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ECOLOGY
State of Washington

Quality Assurance Project Plan

Shell Mart McKenzie Automotive and Fargher Lake Grocery Groundwater Assessment Monitoring

January 2019

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Publication Information

Each study conducted by the Washington State Department of Ecology (Ecology) must have an approved Quality Assurance Project Plan (QAPP). 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.

This Quality Assurance Project Plan is available on Ecology's website at https://fortress.wa.gov/ecy/publications/SummaryPages/1903101.html

Data for this project will be available on Ecology's Environmental Information Management (EIM) website: www.ecology.wa.gov/eim/index.htm. Search on Study IDs:

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Quality Assurance Project Plan

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January 2019

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Signatures are not available on the Internet version.
EAP: Environmental Assessment Program

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2.0 Abstract

Fargher Lake Grocery and Shell Mart McKenzie Automotive are listed on the Washington State Department of Ecology's Toxics Cleanup Program contaminated sites list because of petroleum releases from leaking underground storage tanks.

In 1987, the domestic water supply well for the Fargher Lake Grocery near Yacolt, Washington, was found to be contaminated with petroleum products from leaking underground storage tanks. Over the course of six years, six underground tanks and gasoline contaminated soil were removed from the site.

A petroleum release at the Shell Mart McKenzie Automotive in Morton, Washington, was reported to Ecology in March 1994. Due to the location and size of the release, an emergency response was initiated by Ecology's Spills Program that included the removal of two underground tanks and some of the adjacent contaminated soil.

Several years have passed since cleanup activities occurred at either of these sites. At the time of the last groundwater monitoring, April 1993 (Fargher Lake Grocery), and May 1996 (Shell Mart McKenzie Automotive), contaminant concentrations still exceeded the applicable Model Toxics Control Act (MTCA) Method A cleanup levels.

The goal of this project is to collect groundwater samples from the shallow aquifer underlying each site to assess current petroleum contaminant concentrations and to confirm that the remedy selected for Fargher Lake Grocery is protective of human health. This information will assist the Toxics Cleanup Program in determining if further actions are needed at either of these sites.

3.0 Background

3.1 Introduction and problem statement

The groundwater assessment of historical leaking underground storage tanks sites was initiated by the Department of Ecology's Toxics Cleanup Program, Southwest Regional Office. The goal is to collect groundwater samples from sites with historical releases of petroleum hydrocarbons to assess current contaminant concentrations. Some of these sites have sat dormant for years because of limited funds to proceed with cleanup activities. Two of these sites are Shell Mart McKenzie Automotive and Fargher Lake Grocery. (Figure 1)

3.2 Study area and surroundings

Figure 1. Project site vicinity map.

Shell Mart McKenzie Automotive

The Shell Mart McKenzie Automotive (McKenzie Automotive) site is located in Southwest Washington in the town of Morton, Lewis County. Morton lies within a narrow east-west trending valley surrounded by foothills of the Cascade Mountains. It lies at an approximate elevation of 900 feet above mean sea level. The town sits between the confluence of Lake Creek and the Tilton River, which flows to the Cowlitz River (WRIA 26). The Cowlitz River Watershed includes the Cowlitz River proper and numerous tributary creeks and streams, several of which originate in the Cascade Mountains and Willapa Hills. The annual precipitation in the watershed ranges from 40 inches in the lower Cowlitz Valley to over 120 inches in the Cascade Mountains. Most of the precipitation falls during the winter months (Ecology, 2012).

Geology of the McKenzie Automotive site was described in the 1994 Site Characterization Report (Olympus 1994). Geology of the upper 25 feet is described as non-stratified and well-graded medium dense to dense silty sandy clayey gravel; the sands are fine-to-medium grained. Shallow groundwater was encountered at 20–21 feet below ground surface (bgs) at the time of the well installation. The direction of groundwater flow was west to northwest at a horizontal gradient of 0.002 to 0.003 ft/ft.

Fargher Lake Grocery

Fargher Lake Grocery is located in southwestern Washington near the town of Yacolt in Clark County. Fargher Lake is found in the foothills of the Cascade Mountains at an approximate elevation of 660 feet above mean sea level. The site is adjacent to Rock Creek, which flows south to the East Fork of the Lewis River (WRIA 27). The Lewis River Watershed stretches from the western flank of the Cascade Mountains to the Columbia River. The watershed consists of the Lewis River proper and numerous tributary creeks and streams. The annual precipitation in the watershed ranges from 40 inches to over 150 inches per year. Most of the precipitation arrives during the winter months. (Ecology, 2016).

The site geology was characterized during a 1992 Remedial Investigation. Site deposits are characteristic of glacial till and consist of unstratified clay, silt, sand, gravel, cobbles, and boulders. These apparent glacial till and outwash deposits appear to extend to a depth of approximately 100 feet below ground surface (bgs) (E&E, 1992). Site soil borings advanced to approximately 30 feet revealed deposits composed primarily of sandy silt with some gravel. A clayey silt and sand layer that averaged about eight feet in thickness was encountered at 15 feet bgs. Groundwater was encountered at about 13 feet bgs, perched in an overlying gravelly clay layer.

3.2.1 History of study area

Shell Mart McKenzie Automotive

Shell Mart McKenzie Automotive was a gasoline station and convenience store located at 103 2nd Street in downtown Morton, Washington (Figure 2). It is currently an automotive shop. In March 1994, a petroleum release of approximately 3200 gallons regular (leaded) gasoline was reported to Ecology. Due to the location and size of the release, an emergency response was initiated by Ecology's Spills Program to minimize the immediate threat to the health and welfare of nearby businesses and community. The emergency response included the removal of two underground storage tanks (4000 gallon regular/leaded and 4000 gallon unleaded) and some of the adjacent contaminated soil. Three tanks were left in place, a 1000 gallon super-tank and two older tanks (2000-3000 gallons) from a previous station. (Oberlander, 1994)

Four monitoring wells were installed during the emergency response. Free product was observed in the well along the west side of the property (MW-4). Groundwater samples collected in 1996 confirmed the presence of petroleum contamination exceeding Model Toxics Control Act (MTCA) Method A cleanup levels in well MW-4. Activity at the site has been limited since the late 1990s.

