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State of Washington

Quality Assurance Project Plan

Black Lake Grocery Groundwater Confirmational Monitoring

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Each study conducted by the Washington State Department of Ecology (Ecology) must have an approved Quality Assurance Project Plan. The plan describes the objectives of the study and the procedures to be followed to achieve those objectives. After completing the study, Ecology will post the final report of the study to the Internet.

The plan for this study is available on the Department of Ecology's website at www.ecy.wa.gov/biblio/1103114.html.

Data for this project will be available on Ecology's Environmental Information Management (EIM) website at www.ecy.wa.gov/eim/index.htm. Search User Study ID, PMART007.

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Quality Assurance Project Plan

Black Lake Grocery
Groundwater Confirmational Monitoring

September 2011

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SWRO: Southwest Regional Office.
EAP: Environmental Assessment Program.
EIM: Environmental Information Management database.

Table of Contents

Page

List of Figures and Tables....3

Abstract....4

Background....4

Project Description....8

Organization, Schedule, and Analytical Costs....9

Quality Objectives....11

Sampling Design and Field Procedures....12

Laboratory Procedures....14

Quality Control Procedures....15
Field....15
Laboratory....16

Data Review and Verification....16

Data Management Procedures....17

Data Reporting....17

References....18

Appendices....20
Appendix A. Summary of Sample Results (ug/L) from November 1993 to June 2009....21
Appendix B. Glossary, Acronyms, and Abbreviations....24

List of Figures and Tables

Page

Figures

Figure 1. General Location of the Black Lake Grocery Site. 5

Figure 2. Black Lake Grocery Site Sample Locations...6

Tables

Table 1. Organization of Project Staff and Responsibilities..9

Table 2. Proposed Schedule for Completing Field and Laboratory Work, Data Entry into EIM, and Reports..10

Table 3. Project Analytical Costs...10

Table 4. Laboratory Analyte Measurement Quality Objectives 11

Table 5. Well Purging Criteria..13

Table 6. Sample Containers and Preservation. 13

Table 7. Laboratory Analytical Methods...15

Abstract

Black Lake Grocery is an active gas station and convenience store located on the northwest shore of Black Lake, Thurston County, Washington. In 1989, soil and groundwater beneath the site were found to be contaminated with gasoline-range petroleum hydrocarbons. To remediate the site several underground storage tanks and petroleum-contaminated soil were removed. In 2004, a treatment wall was constructed along Black Lake's shoreline to remediate the contaminated groundwater before it enters the lake.

Groundwater from on-site monitoring wells has been sampled and analyzed for petroleum constituents from November 1993 to June 2009. Overall, concentrations have decreased since the excavation and removal of contaminated soils and installation of the treatment wall. However, concentrations still exceed the Model Toxics Control Act (MTCA) cleanup levels in several of the wells throughout the project area.

The goal of this project is to provide Ecology's Toxics Cleanup Program (TCP) with current groundwater data so they may evaluate the effectiveness of the treatment wall in remediating the contaminated groundwater before it enters Black Lake. To accomplish this goal Ecology's Environmental Assessment Program (EAP) will collect groundwater samples for total petroleum hydrocarbons as gasoline (TPH-G), and benzene, toluene, ethylbenzene, and xylene (BTEX) from 11 on-site monitoring wells quarterly for one year. The wells will provide monitoring points to evaluate groundwater conditions throughout the project area.

Background

Black Lake Grocery is an active gas station and convenience store located on the northwest shore of Black Lake (Figure 1). The store is situated on a 5.2-acre parcel of land approximately 100 feet from the lakeshore. In 1989, soil and groundwater beneath the site were found to be contaminated with gasoline-range petroleum hydrocarbons (Dames and Moore, 1990).

In 1992, the Washington State Department of Ecology (Ecology) conducted a site hazard assessment. The site was ranked on Ecology's Hazardous Site List as a "2" (rank of 1 is highest priority relative to other statewide sites; rank of 5 is the lowest). By 1995, seven underground storage tanks and 1200 cubic yards of petroleum-contaminated soils were removed. However, total petroleum hydrocarbons (TPH) and benzene, toluene, ethylbenzene, and xylenes (BTEX) for soil still exceeded Model Toxics Control Act (MTCA) Method-A cleanup levels beyond the limits of excavated area. Contaminated material beyond the excavated area was not removed because it was not accessible below the adjacent county roads (Summit, 2000). A remedial investigation/feasibility study was completed in 2001.

In November 2004, remediation continued with the construction of a treatment wall downgradient of the contaminant source (Figure 2). The treatment wall, located near the lakeshore, is approximately 120 feet long, 5 feet wide and 12 feet deep and composed of a reactive material (an engineered sphagnum peat moss). The treatment wall acts as a passive treatment barrier designed to remediate the contaminated groundwater as it flows through the reactive materials and before it enters the lake.

In 2005, sediment and surface water samples were collected near the lake shoreline to determine if petroleum products had migrated into Black Lake. No significant levels of contamination were detected.

Groundwater at the site has been sampled and analyzed for petroleum constituents since November 1993. Overall, concentrations have decreased since excavation and removal of contaminated soils and installation of the treatment wall. However, concentrations still exceed the MTCA cleanup levels in several of the wells throughout the project area. Appendix A summarizes the results.

