.g., paving, installing berms around piles of loose material, placing operations under cover, placing grassy swales or basins in the discharge flow path to trap sediment).

Until your visual observations and sampling results show that pollutants are not found in your discharges or are present in concentrations below benchmark values, the pollution prevention team should engage in an iterative process in which control measures are selected, implemented, evaluated and modified until determined to be completely effective.

There may be circumstances where benchmark values cannot be reasonably achieved because of local natural background concentrations (see 2008 MSGP Part 6.2.1.2). In such cases, EPA allows for benchmark exceedances. For example, high natural background levels of iron in soils or groundwater could cause exceedances of a benchmark value. This provision exempts facilities from further control measure evaluation and benchmark monitoring when natural background levels are solely responsible for the exceedance of a benchmark value.

To make this determination, natural background pollutant concentrations must be greater than the corresponding benchmark value, and there is *no* net facility contribution of the pollutant (i.e., average concentration detected in runoff from all monitored outfalls over four separate events minus the average natural concentration of the parameter for four separate events does not exceed zero).

For example, if the natural background concentration of TSS from an undisturbed watershed is 200 mg/L, an exemption from further benchmark monitoring / control measure evaluation is available if the average of your four benchmark samples is equal to or lower than 200 mg/L. There are additional requisites for claiming a natural background level exemption, including documentation. Details of these are contained in the 2008 MSGP in Part 6.2.1.2 and the Fact Sheet.

4.3 Effluent Limitation Guideline Monitoring Results

What happens if your facility is subject to numeric effluent limits (for ELG compliance monitoring) and your stormwater sample exceeds the effluent limits for one or more parameters? Within 24 hours of receiving the lab report you must prepare a corrective action report, including:

- Identification of the condition triggering the need for corrective action review;
- Description of the problem identified; and
- Date the problem was identified.

Within 14 days of receiving the lab report, you must document the following information:

- Summary of corrective action(s) taken or to be taken;
- Notice of whether any modifications to your control measures and any related changes to your SWPPP are necessary as a result of this discovery or corrective action;
- Date corrective action initiated; and
- Date corrective action completed or expected to be completed.

You must submit these reports with your annual report and retain a copy onsite with your SWPPP

The 2008 MSGP requires that you conduct follow-up monitoring within 30 calendar days of implementing corrective actions (or during the next qualifying runoff event, should none occur within 30 days, see Part 3 of the 2008 MSGP). Monitoring must be performed for any pollutant(s) that exceeded the effluent limit. If the results from the follow-up monitoring exceed the effluent limit(s), you are required to submit an Exceedance Report to EPA no later than 30 after receipt of your lab results. The exceedance report must include:

- NPDES permit tracking number;
- Facility name, physical address, and location;
- Name of receiving water;
- Monitoring data from this and the preceding monitoring event(s)

- An explanation of the situation; what you have done and intend to do (should your corrective actions not yet be complete) to correct the violation; and
- An appropriate contact name and phone number.

In addition to preparing the Exceedance Report, you must continue to monitor, at least quarterly, until your stormwater discharge is in compliance with the effluent limits or until EPA waives the requirement for additional monitoring.

4.4 Specific Pollutants and Control Measure Options

All facilities need to gear their control measures toward their specific pollutants of concern, as determined by the materials and activities onsite. Below is a brief discussion of some of the most common pollutants and control measure options.

- **Total Suspended Solids (TSS)**. Small sediment particles are easily suspended and carried by surface water flows. These particles may be blown onto the site from unpaved areas within or adjacent to your facility as well as being tracked in on the tires of vehicles. Excess particles may be self-generated, particularly in the concrete, asphalt, scrap recycling, automobile salvage, and mining sectors. See the discussion above for control measure options for controlling TSS.

- **Oil and Grease.** Often, oil and grease may be observed as a film, sheen or discoloration on the top of a discharge or receiving water. But such a surface anomaly may not be obvious, in which case detection by a lab would be the only way. This could be a pollutant of concern for any facility, especially if there are exposed vehicles or equipment. Therefore, it is vital that due diligence regarding “reportable quantity” (RQ) spills or leaks be observed. Basically, an RQ for oil is any quantity of oil that causes a film, sheen or discoloration on a receiving water surface (and for which there are separate reporting requirements to regulatory agencies). If detected you must find the source and mitigate it. Start with the vehicle / equipment maintenance and storage areas or where shipping / receiving and the like are done. Above ground storage tanks and waste storage are other likely sources.

  Available control measures range from regularly monitoring these areas and applying an absorbent material (choose a bio-based absorbent like Nature’s Broom, not a clay-based material) as soon as an oil leak or spill is observed. Consider coverage of and secondary containment for storage areas where oil or grease are stored, transferred or disposed of. An oil water separator downstream of the area(s) most likely to contain oil or grease could provide enough treatment to reduce oil and grease to acceptable levels in the discharge.

- **pH**. pH values below benchmark range indicate that acidic substances are exposed to stormwater. In this case you need to determine whether any of your industrial processes use acids and if so, where. Does your facility do plating, or are lead-acid batteries used or stored on-site? If acids are being used to clean parts, for example, where are the parts stored after being treated with the acid? Where are waste acids stored and how are they disposed? Which operations could expose acids to stormwater? Coal piles are also a source of acidified runoff.

  High pH values indicate that a base or alkaline material (such as lye) is exposed to stormwater. Cement and some cleansers can produce high pH values.

  Control measures applicable to controlling pH include housekeeping (sweeping and cleaning areas where materials that affect pH could be exposed to stormwater); overhead coverage and disposal of waste materials in covered receptacles. Low or high pH runoff can be collected and neutralized by adding an appropriate agent to neutralize pH values to the 6.0 – 9.0 range. Alternatively, flow can be directed to come in contact with a neutralizing substance (e.g., acidic coal pile runoff directed to flow through a limestone channel).

- **Chemical Oxygen Demand (COD)**. COD is the amount of dissolved oxygen in water consumed by the chemical breakdown of organic and inorganic matter (i.e., COD is not a specific component in the discharge). Therefore, a high COD value indicates elevated quantities of pollutants in runoff, especially carbon. Examples of facilities that handle materials which could cause high COD levels include the wood and paper product industries. Control measures applicable to controlling COD levels are the basic stormwater ones: good housekeeping and covering materials with the potential to allow carbon or other organic materials to be carried by stormwater.

- **Metals.** Metals originate from many sources and consequently a number of industries must monitor for metals, including facilities such as wood preservative and agricultural chemical makers, mines, and foundries. Depending on a facility's activities, metals can be found in a dissolved form and/or adsorbed to particles or sediment. It is because both the dissolved and particulate forms can occur at the same time is why stormwater discharges are analyzed for "total recoverable metals." After identifying those operations that could expose stormwater to metals sources, implement control measures capable of reducing metals concentrations, including good housekeeping (sweeping and disposing of metal wastes in covered containers), covering / shielding operations, and directing run-on away from any critical outdoor areas. Ion exchange techniques can also be employed to remove dissolved metals.

5. Record-Keeping and Reporting

It is important that accurate record-keeping of monitoring activities become a standard operating procedure at your facility. You need to be able to show that monitoring and sampling events not only meet all permit requirements, but are defensible and abide by all QA/QC procedures. It is always preferable to document too much as opposed to too little when dealing with any sort of permit compliance. Create easy to use log books for keeping track of rain events. Be sure that your site map is up to date and easy to understand. Develop simple instruction sheets for recording sampling, visual assessments, or other monitoring activities. The instructions should be kept in logical locations (e.g. in sample kits, in the SWPPP notebook) and updated as needed.

When possible, use standardized forms such as those provided in the appendices of this monitoring guide to record your monitoring activities. This will provide consistency in information reported. Example forms are provided in this guide in Appendix A (2008 MSGP Industrial Stormwater Monitoring Form), Appendix B (2008 MSGP Visual Monitoring Form), and Appendix C (2008 MSGP Industrial Stormwater Collection Form).

If possible, regularly transfer sampling records and sample results into databases or spreadsheets. This will provide back-up records for hard-copy logs or forms as well as providing an easy way to analyze your sampling data.

5.1 Reporting Monitoring Data

Each state industrial stormwater permit has different requirements for how monitoring data should be reported. Facilities subject to EPA's 2008 MSGP must submit to EPA all monitoring data collected no later than 30 days after receiving complete lab results for all monitored outfalls. You must submit even if your facility is reporting "no discharge" or a change in status from "active and staffed" to "inactive and unstaffed."

Facilities must use the online eNOI system (www.epa.gov/npdes/eNOI) to report results. EPA's Electronic Notice of Intent (eNOI) system is an online electronic permit application system that enables stormwater entities to submit NOI forms to EPA. eNOI also allows registered eNOI users to report discharge monitoring data and submit annual reports and other reporting information to EPA.

If you cannot access eNOI, the paper MSGP Discharge Monitoring Report (MDMR) reporting form (available at www.epa.gov/npdes/stormwater/msgp) can be submitted to the appropriate address identified in the 2008 MSGP (Part 7.6.1).

Even if you submit monitoring data via eNOI, the paper MDMR form can help ensure you have the information you need to complete all the required fields. Rather than go line by line through the MDMR, which the instructions do, this Guide will highlight the information needed to fill out the MDMR.

You will need the following information to submit monitoring data via eNOI and complete the MDMR, at a minimum:

1. Permit tracking number
2. The facility SWPPP

3. Monitoring records
4. Lab reports
5. Corrective actions

Permit Tracking Number – The permit tracking number is a unique identifier assigned to your facility by EPA. EPA tracks report submittals using the Permit Tracking Number rather than facility name or address. Thus, if you do not include the Permit Tracking Number you may not get credit for submitting the MDMR.

Facility SWPPP – The facility SWPPP includes several pieces of information needed for the MDMR, including:

- The number of stormwater outfalls.
- Which, if any, of the outfalls discharge substantially identical effluents.
- Alternative monitoring periods, if the facility is located in an area of irregular stormwater runoff.

Monitoring Records – Detailed monitoring records will make completing the MDMR easier. As previously discussed, monitoring records must include:

- The date(s) of all monitoring events during the MDMR reporting period.
- Any stormwater outfalls that did not have a discharge during the MDMR reporting period.
- Whether the discharge resulted from rainfall or snowmelt.
- The duration of the storm event.
- The number of inches of rainfall from the monitored storm event(s).
- The number of days since the previous measurable storm event, which may or may not be the previous *monitored* measurable storm event.

Lab Reports – The lab will provide a detailed report with the results of your stormwater analyses and detailed QA/QC data to verify that the results are accurate. For each parameter the lab will typically report one of three results to be reported on the MDMR.

1. The measured concentration to be compared against the benchmark or effluent limitation guideline.
2. BQL or below quantitation limit means that the parameter is present at some amount greater than zero but less than the quantitation limit but the method used is not precise enough to give an exact concentration. Report BQL and the numeric quantitation limit on the MDMR.
3. ND or not detected means that the parameter was not detected in the sample. Report ND and the detection limit on the MDMR. Note that the ND level is typically three to five times less than the quantitation limit.

Other lab reports you may need include receiving water hardness results if any of your required parameters are hardness dependent, and data on natural background pollutant levels if you are claiming that an exceedance of a benchmark limit is due to natural background conditions.

Corrective Actions – The 2008 MSGP requires you to implement corrective actions if the lab report indicates an exceedance of one or more numeric effluent limits or if the average of four quarterly samples exceeds the applicable benchmark. You must document discovery of effluent limit(s) or benchmark concentration(s) exceedances within 24 hours of receiving the lab report, including the condition triggering the need for corrective action review; a description of the problem; and the date the problem was identified. Within 14-days of receiving the lab report you must summarize the corrective action that was taken or will be taken, including a description of the corrective action; start and end dates; and whether the SWPPP will be modified. You can submit the corrective action report(s) via eNOI or along with the paper MDMR form.

6. Train Personnel

You must train your stormwater pollution prevention team in the proper procedures for sample collection, visual assessments, tracking and reporting. Trainings should be held regularly to update staff on any permit or SWPPP changes. New employees that become members of the stormwater pollution prevention team should be trained in general stormwater awareness as well as the following monitoring-specific topics:

- How to anticipate a measurable storm event.
- Where to monitor.
- How to collect and document the collection of stormwater samples including the assembling of “field blank” samples.
- How to perform and document visual assessments.
- How to handle and send the samples to the lab.
- How to interpret the results.
- How to keep accurate and complete records and report appropriate information to the permitting authority.

7. References

APHA (American Public Health Association). 1998. *Standard Methods for the Examination of Water and Wastewater, 20th Edition*. American Public Health Association, 20th Edition.

Ecology. 2002. *How To Do Stormwater Sampling: A Guide for Industrial Facilities*. Publication #02-10-071. State of Washington Department of Ecology, Olympia, Washington.

“EPA Administered Permit Programs: The National Pollutant Discharge Elimination System.” *Code of Federal Regulations* Title 40, Pt. 122.

“Guidelines Establishing Test Procedures for the Analysis of Pollutants.” *Code of Federal Regulations* Title 40, Pt. 136.

USEPA (U.S. Environmental Protection Agency). 1992. *NPDES Storm Water Sampling Guidance Document*. EPA 833-8-92-001. U.S. Environmental Protection Agency, Office of Water, Washington D.C.

USEPA (U.S. Environmental Protection Agency). 2008. *NPDES Multi-Sector General Permit for Stormwater Discharges Associated with Industrial Activity (MSGP)*. U.S. Environmental Protection Agency, Washington D.C.