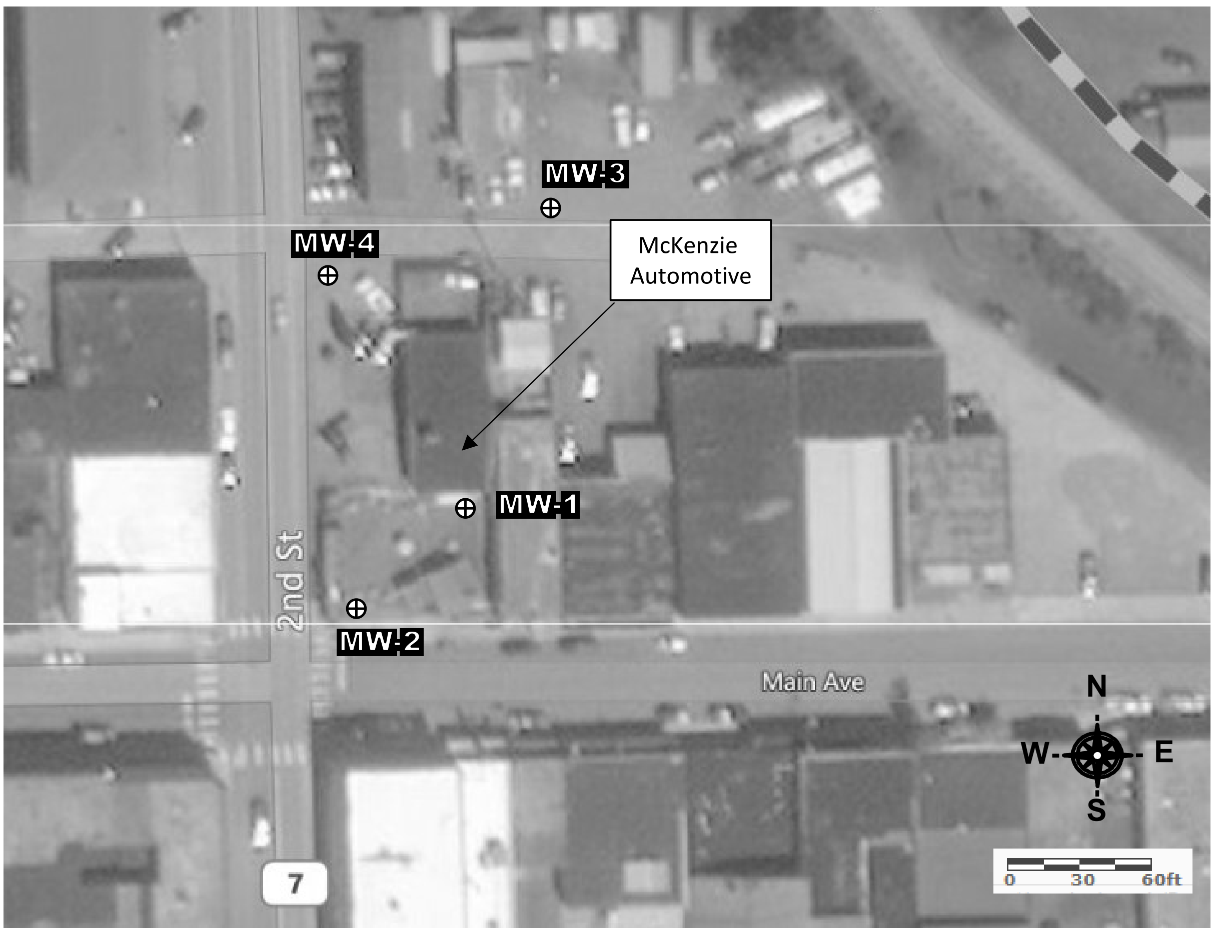

Figure 2. McKenzie Automotive Site.

Fargher Lake Grocery

Fargher Lake Grocery is a gasoline station and convenience store located at the intersection of NW Fargher Lake Hwy (SR 503) and NE 156th Ave. near Yacolt, Washington (Figure 3). In 1987, the domestic water supply well for the store was found to be contaminated with petroleum products. The source of the contamination was thought to be a spill that originated from a faulty coupling on a leaded gasoline retail pump. Follow-up investigations indicated that one or more of the underground storage tanks were leaking. In November 1989, Ecology had six tanks removed and approximately 300 tons of gasoline-contaminated soil were excavated and sent for treatment and disposal. Soil samples taken from the excavation following the tank removal indicated the presence of residual soil contamination exceeding MTCA Method A cleanup levels (Riedel Env., 1990).

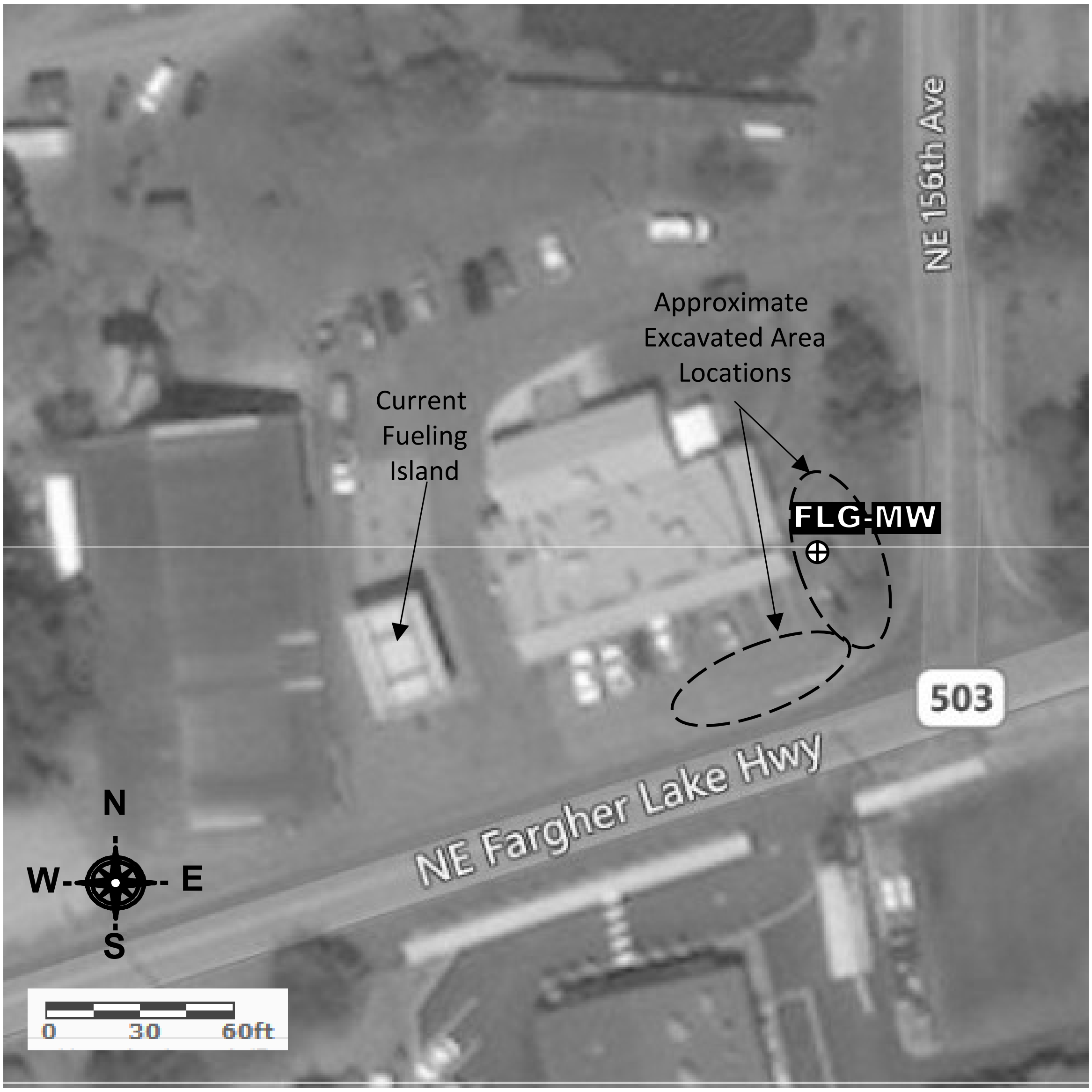

Figure 3. Fargher Lake Grocery Site.