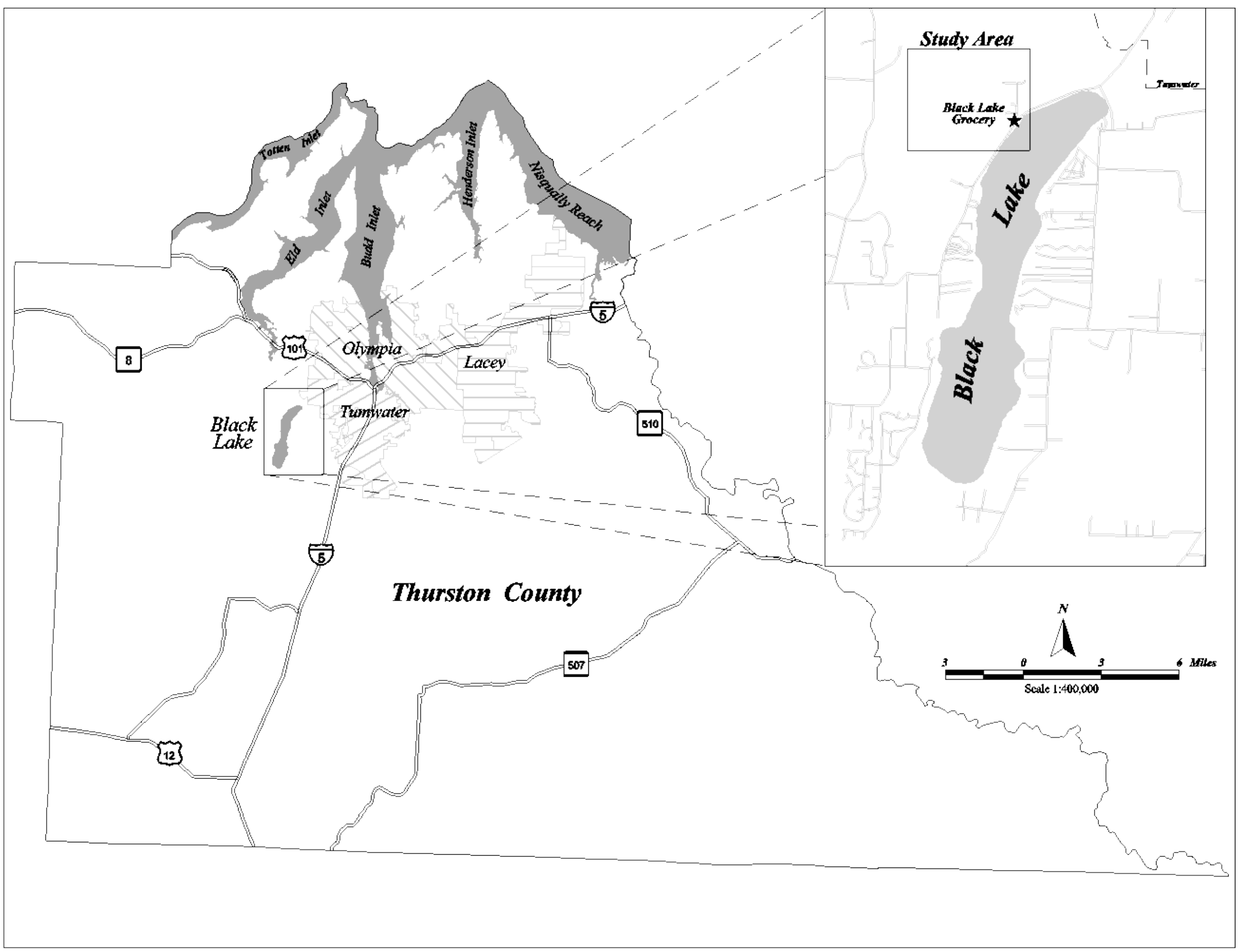

Figure 1. General Location of the Black Lake Grocery Site.