Appendix A – 2008 MSGP Industrial Stormwater Monitoring Form

MSGP Industrial Stormwater/Snowmelt Monitoring Summary Form

Name of Facility:

Address:

Permit Tracking Number:

Pollutants to sample (Method)

Benchmark Levels and ELGs

Industry Sector	Pollutant	Benchmark Level	ELG Daily Max	ELG Monthly Average	ELG Instant Min/Max

Sample Summary

Outfall Identifier	Industry Sector (SIC)	Basis	Frequency	Timing								

Appendix B – 2008 MSGP Visual Monitoring Form

MSGP Quarterly Visual Assessment Form

(Complete a separate form for each outfall you assess)

Name of Facility:			Permit No.:	
Street Address:			City:	State: / Zip Code:
Outfall Number:	"Substantially Identical Outfall"? ☐ No ☐ Yes (identify substantially identical outfalls):_______			
Quarter/Year:	Substitute Sample?: ☐ No ☐ Yes (identify quarter/year when sample was originally scheduled to be collected):			
Person(s)/Title(s) collecting sample:				
Person(s)/Title(s) examining sample:				
Date & Time Storm or Snowmelt Began:	Date & Time Sample Collected: __________	Date & Time Sample Examined: _________		
Nature of Discharge: ☐ Rainfall	☐ Snowmelt			
Rainfall Amount: inches	Previous Storm Ended > 72 hours Before Start of This Storm? ☐ Yes ☐ No* (explain):			
Parameter				
Color	☐ None ☐ Other (describe):			
Odor	☐ None ☐ Musty ☐ Sewage ☐ Sulfur ☐ Sour ☐ Petroleum/Gas ☐ Solvents ☐ Other (describe):			
Clarity	☐ Clear ☐ Slightly Cloudy ☐ Cloudy ☐ Opaque ☐ Other (describe): _________			
Floating Solids	☐ No ☐ Yes (describe):			
Settled Solids**	☐ No ☐ Yes (describe):			
Suspended Solids	☐ No ☐ Yes (describe):			
Oil Sheen	☐ None ☐ Flecks ☐ Globs ☐ Sheen ☐ Slick ☐ Other (describe): _________			
Foam (gently shake sample)	☐ No ☐ Yes (describe):			
Other Obvious Indicators of Storm Water Pollution	☐ No ☐ Yes (describe): ____			

* The 72-hour interval can be waived when the previous storm did not yield a measurable discharge or if you are able to document (attach applicable documentation) that less than a 72-hour interval is representative of local storm events during the sampling period.

** Observe for settled solids after allowing the sample to sit for approximately one-half hour.

Sampling not performed due to adverse conditions: ☐ No ☐ Yes (explain): ____
____

Sampling not performed due to no measurable storm event occurring that resulted in a discharge during the monitoring quarter:
☐ No ☐ Yes (explain): ____

Detail any concerns, additional comments, descriptions of pictures taken, and any corrective actions taken below (attach additional sheets as necessary).

Certification by Facility Responsible Official (Refer to MSGP Subpart 11 Appendix B for Signatory Requirements)

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

A. Name _______________________________________ B. Title _______________________________________

C. Signature____________________________________ D. Date Signed__________________________________

Appendix C – 2008 MSGP Industrial Stormwater Collection Form

MSGP Industrial Stormwater/Snowmelt Discharge Collection Form

Name of Facility:

Address:

Person(s)/Title(s) collecting sample:

Permit Tracking Number:

Outfall Numbers/Sample Locations:

Discharge Information

Nature of Discharge (circle one): Rainfall or Snowmelt

Rainfall Amount (inches):

Date of Discharge Sampling:

Date & Time Storm Began:

Date & Time Storm Ended:

Date & Time of Previous Measurable Storm Event:

Sample Collection Information

Date & Time Sample Collection Began:

Date & Time Sample Collection Ended (if different):

Date	Time	Sample Identification/Outfall	Preservative (Y/N)	Number of Containers	Type of Analyses Required								Collection Method	Laboratory Log Number (Shaded area for laboratory use only)

Sampled by: (*signature*)	Date/Time:	Relinquished by: (*signature*)	Date/Time:	Received by: (*signature*)	Date/Time:
Received by: (*signature*)	Date/Time:	Received by: (*signature*)	Date/Time:	Received by: (*signature*)	Date/Time:

The 72-hour interval can be waived when the previous storm did not yield a measurable discharge or if you are able to document (attach applicable documentation) that less than a 72-hour interval is representative of local storm events during the sampling period.

Detail any concerns, additional comments, descriptions of pictures taken, and any corrective actions below (attach additional sheets as necessary).

Certification by Facility Responsible Official (Refer to MSGP Subpart 11 Appendix B for Signatory Requirements)

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

A. Name____ B. Title____

C. Signature____ C. Date Signed____

E.410
SUBSURFACE SAMPLING – GENERAL PUSH-PROBE TECHNOLOGY

Last Revision or Review: June 2010

1. OBJECTIVE

Geoprobe© equipment is a proprietary system capable of performing both sampling and onsite analysis functions. The proprietary name Geoprobe© has become synonymous with pushprobe technology, where the samplers or monitoring technology are advanced to depth by hydraulic push. The push may be assisted by inducing a vibration to the sampler.

Generally, sampling is accomplished using hydraulically pushed probes and analysis is accomplished using a gas chromatograph (GC). This equipment was originally developed to screen for the subsurface presence of volatile organic compounds (VOCs) in unsaturated zone soil gas. It may also be used to obtain soil and ground water samples and to screen such samples for VOCs or semivolatile organic compounds (SVOCs). However, the analytes of primary interest in Geoprobe work are generally VOCs.

Geoprobe equipment offers a relatively high degree of mobility for sampling and the ability to produce screening level analytical results while still mobilized to a site. The cost-effectiveness of this approach is reduced when soil or ground water samples are of interest, the analytes involved are SVOCs, or a higher degree of analytical quality is necessary.

The purpose of this document is to provide Terracon Geoprobe operators with a standard field procedure for general application. It may be supplemented by the generation of written site-specific sampling and analysis plans (SAPs) prepared prior to field work. Project Managers are generally responsible for providing Geoprobe operators with a SAP sufficiently in advance of proposed site work to allow for proper mobilization (including procurement of any necessary sampling equipment, sample containers, analytical standards, reagents, personal protective equipment, or other necessary equipment) and are required to consult with Geoprobe operators in the development of such SAPs.

2. SAFETY AND HEALTH

All Terracon field work is carried out under the provisions of a safety and health plan. Most Geoprobe work is covered by generic safety and health plans pertinent to intrusive work where petroleum hydrocarbons are anticipated or where there is a potential to encounter low concentrations of either petroleum hydrocarbons or chlorinated compounds. For any project involving greater potential hazard (e.g., work inside spaces with restricted ventilation and the potential to encounter high concentrations of volatile compounds, work involving the potential to encounter high concentrations of chlorinated compounds, or solvent extraction prior to analysis), the Project Manager will ensure that a site-specific safety and health plan is obtained from the Corporate Safety and Health Manager prior to mobilization.

3. EQUIPMENT

Geoprobe equipment may vary from unit to unit. But should carry the equivalent of the following equipment mounted in mobile one ton van:

1. Geoprobe components -

a. GW-40 hydraulically powered probe.
b. 1 inch nominal diameter 3 feet length probe rods.
c. Soil piston samplers and acetate liners.

2. GC components[1] -

a. Shimadzu GC-14A laboratory quality GC.
b. Shimadzu electron capture detector (ECD).
c. Shimadzu flame ionization detector (FID).
d. Photoionization detector (PID).
e. 30 m x 0.53 mm ID Supelco 3 mm Vocol capillary column.
f. Shimadzu gas flow controller.
g. Compressed air (service to FID).
h. Compressed hydrogen (service to FID).
i. Ultrapure compressed nitrogen or helium (carrier gas).
j. Regulators for compressed gas bottles.
k. Various size glass syringes (1 uL to 5 mL).
l. Appropriate analytical standards.
m. 40 mL nominal volatile organic analysis (VOA) vials.

3. Data system components -

a. APEX CSI dual channel A to D converter.
b. Sager NP 700 486-66 laptop computer.
c. APEX data system program (Version 2.1).

4. Miscellaneous equipment -

a. Scale.
b. Oven.
c. Fire extinguisher.

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[1] *Current equipment is listed. Equipment may change as appropriate for the analytes of concern and to reflect new technological developments. For example, the PID is currently out of service and is expected to be replaced in the future. Therefore, specific information regarding it is not listed. The standard column currently in use is listed. However, other columns may be more appropriate for the analyte(s) of concern in a specific project.*

d. Various tools.
e. Clean distilled and/or deionized water (hereinafter referred to as distilled) water.

4. METHODS

A. Sample Collection and Holding

The Geoprobe van, the working end of the hydraulic system (i.e., those portions of the system in contact with probe rods), all used probe rods, and all used sample contacting equipment will be cleaned prior to coming onsite for the first time in a project. Hydraulic lines will also be checked and tightened, if necessary, to ensure that no leaks are occurring. Clean probe rods will be used for each probe and used probe rods will be kept segregated from clean probe rods from the time they have been used until they have been cleaned. The working end of the hydraulic system will also be checked between probes and cleaned as necessary to reduce potential cross-contamination (see Section 4.D below regarding cleaning procedures).

1. Soil Gas Samples (Onsite Analysis)

a. Soil gas samples provide semiquantitative information concerning concentrations of VOCs in soil gas at the time of sampling. These may be influenced by the proximity of sources of VOC contamination (e.g., vertical contamination in the unsaturated zone soil profile or contaminated ground water) as well as a variety of other factors (e.g., soil and VOC characteristics and ambient temperature).

b. Soil gas samples will be taken at a depth of at least 6 feet below ground level (BGL). When attempting to characterize contaminated ground water plumes, soil gas samples will be taken within 3 feet of ground water.

c. Soil gas probes will be placed into the ground in a manner that will maintain a seal between the probe and the surrounding soil.

d. The suitability of each sampling location will be determined by testing the air permeability of the soil from which the sample is to be taken. An amount of air equal to five to 10 times the internal volume of the probe will be extracted prior to sampling. If this volume cannot be drawn within 10 minutes, soil gas cannot be used to test for VOC contamination at that location.

e. The sample will be collected for analysis without opening the system to outside air.

f. The sampling stream will be completely free of elastomers and each component of the sampling stream shall be new and clean or have been cleaned prior to each use. The cleanliness of the sampling stream shall be verified by running analytical blanks as specified in this document.

g. Soil gas samples will be analyzed immediately after the sample has been obtained.

2. Soil Samples (On/Offsite Analysis)

a. Currently accepted standard procedures for sample collection, sample preparation, and analysis of VOC contaminated soil samples necessarily involve substantial losses. Therefore, results for such samples should only be considered semiquantitative. Additionally, quantitative comparison of results should take into account whether they are based on dry or wet sample weight. Generally, commercial analytical laboratories report on a wet weight basis. However, results may be reported on a dry weight basis under certain circumstances.

b. Soil samples will be obtained using any standard Geoprobe sampler. Typically these consist of various size piston samplers. Preference is given to the use of large bore samplers with removable acetate liners. These are capable of recovering cores 24 inches long and 1-1/8 inches in diameter. Standard thin-walled samplers (Shelby tubes) may also be utilized.

c. A variety of containers are appropriate for the collection and storage of soil samples. These include the acetate liners noted above. When such liners are used, the ends must be sealed during storage prior to analysis and aliquots to be analyzed should be obtained from as near the center of the sample as possible. Soil samples to be sent offsite for analysis should be collected in clean, 4 ounce glass containers with Teflon-lined lids. Soil should be placed in these containers rapidly, with as little matrix disturbance as possible, and in a manner that minimizes headspace. The container should be tightly sealed immediately after the sample is placed in it. All soil samples should be preserved by cooling to 4 ^{o}C if they are not analyzed immediately after collection. Geoprobe analysis of soil samples for VOCs must be completed within 24 hours of sample collection.

d. Soil samplers will be cleaned prior to initial use at a site. They will also be cleaned prior to each subsequent use. The cleanliness of soil samplers shall be verified by running analytical blanks as specified in this document.

3. Ground Water Samples (On/Offsite Analysis)

a. Ground water samples obtained using Geoprobe equipment can be expected to contain substantial concentrations of sediments. Therefore, they should be considered equivalent in character to borehole water samples.

b. Ground water samples will normally be collected by vacuum extraction using the same probe rods and tubing utilized for soil gas sample collection. The Geoprobe may also be used to install small diameter slotted well points or push screen point samplers. Additionally, ground water samples may be obtained through probe rods or from slotted well points using stainless steel mini-bailers.

c. Ground water samples will be placed in clean, glass 40 mL VOA vials with open caps and Teflon septums. The sample shall be placed into these vials rapidly, with as little turbulence as possible, and in a manner that eliminates headspace. The container should be tightly sealed immediately after the sample is placed in it. All ground water samples should be preserved by cooling to 4 °C if they are not analyzed immediately after collection. Geoprobe analysis of ground water samples for VOCs must be completed within 24 hours of sample collection.

d. The sampling stream will be completely free of elastomers and each component of the sampling stream shall be new and clean or have been cleaned in accordance with the procedures specified in this document prior to each use. When reusable equipment is used (e.g., stainless steel mini-bailers), it will be cleaned prior to initial use and each subsequent use. The cleanliness of the sampling stream shall be verified by running analytical blanks as specified in this document.

Probe holes will generally be abandoned by backfilling with bentonite pellets immediately after rods and samplers have been withdrawn. In the event more restrictive project, local, or state requirements exist, they will be identified prior to field work and complied with.

B. Sample Preparation and Analysis (Onsite Analysis)

Manufacturer instructions will be complied with in the operation of the GC and ancillary equipment for the analysis of environmental samples. Information from the scientific literature will also be relied on for guidance. Selection of columns, GC operating parameters, and detectors will be consistent with and appropriate for the types of analytes of concern.

1. Soil Gas Samples

Soil gas samples are obtained with a glass syringe and run by direct injection into the GC. No other sample preparation is required. The volume of the injection can be varied to keep the response within the range of the calibration curve and bracketed by standards. Soil gas samples must be run at the time they are obtained. They may not be held for subsequent analysis.