A 1992 Remedial Investigation confirmed the continued presence of contaminated soil east and north of the 1989 excavation (E&E, 1992). In March 1993, Ecology implemented a cleanup action plan to remove petroleum-contaminated soils and address contaminated groundwater. Because of structural confinements, not all of the contaminated soil could be removed from the site. The drinking water well serving Fargher Lake Grocery and a monitoring well north of the site were properly abandoned. A monitoring well (FLG-MW) was installed in the backfilled, excavated area. Groundwater samples collected from FLG-MW had gasoline-range petroleum hydrocarbons exceeding their respective MTCA Method A cleanup levels (Enviros, 1993). Activity at the site has been limited since the mid-1990s.

3.2.2 Summary of previous groundwater studies and existing data

Shell Mart McKenzie Automotive

The four monitoring wells at McKenzie Automotive have been sampled twice: once when they were installed in 1994 and again in 1996. Only analytical data for well MW-4 have been reported. Groundwater samples collected in 1996 confirmed the presence of petroleum contamination exceeding MTCA Method A cleanup levels in well MW-4 at concentrations of 100 mg/L (TPH-G), 7500 ug/L (benzene), 18,000 ug/L (toluene), 1200 ug/L (ethylbenzene), and 7200 ug/L (total xylene) (Coppel, 1996).

Fargher Lake Grocery

One monitoring well (FLG-MW) was installed in the backfilled excavated area during implementation of the 1993 cleanup action plan. Groundwater samples collected from FLG-MW in April 1993 had gasoline-range petroleum hydrocarbons exceeding their respective MTCA Method A cleanup levels (Enviros, 1993). Concentrations were reported as 7100 ug/L (TPH-G), 900 ug/L (benzene), 640 ug/L (toluene), 110 ug/L (ethylbenzene), and 1100 ug/L (total xylene).

3.2.3 Parameters of interest and potential sources

Both McKenzie Automotive and Fargher Lake Grocery are Leaking Underground Storage Tank (LUST) sites. The parameters of interest include:

- Total petroleum hydrocarbons as gasoline (TPH-G).
- Total petroleum hydrocarbons as diesel (TPH-D).
- Gasoline compounds: benzene, toluene, ethylbenzene and xylene (BTEX).
- Lead.

3.2.4 Regulatory criteria or standards

This site is regulated under Washington's Model Toxics Control Act (MTCA) (WAC 173-340). The cleanup criteria established for this site are listed in Table 1.

Table 1. MTCA Method A cleanup levels for groundwater.

Parameters of Interest	MTCA Method A Cleanup Level	Units
Benzene	5	ug/L
Toluene	1000	ug/L
Ethylbenzene	700	ug/L
Total Xylene	1000	ug/L
TPH – gasoline	800-1000*	ug/L
TPH - diesel	500	ug/L
Lead	15	ug/L

* MTCA Method A Cleanup Level for Gasoline is 800 ug/L if benzene is present in groundwater and 1000 ug/L if benzene is not detectable in groundwater.

4.0 Project Description

Ecology's Toxics Cleanup Program (TCP) requested that EAP collect groundwater samples from McKenzie Automotive and Fargher Lake Grocery. Several years have passed since cleanup activities or environmental monitoring has occurred at either of these sites. At the time of the last groundwater monitoring—May 1996 (McKenzie Automotive) and April 1993 (Fargher Lake Grocery)—contaminant concentrations still exceeded the applicable MTCA cleanup levels in shallow groundwater. Current groundwater data are needed to assess the present-day petroleum contaminant concentrations at each sample location and to verify that the remedy selected for Fargher Lake Grocery was protective of human health. This information will assist TCP in determining if further actions are needed at either of these sites.

4.1 Project goal

The project goal is to procure groundwater samples for petroleum constituents that are representative of current concentrations at each location.

4.2 Project objective

The project objective is to collect groundwater samples in the spring of 2019 for analysis of petroleum constituents from the following wells:

- Four site monitoring wells at McKenzie Automotive
- One monitoring well and two domestic wells at Fargher Lake Grocery

4.3 Information needed and sources

Groundwater data for these projects are limited to results collected in the 1990s, which showed that petroleum contaminants exceeded the applicable MTCA cleanup levels at the time. Current data for these projects are needed to assess the current petroleum contaminant concentrations and will be compared to the historical data.

4.4 Tasks required

- Measure water levels in the existing site monitoring wells in the spring of 2019.
- Sample the existing site monitoring wells for water quality parameters and petroleum constituents in the spring of 2019.
- Assess data quality.
- Compare analytical data for petroleum in groundwater data to MTCA Method A cleanup levels for groundwater.
- Load project data into Ecology's Environmental Information Management database (EIM)
- Prepare data analysis report.

4.5 Systematic planning process used

This QAPP is the systematic planning process for the project.

5.0 Organization and Schedule

5.1 Key individuals and their responsibilities

Table 2. Organization of project staff and responsibilities.

Staff (All EAP except client)	Title	Responsibilities
Deirdra Hahn Toxics Cleanup Program Southwest Regional Office Phone: 360-407-7080	EAP Client	Clarifies scope of the project. Provides internal review of the QAPP and approves the final QAPP.
Pam Marti EAP - GFF Unit SCS Section Phone: 360-407-6768	Project Manager/ Principal Investigator	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.
Varies per sampling event	Field Assistant	Helps collect samples and records field information.
Kirk Sinclair EAP - GFF Unit SCS Section Phone: 360-407-6557	Peer Reviewer for the Project Manager	Provides internal review of the draft QAPP.
Jessica Archer EAP - SCS Section Phone: 360-407-6698	Section Manager for the Project Manager	Reviews the project scope and budget, tracks progress, reviews the draft QAPP, and approves the final QAPP.
Alan Rue Manchester Environmental Laboratory Phone: 360-871-8801	Director	Reviews and approves the final QAPP.
Arati Kaza Phone: 360-407-6964	Ecology Quality Assurance Officer	Reviews the draft QAPP and approves the final QAPP.

EAP: Environmental Assessment Program
EIM: Environmental Information Management database
GFF: Groundwater Forests & Fish Unit
SCS: Statewide Coordination Section
QAPP: Quality Assurance Project Plan

5.2 Special training and certifications

A hydrogeologist license is required for the person overseeing hydrogeologic studies (Chapter 18.220.020 RCW).

All EAP field staff who work on hazardous waste sites are required to complete a 40-hour Hazardous Materials Safety & Health Training and take an annual 8-hour annual hazard recognition refresher training. They are also required to maintain certification in First Aid/CPR.

All field staff should have a detailed working knowledge of the project QAPP and any applicable SOPs to ensure credible and useable data are collected. This includes being familiar with the sample equipment and instruments being used. See Section 8.0.

5.3 Organization chart

See Table 2.