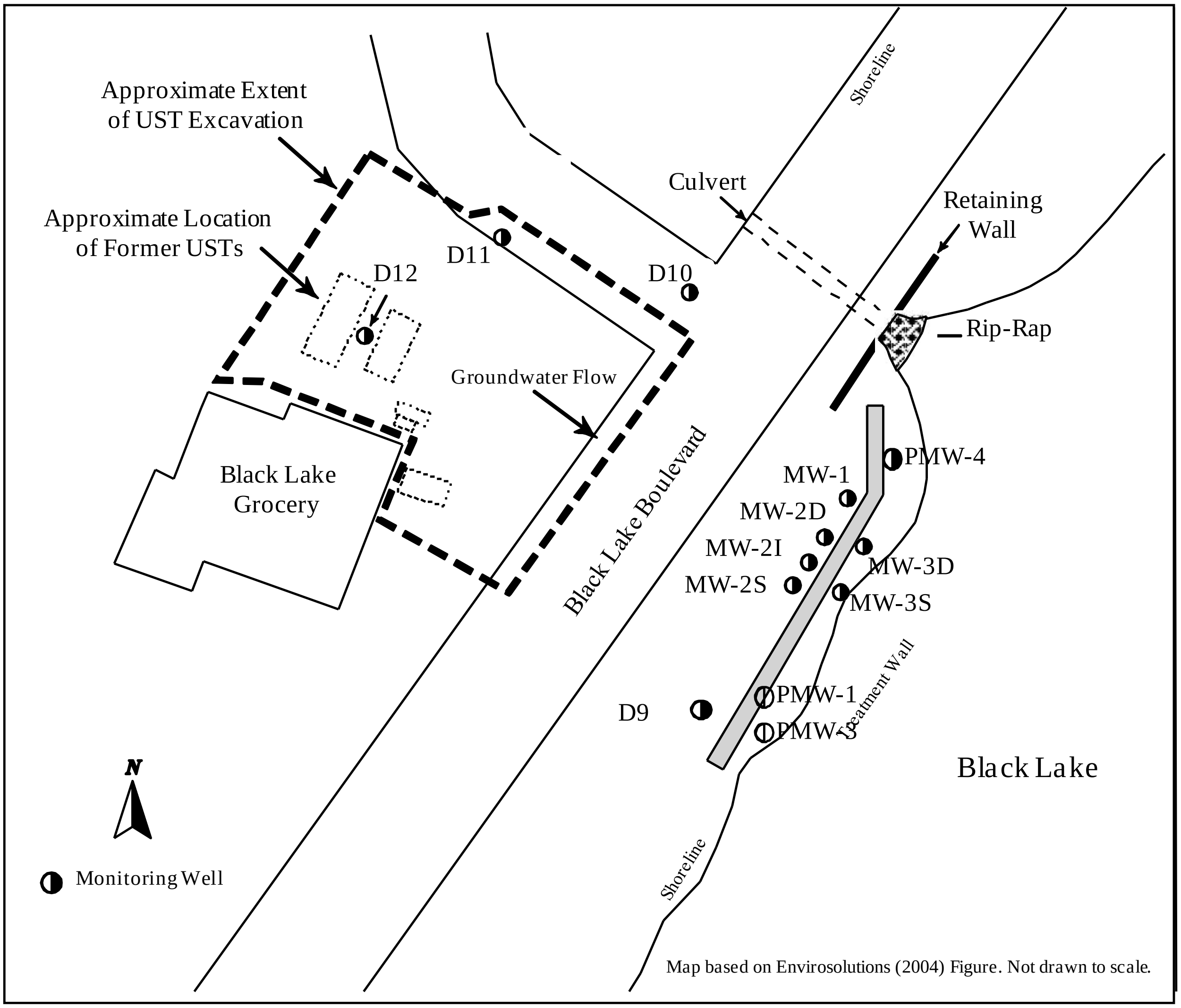

Figure 2. Black Lake Grocery Site Sample Locations.

Black Lake Grocery sits on a small bluff, approximately 10 feet above the shore of Black Lake. The bluff separates the site into an upper and lower area. Black Lake Grocery, the source of the contamination, is located on the upper portion of the site, while the treatment wall is located on the lower portion of the site.

The geology of the area consists of Vashon glacial drift deposits (recessional sand, glacial till, and advance outwash), underlain by recessional outwash deposits of the Salmons Springs Formation, which is underlain by Tertiary volcanic rocks (Noble and Wallace, 1966; Wallace and Molenaar, 1961). In addition to Vashon glacial drift, lacustrine deposits of ancestral Lake Russell exist in the area surrounding the site. Deposits of Lake Russell exist as a relatively thin mantle of clay found up to an elevation of about 150 feet and is underlain by Vashon glacial drift.

Geology of the upper portion of the site contains deposits of silt and fine sand. These deposits are mapped by Noble and Wallace (1966) as recessional outwash of the Vashon deposits. However, the location and texture of the deposits, such as well-sorted sands, indicate the deposits may represent former shoreline deposits of glacial Lake Russell.

Test borings drilled on the lower portion of the site by Blazer and Summit (Blazer, 1994; Summit, 2000) indicate the site is underlain by fine-grained lacustrine deposits (silts and clays). Soil borings advanced at the site reveal clay and silty clay from approximately 5 feet to 35 feet below ground surface.

The general direction of groundwater flow beneath the site is to the east toward Black Lake. Groundwater appears to move relatively slowly, approximately 1.8 to 3.7 feet per year based on water level measurements and slug tests (Summit, 2005).

It appears that the shallow groundwater system may change from confined conditions on the upper portion of the Black Lake Grocery site to unconfined conditions near the shore of Black Lake. Since a distinct confining layer has not been identified, the difference in behavior of the surficial aquifer is attributed to the difference in elevation between the two portions of the site and the proximity to Black Lake.

Project Description

The primary goal of this project is to provide the Toxics Cleanup Program (TCP) with current groundwater data for total petroleum hydrocarbons as gasoline (TPH-G), and benzene, toluene, ethylbenzene, and xylene (BTEX). This data will allow TCP to evaluate the effectiveness of the treatment wall in remediating the contaminated groundwater before it enters Black Lake.

