Quality Assurance Project Plan

County Construction Recyclers Landfill Groundwater and Surface Water Assessment Monitoring

November 2022

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This plan was prepared under a licensed hydrogeologist. A signed and stamped copy is available upon request.

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COVER PHOTO: Inlet and outlet line at secondary pond northeast corner, view looking south. Photo by Chris Martin.

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Signatures are not available on the Internet version.
NWRO: Ecology's Northwest Regional Office
EAP: Environmental Assessment Program

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2.0 Abstract

The County Construction Recyclers (CCR) landfill, located in Everson, Washington, accepted construction and demolition waste under Chapter 173-304 WAC. Currently, the closed facility is regulated under WAC 173-350-400 as a limited purpose landfill. The CCR landfill began operations in 1990 accepting inert and demolition waste as described in Chapter 173-304 WAC and Whatcom County Code 24.08 Inert and Demolition Waste Rules and Regulations. The eastern and western portions of the CCR landfill were closed around 1997 and 2008, respectively, with low permeability caps and soil layers seeded with grass.

An interim leachate collection system was developed. The collected leachate was hauled to a publicly owned treatment works (POTWs) for pre-treatment and disposal until a temporary permit was rule authorized in July 2000 to the CCR landfill for discharge of treated industrial wastewater to groundwater at spray fields near the landfill.

The leachate in groundwater attributable to the landfill may be monitored using monitoring wells and surface water locations on site. For this study's objectives, monitoring wells upgradient, cross-gradient, and downgradient of the landfill, as well as surface water locations, will be sampled twice across the site. Ecology's Environmental Assessment Program will collect chemical[1], metal, and nutrient contaminants, polycyclic aromatic hydrocarbons, volatile organic compounds (for well MW-21), and hydrocarbon identification samples from the monitoring sites. The goal of the sampling is to (1) identify if contaminants of concern from the landfill leachate exceed (do not meet) water quality standards, (2) sample when the groundwater table is at its lowest and highest, and (3) confirm groundwater flow direction.

3.0 Background

3.1 Introduction and problem statement

The County Construction Recyclers (CCR) landfill is located in Everson, Washington in Whatcom County. The CCR landfill began operation in February 1990. It was permitted and operated as a demolition debris and construction waste landfill under Chapter 173-304 WAC[2]. The regulations at the time did not require liner controls or impervious cover controls.

A detailed site history is included in Section 3.2.1.

When the Solid Waste Handing Standards, Chapter 173-350 WAC, were enacted in 2003, the CCR landfill was still in operation. As such, some of the components of the landfill are subject to the new regulations under WAC 173-350-400. These components include leachate treatment and disposal, run-on/runoff control system, final closure design for unclosed portions of the landfill, seismic impact zone analysis for affected systems, and active area set back requirements. Most facilities at the CCR landfill were exempt from modification, including bottom liner and leachate collection system. The CCR landfill was fully closed in the fall of 2008. The final footprint

[1] Chemical parameters include, but are not limited to, pH, turbidity, total solids (suspended and dissolved), hardness, oxidation-reduction potential, electrical conductivity, temperature, and dissolved oxygen.
[2] Chapter 173-304 WAC: Minimum Functional Standards for Solid Waste Handling. Available at https://apps.leg.wa.gov/wac/default.aspx?cite=173-304.

covers 14-acres and consists of two portions: an eastern portion (about ⅔ of the landfill) that was closed before 2000, and a western portion (about ⅓ of the landfill) that was closed in 2008. Both portions are covered with a low permeability cap and vegetated with grass.

Due to the unique history, the CCR landfill is subject to both water quality regulations under RCW 90.48, Chapter 173-200 WAC, Chapter 173-201A WAC, and Solid Waste Handling Standards in Chapter 173-350 WAC. The facility has a permit-by-rule to monitor their discharges.

3.2 Study area and surroundings

The CCR landfill site is in a rural area of Whatcom County, about 10 miles east of Ferndale and about eight miles northeast of Bellingham. The original elevation ranged 150 – 180 feet above the mean sea level. The closed landfill surface is about 20 – 30 feet higher than the original land surface and is not subject to run-off. The site's southwest corner has the highest elevation.

Geographically, the site is in a topographical high area and is within the headwater area of a tributary of Tenmile Creek, which is part of the Nooksack Water Resources Inventory Area (WRIA 01). The Nooksack River is the primary drainage feature in the area. Tenmile Creek flows into the Lower Nooksack River near the town of Ferndale. Lake Fazon, with a size of 32 acres, is a surface water body located 4,500 feet to the southeast of the landfill site. A farm pond (Muenscher Pond) is about three acres in size and lies about 800 feet to the southeast of the site.

The mean annual temperature is 49 to 50 degrees Fahrenheit, and the mean annual precipitation is 45 to 50 inches (USGS, 2000). There is light rainfall in the summer with the fall/winter providing most of the precipitation.

Surface runoff generated from precipitation flows to the south and north depending on its point of origin. Two drainage ditches run along the northern property boundary. One collects runoff from the northwest half of the landfill and extends from just east of well MW-17/GP-4 and flows east. The other drainage ditch collects runoff from the northeastern half of the landfill, starting near MW-20/GP-6 and flows west. This second ditch also receives the outfall from the groundwater collection system that surrounds the landfill.

One collection pipe runs along the southeast half/side and east side of the landfill to well MW-21. The drainage then runs in a hard pipe to the head of the eastern drainage ditch. The other collection line runs along the west and southwest sides of the landfill to the center where the drainage is hard-piped under the landfill and discharges to the east drainage ditch.

Surface water features on the site include a 5.5-acre lagoon at the south side that flows into a farm pond located immediately south the CCR landfill. On the northern part of the property, a 9.5-acre lagoon drains to a sedimentation pond/swale, which is further drained by two vertically oriented 6-inch PVC pipes to the north into a seasonally intermittent stream.

The CCR site is generally underlain by the Everson-Vashon semi-confining unit, which is highly heterogeneous and composed of unsorted gravelly sandy silt or gravelly silty sand, silt, clay, and clean sand lenses. The thickness of the unit ranges from 16 feet to 45 feet based on bore logs of the on-site monitoring wells. Groundwater at the site flows to the east-northeast.

At least 23 monitoring wells were constructed during 2002-2008 (Figure 1).