5.4 Proposed project schedule

Table 3. 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 2019	Pam Marti
Laboratory analyses completed	June 2019	
Environmental Information System (EIM) database		
EIM Study ID	McKenzie Automotive: FS29172624 Fargher Lake Grocery: FS1045	
Product	Due date	Lead staff
EIM data loaded	September 2019	Pam Marti
EIM data entry review	September 2019	Pam Marti
EIM complete	September 2019	Pam Marti
Final report		
Author lead	Pam Marti	
Schedule		
Draft due to supervisor	September 2019	
Draft due to client/peer reviewer	October 2019	
Draft due to external reviewer(s)	NA	
Final (all reviews done) due to publications coordinator (Joan)	November 2019	
Final report due on web	December 2019	

5.5 Budget and funding

Table 4 and Table 5 present the estimated analytical costs for one round of sampling for each project. Samples will be analyzed by Manchester Laboratory.

Table 4. Project budget and funding McKenzie Automotive.

Parameter	Number of Samples			Cost per Sample (1)	Cost per Parameter
	Field	QC	Total		
BTEX/TPH-G	4	2	6	$130	$780
TPH-Dx	4	1	5	$160	$800
Total Lead(2)	4	1	5	$40	$200
Total Project Cost					$1780

Table 5. Project budget and funding Fargher Lake Grocery.

Parameter	Number of Samples			Cost per Sample (1)	Cost per Parameter
	Field	QC	Total		
BTEX/TPH-G	3	2	5	$130	$650
TPH-Dx	3	1	4	$160	$640
Total Lead(2)	3	1	4	$40	$160
Total Project Cost					$1450

(1) Assumes Manchester Environmental Laboratory (MEL) planned price.
(2) Samples will be field filtered if turbidity measurements are greater than 5 NTUs.

6.0 Quality Objectives

The quality objective for this project is to collect groundwater data of known, acceptable, and documentable quality. This will be achieved by establishing measurement quality objectives for precision and bias (accuracy), sensitivity, completeness, comparability, and representativeness, and by testing data against these criteria.

6.1 Data quality objectives

Data quality objectives (DQOs) establish acceptable quantitative criteria on the quality and quantity of the data to be collected, relative to the ultimate use of the data. These criteria are known as performance or acceptance criteria, or DQOs, and represent the overarching quality objectives of the study and include collected data meeting measurement quality objectives (MQOs).

The main DQO for this project is to collect groundwater samples for petroleum constituents that are representative of current concentrations at each location. Samples will be analyzed using standard methods to obtain data that meet the Measurement Quality Objectives that are described below and that are comparable to previous study results.

6.2 Measurement quality objectives

Measurement quality objectives (MQOs) are performance or acceptance criteria for individual data quality indicators, including quantitative factors (precision, bias, sensitivity, and completeness) and qualitative factors (comparability and representativeness).

6.2.1 Targets for precision, bias, and sensitivity

The MQOs for project results, expressed in terms of acceptable precision, bias, and sensitivity, are described in this section and summarized in Table 6 below.

Table 6. Measurement quality objectives field measurements and laboratory analyses.

MQO →	Precision		Bias			Sensitivity
Parameter	Duplicate Samples	Matrix Spike-Duplicates	Verification Standards (LCS,CRM, CCV)	Matrix Spikes	Surrogate Standards*	MRL or Lowest Conc. of Interest
	Relative Percent Difference (% RPD)		Recovery Limits (%)			Concentration Units
Field Measurements						
Water Level	+/-0.03'	n/a	n/a	n/a	n/a	0.01 ft
Temperature	10%	n/a	n/a	n/a	n/a	0.1 °C
pH	10%	n/a	n/a	n/a	n/a	0.1 standard unit
Specific Conductivity	10%	n/a	n/a	n/a	n/a	10 umhos/cm
Dissolved Oxygen	10%	n/a	n/a	n/a	n/a	0.1 mg/L
Oxidation Reduction Potential	10%	n/a	n/a	n/a	n/a	0.1 millivolts
Laboratory Analyses						
BTEX	≤ 40%	≤ 50%	70 - 130%	70 - 130%	70 - 130%	1.0 ug/L
TPH-G	≤ 50%	≤ 40%	70 - 130%	n/a	70 - 130%	0.07 mg/L
TPH-Dx	≤ 40%	≤ 40%	70 - 130%	n/a	50-150%	0.15 mg/L
Lead	≤ 20%	≤ 20%	85 - 115%	75 - 125%	n/a	0.1 ug/L

*Surrogate recoveries are compound specific.

6.2.1.1 Precision

Precision is a measure of the variability between results of replicate measurements that is due to random error. It is usually assessed using duplicate field measurements or laboratory analysis of duplicate samples. Random error is imparted by the variation in concentrations of samples from the environment as well as other introduced sources of variation (e.g., field and laboratory procedures).

Duplicate samples will be collected in the field by filling two sets of bottles at the same time from a pre-selected well. Previous analytical results will be used to select an appropriate well. Otherwise, professional judgement will be used in selecting the duplicate location.

Precision for field and laboratory duplicate samples will be expressed as relative percent difference (RPD) as shown in Table 6. The smaller the RPD, the more precise the measurement process. Good precision is indicative of relative consistency and comparability between different samples.

The targets for precision are based on past performance characteristics of measurements performed by MEL.

6.2.1.2 Bias

Bias is defined as the difference between the sample value and true value of the parameter being measured. Bias is usually addressed by calibrating field and laboratory instruments, and by analyzing lab control samples, matrix spikes, and standard reference materials (see Table 6). Bias in field measurements and samples will be minimized by strictly following Ecology's measurement, sampling, and handling protocols.

6.2.1.3 Sensitivity

Sensitivity is a measure of the capability of a method to detect a substance. It is commonly described as a detection limit. In a regulatory setting, the method detection limit (MDL) [1] is often used to describe sensitivity. Targets for lab measurement sensitivity required for the project are listed in Table 6.

6.2.2 Targets for comparability, representativeness, and completeness

6.2.2.1 Comparability

Comparability expresses the confidence with which one set of data can be compared to another. Comparability will be ensured to the extent possible by implementing standardized procedures for sampling and analysis. SOPs to be used during this project are listed in Section 8.2.

6.2.2.2 Representativeness

Representativeness expresses the degree to which data accurately and precisely represent the actual site conditions. Groundwater samples will be collected in the spring of 2019. Samples are assumed to be representative of high water-table conditions. Groundwater samples will be collected using industry standard sampling methods, which will help ensure that representative samples are collected.

6.2.2.3 Completeness

Completeness establishes whether a sufficient amount of valid measurements were obtained to meet project objectives. The number of samples and results expected establishes the comparative basis for completeness.

The completeness goal for this project is to collect and analyze 100% of the measurements and samples. However, problems occasionally arise during sample collection that cannot be controlled; thus a completeness of 95% is acceptable. Examples of potential problems that may be encountered are low yielding wells or equipment failure.

[1] The lowest quantity of a physical or chemical parameter that is detectable (above background noise) by each field instrument or laboratory method.