2. Soil and Ground Water Samples

a. VOCs

1) VOCs must be extracted from the soil or ground water matrix for analysis by GC. This may be accomplished by purge and trap or headspace procedures. The normal Geoprobe procedure will be heated headspace. Research indicates that results by either approach can be expected to correlate well in the case of water samples that do not contain substantial concentrations of sediments. Data pertaining to the effect of sediments is lacking; however, purge and trap would be expected to be a more effective extraction procedure than headspace in the case of VOCs that are more likely to be adsorbed (i.e., having higher log octanol/water partition coefficients). Differences in the efficiency of extraction procedures for

specific VOCs should be considered when comparing Geo-probe and analytical laboratory results for split samples.

2) Soil Heated Headspace Analysis

a) Weigh a clean, dry, 40 mL VOA vial (with the top off). Record this weight to the nearest 0.1 g. The approximate mean weight of such vials is 24.1 g.

b) Place approximately 5 g of the soil sample in the vial and obtain their combined weight. Record this weight to the nearest 0.1 g and proceed to the next step (the combined weight minus the empty vial's weight is the weight of the sample). In the case of heavily contaminated samples, the mass of sample used can be reduced to keep the response within the range of the calibration curve and bracketed by standards.

c) Using a graduated cylinder, add 20 mL of clean, distilled water into the vial with the sample and cover it snugly by screwing on the vial's open top cap and Teflon seal.

d) Shake the sample to attempt to break the soil up.

e) Heat the sample in an oven at 60 ^{o}C for 15 minutes to facilitate volatilization of VOCs from the sample into the vial headspace.

f) Using a clean glass syringe, obtain a headspace gas sample through the Teflon seal for direct injection into the GC. The volume of the injection can be varied to keep the response within the range of the calibration curve and bracketed by standards.

3) Ground Water Heated Headspace Analysis

a) Using a clean graduated cylinder, place 20 mL[2] of the ground water sample into a clean 40 mL VOA vial and cover it snugly by screwing on the vial's open top cap and Teflon seal.

b) Heat the sample in an oven at 60 ^{o}C for 15 minutes to facilitate volatilization of VOCs from the sample into the vial headspace.

c) Using a clean glass syringe, obtain a headspace gas sample through the Teflon seal for direct injection into the GC. The volume of the injection can be varied to keep the response within the range of the calibration curve and bracketed by standards.

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[2] *The intention is to fill the vial to a volume exactly the same as that used for standards and approximately half full. Since the actual volume of these vials is approximately 44 mL, this will make the volumetric concentration of headspace gas slightly less than that of the ground water sample, if all VOCs can be driven from the aqueous to the gaseous phase. However, aqueous phase samples and standards having the same contaminant concentrations should produce equal gas phase concentrations.*

b. Various chemical extraction methods are available which may be used for SVOCs. Selection of an appropriate method will be made on a case-by-case basis. Whenever such a method is used, quality assurance (QA) measures will be utilized to evaluate its effectiveness (e.g., submittal of duplicate samples for laboratory confirmation or analysis of soil media certified performance evaluation samples) and appropriate provisions will be incorporated within the project safety and health plan.

3. Temperature Programs

The temperature program utilized must be appropriate for the analyte(s) of concern. Standard programs are as follows:

a. Chlorinated Solvents

1) Injector 225 ^{o}C
2) Initial column[3] 35 ^{o}C for 2 minutes
3) Column ramp rate 10 ^{o}C/minute
4) Final column 100 ^{o}C for 2 minutes
5) ECD and PID 250 ^{o}C

b. Petroleum Hydrocarbons

1) Injector 225 ^{o}C
2) Initial column 60 ^{o}C for 2 minutes
3) Column ramp rate 10 ^{o}C/minute
4) Final column
    1) BTEX/Gas TPH 150 ^{o}C for 2 minutes
    2) Diesel TPH 200 ^{o}C
5) FID and PID 250 ^{o}C

4. Compressed Gas Flow Rates

The standard column nitrogen gas flow rate is 10 mL/minute. The standard FID gas flow rates are 20 mL/minute for air and 4 mL/minute for hydrogen.

C. Analytical Quality Control and Assurance

Quality control (QC) and assurance (QA) terms have been variously defined. In this procedure they are defined as follows: QC consists of those activities performed for the purpose of controlling analytical quality; and QA consists of those activities performed for the purpose of providing assurance that analytical quality is in fact being achieved. By these definitions, QC activities include training of personnel, utilization of standard procedures, maintaining clean conditions through the use of new or properly cleaned equipment and reagents, maintenance of equipment, calibration activities, and documentation. QA activities include analysis of blanks,

[3] *When ambient air temperature exceeds 75 ^{o}F the initial column temperature will be 45 ^{o}C.*

analysis of known concentrations or spikes (including surrogates), analysis of replicate samples, analysis of evaluation samples, and audits. QA activities provide evidence that the analytical process is under control and capable of producing suitably unbiased, accurate, and precise results.

1. Quality Control

A primary QC requirement is that GC operators be properly trained and knowledgeable. However, operator training will not be otherwise addressed in this document. The purpose of this procedure is to help ensure that standard methods are available and implemented. Equipment cleaning procedures are specified in Section 4.D of this document. In general, maintenance of all equipment will be performed as specified in manufacturer instructions. Documentation requirements are specified in Section 5 below. Minimum calibration requirements are as follows:

a. Standards for calibration will be prepared from pure standard materials or purchased as certified solutions. Standards will be prepared in methanol. Standards will be stored with minimal headspace, at 4 ^{o}C, and protected from light. All standards must be replaced after six months, or sooner if comparison with check standards or other QA measures indicate a problem.

b. Initial calibration. When new equipment has been placed in operation, an initial calibration curve will be generated. A minimum of three standard levels will be used for initial instrument calibration when either an FID or PID is in use. When an ECD is used, a minimum of five standard levels will be used.

c. Continuing calibration. The calibration curve will be verified each working day by the injection of one or more calibration standards prior to analysis of any samples. If the response for analytes is within the range of 80 to 120 percent of that predicted, sample analysis may continue with the same calibration curve. If recovery is outside of that range, a new calibration curve will be prepared for the analyte involved by running two additional standards. Calibration standards will be run at a frequency of at least one for every 10 samples. When an ECD is in use, this frequency will be increased to one for every five samples. When a new calibration curve is required, results for all samples which have been run since the last satisfactory continuing calibration will be appropriately qualified to indicate that circumstance.

d. The type of calibration standard will be appropriate to the type of sample being analyzed. Gas phase standards will be used when analyzing soil gas and aqueous phase standards will be used to produce headspace gas for injection when analyzing soil and ground water samples. The working range will generally be defined by initial calibration standards of the following concentrations -

1) Gas phase: 15, 30, and 60 ug/L for all detectors. These concentrations will be achieved by varying injection volumes from a single concentration standard.

2) Aqueous phase: 5, 25, and 100 ug/L for FID and PID and 1, 5, 10, 25, and 50 ug/L for ECD. These concentrations will be achieved by a combination of varying the mass of standard injected into distilled water and/or injection volumes.

e. The calibration curve will be linear and pass through the origin. Additionally, the calculated correlation coefficient for it shall be 0.95 or greater.

f. Other combinations of calibration standards may be used if information on site conditions indicates they would produce equivalent or better results.

Additional QC requirements are as follows:

a. Glass syringes may be used on one sample per day. After use, they must be cleaned prior to reuse. Cleaning is accomplished by washing as necessary, rinsing with hexane and methanol, and baking at a temperature of at least 60 ^{o}C for at least 15 minutes.

b. The GC sample injector port septum will be replaced regularly, depending on use, to prevent possible gas leakage.

c. When pulling gas or aqueous phase samples from probes, tubing will be connected to the vacuum pump via an adaptor which does not come into contact with the sample stream. The adaptor will be replaced periodically as necessary to ensure cleanliness and a good fit. At the end of each working day, adaptors which have been used will be cleaned with a detergent solution, rinsed with control water, and baked at a temperature of at least 60 ^{o}C for at least 15 minutes prior to being reused.

2. Quality Assurance

a. Method Blanks

Method blanks will be run for the purpose of evaluating process bias. The following method blanks will be performed:

1) A method blank will be run at the beginning and, generally, near the end of each day of operation. However, the second method blank will not be run if cleaning of sample contacting equipment has not been performed or if results for a site are predominantly low or below detection limits. The method blank will include final rinse water from cleaning of probe rods and/or sample contacting equipment and aliquots of any reagents used in sample preparation. Distilled or "control water" will be substituted for final rinse water if the latter is unavailable.

2) If analytes are detected in a method blank, the source of the contamination will be identified and measures instituted to eliminate it. Results for any project samples which have already been run since the last clean method blank will also be evaluated to determine the impact of this circumstance. If the analytes involved were detected in them, they will be rerun. Otherwise, they will not be rerun.

b. Known Concentrations or Spikes

Continuing calibration standards will be utilized as known concentrations for the purpose of evaluating process accuracy and bias. Surrogates and matrix spikes will not normally be analyzed. If surrogates or matrix spikes are analyzed, the acceptance range is 80 to 120 percent recovery. Results within this range indicate an acceptable level of accuracy. If results are outside of this range, data must be appropriately qualified to indicate that circumstance and corrective action taken to regain process control.

c. Replicates

For every 10 samples (or at least once per day), a replicate shall be run for the purpose of evaluating process precision. Replicates shall be carefully prepared to minimize sampling variation as a source of error. All available site information shall be utilized to ensure that detectable concentrations of analytes are present in replicates. If detectable concentrations of analytes are not present in samples, a replicate of at least one continuing calibration standard per day shall be run. Results of 25 percent or less relative percent difference (RPD) indicate an acceptable level of precision. The RPD for comparison with this criterion is calculated as the absolute difference between replicate results divided by their mean. If results exceed this RPD, data must be appropriately qualified to indicate that circumstance and corrective action taken to improve process control.

d. Performance Evaluation Samples

The Geoprobe QA Officer will ensure that at least one certified performance evaluation sample (water media) per quarter shall be run on a single blind basis. The nature of such samples shall take the general sample load into consideration. When target compounds are predominantly volatile petroleum hydrocarbons, most performance evaluation samples will consist of the compounds benzene, toluene, ethylbenzene, and xylenes (BTEX). At least once a year, a performance evaluation sample (water media) for selected volatile halocarbons will also be run.

e. QA Audits

QA audits will be performed by the Geoprobe QA Officer on an on-call and project-specific basis. The file on at least one completed Geoprobe project involving onsite GC analysis will be randomly selected for audit each quarter. At or about the same time, the Geoprobe QA Officer will visually inspect the Geoprobe van and all onboard associated equipment.

The Geoprobe QA Officer will prepare a report following each calendar year for submittal to all Southern Division Office Managers. It will include the following information for that period:

1. Performance evaluation sample results.
2. Routine project file audit results.
3. On-call project-specific audit results.
4. Geoprobe van visual inspection results.

D. Equipment Cleaning

Cleaning of field equipment will be performed in accordance with ASTM Standard D 5088-90. At a minimum, this means that probe rods and sample contacting equipment will be washed with a detergent solution and rinsed with "control water". Control water is defined as water having a known chemistry. Water from any public water supply operating in compliance with the Safe Drinking Water Act should meet this requirement. It will generally not be necessary to document the quality of control water unless there are unresolved method blank detections. Trihalomethanes are the volatile contaminants most likely to be encountered in control water. Where more rigorous cleaning procedures are necessary, they will be specified in the site-specific SAP.

5. DOCUMENTATION

A separate project file (alpha identifier) will be maintained for Geoprobe projects. This file will include the following minimum documents:

1. That portion of the project SAP covering Geoprobe work.
2. The site-specific safety and health plan for all work requiring one.
3. A short narrative project report to include -
    a. A summary of field work performed.
    b. A summary of field methods actually used if there were any substantial deviations from or changes to the SAP.
    c. Reasons for any changes to the SAP.
    d. A site diagram with sufficient detail or information to approximately identify the location of all probes performed and/or samples obtained.
    e. The identity of onsite Terracon project personnel.
    f. The identity of onsite client project personnel.
    g. The identity of onsite regulatory or other significant personnel.
4. Results for each sample run (including calibration and QA samples). Results include the chromatogram obtained and output values determined for analytes (i.e., retention time, area, peak height, and concentration). The source of calibration should be identified for all samples.
5. The initial calibration curve, results of continuing calibration standards, and any subsequent calibration curves.
6. Results for all QA samples including calculated recovery and relative percent difference (RPD) values.
7. Other relevant project data.

STANDARD OPERATING PROCEDURE

E.700
WELL CONSTRUCTION - TEMPORARY

Last Review or Revision: June 2010

Objective

To provide standard procedures for the design and installation of temporary monitoring wells that will result in reliable construction and provide for the collection of representative groundwater samples.

Background

The standard practice for design and installation of monitoring wells is contained in ASTM D 5092 - 90 "Design and Installation of Groundwater Monitoring Wells in Aquifers." Terracon procedures incorporate the provisions of ASTM D 5092 that describe the specific procedures to be used in installing monitoring wells in unconsolidated formations for subsurface characterization of sites. The ASTM standard should be referred to when installation of monitoring wells is required outside of the temporary monitoring wells described here.

Equipment

The augers required for 2-inch diameter monitoring wells are 4-1/4-inch inside diameter hollow stem augers. For 4-inch wells the 6-1/4-inch inside diameter hollow stem augers are recommended. Flight augers are not recommended for installation of monitoring wells unless aquifer conditions are well known and will allow installation of screen and riser pipe without formation cave-in.

Monitoring Well Material

a) Riser Pipe

The riser pipe used is threaded, flush jointed Tri-Loc (or equivalent) Schedule 40 PVC pipe. This riser pipe has been found to provide a reliable and durable well.

b) Screen

Slot openings generally used for monitoring wells are 0.010 and 0.020 inch. The slot opening commonly used is 0.010 which will be effective with the use of gravel pack #20-40. If a larger slot opening is desired (.020), a gravel pack of #10-20 is recommended.

c) Gravel Pack

The standard gravel pack used is graded as #20-40 which is suited for use with a slot size of .010. Gravel pack should extend approximately two feet above the slotted screen. Gravel pack grading should be specified by the Project Manager or the Drilling Coordinator of the NE Division.

d) Bentonite

Bentonite pellets (1/4-inch size) are used to provide a relatively impermeable layer above the screen and gravel pack. One 5-gallon bucket of bentonite pellets should provide a two foot layer in the annulus of a boring created with 4 1/4-inch inside diameter augers and containing 2-inch monitoring well pipe.

e) Surface Security Materials

The well is secured with an expansion cap utilizing a keyed alike lock. A commercial flush mount protector or above-grade metal protector is used based on surface use conditions or client requirements.