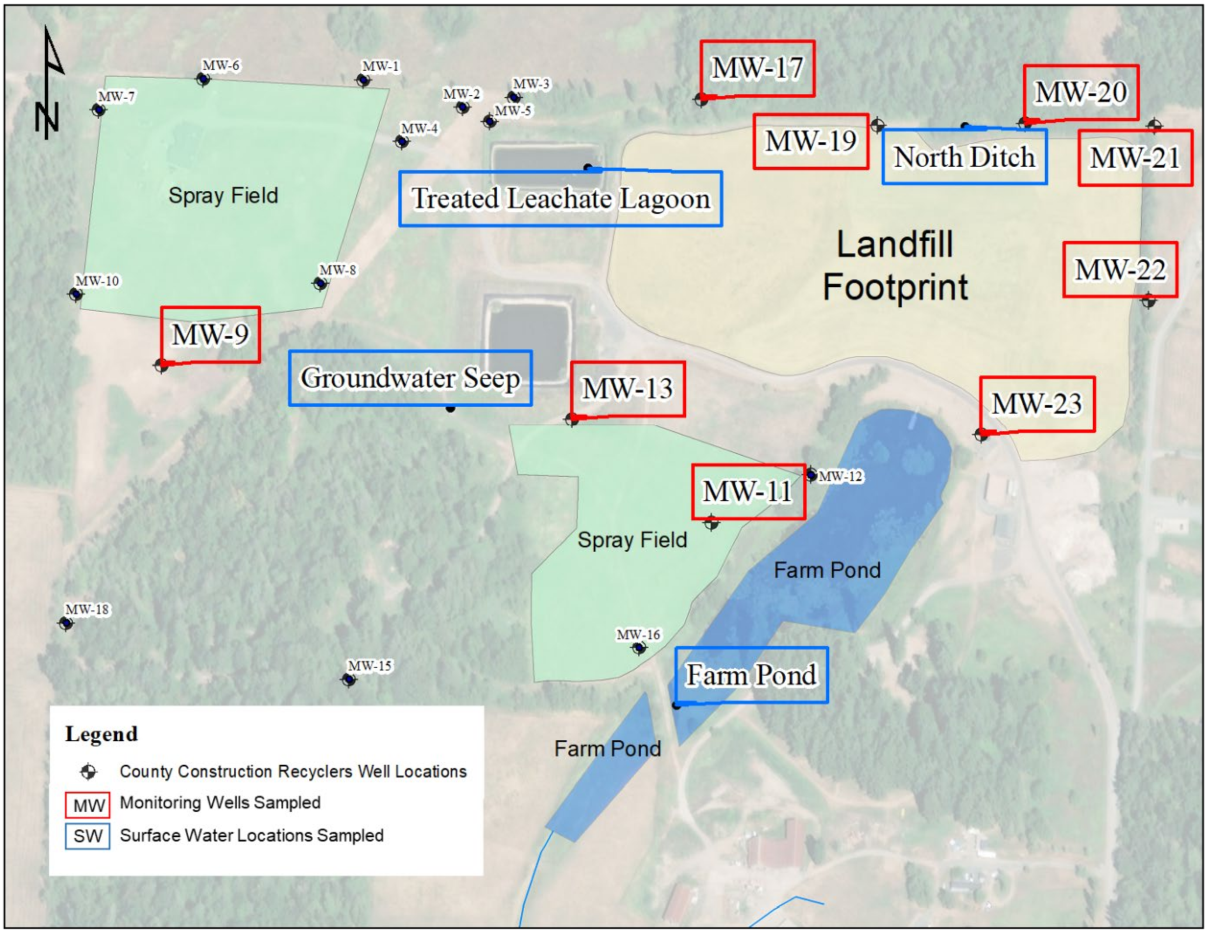

Figure 1. Map of the study area including monitoring wells, surface water locations, spray fields, and the landfill footprint.

3.2.1 History of study area

The CCR facility began operation in February 1990. The landfill was constructed and designed in accordance with WAC 173-304-461. The regulations at that time did not require liner controls or impervious cover controls. In December 1991, leachate was detected emanating from the base of the fill. At that time, the Whatcom County Health Department required that the leachate be collected and properly handled. An interim collection system was developed, and the leachate was hauled to the publicly owned treatment works (POTWs) in Ferndale for pre-treatment and disposal. This temporary method was selected because of its availability and the constituents of the leachate were not fully known at the time. A temporary permit was rule authorized in July 2000 to CCR for discharge of treated leachate to groundwater at two spray fields near the landfill. Only the South spray field is currently used.

In 2000, CCR submitted an “Application for a Wastewater Discharge Permit for Discharge of Industrial Wastewater to Groundwater” and an accompanying Engineering Report, and Ecology issued a Temporary State Waste Discharge Permit No. ST 7429 in 2000 through a *Permit by Rule* that is authorized under RCW 90.48.200. The permit was renewed in the subsequent years to authorize CCR to continue to discharge treated leachate to the spray fields near the landfill.

The new permit became effective on September 16, 2005, through a *Permit by Rule* that is authorized under RCW 90.48.200. The new temporary permit is in effect until the effective date of the permanent permit at which time the Temporary State Waste Discharge Permit will be terminated. Because of coverage under an existing State Waste Discharge Permit, discharges at this site are considered as existing discharges. CCR landfill is also currently covered under General Industrial Stormwater Permit No. WAR000356, which will also be terminated on the effective date of the permanent permit. The remaining General Industrial Stormwater Permit No. CNE000356 will remain in effect to cover continued recycling activities. The rule authorized Discharge of Industrial Wastewater to Groundwater permit remains effective to date.

During landfill operations, CCR accepted only inert and demolition waste for disposal as described in Chapter 173-304 WAC and Whatcom County Code 24.08, Inert and Demolition Waste Rules and Regulations. Waste was transported to the facility by independent haulers. Most of the waste was roofing, wood, concrete, bricks and mortar, asphalt, metal, asphalt shingles with incidental plastic, metal, rebar, dirt, windows, window glass, doors, conduit, metal roofing, plumbing pipe, cast iron sinks and tubs, vinyl flooring, plastic, and impacted environmental media (including petroleum-impacted soil) not exceeding MTCA Method A cleanup standards for industrial sites.

The CCR attendant inspected each load for volume and the presence of unacceptable waste. The load was then directed either to the active area for mechanical end dumps or a hand off load area. The loads were again inspected for unacceptable waste and recyclable material. The landfill progressed by the filling of cells that in turn were surrounded by compacted soil firebreaks prior to opening a new cell. Upon completing an area to the predetermined final closure height, a 1.5-foot layer of compacted clay was placed on the fill as a low permeability liner. The landfill accepted between 30,000 and 60,000 cubic yards of waste per year. The total in-place volume of the landfill is about 295,000 cubic yards.