7.0 Study Design

This study is designed to collect representative groundwater monitoring data to assess the current concentrations of petroleum constituents of concern at the McKenzie Automotive and Fargher Lake Grocery sites. Additionally, these data will verify that the cleanup action selected for Fargher Lake Grocery was protective of human health. It has been many years since investigations and cleanup activities have occurred at either of these sites. This information collected will assist TCP in determining if further action is needed at the selected sites.

7.1 Study boundaries

The study boundaries will be defined by the locations of existing site monitoring wells. Wells are typically located within the site's property borders, road right-of-ways and potentially adjacent downgradient properties.

7.2 Field data collection

7.2.1 Sampling locations and frequency

Groundwater samples will be collected once from each of the sites' existing monitoring and drinking water wells.

<u>Shell Mart McKenzie Automotive</u>

Four shallow wells were installed during the 1994 emergency response. The wells are constructed on 4" PVC to a depth of 25 feet with screen intervals from 15 to 25 feet below ground surface.

<u>Fargher Lake Grocery</u>

In March 1993, one monitoring well (FLG-MW) was installed in the backfilled excavated area. The well is constructed of 4" PVC to a total depth of 15 feet with a screen interval from 8 to 15 feet below ground surface. Water for the Fargher Lake Grocery is provided from two water supply wells. Both wells are 6" in diameter and completed to depths of 325 feet with a screen interval from 295 to 325 feet bgs and 405 feet with a screen interval from 380 to 400 feet bgs.

7.2.2 Field parameters and laboratory analytes to be measured

Field measurements will be recorded from each monitoring well and will include water level measurements and water quality parameters: pH, temperature, specific conductivity, dissolved oxygen, and oxidation reduction potential.

The primary parameters to be determined are petroleum constituents: benzene, toluene, ethylbenzene, and xylene (BTEX); total petroleum hydrocarbons as gasoline (TPH-G); total petroleum hydrocarbons as diesel (TPH-D); and lead.

7.3 Modeling and analysis design

Not applicable.

7.4 Assumptions in relation to objectives and study area

The underlying assumption in this study design is that existing monitoring and drinking water wells will provide information representative of site conditions.

7.5 Possible challenges and contingencies

7.5.1 Logistical problems

McKenzie Automotive is an operating mechanics shop and Fargher Lake Grocery is an operating gas station and convenience store. The property owners will be contacted prior to any site visits and sampling. Any monitoring wells located near active areas of the businesses will be sampled during non-peak business hours.

Any circumstance that interferes with data collection and quality will be noted and discussed in the final memo.

7.5.2 Practical constraints

Practical constraints to groundwater sampling are typically determined by characteristics of the site's geology or monitoring well construction.

Both sites' underlying geology is characterized by formations high in silt content. Shallow groundwater monitoring wells at both locations are described as low-yielding and slow to recover. Due to these site conditions, wells will be pumped at a rate that minimizes this potential impact.

Any practical constraints will be discussed in the final memo.

7.5.3 Schedule limitations

Changes in project prioritization and workload for EAP staff could affect the project schedule. Factors that can cause delays to the proposed project schedule include:

- Time required for QAPP review and approval.
- Unforeseen field or laboratory complications (e.g., inability to collect samples from selected wells, problems with laboratory analytical equipment).
- The need for additional samples to provide TCP with enough information for site decisions.

Any unforeseen limitations which affect the project schedule will be discussed with the client and appropriate supervisor as needed and discussed in the final memo.

8.0 Field Procedures

8.1 Invasive species evaluation

Does not apply to this type of study.

8.2 Measurement and sampling procedures

Groundwater measurements and sampling activities for this study will follow standard operating procedures (SOPs) developed by EAP. These include the following SOPs:

- EAP052 for depth to water measurements (Marti, 2016a)
- EAP078 for purging and sampling monitoring wells (Marti, 2016b)
- EAP077 for purging and sampling water supply wells (Marti, 2016c)

Field measurements will be made at all sampling sites and recorded on waterproof paper in a field notebook at regular intervals.

Staff will measure static water levels in all the monitoring wells upon arriving at the site. Staff will also measure water levels before and during the purging process to ensure the wells are not being over-pumped. For optimal sampling, the drawdown should not exceed 0.3 ft. Measurements will be collected according to SOP EAP052 (Marti, 2016).

To prevent potential cross-contamination of the sample equipment, each site's wells will be sampled in order of the historically lowest concentration of contaminants to the highest. Sample order will be based on previous sample results and professional judgment.

The monitoring wells at both locations are described as low-yielding and slow to recover. Because of these conditions, they will be sampled with either a mechanical bladder pump or a peristaltic pump using industry-standard, low-flow sampling techniques. Wells will be purged at a rate of < 0.5-liter/minute using dedicated tubing at each well. The wells will be purged through a continuous flow cell until field parameters stabilize (pH, temperature, specific conductance, dissolved oxygen, and oxidation reduction potential) as specified in SOP EAP078 (Marti, 2016).

Because the wells are reported to be low-yielding and slow to recover they may experience water level drops while purging. Should any water levels drop more than the accepted criteria as specified in SOP EAP078 (Marti, 2016), they will be allowed to recharge with native formation water to complete the purging process before sampling. If it appears that a well may purge dry, then it will be determined in the field what actions will be taken. Either the well will be allowed to recharge and equilibrate before sampling or samples will be collected with minimal purging. Any deviations from the sample plan will be discussed in the technical memo.

Samples will be collected from the monitoring wells directly from the pump discharge line after they are fully purged. Samples will be stored on ice while being transferred to Ecology's Manchester Environmental Laboratory (MEL) using standard chain-of-custody procedure.

Groundwater samples will be analyzed for the parameters of interest (Table 6). Any deviations from the sample plan will be discussed in the final memo.

8.3 Containers, preservation methods, holding times

Table 7 shows the parameter, sample containers, preservation, and holding time required to meet project goals and objectives.

Table 7. Sample containers, preservation, and holding times.

Parameter	Matrix	Minimum Quantity Required	Container	Preservative	Holding Time
TPH-Gx	Groundwater	40 mL No Headspace	(3) 40 mL VOA vials with septum	Preserve to pH < 2 with 1:1 HCl Cool to ≤6°C	14 days if preserved
TPH-Dx	Groundwater	1 Liter	1 L narrow-mouth amber glass jar	1:1 HCl, Cool to ≤6°C	14 days if preserved
BTEX	Groundwater	40 mL No Headspace	(3) 40 mL VOA vials with septum	Preserve to pH < 2 with 1:1 HCl Cool to ≤6°C	14 days if preserved
Total metals	Groundwater	350 mL	500 mL HDPE bottle	Pre-acidified with HNO_3 Cool to ≤6°C	6 months

8.4 Equipment decontamination

Sample equipment used at more than one well, such as an E-tape or bladder pump, will be decontaminated between sample locations. The E-tape probe will be washed in a laboratory grade detergent/water, followed by a clean water rinse, then a deionized water rinse. Any pumps placed in a well will be washed in a laboratory-grade detergent, followed by a tap water rinse and a deionized water rinse. Pump tubing will be dedicated to each well and not reused. Field blanks (Section 10) will test the efficacy of this procedure.