Tasks to meet this objective are:

- Collect groundwater samples and water level measurements from 11 monitoring wells quarterly for one year for the target analytes TPH-G and BTEX (Figure 2). Collect samples in July and October 2011, January and April 2012.
- Collect groundwater samples from 11 monitoring wells twice for one year for total iron, dissolved iron, sulfate, nitrate, dissolved organic carbon (DOC), and turbidity to evaluate the natural attenuation properties of the site and treatment wall. Collect samples in October 2011 and April 2012, representing low and high groundwater conditions.
- Prepare a technical report at the completion of all sampling which will include:
    - Maps of the study area showing sample sites, water levels in monitoring wells, groundwater flow direction, and contaminant concentrations and distribution.
    - Discussion of water quality results.
    - Comparison of results to the cleanup standards for the constituents of concern, to use in evaluating the effectiveness of the cleanup action.
    - Significant or potentially significant findings.

Organization, Schedule, and Analytical Costs

Table 1 lists the people involved in this project. All are employees of the Washington State Department of Ecology.

Table 1. Organization of Project Staff and Responsibilities.

Staff (all are EAP except client)	Title	Responsibilities
Mohsen Kourehdar Toxics Cleanup Program Southwest Regional Office Phone: 360-407-6256	EAP Client	Clarifies scope of the project. Provides internal review of the QAPP and approves the final QAPP.
Pam Marti GWFF Unit Statewide Coordination Section Phone: 360-407-6768	Project Manager	Writes the QAPP. Oversees field sampling and transportation of samples to the laboratory. Conducts QA review of data, analyzes and interprets data, and enters data into EIM. Writes the draft report and final report.
Martha Maggi GWFF Unit Statewide Coordination Section Phone: 360-407-6453	Unit Supervisor for the Project Manager	Provides internal review of the QAPP, approves the budget, and approves the final QAPP.
Will Kendra Statewide Coordination Section Phone: 360-407-6696	Section Manager for the Project Manager	Reviews the project scope and budget, tracks progress, reviews the draft QAPP, and approves the final QAPP.
Robert F. Cusimano Western Operations Section Phone: 360-407-6596	Section Manager for the Study Area	Reviews the project scope and budget, tracks progress, reviews the draft QAPP, and approves the final QAPP.
Stuart Magoon Manchester Environmental Laboratory Phone: 360-871-8801	Director	Approves the final QAPP.
William R. Kammin Phone: 360-407-6964	Ecology Quality Assurance Officer	Reviews the draft QAPP and approves the final QAPP.

EAP: Environmental Assessment Program.
GWFF: Groundwater / Forest and Fish.
EIM: Environmental Information Management database.
QAPP: Quality Assurance Project Plan.

Table 2 shows the proposed timeline for the work to be completed on this project.

Table 2. Proposed Schedule for Completing Field and Laboratory Work, Data Entry into EIM, and Reports.

Field and laboratory work	Due date	Lead staff
Field work completed	April 2012	Pam Marti
Laboratory analyses completed	May 2012	
Environmental Information System (EIM) database		
EIM user study ID	PMART007	
Product	Due date	Lead staff
EIM data loaded	June 2012	Pam Marti
EIM quality assurance	July 2012	Barb Carey
EIM complete	August 2012	Pam Marti
Final report		
Author lead	Pam Marti	
Schedule		
Draft due to supervisor	August 2012	
Draft due to client/peer reviewer	September 2012	
Final (all reviews done) due to publications coordinator	October 2012	
Final report due on web	November 2012	

Table 3 presents the estimated analytical costs for one year of quarterly sampling on this project. Ecology's Manchester Environmental Laboratory (MEL) will analyze all the samples.

Table 3. Project Analytical Costs.

Parameter	Number of Samples [1]			Cost per Sample [2]	Cost per Parameter
	Field	QC	Total		
BTEX	44	8	52	$78.00	$4056
TPH-G	44	8	52	$77.87	$4050
Total Iron	22	4	26	$39.45	$1025
Dissolved Iron	22	4	26	$20.76	$540
Nitrate-N	22	4	26	$13.50	$351
Sulfate	22	4	26	$13.50	$351
DOC	22	4	26	$37.34	$971
Turbidity	22	4	26	$11.42	$397
Total Project Cost					$11,661

[1] Assumes 11 monitoring wells, 1 duplicate, and 1 quality assurance sample for each parameter per sample event.
[2] Assumes MEL *planned* price (50% discount).

Quality Objectives

The primary goal of this project is to determine if the treatment wall is effective in remediating the contaminated groundwater before it enters Black Lake. To do this the samples collected must be representative of groundwater conditions. However, variations in groundwater chemistry can occur due to natural environmental heterogeneity or alterations caused by the sampling or analytical procedures.

For this project to succeed, the precision (random error) and bias (systematic error) of the sample results must be low to reveal variability in concentrations between samples. Standard procedures will be used when collecting and handling the groundwater samples to minimize any bias caused by the sampling process.

The precision and bias routinely obtained by MEL for the selected analytical methods will meet the measurement quality objectives (MQOs) for this project. Table 4 lists the MQOs for assessing project data quality.