In late December 2007, the recycling sorting line was removed, and only previously separated wood and metal were being recycled. CCR began final closure of the landfill in the summer of 2008 and completed closure by the fall of 2008.

3.2.2 Summary of previous studies and existing data

Many groundwater monitoring wells and gas probes have been installed on-site. The sampling of on-site groundwater monitoring wells occurred from the second quarter of 2002 to the last quarter of 2009. The analytes assessed include: physical parameters (pH, conductivity, temperature, dissolved oxygen, alkalinity, carbonate, and bicarbonate hardness, total dissolved solids), anions (chloride, ammonia, fluoride, nitrate-N, nitrite-N, nitrate/nitrite-N, sulfate), fecal coliform, heavy and trace metals (Sb, As, Ba, Be, Cd, Cr, Co, Cu, Fe, Pb, Mn, Hg, Ni, Se, Ag, Th, V, Zn), common cations (Ca, Mg, K, Na), and total organic carbon. The average results are summarized for the wells Ecology will sample in 2022-2023 (MW-9, -11, -13, -17, -19, -20, -21, -22, and -23) in Appendix A.

A Bennett Engineering, (2010) report indicates that all groundwater results were below the groundwater quality criteria (Chapter 173-200 WAC) except for the pH results in three groundwater wells (MW-4, -8, and -12). The pH results in these wells were below the lower groundwater pH standard of 6.5. The temperature in the farm pond was above the surface water standard, but all other parameters were compliant with applicable surface water standards (Chapter 173-201A WAC).

Most of the gas probes around the perimeter had non-detectable methane gas concentrations. GP-1 exceeded the WAC 173-350 standard (100% LEL) at the landfill boundary (Bennett Engineering, 2010).

Ecology's Northwest Regional Office (NWRO) staff have extensively measured this site's groundwater levels. . They have observed the wells' groundwater levels below measuring point to change between the maximums and minimums by an average of nearly 11 feet (maximum = 14.09' and minimum = 5.34' of change). NWRO staff have also observed that the groundwater table is at its lowest during August to October, whereas it is at its highest during December to April.

3.2.3 Parameters of interest and potential sources

The groundwater monitoring wells to be sampled are MW-9 as an upgradient well; MW-11, MW-13, and MW-17 as cross-gradient wells; and MW-19, MW-20, MW-21, MW-22, and MW-23 as downgradient wells. The four surface water sites include the farm pond, north ditch, treated leachate lagoon, and a groundwater seep. All sampling sites are located at the CCR landfill (Figure 1).

The groundwater and surface water sites will be analyzed for the same contaminants. The parameters of interest include:

- Field parameters:
  - pH, conductivity, temperature, turbidity, oxidation/reduction potential (ORP), dissolved oxygen (DO)
- Lab parameters:
  - General chemistry (biochemical oxygen demand (BOD), total dissolved solids (TDS), total suspended solids (TSS), total alkalinity, and hardness [as CaCO3]
  - Nutrients (nitrate + nitrite as N, ammonia, chloride, sulfate)
  - Metals (common metals [Ca, Mg, K, Na], total and dissolved trace and heavy metals [As, Cd, Cr, Cu, Fe, Mn, Ni, Pb, Se, Zn]
  - Organics (volatile organic compounds [VOCs] (only at MW-21), total petroleum hydrocarbons – hydrocarbon identification [TPH-HCID], and polycyclic aromatic hydrocarbons [PAHs])

3.2.4 Regulatory criteria or standards

The CCR landfill site is regulated by Ecology's Solid Waste Management Program and Ecology's Water Quality Program. Groundwater results will be compared to Chapter 173-200 WAC, and surface water results are compared to Chapter 173-201A WAC. The applicable water quality standards are listed in Chapter 173-200 WAC and Chapter 173-201A WAC. The site also has several Whatcom County and State permits.

4.0 Project Description

The Solid Waste Management Program at Ecology's NWRO asked Ecology's Environmental Assessment Program (EAP) to conduct groundwater and surface water sampling at the County Construction Recyclers (CCR) limited purpose landfill. EAP will collect samples from nine monitoring wells and four surface water sites. The nine groundwater monitoring wells include MW-9 as an upgradient well; MW-11, -13, -17 as cross-gradient wells; and MW-19, -20, -21, -22, and -23 as downgradient wells. The four surface-water-sampling sites include the farm pond, north ditch, treated leachate lagoon, and a groundwater seep.

Groundwater and surface water data are needed to assess whether landfill and land application activities on the site have affected the shallow groundwater and nearby surface water. This information will assist Ecology in determining if further actions are needed at this site as related to groundwater and surface water quality.

4.1 Project goals

The project goals are to obtain groundwater and surface water samples and analyze those samples for contaminants of potential concern that are representative of current concentrations at each sample location. The data produced by this project will document if contaminants of concern are present in the project area and at what concentration.

Landfill gas readings will be collected by Ecology's Solid Waste Management Program from perimeter gas probes and landfill vents. A QED Landtec GEM5000 Gas Analyzer will be used to collect the gas readings. Visit https://www.landtecna.com/product/gem5000-complete-package/ for details on the instrumentation.

4.2 Project objectives

The project objective is to collect nine groundwater samples twice over the course of a year-sourced upgradient, cross-gradient, and downgradient of the landfill. Also, four surface water sites nearby the landfill will be sampled concurrent with the groundwater sites. The collected samples will be analyzed for the contaminants of potential concern. This will enable the client to determine if the landfill leachate is below regulatory concern.

4.3 Information needed and sources

Water quality data for this project are needed to assess whether the site's groundwater and surface water have been impacted by site activities. Groundwater quality data will be collected from nine monitoring wells and surface water quality data from four surface water sites for contaminants of potential concern discussed in Section 3.2.3.

4.4 Tasks required

- Measure depth to water in the nine monitoring wells twice (during the groundwater table extremes).

- Sample the nine groundwater monitoring wells, and four surface water locations described in Section 3.2.3 twice, in October 2022 and March/April 2023, for water quality parameters and contaminants of potential concern.
- Evaluate results for quality assurance (QA) using EAP QA procedures.
- Compare analytical data for contaminants of potential concern to groundwater standards in WAC 173-200.
- Enter project data into Ecology's Environmental Information Management database (EIM).
- Prepare a final technical memorandum report at the end of the 2023 monitoring that includes results of the above five activities.

4.5 Systematic planning process

This quality assurance project plan (QAPP) serves as the planning document for the project.