Procedures

a) Background

Personnel involved in drilling operations must be familiar with the drilling procedures in ASTM D 5092. The Project Manager will specify the sampling interval, decontamination requirements, screen slot size, gravel pack size, and completion and survey requirements.

b) Mobilization

The project manager will prepare the mobilization sheets for the required drilling operation. The mobilization sheets should summarize types and quantities of well materials, drilling supplies, appropriate equipment, boring depths and boring locations. The enclosed tables should be referred to for calculating the volumes of gravel pack, bentonite, and grout required.

c) Field Operations

The field crews will review the mobilization sheets for adequacy. Unless otherwise specified the field crew will determine the specific use of equipment such as grout trailer, ready mix etc. The field crews will complete the monitoring wells as specified and complete forms for describing boring logs and well details. Any deviation from standard procedures or unusual observations should be noted by the field crews and reported to the project manager.

d) Well Security

The well is secured in accordance with the project manager's instructions and TSOPs E.900, E.905, E.910, or E.920. The proper well security materials to be used in completing the top of a monitoring well should be specified by the project manager and based on the expected ground surface use, regulatory requirements, and client desires. Care should be taken in installation of monitoring wells that will be subjected to vehicle traffic.

e) Well Documentation.

The well will be plugged and abandoned in accordance with TSOP E.1700.

e) Plugging and Abandonment.

The attached field boring log and monitoring well completion sheets are to be completed for each monitoring well.

Attached Supporting Documents

- Volume of Soil Boring, Annulus around 2” and 4” Casings, and Grout Mixtures
- **Terracon Form 130** – Log of Boring No., Monitoring Well Details, and Boring Elevations.
- **ASTM D 5092-90** *Design and Installation of Groundwater Monitoring Wells*
- Brainard Kilman Field Facts

VOLUME OF SOIL BORING

CUBIC FEET PER LINEAR FOOT

LENGTH (ft.)	DIAMETER OF SOIL BORING					
				INSIDE DIAMETER OF HOLLOW STEM AUGER		
				3.25	4.25	6.25
	2	4	6	7.25	8.25	10.25
1	0.028	0.088	0.201	0.29	0.37	0.57
2	0.06	0.18	0.4	0.6	0.7	1.1
3	0.08	0.26	0.6	0.9	1.1	1.7
4	0.11	0.35	0.8	1.2	1.5	2.3
5	0.14	0.44	1.0	1.5	1.9	2.9
6	0.17	0.53	1.2	1.7	2.2	3.4
7	0.20	0.62	1.4	2.0	2.6	4.0
8	0.22	0.70	1.6	2.3	3.0	4.6
9	0.25	0.79	1.8	2.6	3.3	5.1
10	0.28	0.88	2.0	2.9	3.7	5.7
11	0.31	0.97	2.2	3.2	4.1	6.3
12	0.34	1.06	2.4	3.5	4.4	6.8
13	0.36	1.14	2.6	3.8	4.8	7.4
14	0.39	1.23	2.8	4.1	5.2	8.0
15	0.42	1.32	3.0	4.4	5.6	8.6
16	0.45	1.41	3.2	4.6	5.9	9.1
17	0.48	1.50	3.4	4.9	6.3	9.7
18	0.50	1.58	3.6	5.2	6.7	10.3
19	0.53	1.67	3.8	5.5	7.0	10.8
20	0.56	1.76	4.0	5.8	7.4	11.4
22	0.62	1.94	4.4	6.4	8.1	12.5
24	0.67	2.11	4.8	7.0	8.9	13.7
25	0.70	2.20	5.0	7.3	9.3	14.3
26	0.73	2.29	5.2	7.5	9.6	14.8
28	0.78	2.46	5.6	8.1	10.4	16.0
30	0.84	2.64	6.0	8.7	11.1	17.1
32	0.90	2.82	6.4	9.3	11.8	18.2
34	0.95	2.99	6.8	9.9	12.6	19.4
35	0.98	3.08	7.0	10.2	13.0	20.0
36	1.01	3.17	7.2	10.4	13.3	20.5
38	1.06	3.34	7.6	11.0	14.1	21.7
40	1.12	3.52	8.0	11.6	14.8	22.8
45	1.3	4.0	9.0	13.1	16.7	25.7
50	1.4	4.4	10.1	14.5	18.5	28.5
55	1.5	4.8	11.1	16.0	20.4	31.4
60	1.7	5.3	12.1	17.4	22.2	34.2
65	1.8	5.7	13.1	18.9	24.1	37.1
70	2.0	6.2	14.1	20.3	25.9	39.9
75	2.1	6.6	15.1	21.8	27.8	42.8
80	2.2	7.0	16.1	23.2	29.6	45.6
85	2.4	7.5	17.1	24.7	31.5	48.5
90	2.5	7.9	18.1	26.1	33.3	51.3
95	2.7	8.4	19.1	27.6	35.2	54.2
100	2.8	8.8	20.1	29.0	37.0	57.0
125	3.5	11.0	25.1	36.3	46.3	71.3
150	4.2	13.2	30.2	43.5	55.5	85.5
175	4.9	15.4	35.2	50.8	64.8	99.8
200	5.6	17.6	40.2	58.0	74.0	114.0

GALLONS PER LINEAR FOOT

LENGTH (ft.)	DIAMETER OF SOIL BORING					
				INSIDE DIAMETER OF HOLLOW STEM AUGER		
				3.25	4.25	6.25
	2	4	6	7.25	8.25	10.25
1	0.17	0.66	1.5	2.14	2.78	4.29
2	0.3	1.3	3.0	4.3	5.6	8.6
3	0.5	2.0	4.5	6.4	8.3	12.9
4	0.7	2.6	6.0	8.6	11.1	17.2
5	0.9	3.3	7.5	10.7	13.9	21.5
6	1.0	4.0	9.0	12.8	16.7	25.7
7	1.2	4.6	10.5	15.0	19.5	30.0
8	1.4	5.3	12.0	17.1	22.2	34.3
9	1.5	5.9	13.5	19.3	25.0	38.6
10	1.7	6.6	15.0	21.4	27.8	42.9
11	1.9	7.3	16.5	23.5	30.6	47.2
12	2.0	7.9	18.0	25.7	33.4	51.5
13	2.2	8.6	19.5	27.8	36.1	55.8
14	2.4	9.2	21.0	30.0	38.9	60.1
15	2.6	9.9	22.5	32.1	41.7	64.4
16	2.7	10.6	24.0	34.2	44.5	68.6
17	2.9	11.2	25.5	36.4	47.3	72.9
18	3.1	11.9	27.0	38.5	50.0	77.2
19	3.2	12.5	28.5	40.7	52.8	81.5
20	3.4	13.2	30.0	42.8	55.6	85.8
22	3.7	14.5	33.0	47.1	61.2	94.4
24	4.1	15.8	36.0	51.4	66.7	103.0
25	4.3	16.5	37.5	53.5	69.5	107.3
26	4.4	17.2	39.0	55.6	72.3	111.5
28	4.8	18.5	42.0	59.9	77.8	120.1
30	5.1	19.8	45.0	64.2	83.4	128.7
32	5.4	21.1	48.0	68.5	89.0	137.3
34	5.8	22.4	51.0	72.8	94.5	145.9
35	6.0	23.1	52.5	74.9	97.3	150.2
36	6.1	23.8	54.0	77.0	100.1	154.4
38	6.5	25.1	57.0	81.3	105.6	163.0
40	6.8	26.4	60.0	85.6	111.2	171.6
45	7.7	29.7	67.5	96.3	125.1	193.1
50	8.5	33.0	75.0	107.0	139.0	214.5
55	9.4	36.3	82.5	117.7	152.9	236.0
60	10.2	39.6	90.0	128.4	166.8	257.4
65	11.1	42.9	97.5	139.1	180.7	278.9
70	11.9	46.2	105.0	149.8	194.6	300.3
75	12.8	49.5	112.5	160.5	208.5	321.8
80	13.6	52.8	120.0	171.2	222.4	343.2
85	14.5	56.1	127.5	181.9	236.3	364.7
90	15.3	59.4	135.0	192.6	250.2	386.1
95	16.2	62.7	142.5	203.3	264.1	407.6
100	17.0	66.0	150.0	214.0	278.0	429.0
125	21.3	82.5	187.5	267.5	347.5	536.3
150	25.5	99.0	225.0	321.0	417.0	643.5
175	29.8	115.5	262.5	374.5	486.5	750.8
200	34.0	132.0	300.0	428.0	556.0	858.0

VOLUME OF ANNULUS AROUND 2" CASING

CUBIC FEET PER LINEAR FOOT

LENGTH	DIAMETER OF SOIL BORING					
				INSIDE DIAMETER OF HOLLOW STEM AUGER		
				3.25	4.25	6.25
(ft.)	2	4	6	7.25	8.25	10.25
1	0	0.065	0.178	0.26	0.34	0.54
2	0	0.13	0.4	0.5	0.7	1.1
3	0	0.20	0.5	0.8	1.0	1.6
4	0	0.26	0.7	1.0	1.4	2.2
5	0	0.33	0.9	1.3	1.7	2.7
6	0	0.39	1.1	1.6	2.0	3.2
7	0	0.46	1.2	1.8	2.4	3.8
8	0	0.52	1.4	2.1	2.7	4.3
9	0	0.59	1.6	2.3	3.1	4.9
10	0	0.65	1.8	2.6	3.4	5.4
11	0	0.72	2.0	2.9	3.7	5.9
12	0	0.78	2.1	3.1	4.1	6.5
13	0	0.85	2.3	3.4	4.4	7.0
14	0	0.91	2.5	3.6	4.8	7.6
15	0	0.98	2.7	3.9	5.1	8.1
16	0	1.04	2.8	4.2	5.4	8.6
17	0	1.11	3.0	4.4	5.8	9.2
18	0	1.17	3.2	4.7	6.1	9.7
19	0	1.24	3.4	4.9	6.5	10.3
20	0	1.30	3.6	5.2	6.8	10.8
22	0	1.43	3.9	5.7	7.5	11.9
24	0	1.56	4.3	6.2	8.2	13.0
25	0	1.63	4.5	6.5	8.5	13.5
26	0	1.69	4.6	6.8	8.8	14.0
28	0	1.82	5.0	7.3	9.5	15.1
30	0	1.95	5.3	7.8	10.2	16.2
32	0	2.08	5.7	8.3	10.9	17.3
34	0	2.21	6.1	8.8	11.6	18.4
35	0	2.28	6.2	9.1	11.9	18.9
36	0	2.34	6.4	9.4	12.2	19.4
38	0	2.47	6.8	9.9	12.9	20.5
40	0	2.60	7.1	10.4	13.6	21.6
45	0	2.9	8.0	11.7	15.3	24.3
50	0	3.3	8.9	13.0	17.0	27.0
55	0	3.6	9.8	14.3	18.7	29.7
60	0	3.9	10.7	15.6	20.4	32.4
65	0	4.2	11.6	16.9	22.1	35.1
70	0	4.6	12.5	18.2	23.8	37.8
75	0	4.9	13.4	19.5	25.5	40.5
80	0	5.2	14.2	20.8	27.2	43.2
85	0	5.5	15.1	22.1	28.9	45.9
90	0	5.9	16.0	23.4	30.6	48.6
95	0	6.2	16.9	24.7	32.3	51.3
100	0	6.5	17.8	26.0	34.0	54.0
125	0	8.1	22.3	32.5	42.5	67.5
150	0	9.8	26.7	39.0	51.0	81.0
175	0	11.4	31.2	45.5	59.5	94.5
200	0	13.0	35.6	52.0	68.0	108.0

GALLONS PER LINEAR FOOT

LENGTH	DIAMETER OF SOIL BORING					
				INSIDE DIAMETER OF HOLLOW STEM AUGER		
				3.25	4.25	6.25
(ft.)	2	4	6	7.25	8.25	10.25
1	0	0.491	1.33	1.91	2.55	4.06
2	0	1.0	2.7	3.8	5.1	8.1
3	0	1.5	4.0	5.7	7.7	12.2
4	0	2.0	5.3	7.6	10.2	16.2
5	0	2.5	6.7	9.6	12.8	20.3
6	0	2.9	8.0	11.5	15.3	24.4
7	0	3.4	9.3	13.4	17.9	28.4
8	0	3.9	10.6	15.3	20.4	32.5
9	0	4.4	12.0	17.2	23.0	36.5
10	0	4.9	13.3	19.1	25.5	40.6
11	0	5.4	14.6	21.0	28.1	44.7
12	0	5.9	16.0	22.9	30.6	48.7
13	0	6.4	17.3	24.8	33.2	52.8
14	0	6.9	18.6	26.7	35.7	56.8
15	0	7.4	20.0	28.7	38.3	60.9
16	0	7.9	21.3	30.6	40.8	65.0
17	0	8.3	22.6	32.5	43.4	69.0
18	0	8.8	23.9	34.4	45.9	73.1
19	0	9.3	25.3	36.3	48.5	77.1
20	0	9.8	26.6	38.2	51.0	81.2
22	0	10.8	29.3	42.0	56.1	89.3
24	0	11.8	31.9	45.8	61.2	97.4
25	0	12.3	33.3	47.8	63.8	101.5
26	0	12.8	34.6	49.7	66.3	105.6
28	0	13.7	37.2	53.5	71.4	113.7
30	0	14.7	39.9	57.3	76.5	121.8
32	0	15.7	42.6	61.1	81.6	129.9
34	0	16.7	45.2	64.9	86.7	138.0
35	0	17.2	46.6	66.9	89.3	142.1
36	0	17.7	47.9	68.8	91.8	146.2
38	0	18.7	50.5	72.6	96.9	154.3
40	0	19.6	53.2	76.4	102.0	162.4
45	0	22.1	59.9	86.0	114.8	182.7
50	0	24.6	66.5	95.5	127.5	203.0
55	0	27.0	73.2	105.1	140.3	223.3
60	0	29.5	79.8	114.6	153.0	243.6
65	0	31.9	86.5	124.2	165.8	263.9
70	0	34.4	93.1	133.7	178.5	284.2
75	0	36.8	99.8	143.3	191.3	304.5
80	0	39.3	106.4	152.8	204.0	324.8
85	0	41.7	113.1	162.4	216.8	345.1
90	0	44.2	119.7	171.9	229.5	365.4
95	0	46.6	126.4	181.5	242.3	385.7
100	0	49.1	133.0	191.0	255.0	406.0
125	0	61.4	166.3	238.8	318.8	507.5
150	0	73.7	199.5	286.5	382.5	609.0
175	0	85.9	232.8	334.3	446.3	710.5
200	0	98.2	266.0	382.0	510.0	812.0