8.5 Sample ID

MEL will provide the field lead with work order numbers for all scheduled sampling dates. The work order number will be combined with a field ID number that is given by the field lead. This combination of work order number and field ID number constitute the sample ID. All sample IDs will be recorded in field logs and in an electronic spreadsheet for tracking purposes.

8.6 Chain-of-custody

Chain-of-custody procedures will be followed according to MEL protocol (Ecology, 2016).

Once collected, samples will be properly labeled and stored in an ice-filled cooler inside the sampling vehicle. If the sample vehicle is left unattended, it will be locked to maintain chain-of-custody. 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.

8.7 Field log requirements

A field log will be maintained by the field lead and used during each sampling event. The following information will be recorded:

- Name of sample location
- Field staff
- Environmental conditions
- Field measurement results
- Date, Time, Sample ID, description of samples collected
- Identity of QC samples (if appropriate)
- Pertinent observations and/or any problems with sampling, including deviations from the QAPP
- Unusual circumstances that might affect interpretation of results

Field logs will consist of waterproof 8.5 x 11-inch field sheets pre-printed for ease of recording and kept in an enclosed metal clipboard. Permanent, waterproof ink or pencil will be used for all entries. Corrections will be made with single line strikethroughs, initialed and dated.

8.8 Other activities

Any field staff new to the type of sampling conducted for this study will be trained by senior field staff or the project manager following relevant Ecology SOPs and the site safety worksheet.

The field lead will notify MEL of the schedule for sampling events a few weeks before sampling. Samples will be collected between Monday and Wednesday so that holding times can be met. The lab will be notified immediately if there will be any deviations from the scheduled date of sampling. The field lead will work with the laboratory to develop a schedule for delivery of sampling containers in order to ensure that the appropriate number and type of required sample containers are available.

If a sample is damaged during transit or testing, a new sample may be collected and submitted for analysis. The laboratory should notify the project lead as soon as possible when a sample is unsuitable.

Purge water from the wells will be stored on-site in properly labeled 55-gallon drums. This waste will be transported and disposed of in accordance with State of Washington regulations (Chapter 173-340-400 WAC).

9.0 Laboratory Procedures

9.1 Lab procedures table

Analytes for both projects, along with the expected number of samples and an expected range of results are listed in Table 8.

Table 8. Measurement methods (laboratory).

Analyte	Sample Matrix	Samples Number	Expected Range of Results	Method Reporting Limit	Analytical (Instrumental) Method
BTEX	Water	11	<1-10,000 ug/L	1 ug/L	EPA SW-846 Method 8021
TPH-Gx	Water	9	<0.1-100 mg/L	0.07 mg/L	NWTPH-Gx
TPH-Dx	Water	9	< 0.1 – 7 mg/L	0.15 mg/L	NWTPH-Dx
Lead	Water	9	<0.1-1 ug/L	0.1 ug/L	EPA 200.8

9.2 Sample preparation method(s)

The laboratory will follow standard sample preparation procedures for the measurement methods listed in Table 8.

9.3 Special method requirements

There are no special method requirements for this project.

9.4 Laboratories accredited for methods

All analysis will be performed by Ecology's Manchester Environmental Laboratory.

10.0 Quality Control Procedures

Quality control (QC) procedures provide the information needed to assess the quality of the data that is collected. They can also help identify problems or issues associated with data collection and analysis while the project is underway.

Total precision for field sampling and laboratory analysis will be assessed by collecting replicate samples. MEL routinely duplicates sample analyses in the laboratory to determine laboratory precision. The difference between field variability and laboratory variability is an estimate of the sample field variability. Field blanks, such as an equipment blank, will be used to check for sample contamination.

The primary types of quality control samples used to evaluate and control the accuracy of laboratory analyses are check standards, duplicates, spikes, and blanks (MEL, 2016). Check standards serve as an independent check on the calibration of the analytical system and can be used to evaluate bias. Duplicates are used to evaluate laboratory precision. Matrix spikes are used to check for matrix interference with detection of the analyte, and can be used to evaluate bias as it relates to matrix effects. Blanks are used to check for sample contamination in the laboratory process.

10.1 Table of field and laboratory quality control

Table 9. Quality control samples, types, and frequency.

Parameter	Field		Laboratory			
	Blanks	Replicates	Check Standards	Method Blanks	Analytical Duplicates	Matrix Spikes
BTEX	1	1/20 samples	1/batch	1/batch	1/batch	1/batch
TPH-G	1	1/20 samples	1/batch	1/batch	1/batch	n/a
TPH-D	1	1/20 samples	1/batch	1/batch	1/batch	n/a
Lead	1	1/20 samples	1/batch	1/batch	1/batch	n/a

The QC samples will all have MQOs (evaluation criteria) associated with them. These are described in Section 6.2. These criteria must be met to obtain fully usable data.

10.2 Corrective action processes

QC results may indicate problems with data during the course of the project. Corrective action processes will be used if (1) activities are found to be inconsistent with the QAPP, (2) analysis results do not meet MQOs or performance expectations, or (3) some other unforeseen problem arises. Prescribed procedures will be followed to resolve the problems. Options for corrective actions might include:

- Retrieving missing information.
- Re-calibrating the measurement system.
- Re-analyzing samples within holding time requirements.
- Modifying the analytical procedures.
- Requesting collection of additional samples or taking additional field measurements.
- Qualifying results.

11.0 Management Procedures

11.1 Data recording and reporting requirements

All field data will be recorded in a field notebook/data sheets. Field notes will be checked for missing or improbable measurements before leaving each site. Field-generated data will be quality assured and entered into EIM as soon as practical after returning from the field. Data entry will be checked against the field notes for any errors and omissions. Missing or unusual data will be brought to the attention of the project manager and client for consultation.

Lab results will be checked for missing and/or improbable data. Data received from MEL through Ecology's Laboratory Information Management System (LIMS) will be checked for omissions against the *Request for Analysis* forms by the field lead. Data requiring additional qualifiers will be reviewed by the project manager.

11.2 Laboratory data package requirements

Laboratory-generated data reduction, review, and reporting will follow the procedures outlined in the MEL *Users Manual* (Ecology, 2016). Variability in lab duplicates will be quantified using the procedures outlined in the MEL *Users Manual*. Any estimated results will be qualified and their use restricted as appropriate. A standard case narrative of laboratory QA/QC results will be sent to the project manager for each set of samples.

11.3 Electronic transfer requirements

MEL will electronically transfer all laboratory-generated data to the project manager through the LIMS to EIM data feed. There is already a protocol in place for how and what MEL transfers to EIM through LIMS.

11.4 EIM/STORET data upload procedures

All field and laboratory data will be entered into EIM once data QA is complete following existing Ecology business rules and the EIM User's Manual.

12.0 Audits and Reports

12.1 Field, laboratory, and other audits

Field audits are always appropriate for a project involving either field measurements or sampling. It is likely that insufficient QA resources are currently available for auditing activities; however, there could be a field consistency review of the project by another experienced EAP hydrogeologist. The aim of such reviews is to improve field-work consistency, improve adherence to SOPs, provide a forum for sharing innovations, and strengthen our data quality assurance program.