5.0 Organization and Schedule

5.1 Key individuals and their responsibilities

Table 1 shows the responsibilities of those who will be involved in this project.

Table 1. Organization of project staff and responsibilities.

Staff[1]	Title	Responsibilities
Tim O'Connor Solid Waste Management Program, NWRO	EAP Client/ Licensed Hydrogeologist	Clarifies scope of the project. Provides internal review of the QAPP and approves the final QAPP. Samples landfill gas.
Bill Angel Whatcom County Health Department	Environmental Health Specialist	Contact facility owners to schedule sampling efforts.
Eric Daiber GMU, SCS, EAP	Project Manager/ Principal Investigator	Writes the QAPP. Conducts field sampling and transportation of samples to the lab. Conducts QA review of data, analyzes and interprets data, and enters data into EIM. Writes the draft report and final report.
Pam Marti GMU, SCS, EAP	Unit Supervisor for the Project Manager/ Licensed Hydrogeologist	Oversees project objectives and goals. Provides internal review of the QAPP, approves the budget, and approves the final QAPP. Oversees field sampling, data interpretation and report preparation.
Eugene Freeman GMU, SCS, EAP	Project Management Assistant/Licensed Hydrogeologist	Provides internal review of the QAPP. Provides technical support in data interpretation. Reviews draft and final report.
Chris Martin Water Quality Program, NWRO	WQP Technical Assistance/Licensed Hydrogeologist	Provides internal review of the QAPP. Provides technical project and sampling support.
Jessica Archer SCS, EAP	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 Lab, EAP	Director	Reviews and approves the final QAPP.
Contract Laboratory	Project Manager	Reviews draft QAPP, coordinates with MEL QA Coordinator
Arati Kaza Quality Assurance	Ecology Quality Assurance Officer	Reviews and approves the draft QAPP and the final QAPP.

EAP: Ecology's Environmental Assessment Program
EIM: Environmental Information Management database
GMU: Groundwater Monitoring Unit
NWRO: Ecology's Northwest Regional Office
QAPP: Quality Assurance Project Plan
SCS: Statewide Coordination Section

5.2 Special training and certifications

A hydrogeologist license is required for the person overseeing hydrogeologic studies (Chapter 18.220.020 RCW). Pam Marti and Eugene Freeman, licensed hydrogeologists, will oversee this project.

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

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

5.3 Organization chart

See Table 1.

5.4 Proposed project schedule

Tables 2 – 4 list key activities, due dates, and lead staff for this project.

Table 2. Schedule for completing field and laboratory work

Task	Due date	Lead staff
Field work	October 2022 and April 2023	Eric Daiber
Lab analyses	December 2022 and June 2023	MEL Staff
Contract lab data validation	January 2023 and June 2023	Christina Frans

Table 3. Schedule for data entry

Task	Due date	Lead staff
EIM data loaded*	July 2023	Eric Daiber
EIM QA	August 2023	Melissa Peterson
EIM complete	October 2023	Eric Daiber

*EIM Project ID: EDAI0002

EIM: Environmental Information Management database

Table 4. Schedule for final report

Task	Due date	Lead staff
Draft to supervisor	November 2023	Eric Daiber
Draft to client/ peer reviewer	December 2023	Eric Daiber
Draft to external reviewers	January 2024	Eric Daiber
Final draft to publications team	January 2024	Eric Daiber
Final report due on web	March 2024	Publications Team

5.5 Budget and funding

Tables 5 shows the total analytical costs for Ecology's Manchester Environmental Laboratory (MEL) associated with both rounds of sampling. The cost may change if wells or surface water sites are added/removed during the project.

Table 5. Laboratory budget details for both sampling events

Parameter	Number of Samples	Number of QA Samples	Total Number of Samples	Cost Per Sample ($)	Lab Subtotal ($)
Determination of Trace Elements (Total)	26	8	34	$198	$6,732
Determination of Trace Elements (Dissolved)	26	8	34	$174	$5,916
Hardness, Total (as $CaCO_3$), Calculated	26	8	34	$25	$850
Biochemical Oxygen Demand (BOD), 20 degrees C	26	8	34	$60	$2,040
Cadmium Reduction Flow Injection	26	8	34	$15	$510
Alkalinity	26	8	34	$20	$680
Flow Injection Analysis	26	8	34	$15	$510
Inorganic Anions, Ion Chromatography	26	8	34	$15	$510
Total Dissolved Solids Dried @ 180 degrees C	26	8	34	$15	$510
Total Suspended Solids Dried @ 103 -105 degrees C	26	8	34	$15	$510
Hydrocarbon Identification Qualitative	26	8	34	$85	$2,890
Semivolatile Organics by GC/MS	26	8	34	$250	$8,500
Volatile Organics Analysis[1]	2	0	2	$185	$370
				Total	$30,528

[1] The volatile organics analysis will not have QA samples because this analysis was requested for informational purposes only.

Table 6 shows the estimated budget details for both rounds of sampling.

Table 6. Estimated total project budget and funding

Item	Cost ($)
Equipment	$1,000
Travel and Per Diem (2 people)	$6,000
Contracts	$612
Laboratory (See Table 6 for details.)	$30,528
Total	$38,140

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 (MQOs) for precision and bias (accuracy), sensitivity, completeness, comparability, and representativeness, and by testing data against these criteria.

6.1 Data quality objectives[3]

Data quality objectives (DQOs) establish acceptable quantitative criteria for the quality and quantity of the data to be collected, relative to the ultimate use of the data. DQOs serve as performance or acceptance criteria and represent the overarching quality objectives of the study. The main DQO for this project is to collect known, acceptable, and defensible groundwater and surface water samples for the contaminants of potential concern that are representative of current concentrations at the nine wells and four surface water locations (Figure 1).

Fieldwork to collect samples will be conducted following SOPs EAP052 for depth to water measurements (Marti, 2020), EAP078 for purging and sampling monitoring wells (Marti, 2020), and EAP015 for manually obtaining surface water samples (Joy, 2019). Samples will be analyzed using accredited methods (see Table 10) to obtain data that meet the measurement quality objectives (MQOs) that are described below and that are comparable to previous results.

6.2 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 Tables 7 and 8.

[3] DQO can also refer to ***Decision*** Quality Objectives. The need to identify Decision Quality Objectives during the planning phase of a project is less common. For projects that do lead to important decisions, DQOs are often expressed as tolerable limits on the probability or chance (risk) of the collected data leading to an erroneous decision. And for projects that intend to estimate present or future conditions, DQOs are often expressed in terms of acceptable uncertainty (e.g., width of an uncertainty band or interval) associated with a point estimate at a desired level of statistical confidence.