Table 4. Laboratory Analyte Measurement Quality Objectives

Parameter	LCS% Recovery Limits	Laboratory Replicates (RPD)	Matrix Spikes% Recoveries	Matrix Spikes Duplicates (RPD)	Required Reporting Limit
BTEX	75-125%	30%	75-125%	30%	1 ug/L
TPH-G	70-130%	40%	70-130%	40%	0.14 mg/L
Total Iron	85-115%	20%	75-125%	20%	50 ug/L
Dissolved Iron	85-115%	20%	75-125%	20%	50 ug/L
Nitrate-N	80-120%	20%	75-125%	20%	0.01 mg/L
Sulfate	90-110%	20%	75-125%	20%	0.3 mg/L
DOC	80-120%	20%	75-125%	20%	1 mg/L
Turbidity	95-105%	20%	NA	NA	0.5 NTU

LCS: Laboratory Control Standard.
RPD: Relative Percent Difference.

These goals are based on performance characteristics of measurements done by MEL. Analytical and field quality control samples are discussed in the *Quality Control Procedures* section below.

Sampling Design and Field Procedures

Staff will sample groundwater quarterly over a one-year period from eleven existing site monitoring wells to determine current concentrations and distribution of petroleum constituents TPH-G and BTEX upgradient and downgradient of the treatment wall. Monitoring will include (Figure 2):

- The upgradient portion of the plume (D10, D11, and D12).
- The area immediately upgradient of the treatment wall in the shallow and deep zones (D9, MW-2S, and MW-2D).
- Groundwater conditions inside the treatment wall (PMW-1).
- The shallow groundwater immediately downgradient of the treatment wall (MW-3S, PMW-3, and PMW-4).
- The deeper groundwater immediately downgradient of the treatment wall (MW-3D).

In addition, staff will collect samples twice from the same wells over the year to evaluate the natural attenuation properties of the site.

The wells to be sampled were installed between 1993 and 2004. All but one well are constructed of 2-inch PVC. The wells range in depth from 5 to 18 feet with 3- to 10-foot screen lengths. Samples collected from the monitoring wells will be assumed to be representative of the groundwater quality of the site.

Staff will measure water levels in all site monitoring wells before sampling according to standard operating procedure (SOP) EAP052 (Marti, 2009).

Wells will be sampled in order from the historically lowest concentration of dissolved petroleum hydrocarbons to the highest. Sample order will be based on previous sample results.

A peristaltic pump has been selected as the sample method because of the expected low yields of the wells due to the fine-grained formation materials in the wells screened intervals. There can be significant changes in solution chemistry with suction lift devices such as a peristaltic pump. Because peristaltic pumps apply a vacuum, they can cause depressurization and degassing of the sample and thus may not be suitable for volatile and gas sensitive analytes. However, the possible effects of the pressure change may be small due to the shallow depths to water and the expected high contaminant concentrations in several of the wells.

The wells will be purged and sampled with a peristaltic pump, using dedicated tubing, at a pump rate of less than 0.5 liter per minute. The wells will be purged through a continuous-flow cell where pH, temperature, specific conductance, and dissolved oxygen will be monitored and recorded at regular intervals. Purging will continue until field parameter readings stabilize as shown in Table 5.

Table 5. Well Purging Criteria.

Purge Parameters	Stabilization Criteria
pH	±0.1 standard unit
Temperature	±0.1 ^{o}C
Specific Conductance	±10 umhos/cm for values <1000 umhos/cm
	±20 umhos/cm for values >1000 umhos/cm
Dissolved Oxygen	±0.05 mg/L for values < 1 mg/L
	±0.2 mg/L for values > 1 mg/L
Or	
All parameters	< ±10% change over 3 consecutive readings at 3 minute intervals

Samples will be collected from each well at the completion of purging. The flow cell will be disconnected and the samples collected directly from the pump's discharge tubing into appropriate sample containers (Table 6). Filtered samples will be field-filtered, with a clean, high-capacity, in-line 0.45-micron membrane filter. Samples are listed in the order of sample collection.

Table 6. Sample Containers and Preservation.

Parameter	Matrix	Minimum Quantity Required	Container	Preservative
BTEX	Groundwater	40 mL No Headspace	Three 40 mL vials with Teflon lined septa caps	Preserve to pH < 2 with 1:1 HCl Cool to ≤6°C
TPH-Gx	Groundwater	40 mL No Headspace	Three 40 mL vials with Teflon lined septa caps	Preserve to pH < 2 with 1:1 HCl Cool to ≤6°C
Total Iron	Groundwater	350 mL	500 mL HDPE bottle	Pre-acidified with HNO3 Cool to ≤6°C
DOC	Groundwater, Filtered	50 mL	60 mL narrow mouth polyethylene bottle	Pre-acidified with 1:1 HCl Cool to ≤6°C
Sulfate	Groundwater, Filtered	100 mL	500 mL wide-mouth polyethylene bottle	Cool to ≤6°C
Nitrate-N	Groundwater, Filtered	125 mL	125 mL clear wide-mouth polyethylene bottle	Pre-acidified with H2SO4 Cool to ≤6°C
Dissolved Iron	Groundwater, Filtered	350 mL	500 mL HDPE bottle	Pre-acidified with HNO3 Cool to ≤6°C
Turbidity	Groundwater	500 mL	500 mL wide-mouth polyethylene bottle	Cool to ≤6°C

Field personnel will wear nitrile gloves while handling the samples throughout the sample collection process. They will take care to avoid contaminating the samples with extraneous material.