VOLUME OF ANNULUS AROUND 4" CASING

CUBIC FEET PER LINEAR FOOT

LENGTH (ft.)	DIAMETER OF SOIL BORING					
				INSIDE DIAMETER OF HOLLOW STEM AUGER		
				3.25	4.25	6.25
	2	4	6	7.25	8.25	10.25
1	0	0	0.11	0.2	0.26	0.46
2	0	0	0.2	0.4	0.5	0.9
3	0	0	0.3	0.6	0.8	1.4
4	0	0	0.4	0.8	1.0	1.8
5	0	0	0.6	1.0	1.3	2.3
6	0	0	0.7	1.2	1.6	2.8
7	0	0	0.8	1.4	1.8	3.2
8	0	0	0.9	1.6	2.1	3.7
9	0	0	1.0	1.8	2.3	4.1
10	0	0	1.1	2.0	2.6	4.6
11	0	0	1.2	2.2	2.9	5.1
12	0	0	1.3	2.4	3.1	5.5
13	0	0	1.4	2.6	3.4	6.0
14	0	0	1.5	2.8	3.6	6.4
15	0	0	1.7	3.0	3.9	6.9
16	0	0	1.8	3.2	4.2	7.4
17	0	0	1.9	3.4	4.4	7.8
18	0	0	2.0	3.6	4.7	8.3
19	0	0	2.1	3.8	4.9	8.7
20	0	0	2.2	4.0	5.2	9.2
22	0	0	2.4	4.4	5.7	10.1
24	0	0	2.6	4.8	6.2	11.0
25	0	0	2.8	5.0	6.5	11.5
26	0	0	2.9	5.2	6.8	12.0
28	0	0	3.1	5.6	7.3	12.9
30	0	0	3.3	6.0	7.8	13.8
32	0	0	3.5	6.4	8.3	14.7
34	0	0	3.7	6.8	8.8	15.6
35	0	0	3.9	7.0	9.1	16.1
36	0	0	4.0	7.2	9.4	16.6
38	0	0	4.2	7.6	9.9	17.5
40	0	0	4.4	8.0	10.4	18.4
45	0	0	5.0	9.0	11.7	20.7
50	0	0	5.5	10.0	13.0	23.0
55	0	0	6.1	11.0	14.3	25.3
60	0	0	6.6	12.0	15.6	27.6
65	0	0	7.2	13.0	16.9	29.9
70	0	0	7.7	14.0	18.2	32.2
75	0	0	8.3	15.0	19.5	34.5
80	0	0	8.8	16.0	20.8	36.8
85	0	0	9.4	17.0	22.1	39.1
90	0	0	9.9	18.0	23.4	41.4
95	0	0	10.5	19.0	24.7	43.7
100	0	0	11.0	20.0	26.0	46.0
125	0	0	13.8	25.0	32.5	57.5
150	0	0	16.5	30.0	39.0	69.0
175	0	0	19.3	35.0	45.5	80.5
200	0	0	22.0	40.0	52.0	92.0

GALLONS PER LINEAR FOOT

LENGTH (ft.)	DIAMETER OF SOIL BORING					
				INSIDE DIAMETER OF HOLLOW STEM AUGER		
				3.25	4.25	6.25
	2	4	6	7.25	8.25	10.25
1	0	0	0.84	1.48	1.95	3.46
2	0	0	1.7	3.0	3.9	6.9
3	0	0	2.5	4.4	5.9	10.4
4	0	0	3.4	5.9	7.8	13.8
5	0	0	4.2	7.4	9.8	17.3
6	0	0	5.0	8.9	11.7	20.8
7	0	0	5.9	10.4	13.7	24.2
8	0	0	6.7	11.8	15.6	27.7
9	0	0	7.6	13.3	17.6	31.1
10	0	0	8.4	14.8	19.5	34.6
11	0	0	9.2	16.3	21.5	38.1
12	0	0	10.1	17.8	23.4	41.5
13	0	0	10.9	19.2	25.4	45.0
14	0	0	11.8	20.7	27.3	48.4
15	0	0	12.6	22.2	29.3	51.9
16	0	0	13.4	23.7	31.2	55.4
17	0	0	14.3	25.2	33.2	58.8
18	0	0	15.1	26.6	35.1	62.3
19	0	0	16.0	28.1	37.1	65.7
20	0	0	16.8	29.6	39.0	69.2
22	0	0	18.5	32.6	42.9	76.1
24	0	0	20.2	35.5	46.8	83.0
25	0	0	21.0	37.0	48.8	86.5
26	0	0	21.8	38.5	50.7	90.0
28	0	0	23.5	41.4	54.6	96.9
30	0	0	25.2	44.4	58.5	103.8
32	0	0	26.9	47.4	62.4	110.7
34	0	0	28.6	50.3	66.3	117.6
35	0	0	29.4	51.8	68.3	121.1
36	0	0	30.2	53.3	70.2	124.6
38	0	0	31.9	56.2	74.1	131.5
40	0	0	33.6	59.2	78.0	138.4
45	0	0	37.8	66.6	87.8	155.7
50	0	0	42.0	74.0	97.5	173.0
55	0	0	46.2	81.4	107.3	190.3
60	0	0	50.4	88.8	117.0	207.6
65	0	0	54.6	96.2	126.8	224.9
70	0	0	58.8	103.6	136.5	242.2
75	0	0	63.0	111.0	146.3	259.5
80	0	0	67.2	118.4	156.0	276.8
85	0	0	71.4	125.8	165.8	294.1
90	0	0	75.6	133.2	175.5	311.4
95	0	0	79.8	140.6	185.3	328.7
100	0	0	84.0	148.0	195.0	346.0
125	0	0	105.0	185.0	243.8	432.5
150	0	0	126.0	222.0	292.5	519.0
175	0	0	147.0	259.0	341.3	605.5
200	0	0	168.0	296.0	390.0	692.0

GROUT MIXTURES

PORTLAND CEMENT GROUT

CUBIC FEET	CEMENT 94 lb. sack	BENTONITE lbs.	WATER gallons
1	0.6339	3.17	5.07
1.577	1.0	5.0	8.0
2	1.27	6.3	10.1
3	1.90	9.5	15.2
4	2.54	12.7	20.3
5	3.17	15.9	25.4
6	3.80	19.0	30.4
7	4.44	22.2	35.5
8	5.07	25.4	40.6
9	5.71	28.5	45.6
10	6.34	31.7	50.7
11	6.97	34.9	55.8
12	7.61	38.0	60.8
13	8.24	41.2	65.9
14	8.87	44.4	71.0
15	9.51	47.6	76.1
16	10.14	50.7	81.1
17	10.78	53.9	86.2
18	11.41	57.1	91.3
19	12.04	60.2	96.3
20	12.68	63.4	101.4
22	13.95	69.7	111.5
24	15.21	76.1	121.7
25	15.85	79.3	126.8
26	16.48	82.4	131.8
28	17.75	88.8	142.0
30	19.02	95.1	152.1
32	20.28	101.4	162.2
34	21.55	107.8	172.4
35	22.19	111.0	177.5
36	22.82	114.1	182.5
38	24.09	120.5	192.7
40	25.36	126.8	202.8
45	28.5	142.7	228.2
50	31.7	158.5	253.5
55	34.9	174.4	278.9
60	38.0	190.2	304.2
65	41.2	206.1	329.6
70	44.4	221.9	354.9
75	47.5	237.8	380.3
80	50.7	253.6	405.6
85	53.9	269.5	431.0
90	57.1	285.3	456.3
95	60.2	301.2	481.7
100	63.4	317.0	507.0
125	79.2	396.3	633.8
150	95.1	475.5	760.5
175	110.9	554.8	887.3
200	126.8	634.0	1014.0

BENTONITE GROUT

CUBIC FEET	BENTONITE 50 lb sack	WATER gallons
1	0.444	6.22
2	0.9	12.4
2.25	1	14
3	1.3	18.7
4	1.8	24.9
5	2.2	31.1
6	2.7	37.3
7	3.1	43.5
8	3.6	49.8
9	4.0	56.0
10	4.4	62.2
11	4.9	68.4
12	5.3	74.6
13	5.8	80.9
14	6.2	87.1
15	6.7	93.3
16	7.1	99.5
17	7.5	105.7
18	8.0	112.0
19	8.4	118.2
20	8.9	124.4
22	9.8	136.8
24	10.7	149.3
25	11.1	155.5
26	11.5	161.7
28	12.4	174.2
30	13.3	186.6
32	14.2	199.0
34	15.1	211.5
35	15.5	217.7
36	16.0	223.9
38	16.9	236.4
40	17.8	248.8
45	20.0	279.9
50	22.2	311.0
55	24.4	342.1
60	26.6	373.2
65	28.9	404.3
70	31.1	435.4
75	33.3	466.5
80	35.5	497.6
85	37.7	528.7
90	40.0	559.8
95	42.2	590.9
100	44.4	622.0
125	55.5	777.5
150	66.6	933.0
175	77.7	1088.5
200	88.8	1244.0

STANDARD OPERATING PROCEDURE

E.1805
FIELD MEASUREMENT – SURFACE ELEVATIONS

Last Review or Revision: June 2010

Objective

The purpose of this procedure is to establish proper and accurate methods to be used when surveying elevations on environmental sites.

Background

On many environmental sites, the horizontal spacing of monitoring wells may be less than 100 feet. The hydraulic gradient between these wells may be less than 0.1 feet, which necessitates an accurate survey of the top of casing elevations to 0.01 feet. Inaccurate elevations in some cases could result in an inaccurate determination of groundwater flow direction.

Procedures

a) In performing an elevation survey of a site, the first task is to choose a benchmark (BM). The BM should be of a permanent nature, that will exist over time and will not change in elevation. When using a fire hydrant as a BM, do not use the operating plug or adjustment nut. The elevation on the operating plug can change after the fire hydrant is used. Poured-in-place concrete, sign foundations and hydrants will make a good BM. Attempt to identify a BM with a known elevation to USGS or another datum.

b) When setting up the level, the instrument person should first ensure that the tripod legs are stabilized and then the instrument can be leveled using the leveling screws. Instruments which are leveled using a bar level need to be turned at right angles and re-leveled until the instrument indicates level in all directions without adjustment. Instruments with a bull's eye level ordinarily need to be leveled once, but the instrument should be turned 360° to ensure that it is accurately leveled.

c) When using the level, the instrument person should be able to accurately read the rod to 0.01 feet. This entails limiting the distance of the shot so that this accuracy can be maintained. Windy conditions will affect accuracy, especially on shots made where the rod is extended beyond 15 feet in the air. If the instrument person has difficulty reading the rod due to the wind blowing and bending the rod, or because the rod person has difficulty holding the rod in a stable position, the instrument person has the responsibility of resetting to ensure an accurate shot.

d) Finally, the instrument person should perform a closed loop, utilizing balanced backsight and foresight distances. This requires shooting back to the point of beginning, usually the BM. Upon completion of the loop, the instrument person is responsible for immediately calculating the closure error. On a small site with no turning points, this consists of resetting the instrument, thus creating a turning point and a loop. In these situations, the BM elevation should close with less than 0.01 foot difference. In situations where there are several turning points, the closure error should not be greater than 0.01 foot per 100 linear feet of surveyed distance.

Attached Supporting Documents

- Terracon Survey Notes Form

Standard Operating Procedures for Decommissioning Wells

Well Decommissions:

For resource protection wells and geotech soil borings that were constructed in accordance with WAC-173-160-420 will be decommissioned in one of the following ways.

1. Wells with an inside diameter equal to or greater than one inch and constructed in accordance with these regulations as verified through a field examination and review of the drilling report shall be decommissioned by filling the casing from bottom to land surface with bentonite, bentonite slurry, neat cement grout or neat cement.

2. Wells with an inside casing diameter less than one inch shall be decommissioned by pressure grouting the entire casing length with bentonite slurry, neat cement grout, or neat cement or pulling the entire casing string.

For resource protection wells and geotechnical soil borings that were not constructed in accordance with WAC-173-160-420 , or for which a drilling report required is missing, the wells will be decommissioned by overdrilling to remove or perforate the casing and sealing from bottom to land surface with bentonite, bentonite slurry, neat cement grout or neat cement.