Table 7. Measurement quality objectives for field measurements of water samples prior to sampling

Parameter	Acceptable Range Between Readings	Instrument Sensitivity
Water Level	+/-0.03 ft	0.01 ft
Temperature	+/-10 %	0.1 °C
pH	+/-10 %	0.1 standard unit
Specific Conductivity	+/-10 %	10 µmhos/cm
Dissolved Oxygen	+/-10 %	0.1 mg/L
Oxidation Reduction Potential	+/-10 %	0.1 millivolts
Turbidity	+/-10 %	0.1 NTU

Table 8: Measurement quality objectives for laboratory analyses of water samples

Parameter	Lab Duplicate (RPD)	Matrix Spike Duplicate (RPD)	Lab Control Standard (% Recovery)	Matrix Spike (% Recovery)	Surrogate Standards (% Recovery)	MRL or Lowest Concentrations of Interest
Metals	≤ 20	≤ 20	85 – 115	75 – 125	N/A	0.01 – 250 ug/L
Hardness (as $CaCO_3$)	≤ 20	≤ 20	85 – 115	75 – 125	N/A	0.300 mg/L
Chloride	≤ 20	≤ 20	90 – 110	75 – 125	N/A	0.100 mg/L
Sulfate	≤ 20	≤ 20	90 – 110	75 – 125	N/A	0.300 mg/L
Ammonia	≤ 20	≤ 20	80 – 120	75 – 125	N/A	0.0100 mg/L
Nitrate-Nitrite as N	≤ 20	≤ 20	80 – 120	75 – 125	N/A	0.0100 mg/L
Alkalinity	≤ 20	≤ 20	80 – 120	N/A	N/A	5 mg/L
Total Dissolved Solids	≤ 20	≤ 20	80 – 120	75 – 125	N/A	0.950 mg/L
Total Suspended Solids	≤ 20	N/A	80 – 120	N/A	N/A	1.00 mg/L
Biochemical Oxygen Demand[1]	≤ 30	N/A	70 – 130	N/A	N/A	2.00 mg/L
VOCs	≤ 30 or ≤ 40	≤ 30 or ≤ 40	75 – 125 or 60 – 140	70 – 130 or 60 – 140	80 – 120	1.00 – 2.00 ug/L, 0.2 ug/L (vinyl chloride)
PAHs	40	40	Varies	Varies	Varies	0.05 ug/L
Hydrocarbon Identification	N/A	N/A	N/A	N/A	N/A	N/A

[1] The biochemical oxygen demand will be contracted to Edge Analytical.
RPD Relative percent difference
MRL Method reporting limit
TAL Total analyte list
VOCs Volatile organic compounds
PAHs Polycyclic aromatic hydrocarbons

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 lab 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 lab procedures).

One duplicate sample will be collected per sampling trip. Duplicate samples will be collected by filling two sets of bottles at the same time from a pre-selected well. Precision for field and lab duplicate samples will be expressed as relative percent difference (RPD) as shown in Table 8. 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.

The VOC sample will not have a duplicate analysis. The VOC sample is for informational purposes only.

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 lab instruments, and by analyzing lab control samples, matrix spikes, and standard reference materials (see Table 8). 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. For this project, two measures of sensitivity are taken into account: the method reporting limit (MRL) and the lower limit of quantitation (LLOQ). The MRL and LLOQ not only take into account whether a compound is present, but also accuracy and precision of the measured value.

The analytical methods for the metals to be assessed (EPA methods 200.7 and 200.8) employ MRLs, and an associated method detection limit (MDL), which is the lowest concentration of a compound that can be positively identified. The analytical methods used for hardness (SM2340B), total dissolved solids (SM2540C), total suspended solids (SM2540D), Biochemical Oxygen Demand (SM5210B), chloride and sulfate (EPA300.0), ammonia (SM4500NH3H), nitrate-nitrite as N (SM4500NO3I), VOCs (SW8260D and SW8260SIM), and PAHs (SW8270ESIM) also have MRLs and MDLs. Targets for lab measurement sensitivity required for the project are listed in Table 8.

The hydrocarbon identification is performed using the method Hydro-ID (MEL, 2016). The method reports if there are hydrocarbons present or absent.

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.

Laboratory analyses will follow the methods described in Section 9.1 (Lab procedures) for each suite of analytes. Laboratory-specific SOPs for the preparation and analysis of samples, data reduction, and data review for each analysis will be followed.

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 twice, once in the fall and once in the spring, to account for seasonal variability. Samples are assumed representative of site conditions at the time they are collected. Groundwater and surface water 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.

6.3 Acceptance criteria for quality of existing data

Previous groundwater monitoring results related to this project are limited. General parameters along with lab analyses were collected from the second quarter of 2002 to the final quarter of 2009. The existing data sets were collected by a licensed individual and are of acceptable quality for use in this project.

The analytical results collected in 2002, were focused primarily on the western portion of the site. This study will focus upgradient, cross-gradient, and downgradient of the landfill. The current study will be able to better define the current conditions on the site.

6.4 Model quality objectives

Not applicable, this project will not involve any modeling.

7.0 Study Design

This study is designed to collect representative groundwater and surface water data to assess concentrations of the contaminants of potential concern at the closed County Construction Recyclers landfill. This information will assist Ecology in determining if this site is meeting their permit requirements to protect groundwater and surface water quality.

7.1 Study boundaries

The study boundaries, along with the groundwater and surface water sampling locations, are delineated in Figure 1.

7.2 Field data collection

7.2.1 Sampling locations and frequency

Groundwater samples will be collected from nine monitoring wells twice, once during the low-water level period in the early fall and once during the high-water level period in late spring. Surface water samples will be collected from four locations concurrently with the groundwater samples.

Groundwater sampling will occur from upgradient to downgradient, i.e. order of wells to be sampled will be MW-9, -11 -13, -17, -19, -20, -21, -22, to -23.