Filled sample bottles will be labeled with a unique sample number obtained from MEL, placed in plastic bags, and then stored in ice-filled coolers. Samples will be transported to Ecology's Operation Center in Lacey, Washington. Samples will be kept in the walk-in cooler until picked up by the laboratory courier and transported to the MEL in Manchester, Washington. Chain-of-custody procedures will be followed according to MEL protocol (Ecology, 2008).

Field activities will be recorded in a field notebook or field data sheets. A hand-held GPS will be used to record sampling locations.

Sample equipment that will be used at more than one well, such as the water level probe, will be decontaminated between sample locations. The water level probe will be washed in a laboratory grade detergent/water, followed by a clean water rinse, then a deionized water rinse. Pump tubing will be dedicated to each well and not reused.

Purge water will be collected and disposed of in accordance with WAC 173-303.

Laboratory Procedures

MEL will analyze all groundwater samples. They will use standard methods and reporting limits for analysis of all the groundwater samples as shown in Table 7. MEL performs the requested analysis on a routine basis; therefore no problems with the laboratory methods are expected. Should any problems arise, MEL will contact the project manager and appropriate adjustments will be made.

Table 7. Laboratory Analytical Methods.

Laboratory Analysis	Method	Reference	Reporting Limit	Holding Time
BTEX	EPA SW-846 Method 8021	EPA 1996	1 ug/L	14 days - preserved
TPH-G	NWTPH-Gx	Ecology 2008	0.14 mg/L	14 days - preserved
Total Iron	EPA Method 200.7	EPA 1991	50 ug/L	6 months
Dissolved Iron	EPA Method 200.7	EPA 1991	50 ug/L	6 months
Nitrate	SM 4500-NO3- I	Std. Methods 20th ed.	0.01 mg/L	28 days
Sulfate	EPA Method 300.0	Std. Methods 20th ed.	0.5 mg/L	28 days
Dissolved Organic Carbon	SM 5310B	Std. Methods 20th ed.	1 mg/L	28 days
Turbidity	EPA Method 180.1	Std. Methods 20th ed.	0.5 NTU	48 hours

EPA: U.S. Environmental Protection Agency.

Previous samples collected at this site were analyzed using the same methods. Therefore, data collected for this project should be compatible and comparable to past data.

Quality Control Procedures

Field

Field quality control will be maintained through the use of standard operating procedures for sample collection, handling, and documentation. Any problems occurring during the sample process will be recorded in the field notebook or field datasheets.

Field quality control will also consist of collecting and analyzing field replicate samples. Field replicates are two (duplicates) samples collected at the same time and place. Replicate results provide an estimate of the total random variability (precision) of individual results. A field replicate will be collected from one monitoring well for each sampling event. The field replicate will be collected from a monitoring well which is known to have moderate levels of petroleum hydrocarbons. The replicate samples will be collected by filling two sets of bottles at the selected well at the same time. The relative percent difference (RPD) will be calculated for each duplicate set and will be used to estimate overall precision.

Laboratory

Routine quality control procedures will suffice to demonstrate that the Measurement Quality Objectives (MQOs) for this project have been met. Laboratory quality control tests consist of method blanks, matrix spikes, as wells as duplicate and check standards (lab control standards). Surrogate recoveries will also be included for the organic analysis. Surrogate recoveries will be used to judge the accuracy for analysis of similar target analytes. Analytical precision can be estimated from duplicate and check standards, duplicate sample analysis, and duplicate spiked sample analyses. Analytical bias will be estimated from matrix spikes, matrix spike duplicates, and check standards. Recoveries from check standards provide an estimate of bias due to calibration. Mean percent recoveries of spiked sample analyses provide an estimate of bias due to interference.

Laboratory staff will report results of quality control analyses in the same units as expressed for the MQOs. They will also conduct quality assurance review of all analytical data generated at MEL prior to releasing the data to the project lead.

Data Review and Verification

At the completion of each sampling event, all field data and laboratory analytical data will be compiled and evaluated against the project MQOs.

Field methods and forms will be reviewed to assure consistency. Field datasheets will be checked for missing or improbable measurements before leaving each site. Field data entered into spreadsheets or databases will be checked against the field datasheets for errors or omissions. Missing or unusual field parameter data will be omitted from the data set.

Field replicate variability will be evaluated by calculating the relative percent difference (RPD) for each duplicate set of samples and compared to the quality objectives listed in Table 4.

Laboratory-generated data review and reporting will follow the procedures outlined in MEL's *Lab Users Manual* (Ecology 2008). Lab results will be checked for missing or questionable data. Individual data which fails to achieve QA/QC objectives will be flagged with appropriate qualifiers and their use restricted as appropriate. A standard case narrative of laboratory QA/QC results will be sent to the project manager for each sampling event.

If the data review and verification suggests widespread problems with QA/QC for a sample event, the sample event or individual sample may be repeated at the discretion of the project client and manager.