12.2 Responsible personnel

See Section 12.1.

12.3 Frequency and distribution of reports

A final technical memo or report will be published according to the project schedule shown in Section 5.4.

12.4 Responsibility for reports

The EAP project manager will be the lead on any final technical memo or report.

13.0 Data Verification

13.1 Field data verification, requirements, and responsibilities

Initial field data verification will be performed by the project manager immediately after completing field measurements/sample collection and prior to departing the site. This process involves checking the data sheet for omissions or outliers. If measurement data are missing or a measurement is determined to be an outlier, the measurement will be repeated.

After the sampling event, the project manager will compare all field data to determine compliance with MQOs. Values that are out of compliance with the MQOs will be noted. At the conclusion of the study, all out-of-compliance values (if any) will be compiled and assessed for usability by the project lead.

13.2 Laboratory data verification

MEL staff will perform the laboratory verification following standard laboratory practices. After the laboratory verification, a secondary verification of each data package will be performed by the project manager. This secondary verification will entail a detailed review of all parts of the laboratory data package with special attention being paid to laboratory QC results. If any issues are discovered, they will be resolved by the project manager.

13.3 Validation requirements, if necessary

Not Applicable.

14.0 Data Quality (Usability) Assessment

14.1 Process for determining project objectives were met

After all laboratory and field data are verified, a detailed examination of the data package using statistics and professional judgment will be performed. The project manager will examine the entire data package to determine if all the criteria for MQOs, completeness, representativeness, and comparability have been met. If the criteria have not been met, the project manager will decide if affected data should be qualified or rejected based upon the decision criteria from the QAPP. The project manager and client will decide how any qualified data will be used in the technical analysis.

14.2 Treatment of non-detects

Any non-detects will be included in the study analysis. The method described in MTCA [WAC 173-340-709(5)] for handling non-detect data is to:

(a) Assign a value equal to one-half of the method detection limit for measurements below the MDL.

(b) Assign a value equal to the MDL for measurements above the MDL but below the practical quantitation limit.

14.3 Data analysis and presentation methods

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. Verified analytical data will be shared with the client in a technical memo or report.

The technical memo or report will be prepared at the completion of the sampling and will include the following:

- Maps of the study area showing sample sites, 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 and comparison of results to site's historical data if available
- Conclusions and recommendations

14.4 Sampling design evaluation

The project manager will decide whether the data package meets the MQOs, criteria for completeness, representativeness, and comparability, and whether meaningful conclusions can be drawn from the data. If so, the sampling design will be considered effective.

14.5 Documentation of assessment

The project manager will include a section in the technical memo or report summarizing the findings of the data quality assessment.

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16.0 Appendices

Appendix A. Glossaries, Acronyms, and Abbreviations

Glossary of General Terms

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.

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.

Oxidation Reduction Potential: A measure of the tendency of a chemical species to acquire electrons and thereby be reduced. Each species has its own intrinsic reduction potential; the more positive the potential, the greater the species affinity for electrons and tendency to be reduced.

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.

Turbidity: A measure of water clarity. High levels of turbidity can have a negative impact on aquatic life.

Acronyms and Abbreviations

DO	(see Glossary above)
e.g.	For example
Ecology	Washington State Department of Ecology
EIM	Environmental Information Management database
EPA	U.S. Environmental Protection Agency
i.e.	In other words
LUST	Leaking Underground storage tank
MEL	Manchester Environmental Laboratory
MQO	Measurement quality objective
QA	Quality assurance
QC	Quality control
RPD	Relative percent difference
SOP	Standard operating procedures
TCP	Toxics Cleanup Program
USGS	United States Geological Survey
WAC	Washington Administrative Code
WRIA	Water Resource Inventory Area

Units of Measurement

°C	degrees centigrade
ft	feet
mg/L	milligrams per liter (parts per million)
NTU	nephelometric turbidity units
ug/L	micrograms per liter (parts per billion)

Quality Assurance Glossary

Accreditation: A certification process for laboratories, designed to evaluate and document a lab's ability to perform analytical methods and produce acceptable data. For Ecology, it is "Formal recognition by (Ecology)…that an environmental laboratory is capable of producing accurate analytical data." [WAC 173-50-040] (Kammin, 2010)

Accuracy: The degree to which a measured value agrees with the true value of the measured property. USEPA recommends that this term not be used, and that the terms precision and bias be used to convey the information associated with the term accuracy. (USGS, 1998)

Analyte: An element, ion, compound, or chemical moiety (pH, alkalinity) which is to be determined. The definition can be expanded to include organisms, e.g., fecal coliform, Klebsiella. (Kammin, 2010)

Bias: The difference between the population mean and the true value. Bias usually describes a systematic difference reproducible over time, and is characteristic of both the measurement system, and the analyte(s) being measured. Bias is a commonly used data quality indicator (DQI). (Kammin, 2010; Ecology, 2004)

Blank: A synthetic sample, free of the analyte(s) of interest. For example, in water analysis, pure water is used for the blank. In chemical analysis, a blank is used to estimate the analytical response to all factors other than the analyte in the sample. In general, blanks are used to assess possible contamination or inadvertent introduction of analyte during various stages of the sampling and analytical process. (USGS, 1998)

Calibration: The process of establishing the relationship between the response of a measurement system and the concentration of the parameter being measured. (Ecology, 2004)

Check standard: A substance or reference material obtained from a source independent from the source of the calibration standard; used to assess bias for an analytical method. This is an obsolete term, and its use is highly discouraged. See Calibration Verification Standards, Lab Control Samples (LCS), Certified Reference Materials (CRM), and/or spiked blanks. These are all check standards, but should be referred to by their actual designator, e.g., CRM, LCS. (Kammin, 2010; Ecology, 2004)

Comparability: The degree to which different methods, data sets and/or decisions agree or can be represented as similar; a data quality indicator. (USEPA, 1997)

Completeness: The amount of valid data obtained from a project compared to the planned amount. Usually expressed as a percentage. A data quality indicator. (USEPA, 1997)

Continuing Calibration Verification Standard (CCV): A QC sample analyzed with samples to check for acceptable bias in the measurement system. The CCV is usually a midpoint calibration standard that is re-run at an established frequency during the course of an analytical run. (Kammin, 2010)

Control chart: A graphical representation of quality control results demonstrating the performance of an aspect of a measurement system. (Kammin, 2010; Ecology 2004)

Control limits: Statistical warning and action limits calculated based on control charts. Warning limits are generally set at +/- 2 standard deviations from the mean, action limits at +/- 3 standard deviations from the mean. (Kammin, 2010)

Data integrity: A qualitative DQI that evaluates the extent to which a data set contains data that is misrepresented, falsified, or deliberately misleading. (Kammin, 2010)

Data Quality Indicators (DQI): Commonly used measures of acceptability for environmental data. The principal DQIs are precision, bias, representativeness, comparability, completeness, sensitivity, and integrity. (USEPA, 2006)

Data Quality Objectives (DQO): Qualitative and quantitative statements derived from systematic planning processes that clarify study objectives, define the appropriate type of data, and specify tolerable levels of potential decision errors that will be used as the basis for establishing the quality and quantity of data needed to support decisions.
(USEPA, 2006)

Data set: A grouping of samples organized by date, time, analyte, etc. (Kammin, 2010)

Data validation: An analyte-specific and sample-specific process that extends the evaluation of data beyond data verification to determine the usability of a specific data set. It involves a detailed examination of the data package, using both professional judgment, and objective criteria, to determine whether the MQOs for precision, bias, and sensitivity have been met. It may also include an assessment of completeness, representativeness, comparability and integrity, as these criteria relate to the usability of the data set. Ecology considers four key criteria to determine if data validation has actually occurred. These are:

- Use of raw or instrument data for evaluation.
- Use of third-party assessors.
- Data set is complex.
- Use of EPA Functional Guidelines or equivalent for review.