7.2.2 Field parameters and laboratory analytes to be measured

The parameters to be measured and sampled include:

- Depth to water (Field)
- Temperature (Field)
- pH (Field)
- Specific conductivity (Field)
- Dissolved oxygen (DO) (Field)
- Oxidation/reduction potential (ORP) (Field)
- Turbidity (Field)
- Requested Metals (Laboratory)
- Ammonia, Chloride, Nitrate-Nitrite as N, Sulfate (Laboratory)
- Total Alkalinity (Laboratory)
- Hardness (as $CaCO_3$) (Laboratory)
- Volatile Organic Compounds (VOCs) (Laboratory)
- Polycyclic Aromatic Hydrocarbons (PAHs) (Laboratory)
- Biochemical Oxygen Demand (Laboratory)
- Hydrocarbon Identification (Laboratory)
- Total Dissolved/Suspended Solids (Laboratory)

Table 10 provides a list of the requested metals, inorganic analytes (Ca, Mg, K, Na, As, Cd, Cr, Cu, Fe, Mn, Ni, Pb, Se, and Zn), using specified EPA analytical methods.

Ecology's Solid Waste Management Program has requested one down-gradient groundwater well (MW-21) to be sampled for volatile organic compounds using EPA method SW8260D and SW8260SIM.

7.3 Modeling and analysis design

Not applicable, this project will not involve any modeling.

7.4 Assumptions underlying design

The study design is based on the following assumptions:

- Sampling of the nine monitoring wells and four surface water locations will provide information representative of current site conditions.
- Sampling twice, once during a seasonally high-water table and once during a seasonally low-water table, should be able to capture any seasonal climate factors affecting sample results (i.e. temperature, precipitation).
- The groundwater table under the landfill flows to the north-northeast. We are sampling at least one upgradient well to ensure the groundwater table is flowing to the north-northeast.

7.5 Possible challenges and contingencies

7.5.1 Logistical problems

One of the primary challenges relates to accessing the site to sample the wells. Not all wells were constructed along a road; this could create logistical issues with sampling. Ecology will contact the property owners to ensure they are aware of the sampling event prior to arrival. Also, the EAP project manager will coordinate with Ecology's Solid Waste Management and NWRO staff prior to the sampling event.

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

7.5.2 Practical constraints

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

The thickness and depth of the saturated zone found in the Everson-Vashon deposits are variable. The heterogeneity and discontinuity of water bearing zones in the Everson-Vashon semi-confining unit is likely the reason for the variable saturated zone. Some of the wells are completed (screened) in till-like silty sand materials. These wells are noted to have a low transmissivity, reflected in the density of the material and limited lateral extent of the water-bearing materials (PGG, 2005).

The short holding time from time of sampling for the total suspended solids, total dissolved solids and polycyclic aromatic hydrocarbons (PAHs) of 7 days and biochemical oxygen demand of 48 hours, requires planning and advance arrangement with the analytical lab.

Any practical constraints will be discussed in the final technical memorandum.

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 lab analytical equipment).

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

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 SOPs developed by EAP. These include the following SOPs:

- EAP052 for depth to water measurements (Marti, 2020)
- EAP078 for purging and sampling monitoring wells (Marti, 2020)
- EAP015 for manually obtaining surface water samples (Joy, 2019)

Field measurements will be made at all sampling sites and recorded on waterproof field datasheets 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, 2020).

To prevent potential cross-contamination of the sample equipment, the wells will be sampled in order of the lowest concentration of contaminants to the highest. Groundwater sample order will be based on previous sample results, groundwater flow direction, and professional judgment.

The monitoring wells will be sampled with a peristaltic pump using industry-standard, low-flow sampling techniques. Wells will be purged at a rate of < 0.5-liter/minute. New polypropylene tubing will be used at each well for each sampling event. A 1-foot section of silicone tubing will be used for the pumping mechanism. New silicone tubing will be replaced for each well and sampling event. Equipment blanks will be used to detect for sample contamination from the tubing. Any changes in sampling equipment will be addressed in an addendum to this QAPP.

The monitoring wells will be purged through a continuous flow cell until field parameters stabilize (pH, temperature, specific conductance, dissolved oxygen, and oxidation reduction potential (ORP)) as specified in Table 7 and SOP EAP078 (Marti, 2020). A Hydrolab MS5 multiparameter sonde will be used to measure the field parameters. Turbidity measurements in the field will be collected using a Hach 2100Q Portable Turbidimeter.

Should any water levels drop more than the accepted criteria as specified in SOP EAP078 (Marti, 2020), 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 final technical memorandum.

Samples will be collected from the monitoring wells directly from the pump discharge line after they are fully purged and the flow through cell has been removed from the discharge line. The priority of lab samples (according to the client) from highest to lowest are the polycyclic aromatic hydrocarbons and volatile organic compounds along with the requested metals followed by the ammonia, chloride, nitrate-nitrite as N and ammonia, sulfate, alkalinity, biochemical oxygen demand, hydrocarbon identification, total suspended solids, total dissolved solids, and hardness.

Total metals, volatile organic compounds, and polycyclic aromatic hydrocarbons do not require a filter and will be collected first. Following these samples' collection, a filter will be attached and dissolved metals, chloride, sulfate, and nitrate-nitrite as N and ammonia samples collected. The remaining samples will be collected without a 0.45 um disposable in-line filter.

Surface water samples will be collected as grab samples using methods described in SOP EAP015 (Joy, 2019). Samples for dissolved metals will be field filtered using a 0.45 µm disposable in-line filter. Water grab samples will be collected at about 15–30 cm below the water surface. If necessary, a telescopic pole with a clean sample bottle directly attached to the end may be used to collect samples. If a sample bottle cannot be submerged a clean intermediate container will be used to transfer the water to the sample bottles. All sample bottles will be capped as soon as possible after retrieving the water sample.

Using the Hydrolab, field measurements of surface water temperature, dissolved oxygen, pH, oxidation-reduction potential (ORP), and conductivity will be collected at the same depth of sample collection (~15–30 cm below the water surface).

Samples will be stored on ice while being transferred to Ecology's Manchester Environmental Laboratory (MEL) or Edge Analytical using standard chain-of-custody procedures. Groundwater and surface water samples will be analyzed at MEL and Edge Analytical (for biochemical oxygen demand) for the lab parameters of interest (Table 8). Any deviations from the sample plan will be discussed in the final technical memorandum.

8.3 Containers, preservation methods, holding times

Table 9 presents the parameter, sample containers, preservation, and holding time required to meet project goals and objectives.