Data Management Procedures

All field and laboratory data will be entered and stored in Ecology's Environmental Information Management database (EIM) once it has been reviewed and verified. Once all the data has been entered into EIM, a designated EAP staff member will independently review 10% of the project data for possible errors. If significant data entry errors are discovered, a more intensive review will be undertaken.

An EIM user study ID (PMART007) has been created for this project. All monitoring data will be available via the internet once the project data have been validated. The URL address for the database is: http://apps.ecy.wa.gov/eimreporting/search.asp.

All paper and electronic files created for this project will be kept with the project data files according to EAP's record retention schedule.

Data Reporting

Once the data have been reviewed, verified, and validated, the project manager will determine if the data can be used toward the project goals and objectives. A technical report will be prepared at the completion of all sampling and will include the following:

- Maps of the study area showing sample sites, water levels, groundwater flow direction, contaminant concentrations, and distribution.
- Description of field and laboratory methods.
- Discussion of data quality and the significance of any problems encountered.
- Summary tables of field and analytical data.
- Discussion of water quality results. Comparison of results to the cleanup standards for the constituents of concern that will be used to evaluate the effectiveness of the cleanup action.
- Significant or potentially significant findings.
- Recommendations based on project goals.

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Appendices

Appendix A. Summary of Sample Results (ug/L) from November 1993 to June 2009

Table A-1. BTEX and TPH-G Results (ug/L), November 1993 to June 2009.

Well Number	Analyte	11/93	4/95	8/95	12/96	5/00	8/02	2/05	9/05	3/06	10/07	6/09
D9	B	**909**	**830**	**570**	**164**	--	--	1 U	1 U	1 U	1 U	1 U
	T	**3520**	**1500**	680	190	--	--	8.4	16.8	1 U	1 U	1 U
	E	**1720**	**1300**	510	170	--	--	4.9	3.7	1 U	1 U	1 U
	X	**6050**	**2600**	**1100**	418	--	--	33	18.4	1 U	1 U	1 U
	TPH-G	**57,570**	**28,000**	**13,000**	**3300**	--	--	**1510**	160	100 U	100 U	100 U
D10	B	**8450**	--	--	**8150**	**5580**	**8270**	**706**	**3440**	**4000**	**510**	**3700**
	T	**8670**	--	--	**4830**	931	674	79	368	150	22	130
	E	**1450**	--	--	**2190**	**1070**	**1680**	237	525	570	38	540
	X	**5260**	--	--	**9680**	**3660**	**3290**	295	**1050**	290	190	290
	TPH-G	**30,680**	--	--	**45,400**	**40,700**	**32,100**	**5420**	**15,700**	**9000**	**1300**	**6800**
D11	B	**1020**	**4700**	**3500**	**3640**	**2690**	**1950**	**1200**	**1170**	**830**	**1600**	**2100**
	T	**2670**	**4300**	**2500**	**3950**	988	370	570	148	520	150	860
	E	**838**	**820**	**1200**	**1770**	**1570**	**1570**	**1390**	45	**980**	440	**2200**
	X	**4180**	**4000**	**4500**	**6740**	**4220**	**3090**	**3420**	**1170**	**2200**	**2000**	**5100**
	TPH-G	**32,750**	**24,000**	**32,000**	**49,800**	**24,500**	**19,900**	**25,000**	**8710**	**12,000**	**8900**	**53,000**
D12	B	--	--	0.51	0.5 U	0.5 U	0.5 U	**17**	2.2	1.6	**9.6**	1 U
	T	--	--	0.5 U	0.5 U	0.5 U	2 U	34	1.4	1 U	1 U	1 U
	E	--	--	0.67	0.5 U	0.5 U	1 U	5.8	1 U	1 U	1 U	1 U
	X	--	--	1 U	1 U	1 U	1.5 U	31	2	15	24	3 U
	TPH-G	--	--	50 U	50 U	50 U	100 U	360	100 U	100 U	140	100 U

Table A-1 (cont.). BTEX and TPH-G Results (ug/L), November 1993 to June 2009.

Well Number	Analyte	11/93	4/95	8/95	12/96	5/00	8/02	2/05	9/05	3/06	10/07	6/09
MW-2S	B	--	--	--	**7360**	**7930**	**8270**	**2430**	**3420**	**5300**	**4200**	**7800**
	T	--	--	--	**16,600**	**14,300**	**15,800**	**3220**	**3600**	**9500**	**6000**	**8600**
	E	--	--	--	**2960**	**2780**	**3450**	**771**	**904**	**2500**	**1900**	**1500**
	X	--	--	--	**16,000**	**16,300**	**18,100**	**3930**	**5300**	**12,000**	**17,000**	**17,000**
	TPH-G	--	--	--	**122,000**	**104,000**	**91,800**	**40,700**	**41,900**	**62,000**	**36,000**	**170,000**
MW-2D	B	--	--	--	**3040**	**787**	4.18	**47**	**63**	--	--	3.5
	T	--	--	--	**7300**	28.9	2 U	105	21	--	--	1 U
	E	--	--	--	**1830**	41.6	1 U	23	3.7	--	--	1 U
	X	--	--	--	**10,700**	13.4	1.5 U	139	31	--	--	3 U
	TPH-G	--	--	--	**64,000**	425	219	**1200**	395	--	--	100 U
MW-3S	B	--	--	--	**7860**	--	--	**147**	**532**	**750**	**760**	**840**
	T	--	--	--	**11,600**	--	--	43	448	310	**1600**	860
	E	--	--	--	**2730**	--	--	29	105	24	84	**790**
	X	--	--	--	**13,200**	--	--	35	465	41	92	**2900**
	TPH-G	--	--	--	**83,600**	--	--	**1000**	**4700**	**2000**	**2500**	**16,000**
MW-3D	B	--	--	--	**132**	--	0.5 U	1 U	**78**	1.6	**51**	1 U
	T	--	--	--	138	--	2 U	1 U	89	1 U	70	1.4
	E	--	--	--	20.8	--	1 U	1 U	15.5	1 U	44	1 U
	X	--	--	--	**1440**	--	1.5 U	1 U	100	1 U	190	5
	TPH-G	--	--	--	**11,600**	--	100 U	100 U	800	100 U	490	100 U