Examples of data types commonly validated would be:

- Gas Chromatography (GC).
- Gas Chromatography-Mass Spectrometry (GC-MS).
- Inductively Coupled Plasma (ICP).

The end result of a formal validation process is a determination of usability that assigns qualifiers to indicate usability status for every measurement result. These qualifiers include:

- No qualifier – data are usable for intended purposes.
- J (or a J variant) – data are estimated, may be usable, may be biased high or low.
- REJ – data are rejected, cannot be used for intended purposes.
  (Kammin, 2010; Ecology, 2004).

Data verification: Examination of a data set for errors or omissions, and assessment of the Data Quality Indicators related to that data set for compliance with acceptance criteria (MQOs). Verification is a detailed quality review of a data set. (Ecology, 2004)

Detection limit (limit of detection)**:** The concentration or amount of an analyte which can be determined to a specified level of certainty to be greater than zero. (Ecology, 2004)

Duplicate samples: Two samples taken from and representative of the same population, and carried through and steps of the sampling and analytical procedures in an identical manner. Duplicate samples are used to assess variability of all method activities including sampling and analysis. (USEPA, 1997)

Field blank: A blank used to obtain information on contamination introduced during sample collection, storage, and transport. (Ecology, 2004)

Initial Calibration Verification Standard (ICV): A QC sample prepared independently of calibration standards and analyzed along with the samples to check for acceptable bias in the measurement system. The ICV is analyzed prior to the analysis of any samples. (Kammin, 2010)

Laboratory Control Sample (LCS): A sample of known composition prepared using contaminant-free water or an inert solid that is spiked with analytes of interest at the midpoint of the calibration curve or at the level of concern. It is prepared and analyzed in the same batch of regular samples using the same sample preparation method, reagents, and analytical methods employed for regular samples. (USEPA, 1997)

Matrix spike: A QC sample prepared by adding a known amount of the target analyte(s) to an aliquot of a sample to check for bias due to interference or matrix effects. (Ecology, 2004)

Measurement Quality Objectives (MQOs)**:** Performance or acceptance criteria for individual data quality indicators, usually including precision, bias, sensitivity, completeness, comparability, and representativeness. (USEPA, 2006)

Measurement result: A value obtained by performing the procedure described in a method. (Ecology, 2004)

Method: A formalized group of procedures and techniques for performing an activity (e.g., sampling, chemical analysis, data analysis), systematically presented in the order in which they are to be executed. (EPA, 1997)

Method blank: A blank prepared to represent the sample matrix, prepared and analyzed with a batch of samples. A method blank will contain all reagents used in the preparation of a sample, and the same preparation process is used for the method blank and samples. (Ecology, 2004; Kammin, 2010)

Method Detection Limit (MDL): This definition for detection was first formally advanced in 40CFR 136, October 26, 1984 edition. MDL is defined there as the minimum concentration of an analyte that, in a given matrix and with a specific method, has a 99% probability of being identified, and reported to be greater than zero. (Federal Register, October 26, 1984)

Percent Relative Standard Deviation (%RSD): A statistic used to evaluate precision in environmental analysis. It is determined in the following manner:

$$\%RSD = (100 * s)/x$$

where s is the sample standard deviation and x is the mean of results from more than two replicate samples. (Kammin, 2010)

Parameter: A specified characteristic of a population or sample. Also, an analyte or grouping of analytes. Benzene and nitrate + nitrite are all "parameters." (Kammin, 2010; Ecology, 2004)

Population: The hypothetical set of all possible observations of the type being investigated. (Ecology, 2004)

Precision: The extent of random variability among replicate measurements of the same property; a data quality indicator. (USGS, 1998)

Quality assurance (QA): A set of activities designed to establish and document the reliability and usability of measurement data. (Kammin, 2010)

Quality Assurance Project Plan (QAPP): A document that describes the objectives of a project, and the processes and activities necessary to develop data that will support those objectives. (Kammin, 2010; Ecology, 2004)

Quality control (QC): The routine application of measurement and statistical procedures to assess the accuracy of measurement data. (Ecology, 2004)

Relative Percent Difference (RPD): RPD is commonly used to evaluate precision. The following formula is used:

$$[Abs(a-b)/((a + b)/2)] * 100$$

where "Abs()" is absolute value and a and b are results for the two replicate samples. RPD can be used only with 2 values. Percent Relative Standard Deviation is (%RSD) is used if there are results for more than 2 replicate samples (Ecology, 2004).

Replicate samples: Two or more samples taken from the environment at the same time and place, using the same protocols. Replicates are used to estimate the random variability of the material sampled. (USGS, 1998)

Representativeness: The degree to which a sample reflects the population from which it is taken; a data quality indicator. (USGS, 1998)

Sample (field): A portion of a population (environmental entity) that is measured and assumed to represent the entire population. (USGS, 1998)

Sample (statistical): A finite part or subset of a statistical population. (USEPA, 1997)

Sensitivity: In general, denotes the rate at which the analytical response (e.g., absorbance, volume, meter reading) varies with the concentration of the parameter being determined. In a specialized sense, it has the same meaning as the detection limit. (Ecology, 2004)

Spiked blank: A specified amount of reagent blank fortified with a known mass of the target analyte(s); usually used to assess the recovery efficiency of the method. (USEPA, 1997)

Spiked sample: A sample prepared by adding a known mass of target analyte(s) to a specified amount of matrix sample for which an independent estimate of target analyte(s) concentration is available. Spiked samples can be used to determine the effect of the matrix on a method's recovery efficiency. (USEPA, 1997)

Split sample: A discrete sample subdivided into portions, usually duplicates (Kammin, 2010)

Standard Operating Procedure (SOP): A document which describes in detail a reproducible and repeatable organized activity. (Kammin, 2010)

Surrogate: For environmental chemistry, a surrogate is a substance with properties similar to those of the target analyte(s). Surrogates are unlikely to be native to environmental samples. They are added to environmental samples for quality control purposes, to track extraction efficiency and/or measure analyte recovery. Deuterated organic compounds are examples of surrogates commonly used in organic compound analysis. (Kammin, 2010)

Systematic planning: A step-wise process which develops a clear description of the goals and objectives of a project, and produces decisions on the type, quantity, and quality of data that will be needed to meet those goals and objectives. The DQO process is a specialized type of systematic planning. (USEPA, 2006)

References for QA Glossary

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