Table 9. Sample containers, preservation, and holding times

Parameter	Matrix	Minimum Quantity Required	Container	Preservative	Holding Time
Metals[1]	Water	350 mL	500 mL HDPE bottle	Pre-acidified with 1:1 HNO3; Cool to ≤ 6°C	6 months
Hardness (as $CaCO_3$)	Water	100 mL	125 mL w/m poly bottle	H_2SO_4 to pH < 2; Cool to ≤ 6°C	6 months
Chloride	Water	100 mL	500 mL w/m poly bottle	Cool to ≤ 6°C	28 days
Sulfate	Water	100 mL	500 mL w/m poly bottle	Cool to ≤ 6°C	28 days
Alkalinity[1]	Water	500 mL	500 mL w/m poly bottle	Cool to ≤ 6°C	14 days
Nitrate-Nitrite as N and Ammonia	Water	125 mL	125 mL clear w/m poly bottle	H_2SO_4 to pH < 2; Cool to ≤ 6°C	28 days
Total Dissolved Solids[1]	Water	500 mL	500 mL w/m poly bottle	Cool to ≤ 6°C	7 days
Total Suspended Solids[1]	Water	1000 mL	1000 mL w/m poly	Cool to ≤ 6 °C	7 days
Biochemical Oxygen Demand[1]	Water	2000 mL	1 gallon cubitainer	Cool to ≤ 6 °C; Keep in the dark	48 hours
VOCs[1]	Water	40 mL No Headspace	(3) 40 mL vials with septum	Preserve to pH < 2 with 1:1 HCl; Cool to ≤ 6°C	14 days
PAHs[1]	Water	1 L	1 L amber glass bottle	Cool to ≤ 6°C	7 days
Hydrocarbon Identification	Water	1 L[2]	1 L amber glass bottle	Cool to ≤ 6°C	N/A

[1] Minimum volume required is absolute.
[2] 500 mL is potentially the absolute minimum volume required.
VOCs Volatile organic compounds
PAHs Polycyclic aromatic hydrocarbons
w/m wide-mouth
N/A Not Applicable

8.4 Equipment decontamination

New, clean dedicated sample tubing and filters will be used to gather and prepare any water quality samples that are collected for this project.

Sample equipment used at more than one well, such as an E-tape, 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. Pump tubing will be dedicated to each well and not reused.

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, 2016b).

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 a secure walk-in cooler until picked up by the lab courier and transported to MEL in Port Orchard, Washington. Alternatively, samples may be brought to a secure holding area in Tukwila, Washington to be picked up and transported to MEL by the lab. The biochemical oxygen demand samples will be delivered to Edge Analytical in Bellingham, Washington, due to the short holding time for those samples (see Table 9).

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
- Name of 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

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 at least three weeks before sampling. Samples will be collected by MEL on during Monday, Tuesday, or 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 lab 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 lab should notify the project lead as soon as possible when a sample is unsuitable.

Purge water from the wells will be discharged on-site. If the first sampling identifies a well with contaminants at concerning concentrations, then the second sampling event's purge water (for that well) will be collected in a 55-gallon drum. This waste would 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 this project, along with the expected number of samples and an expected range of results, are listed in Table 10.

Table 10. Expected range of results, detection reporting limit, and laboratory measurement methods.

Analyte	Sample Matrix	Samples (Number/ Arrival Date)	Expected Range of Results	Detection or Reporting Limit	Analytical (Instrumental) Method
Metals	Water	17/ October and March	<1 – 50,000 µg/L	0.05 – 250 µg/L	EPA 200.7 (Martin et al, 1994)/ EPA 200.8 (Creed et al., 1994)
Metals	Dissolved Water	17/ October and March	<1 – 50,000 µg/L	0.1 – 250 µg/L	EPA 200.7 (Martin et al, 1994)/ EPA 200.8 (Creed et al., 1994)
Alkalinity	Water	17/ October and March	<5 – 500 mg/L	5 mg/L	SM2320B (APHA, 1998)
Hardness- (as $CaCO_3$)	Water	17/ October and March	<1 – 550 mg/L	0.300 mg/L	SM2340B (APHA, 1998)
Chloride	Water	17/ October and March	<0.001 – 100 mg/L	0.100 mg/L	EPA300.0 (USEPA, 1993)
Sulfate	Water	17/ October and March	<0.300 – 350 mg/L	0.300 mg/L	EPA300.0 (USEPA, 1993)
Nitrate-Nitrite as N and Ammonia	Water	17/ October and March	<0.01 – 10.0 mg/L	0.01 mg/L	SM4500NO3I/ SM4500NH3H (APHA, 1998)
Total Dissolved Solids	Water	17/ October and March	<0.950 – 1,200 mg/L	0.950 mg/L	SM2540C (APHA, 1998)
Total Suspended Solids	Water	17/ October and March	<1.00 – 50.0 mg/L	1.00 mg/L	SM2540D (APHA, 1998)
Biochemical Oxygen Demand	Water	17/ October and March	<2.00 mg/L – 10 mg/L	2.00 mg/L	SM5210B (APHA, 1998)
VOCs	Water	2/ October and March	<1.00 – 1,000 ug/L	0.02 – 2.00 ug/L	SW8260D and SW8260(C)SIM (USEPA, 2018a, USEPA, 2006)
PAHs	Water	17/ October and March	<1.00 – 1,000 ug/L	0.05 ug/L	EPA 8270ESIM (USEPA, 2018b)
Hydrocarbon Identification	Water	17/ October and March	N/A	N/A	HYDRO-ID

VOCs: Volatile organic compounds
PAHs: Polycyclic aromatic hydrocarbons
N/A: Not Applicable

9.2 Sample preparation methods

Samples that require filtering will be field-filtered using a new in-line 0.45 µm capsule filter.

The laboratory will follow sample preparation procedures described in the analytical methods listed in Table 10.

9.3 Special method requirements

There are no special method requirements for this project.

9.4 Laboratories accredited for methods

Ecology's Manchester Environmental Laboratory (MEL) will perform all analyses for the analytes listed in Table 10. Potential contracting for biochemical oxygen demand may be required based on the availability of MEL staff.

10.0 Quality Control Procedures

Quality control (QC) procedures provide the information needed to assess the quality of the collected data. The QC procedures 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 the variability in field duplicates and the variability in laboratory duplicates is an estimate of the field variability. Field blanks, such as an equipment and trip blanks, will be used to check for sample contamination.

The primary types of QC samples used to evaluate and control the accuracy of lab analyses are check standards, duplicates, spikes, and blanks (Ecology, 2016b). 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 11. Quality control samples, types, and frequency.