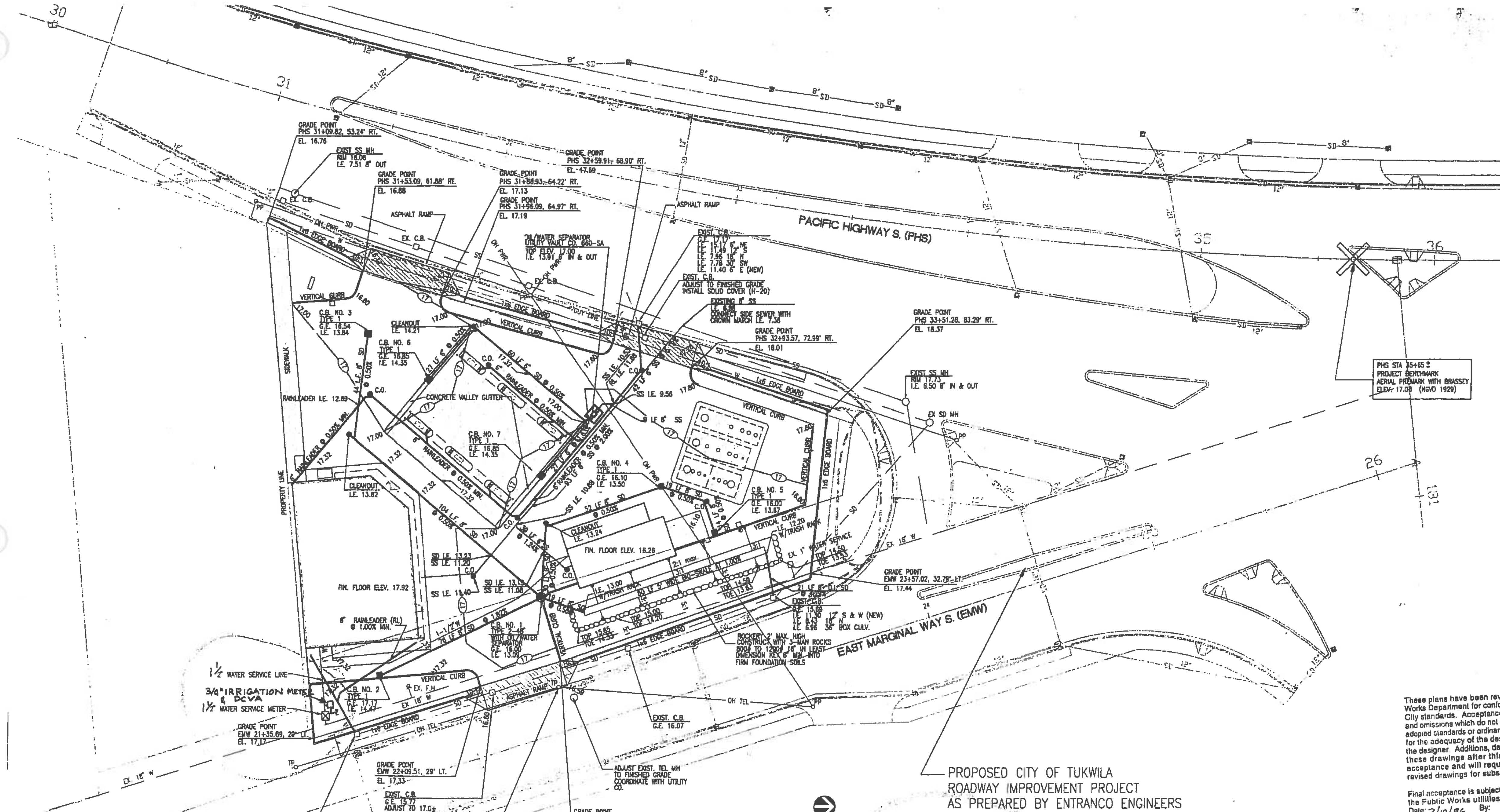
Surface Completions (monuments):

Monuments will be removed and patched to match the existing surface or sealed in place.

1210 Eastside Street SE, Suite 200 ■ Olympia, Washington 98501 ■ 360.459.4670 ■ FAX 360.459.3432
Web Site: www.esnnw.com E-Mail: info@esnnw.com

APPENDIX F

City of Tukwila Utility Maps



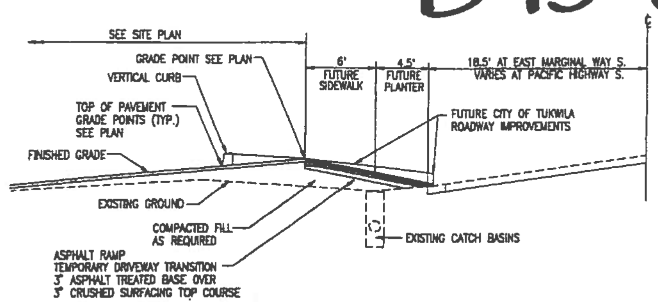
PLAN
SCALE: 1"=20'

APPROXIMATE GRADING QUANTITY
950 B.C.Y. EXPORT
250 C.Y. IMPORTED BACKFILL

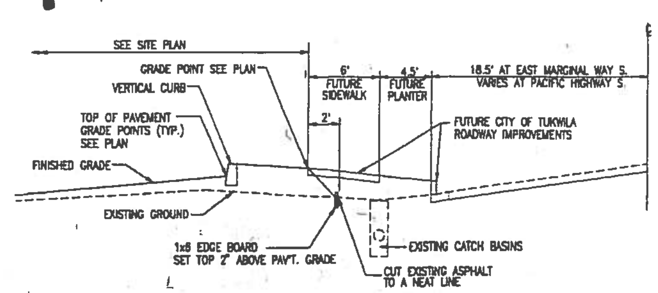
B95-0284

These plans have been reviewed by the Public Works Department for conformance with current City standards. Acceptance is subject to errors and omissions which do not authorize violations of adopted standards or ordinances. The responsibility for the adequacy of the design rests totally with the designer. Additions, deletions or revisions to these drawings after this date will void this acceptance and will require a resubmittal of revised drawings for subsequent approval.

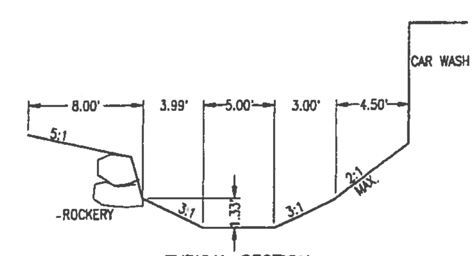
Final acceptance is subject to field inspection by the Public Works utilities inspector.
Date: 3/12/96 By: [signature]



TYPICAL ASPHALT RAMP DRIVEWAY TRANSITION



TYPICAL STREET FRONTAGE SECTION



TYPICAL SECTION

BIOFILTRATION SWALE SEED MIX

	% WEIGHT	% PURITY	% GERMINATION
RED FESCUE (Festuca rubo)	35	90	90
REDTOP (Argrosis alba)	35	92	85
MEADOW FOXTAIL (Alopecurus pratensis)	35	90	80

BIOFILTRATION SWALE DETAILS

RECEIVED
MAR 06 1996
TUKWILA PUBLIC WORKS

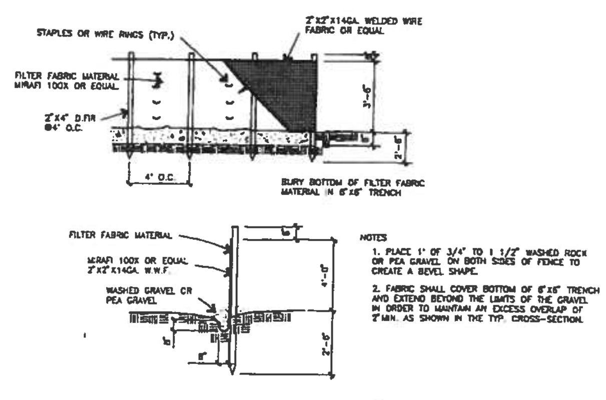
PERMIT REVIEW SET
NOT TO BE USED FOR CONSTRUCTION

DEA DAVID EVANS AND ASSOCIATES, INC.

Roger Ollenburg/architect
515 116th Avenue NE, Suite 202
Bellevue, Washington 98004
206.451-1232
fax: 206 451-1841

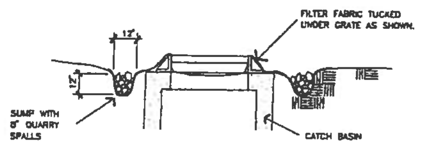
NEW SERVICE STATION
PRADEEP SANDHU
10805 EAST MARGINAL WAY SOUTH
TUKWILA, WASHINGTON
GRADING AND DRAINAGE PLAN

project no.: RAJ9418
file no: 9418-C1
drawn by: R O / EN
checked by: R O
date: 08-28-95
revisions:
12-27-95 ADDED CITY REVIEW COMMENTS
2-9-96 ADDED WATER MAIN ALONG MARGINAL WAY PER CITY OF TUKWILA REQUEST
3-1-96 CHANGED WATER SERVICE LOCATION PER CITY OF TUKWILA REQUEST
sheet: C2 of 3