Table A-1 (cont.). BTEX and TPH-G Results (ug/L), November 1993 to June 2009.

Well Number	Analyte	11/93	4/95	8/95	12/96	5/00	8/02	2/05	9/05	3/06	10/07	6/09
PMW-3	B	--	--	--	--	--	--	1.1	**13.9**	2.7	**6.1**	1 U
	T	--	--	--	--	--	--	8.7	296	320	340	1 U
	E	--	--	--	--	--	--	1 U	9.7	1 U	27	1 U
	X	--	--	--	--	--	--	1 U	32.6	16	34	3 U
	TPH-G	--	--	--	--	--	--	125	523	480	480	150
PMW-4	B	--	--	--	--	--	--	**550**	**503**	**200**	**590**	**144**
	T	--	--	--	--	--	--	940	428	220	200	14
	E	--	--	--	--	--	--	83	287	140	310	42
	X	--	--	--	--	--	--	500	**1090**	610	**1600**	130
	TPH-G	--	--	--	--	--	--	**3750**	503	**2800**	**4500**	**1100**
PMW-1	B	--	--	--	--	--	--	1 U	**272**	1 U	1 U	1 U
	T	--	--	--	--	--	--	1 U	7.2	6.7	1 U	2.4
	E	--	--	--	--	--	--	1 U	2.3	1 U	1 U	1 U
	X	--	--	--	--	--	--	1 U	10.7	1 U	1 U	3 U
	TPH-G	--	--	--	--	--	--	100 U	100 U	100 U	100 U	100 U

B: Benzene — MTCA Method A Cleanup Level - 5 ug/L
T: Toluene — MTCA Method A Cleanup Level - 1000 ug/L
E: Ethylbenzene — MTCA Method A Cleanup Level - 700 ug/L
X: Total Xylene — MTCA Method A Cleanup Level - 1000 ug/L
TPH-G: Total Petroleum Hydrocarbons as Gasoline — MTCA Method A Cleanup Level - 800 ug/L (1000 ug/L if benzene is not detected)
BOLD: Values are greater than MTCA cleanup levels.

Appendix B. Glossary, Acronyms, and Abbreviations

Glossary

Analyte: Water quality constituent being measured (parameter).

Conductivity: A measure of water's ability to conduct an electrical current. Conductivity is related to the concentration and charge of dissolved ions in water.

Depth-to-water: A measure of depth to the water (i.e., water level) in a well.

Dissolved oxygen (DO): A measure of the amount of oxygen dissolved in water.

Groundwater: Water in the subsurface that saturates the rocks and sediment in which it occurs. The upper surface of groundwater saturation is commonly termed the water table.

Parameter: A physical chemical or biological property whose values determine environmental characteristics or behavior.

pH: A measure of the acidity or alkalinity of water. A low pH value (0 to 7) indicates that an acidic condition is present, while a high pH (7 to 14) indicates a basic or alkaline condition. A pH of 7 is considered to be neutral. Since the pH scale is logarithmic, a water sample with a pH of 8 is ten times more basic than one with a pH of 7.

Specific conductance: A measure of water's ability to conduct an electrical current. Specific conductance is related to the concentration and charge of dissolved ions in water.

Turbidity: A measure of water clarity (e.g. the amount of suspended silt or organic matter in water).

Acronyms and Abbreviations

DO	(See Glossary above)
EAP	Environmental Assessment Program
Ecology	Washington State Department of Ecology
EIM	Environmental Information Management database
EPA	U.S. Environmental Protection Agency
GPS	Global Positioning System
MEL	Manchester Environmental Laboratory
MQO	Measurement quality objective
QA	Quality assurance
QC	Quality Control
RPD	Relative percent difference
SOP	Standard operating procedures
DOC	Dissolved organic carbon
WAC	Washington Administrative Code

Units of Measurement

°C	degrees centigrade
mg/L	milligrams per liter (parts per million)
mL	milliliter
NTU	nephelometric turbidity units
ug/L	micrograms per liter (parts per billion)
umhos/cm	micromhos per centimeter, a unit of specific conductance