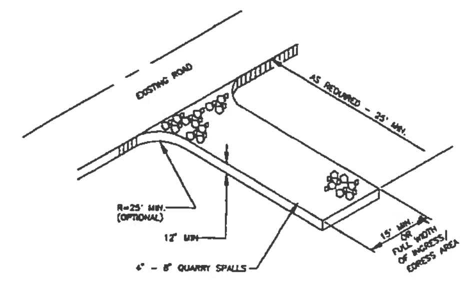
SILTATION FENCE DETAIL

NO SCALE



CATCH BASIN PROTECTION

NO SCALE

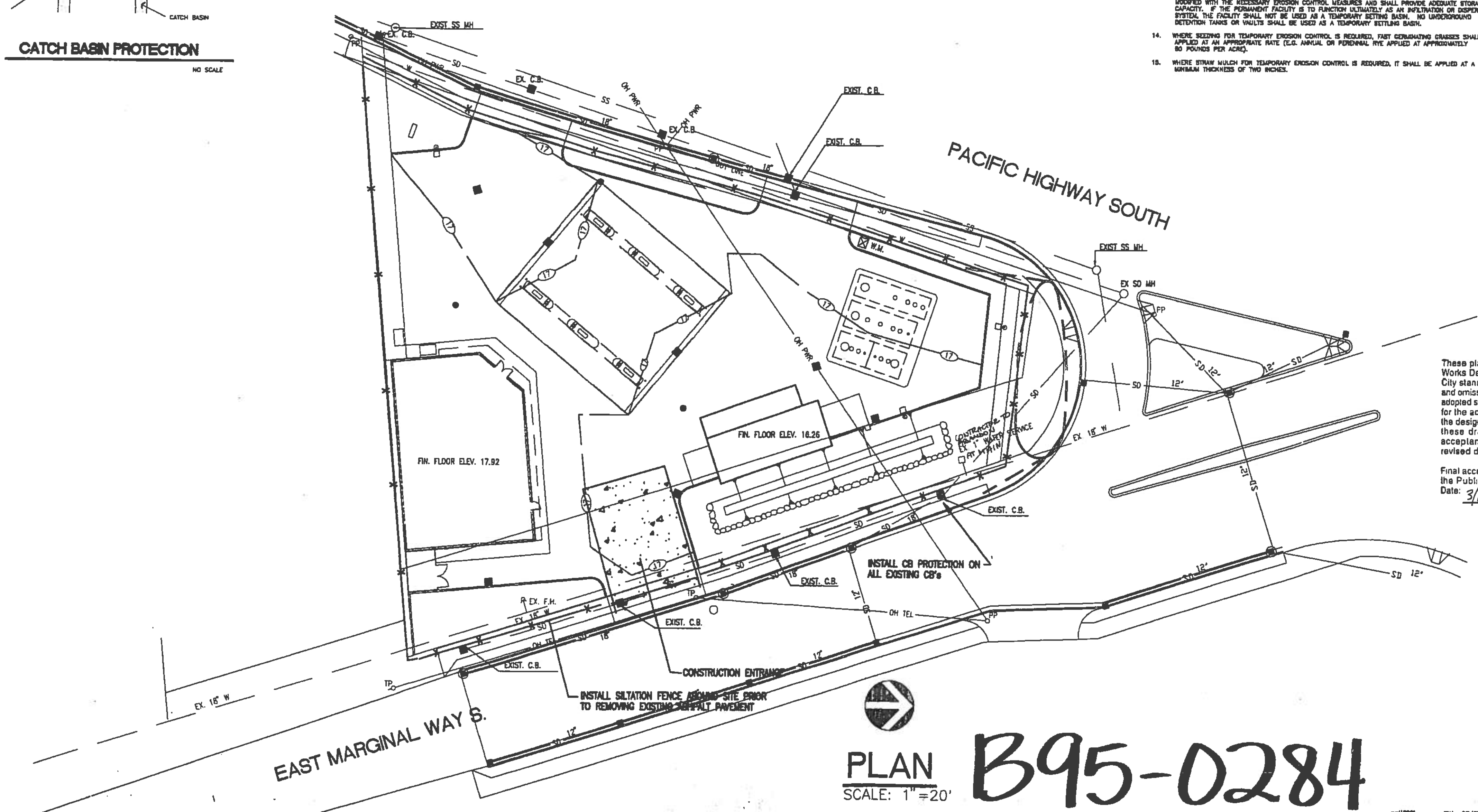


STABILIZED CONSTRUCTION ENTRANCE

NO SCALE

EROSION/SEDIMENTATION CONTROL NOTES

1. APPROVAL OF THIS EROSION/SEDIMENTATION CONTROL (ESC) PLAN DOES NOT CONSTITUTE AN APPROVAL OF PERMANENT ROAD OR DRAINAGE DESIGN (E.G. SIZE AND LOCATION OF ROADS, PIPES, RESTRICTORS, CHANNELS, RETENTION FACILITIES, UTILITIES, ETC.
2. THE IMPLEMENTATION OF THESE ESC PLANS AND THE CONSTRUCTION, MAINTENANCE, REPLACEMENT, AND UPGRADING OF THESE ESC FACILITIES IS THE RESPONSIBILITY OF THE APPLICANT/CONTRACTOR UNTIL ALL CONSTRUCTION IS APPROVED.
3. THE BOUNDARIES OF THE CLEARING LIMITS SHOWN ON THIS PLAN SHALL BE CLEARLY FLAGGED IN THE FIELD PRIOR TO CONSTRUCTION. DURING THE CONSTRUCTION PERIOD, NO DISTURBANCE BEYOND THE FLAGGED CLEARING LIMITS SHALL BE PERMITTED. THE FLAGGING SHALL BE MAINTAINED BY THE APPLICANT/CONTRACTOR FOR THE DURATION OF CONSTRUCTION.
4. THE ESC FACILITIES SHOWN ON THIS PLAN MUST BE CONSTRUCTED IN CONJUNCTION WITH ALL CLEARING AND GRADING ACTIVITIES, AND IN SUCH A MANNER AS TO INSURE THAT SEDIMENT LADEN WATER DOES NOT ENTER THE DRAINAGE SYSTEM OR VIOLATE APPLICABLE WATER STANDARDS.
5. THE ESC FACILITIES SHOWN ON THIS PLAN ARE THE MINIMUM REQUIREMENTS FOR ANTICIPATED SITE CONDITIONS. DURING THE CONSTRUCTION PERIOD, THESE ESC FACILITIES SHALL BE UPGRADED (E.G. ADDITIONAL SUMPS, RELOCATION OF DITCHES AND SILT FENCES, ETC.) AS NEEDED FOR UNEXPECTED STORM EVENTS .
6. THE ESC FACILITIES SHALL BE INSPECTED DAILY BY THE APPLICANT/CONTRACTOR AND MAINTAINED AS NECESSARY TO ENSURE THEIR CONTINUED FUNCTIONING .
7. ANY AREA STRIPPED OF VEGETATION, INCLUDING ROADWAY EMBANKMENTS, WHERE NO FURTHER WORK IS ANTICIPATED FOR A PERIOD OF 15 DAYS, SHALL BE IMMEDIATELY STABILIZED WITH THE APPROVED ESC METHODS (E.G. SEEDING, MULCHING, NETTING, EROSION BLANKETS, ETC.) .
8. ANY AREA NEEDING ESC MEASURE, NOT REQUIRING IMMEDIATE ATTENTION, SHALL BE ADDRESSED WITHIN FIFTEEN (15) DAYS.
9. THE ESC FACILITIES ON INACTIVE SITES SHALL BE INSPECTED AND MAINTAINED A MINIMUM OF ONCE A MONTH OF WITHIN THE 48 HOURS FOLLOWING A STORM EVENT.
10. AT NO TIME SHALL MORE THAN ONE FOOT OF SEDIMENT BE ALLOWED TO ACCUMULATE WITHIN A CATCH BASIN. ALL CATCH BASINS AND CONVEYANCE LINES SHALL BE CLEANED PRIOR TO PAVING. THE CLEANING OPERATION SHALL NOT FLUSH SEDIMENT LADEN WATER INTO THE DOWNSTREAM SYSTEM.
11. STABILIZED CONSTRUCTION ENTRANCES AND WASH PADS SHALL BE INSTALLED AT THE BEGINNING OF CONSTRUCTION AND MAINTAINED FOR THE DURATION OF THE PROJECT. ADDITIONAL MEASURE MAY BE REQUIRED TO INSURE THAT ALL PAVED AREAS ARE KEPT CLEAN FOR THE DURATION OF THE PROJECT (RCW 46.61.655).
12. DURING THE TIME PERIOD OF NOVEMBER 1 THROUGH MARCH 31, ALL PROJECT DISTURBED AREAS GREATER THAN 5,000 SQUARE FEET THAT ARE TO BE LEFT UNWORKED FOR MORE THAN 12 HOURS SHALL BE COVERED BY ONE OF THE FOLLOWING COVER MEASURES: MULCH, SODDING OR PLASTIC COVERING.
13. ANY PERMANENT RETENTION/DETENTION FACILITY USED AS A TEMPORARY SETTLING BASIN SHALL BE MODIFIED WITH THE NECESSARY EROSION CONTROL MEASURES AND SHALL PROVIDE ADEQUATE STORAGE CAPACITY. IF THE PERMANENT FACILITY IS TO FUNCTION ULTIMATELY AS AN INFILTRATION OR DISPERSION SYSTEM, THE FACILITY SHALL NOT BE USED AS A TEMPORARY SETTING BASIN. NO UNDERGROUND DETENTION TANKS OR VAULTS SHALL BE USED AS A TEMPORARY SETTLING BASIN.
14. WHERE SEEDING FOR TEMPORARY EROSION CONTROL IS REQUIRED, FAST GERMINATING GRASSES SHALL BE APPLIED AT AN APPROPRIATE RATE (E.G. ANNUAL OR PERENNIAL RYE APPLIED AT APPROXIMATELY 80 POUNDS PER ACRE).
15. WHERE STRAW MULCH FOR TEMPORARY EROSION CONTROL IS REQUIRED, IT SHALL BE APPLIED AT A MINIMUM THICKNESS OF TWO INCHES.



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Final acceptance is subject to field inspection by the Public Works utilities inspector.
Date: 3/12/96 By: [signature]

PLAN
SCALE: 1"=20'

B95-0284

RECEIVED
MAR 06 1996
TUKWILA PUBLIC WORKS

PERMIT REVIEW SET
NOT TO BE USED FOR CONSTRUCTION

DAVID EVANS AND ASSOCIATES, INC.

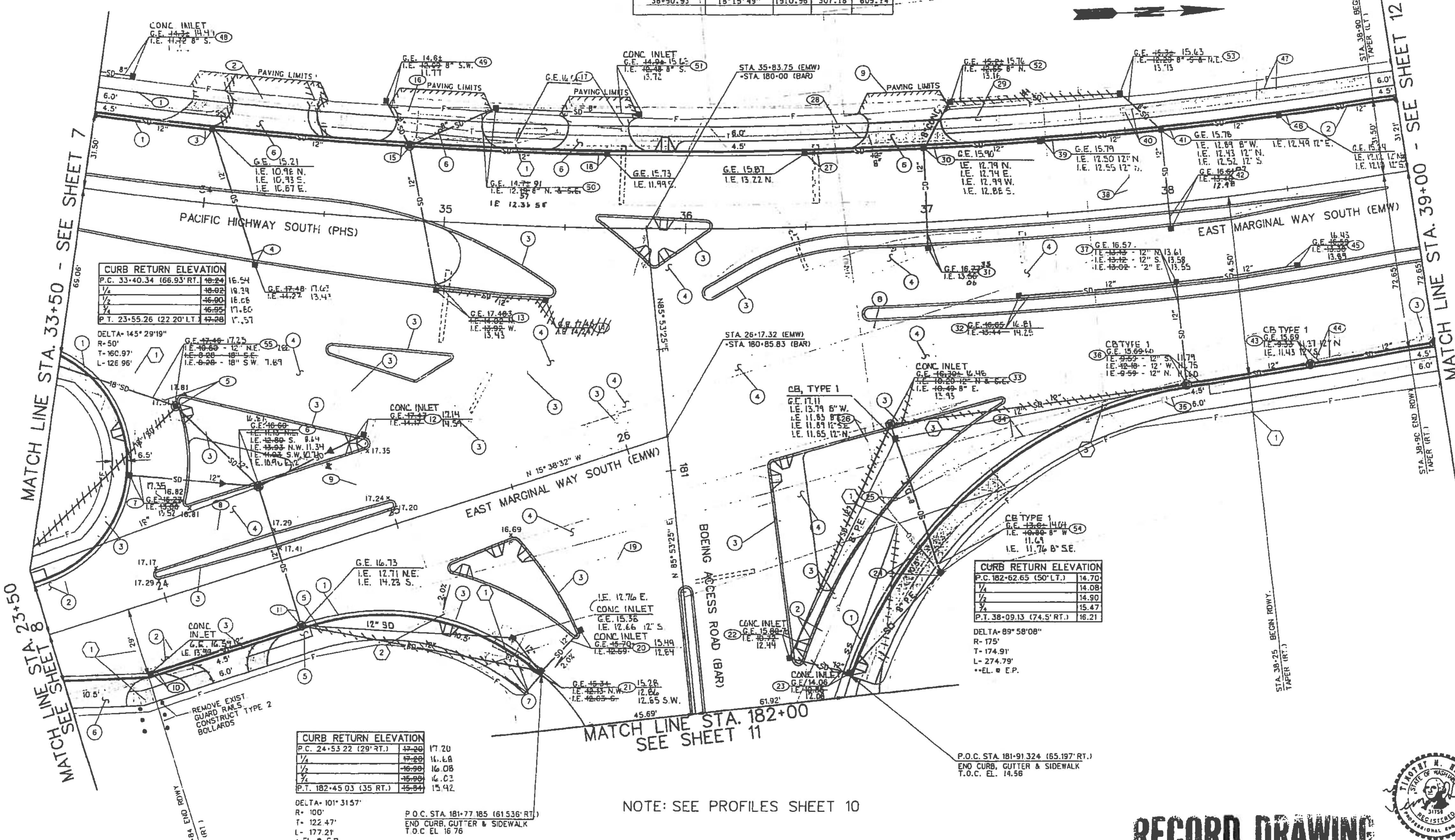
HAROLD P. PETERSON — STATE OF WASHINGTON — REGISTERED PROFESSIONAL ENGINEER — 20904
EXPIRES JUNE 7, 1996

Roger Ollenburg/architect
515 116th Avenue NE, Suite 202
Bellevue, Washington 98004
206 451-1232
fax: 206 451-1841

NEW SERVICE STATION
PRADEEP SANDHU
10805 EAST MARGINAL WAY SOUTH
TUKWILA, WASHINGTON
TEMPORARAY EROSION/SEDIMENTATION CONTROL PLAN

project no.: RAJ9418
file no: 9418-C1
drawn by: R O / EIN
checked by: R O
date: 08-28-95
revisions:
12-27-95 ADDED CITY REVIEW COMMENTS
2-9-96 ADDED WATER MAIN ALONG MARGINAL WAY PER CITY OF TUKWILA REQUEST

sheet: C1 of 3



CURVE DATA				
P.I. STATION	DELTA	RADIUS	TANGENT	LENGTH
32+94.17	17°30'09"	1910.96'	294.17'	583.75'
38+90.93	18°15'49"	1910.96'	307.18'	609.14'

CURB RETURN ELEVATION		
P.C. 33+40.34 (66.93' RT.)	~~18.24~~	16.54
1/4	~~18.02~~	18.39
1/2	~~16.00~~	16.68
3/4	~~16.95~~	17.60
P.T. 23+55.26 (22.20' LT.)	~~17.28~~	17.57

DELTA= 145° 29'19"
R= 50'
T= 160.97'
L= 126.96'

CURB RETURN ELEVATION		
P.C. 24+53.22 (29' RT.)	~~17.20~~	17.20
1/4	~~17.20~~	16.68
1/2	~~16.98~~	16.08
3/4	~~15.98~~	16.03
P.T. 182+45.03 (35 RT.)	~~15.84~~	15.92

DELTA= 101° 31'57"
R= 100'
T= 122.47'
L= 177.21'
*=EL. @ E.P.

CURB RETURN ELEVATION	
P.C. 182+62.65 (50' LT.)	14.70
1/4	14.08
1/2	14.90
3/4	15.47
P.T. 38+09.13 (74.5' RT.)	16.21

DELTA= 89° 58'08"
R= 175'
T= 174.91'
L= 274.79'
*=EL. @ E.P.

NOTE: SEE PROFILES SHEET 10

CITY OF TUKWILA

RECORD DRAWING

EXPIRES 08-05-97

PUBLIC WORKS DEPARTMENT
ENGINEERING • STREETS • WATER • SEWER • PARKS • BUILDING •

ENTRANCO
ENGINEERS SCIENTISTS PLANNERS SURVEYORS
WASHINGTON IDAHO ARIZONA

EAST MARGINAL WAY

ROADWAY PLAN
BOEING ACCESS ROAD INTERSECTION
SEE MATCH LINES

9
78

APPENDIX G

Tank Tightness Testing Results

Northwest Tank & Environmental Services, Inc.
17407 59th Ave SE
Snohomish, WA 98296
PH: (800) 742-9620 FAX: (425) 645-7881
http://www.nwtank.com

Wednesday, November 25, 2015

Boeing Field Chevron
10805 E Marginal Way S
Tukwila, WA 98168

Boeing Field Chevron
10805 E Marginal Way S
Tukwila, WA 98168

RE: Job ID 50431

Dear Valued Customer:

The **Official Report** including all test results and any supporting documentation are enclosed. The test data covered in this report are specific to each test conducted. For your convenience, a summary of testing conducted is provided on the report cover page.

Unless stated otherwise, all compliance testing data must be maintained on site for a minimum of **5 years.** Instructions for specific test types may follow.

Please call if you have any questions or require additional information.

Sincerely,

Svetlana Vovkulin

Northwest Tank & Environmental Services, Inc.

Maintain all test reports on-site for a minimum of 5 years.

OFFICIAL REPORT

Test Report For:

Client
Boeing Field Chevron
10805 E Marginal Way S
Tukwila, WA 98168
Job #: 50431

Site
Boeing Field Chevron
10805 E Marginal Way S
Tukwila, WA 98168

Date Testing Conducted

Monday November 16, 2015

Testing Summary

Pressure Decay Go-Back	Pass

Report Analyst: ____________ Certified Supervisor: Robert Garretson Certificate #: 203723-U3

Work Acknowledgement Form

Customer Name: Boeing Field Chevron
Site Name: Boeing Field Chevron
Site Address: 10805 E Marginal Way S, Tukwila
Job Number: 50431
Ticket / PO#: COD
Date Of Service: 11/16/2015

Testing Company: Northwest Tank & Environmental Services, Inc.
Primary Technician: Robert Garretson
Address: 17407 59th Ave SE
City/State/Zip: Snohomish, WA 98296
PH: (800) 742-9620

Start Time:	08:24:01	End Time:	09:38:35	Number of Technicians:	1

Scope of work scheduled:
Pressure Decay Go-Back

Site Representative Upon Checkin: Paul
Signature: Paul

Monitoring System Issues Observed Upon Arrival:	Dispenser and UST System Issues Observed Upon Arrival:
None	Pump 11 And 12 bagged out

Dispatch Notes:
repairs to dispenser 11/12, isolated vapor piping needs reconnected.

Technician Comments:

-----Pressure Decay-----
Comments - System had pressure upon arrivial.

Before starting test hooked vapor line back to disp 11/12.

After 30 min wait period. Dropped system pressure to .5" WC.

Pressurized system to 2" WC. SYstem holds to passing standard 1.92" WC.

Monitoring System Issues Noted at Departure:	Dispenser and UST System Issues Noted at Departure:
None	None

Monthly Monitoring Records for the last 12 Months

Tanks					
Tank State ID	**Product**	**Tank Overfill and Monthly Monitoring Verification**	**Verification Method**	**Monthly Monitor**	**Records Maintained 12 Months**
3	Regular	BF	Visual	Interstitial	Yes
4	Diesel	BF	Visual	Interstitial	Yes
1	Premium	BF	Visual	Interstitial	Yes
2	Midgrade	BF	Visual	Interstitial	Yes

Lines			
Line ID	**Tank State ID**	**Line Monthly Monitoring Verification**	**Records Maintained 12 Months**
1	1	Annual Line Test	Yes
2	2	Annual Line Test	Yes
3	3	Annual Line Test	Yes
4	4	Annual Line Test	Yes

Post-Operation Checks

Technician has pumped from each product? N/A

Technician has walked the site for remaining tools and hazards? Yes

Technician Signature:

Have all isolated mechanisms been removed? N/A

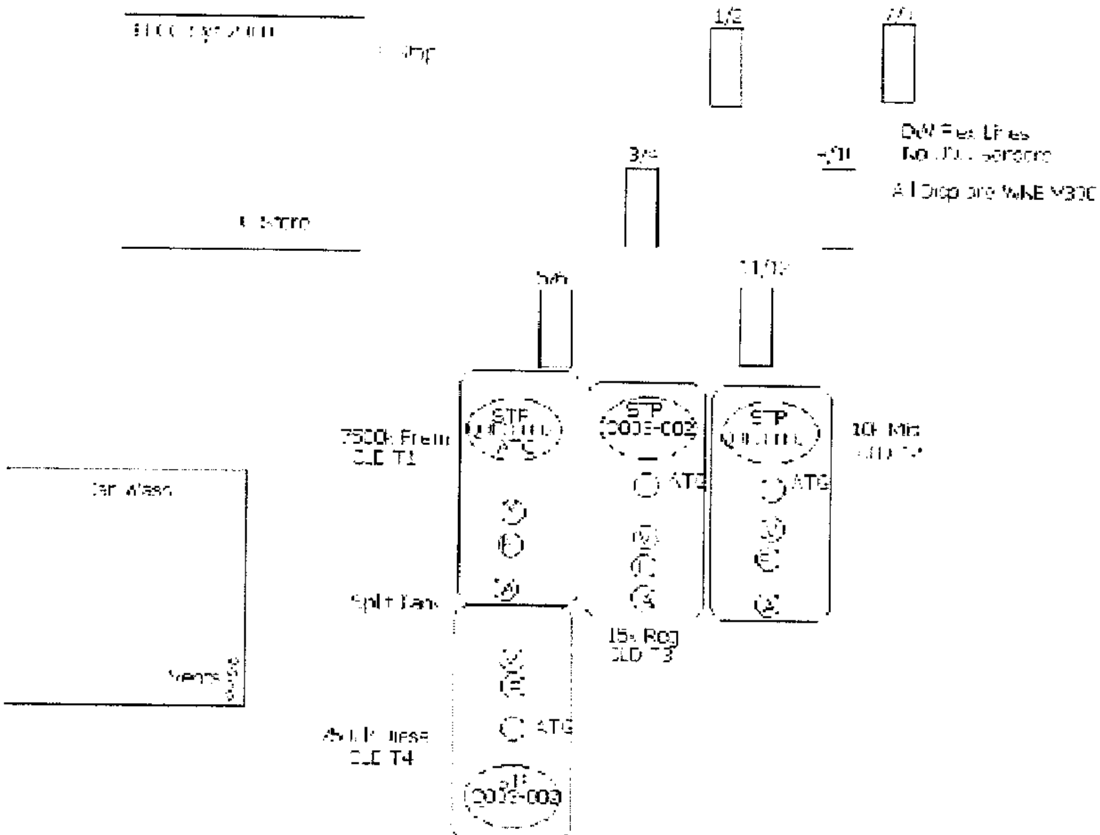
Dispensers out of stand-alone? N/A

Site Representative at Checkout:

Site Map

Customer Name: Boeing Field Chevron **Site Name:** Boeing Field Chevron

Site Address: 10805 E Marginal Way S, Tukwila
Job Number: 50431



Pressure Decay Test CARB Test Procedure TP-201.3 or Procedure in CARB Executive Order for Stage 2 Equipment

Company Name: Boeing Field Chevron
Site Name: Boeing Field Chevron
Address: 10805 E Marginal Way S Tukwila, WA 98168
Air Agency Reg#: PSCAA
Test Date/Time: 11/16/2015 08:35:58 am
Overall Result: Pass

Testing Company Name: Northwest Tank & Environmental Services, Inc.
Address: 17407 59th Ave SE
City/State/Zip: Snohomish, WA 98296
PH: (800) 742-9620
FAX: (425) 645-7881
http://www.nwtank.com

Tank Tie Section

Tanks Manifolded? Yes
Method used to determine manifold: Depressed Vapor Adaptors during PD test.

Type of Stage 1: Dual Point Standard
Total Nozzles: 36
Type of Stage 2: Vac Assist
Tested with vapor cap: Off

Tank#	# of Nozzles	Product	Ullage	Tank Total Capacity
3	12	11331.41	3180.26	14511.7
1	12	3267.60	4032.32	7299.9
2	12	3362.44	6431.40	9793.8
	Totals:	**17961.45**	**13643.98**	**31605.40**

Test Results

Allowable Pressure	Duration	1st Reading	2nd Reading	3rd Reading	4th Reading	5th Reading
1.92	5 min	2	1.98	1.96	1.94	1.92

Comments:
System had pressure upon arrivial. Before starting test hooked vapor line back to disp 11/12. After 30 min wait period. Dropped system pressure to .5" WC. Pressurized system to 2" WC. SYstem holds to passing standard 1.92" WC.

Person Conducting the test:

Robert Garretson — [signature] — 11/16/2015

Print Name — Signature — Date

Tank owner or authorized representative:

RAJ SANDHU — [signature] — 11/25/2015

Print Name — Signature — Date

Permit to work for Petroleum/Convenience Sites

Worker Signatures: I have reviewed and understand the conditions of this permit and its attachments. I will report hazardous conditions or acts identified on this jobs ite to my supervisor or customer representative.	1: 2: 3:

Person In Charge: Robert Garretson
Date: 11/16/2015
Work Order#: 50431
Nearest Hospital: (see hospital map)

Location: Boeing Field Chevron, 10805 E Marginal Way S Tukwila, WA
Time Issued: 11/16/2015 08:26 am
Time Expires: 11/17/2015 08:26 am
Emergency Phone#: 911

REQUIRED PERMITS AND/OR PROCEDURES

[ ] Hot Work
[ ] Excavation Checklist
[ ] Lock-Out Tag-Out
[ ] Pre Entry Checklist
[ ] Confined Space
[ ] One Call
[ ] Hoisting/Rigging
[ ] Management Of Change
[ ] Work Notification
[ ] Other

HAZARDOUS ENERGY LOCK-OUT TAG-OUT (LOTO)- API 1646 Section 12

Has piece of equipment or system been properly isolated? N/A
Has energy isolation been reviewed by all affected workers? N/A
List All Affected Workers:

CONFINED SPACE PRE-ENTRY CHECKLIST / RECLASSIFICATION - API 1646 Section 11

Surrounding areas free of hazards? N/A
Proper notifications made? N/A
Does your knowledge indicate that the area will remain free from all atmoshperic hazards? N/A
Are you trained in confined space entry? Yes

Are you trained in the operation of the air monitor used? N/A
Has the monitor been calibrated before use? N/A
Did you test the atmoshphere in the space before entry? N/A
Did the atmosphere check as acceptable? N/A
Will the atmosphere be continuously monitored? N/A

Sump	Time	Isolation	Lel	Oxygen	Toxicity	Atmosphere	Electrical Loto	Lines Disconnected	Pumps Off	Valves Shut

I ensure this permit has been filled out completely and in conjunction with all applicable OSHA requirements to provide a safe workplace for all workers and myself. I will take action to eliminate hazardous conditions or acts identified on this job site.

Person in Charge Signature:

Job Clearance Form

Contractor instructions prior to start of work. 1. Review form, check appropriate boxes, read and sign at the bottom of this form. 2. Inform dealer, manager or representative of the job to be performed and potential safety concerns and obtain signature.

Station #:	Station Address:	Work Order Number:	Date:
Boeing Field Chevron	10805 E Marginal Way S, Tukwila	50431	11/16/2015

Contractor Company Name:	Contact Person in Charge:	Number of Workers:	JFA Reference Number (if required):	Start Time:	End Time:	Labor:	Travel Time:	Travel Distance:
Northwest Tank & Environmental Services, Inc.	Robert Garretson				11/16/2015 9:38:35 AM	0.00	0.00	0

Problem / Work Description

Return Call: Yes
Damage Claim: No

PPE REQUIRED (CHECK ALL THAT APPLY AND/OR FILL IN "OTHER" BLANK SPACE)

Safety Vest: Yes	Hard Hat: N/A	Shoes/Boots: Yes	Hearing Protection: N/A	Respirator: N/A
Protective Clothing: Yes	Gloves: Yes	Safety glasses/goggles: Yes	Fire Resist Clothing/Welding PPE: N/A	Other:

Contractor to complete section below if circumstances on site or specific to this job may generate additional hazards not described in the JSA.

Task Step	Hazards not covered by JSA	How to reduce or eliminate risk - include extra PPE to be worn
Pressure Decay Site Info Work Permit		

Work documentation requirements: Lower Risk - This form may be used as JSA Medium Risk/Higher Risk - JSA Required Higher Risk - JSA Required and other customer requirements may apply

Examples of higher/medium Risk Tasks:
Hot Work
Excavation Checklist
Lock-Out Tag-Out
Pre Entry Checklist
Confined Space
One Call
Hoisting/Rigging
Management Of Change
Work Notification
Other

This form must be completed for each job and updated and re-signed if circumstances change or additional hazards are identified.

SIGN IN

Operating sites: to be signed by the site representative. Non-Operating sites: to be signed by contractor representative only.
Contractor responsibility to inform site of:

Hazards of the job,
Effects on the site or operation,
Any affect to gasoline deliveries,
Energy isolation needed,
Areas to be barricaded for worker/public safety.

Contractor Representative Name	Signature
Robert Garretson	[signature]
Site Representative Name	Signature
Contractor has discussed Job Clearance Form with me.	
Paul	[signature]

SIGN OUT AND OPERATOR VERIFICATION OF WORK

General safety checks by contractor
Has the work area been left tidy and safe?
Is the site operator aware of status of work including any remaining isolation
Are changes to equipment documented and communicated?
All incidents, near misses, unsafe situations reported?

Contractor Representative Name	Signature
Robert Garretson	[signature]
Site Representative Name	Signature
Paul	[signature]

Site Representative Comments

None

Please refer to work acknowledgement form for a complete list of parts installed.

Permit to Work

Date: 11/16/2015
Job ID: 50431
Company: Boeing Field Chevron
Site: Boeing Field Chevron
Technician: Robert Garretson

Scope of Work:
Pressure Decay Go-Back

Hazard Analysis:
Hot Work
Excavation Checklist
Lock-Out Tag-Out
Pre Entry Checklist
Confined Space
One Call
Hoisting/Rigging
Management Of Change
Work Notification
Other

Site Evaluation	
E-Stop switch located	Yes
Storm drain(s) located	Yes
Hand/Eyewash facility located	Yes
Identify other contractors	N/A
Identify traffic ingress/egress	Yes
Identify evacuation routes	Yes
Assembly Area:	Napa

Personal Protective Equipment	
First Aid Kit stocked	Yes
Note Depleted Stock:	
Nitrile Gloves	Yes
Safety Vest	Yes
Safety Glasses	Yes
Hard Hat	N/A
Hearing Protection	N/A
Knee Pads	Yes
Back Brace	N/A
Harness / Lanyard	N/A

Safety Equipment	
Lockout / Tagout	N/A
Oxygen / Vapor Sensor	N/A
Ventilator	N/A
Retrieval Equipment	N/A
Delineators / Perimeter Fencing	Yes
Ground Fault Circuit Interruptor	N/A
20# Fire Extinguisher	Yes
Static Grounds	N/A
Explosion-Proof Pump	N/A
Absorbant Rags	N/A
Communication Equipment (cell phone)	Yes
Scissor Lift**	N/A
** For work above 6', an elevated work permit is required.	
Refer to your Company Safety manual for standard operating procedures and equipment standards. Please contact your immediate supervisor to clarify procedures not covered in your safety manual.	

Pre-Operation Checks	
Ladder Inspection **	Yes
Extension Cord Inspection	N/A
Oxygen / Vapor Sensor Calibrated	N/A
Tools / Equipment in Good Repair	Yes
Equipment Grounding	N/A
Hazard Communication	N/A
** Work cannot be performed on ladder above 6'.	

Pre-Entry Checklist for Confined Space	
Is the sump greater than 5' deep?	N/A
Is there hazardous liquid/vapor present?	N/A
Is there a lack of oxygen within the space?	N/A
IF ANY OF THESE ARE ANSWERED YES A PERMIT MUST BE ISSUED!	

Job Completion Checklist	
Have all isolation mechanisms been removed	N/A
Have you pumped from each product?	N/A
Are all dispensers out of "stand-alone"	N/A
Have you walked the site for tools or hazards?	N/A