Parameter	Field Blanks	Field Replicate Sample	Verification Standards (LCS, CRM, CCV)	Method Blanks	Matrix Spikes/Matrix Spike Duplicate
Metals	2	1/13 samples	1/batch[1]	1/batch	1 pair/batch
Hardness-(as $CaCO_3$)	2	1/13 samples	1/batch	1/batch	N/A
Chloride	2	1/13 samples	1/batch	1/batch	N/A
Sulfate	2	1/13 samples	1/batch	1/batch	N/A
Nitrate-Nitrite as N and Ammonia	2	1/13 samples	1/batch	1/batch	N/A
Total Dissolved Solids	2	1/13 samples	1/batch	1/batch	N/A
Total Suspended Solids	2	1/13 samples	1/batch	1/batch	N/A
Biochemical Oxygen Demand	2	1/13 samples	1/batch	1/batch	N/A
VOCs	2	1/13 samples	1/batch	1/batch	N/A[2]
PAHs	2	1/13 samples	1/batch	1/batch	1 pair/batch
Hydrocarbon Identification	2	1/13 samples	N/A	1/batch	N/A

[1] A batch is defined as up to 20 samples analyzed together.
[2] VOCs will be for informational purposes only, no supplemental QC samples are required.
CCV Continuing calibration verification
CRM Certified reference material
LCS Laboratory control sample
VOC Volatile organic compounds
PAHs Polycyclic aromatic hydrocarbons

Each type of QC sample listed above will have MQOs associated with it that will be used to evaluate the quality and usability of the results (Section 6.2).

10.2 Corrective action processes

Corrective actions will be taken if activities are found to be inconsistent with the QAPP, field procedures, laboratory analyses, data review processes, MQOs or performance expectations, or if some other unforeseen problem arises. Such actions may include:

- Re-calibrating the analytical instrument.
- Collecting new samples using the method described in the approved QAPP.
- Accepting and qualifying lab results that do not meet all QC criteria.
- Reanalyzing lab samples that do not meet QC criteria.
- Convening project personnel and technical experts to decide on the next steps that need to be taken to improve performance of project components.

11.0 Data Management Procedures

As field and lab data are completed, data will be organized using various tabular and graphical formats for additional review, calculations, characterization, and reporting.

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, 2016b). 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. MEL will send a standard case narrative of laboratory QA/QC results to the project manager for each set of samples.

Laboratory results from MEL analyses will be sent to the Project Manager in pdf format (from LIMS) and be accompanied by a Case Narrative. The Case Narrative will address various data verification checks described in Section 13 below.

11.3 Electronic transfer requirements

Laboratory data generated by MEL will be entered into LIMS by MEL staff. When notified of the availability of data, project staff can then access data through EIM loader.

11.4 EIM/STORET data upload procedures

Data will be loaded into Ecology's Environmental Information Management (EIM) database following EIM guidance. Data from the field and MEL will be entered into an EIM upload template.

After entering lab data into EIM, the project manager will manually check 10% of the entered data for correctness, following EIM Data Review Procedures.

11.5 Model information management

Not applicable, this project will not involve any modeling.

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 QA program.

12.2 Responsible personnel

See Section 12.1.

12.3 Frequency and distribution of reports

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

Validated interim results will be communicated to the project client (Solid Waste Management Program) and Water Quality Program staff as they become available.

12.4 Responsibility for reports

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

13.0 Data Verification

EPA defines data verification as "the process of evaluating the completeness, correctness, and conformance/compliance of a specific data set against the method, procedural, or contractual requirements."

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 field 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 lab verification following standard laboratory practices. After the lab 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 lab data package with special attention being paid to lab QC results. If any issues are discovered, they will be resolved by the project manager.

13.3 Validation requirements, if necessary

The results received from contract lab need to be validated. MEL staff will complete data validation to a Stage 2A for these results.

13.4 Model quality assessment

Not applicable.

14.0 Data Quality (Usability) Assessment

14.1 Process for determining project objectives were met

After all lab 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 loaded into EIM and included in the study analysis. Analytical results that are below the MRL will be flagged with the appropriate data qualifier (e.g., U, J, UJ). For summary statistics and analysis, non-detects will be described in the technical memorandum.

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 memorandum.

The final technical memorandum 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 lab 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 final technical report summarizing the findings of the data quality assessment.

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16.0 Appendices

Appendix A. Historical average, of between one and seven results, from sampling before Nov 15, 2009, for the nine monitoring wells

Parameter	Units	MW-9	MW-11	MW-13	MW-17	MW-19	MW-20	MW-21	MW-22	MW-23
Purge Volume	Liters	n/a	n/a	n/a	20.3	23.9	18.6	20.6	17.1	14.45
Temperature	Celsius	n/a	n/a	n/a	11.0	13.6	11.8	10.4	10.7	10.9
Specific Conductivity	µS/cm	n/a	n/a	n/a	1,220	700	463	735	415	663
pH	SU	6.87	n/a	n/a	8.55	7.05	7.22	8.58	8.07	7.07
Dissolved Oxygen	mg/L	n/a	n/a	n/a	2.57	3.43	1.72	1.81	5.41	3.85
Alkalinity (Total)	mg/L	176	n/a	n/a	271	409	273	440	238	354
Bicarbonate	mg/L $CaCO_3$	176	n/a	n/a	259	409	273	440	238	354
Carbonate	mg/L $CaCO_3$	1	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Ammonia	mg/L	0.23	n/a	n/a	0.17	0.11	0.17	0.40	0.07	0.06
Fluoride	mg/L	n/a	n/a	n/a	1.01	0.12	0.051	1.045	0.2	0.075
Chloride	mg/L	5.3	n/a	n/a	13.2	15	11.3	2.9	2.72	20.2
Nitrate-N	mg/L	0.011	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Nitrate/ Nitrite-N	mg/L	0.011	n/a	n/a	0.229	0.123	0.008	0.013	0.510	0.018
Nitrite-N	mg/L	0.01	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Sulfate	mg/L	2.85	n/a	n/a	327	46.6	25.6	25.6	27.0	54.6
Fecal Coliform	MPN/ 100 mL	n/a	n/a	n/a	2	2	2	2	2	2
Antimony	mg/L	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Arsenic	ug/L	1.48	n/a	n/a	1.68	0.0053	0.0062	0.0223	0.0105	0.0043
Barium	mg/L	12**K**	11**K**	131**K**	7.03**K**	0.108	0.026	0.086	0.044	0.073
Beryllium	mg/L	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Cadmium	mg/L	2**U**	n/a	n/a	0.667	0.00007	0.00009	0.00017	0.00052	0.00006
Chromium	mg/L	5**U**	n/a	n/a	1.67	0.0030	0.0028	0.0010	0.0019	0.0030
Cobalt	mg/L	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Copper	mg/L	2**U**	n/a	n/a	0.672	0.006	0.0105	0.015	0.012	0.008
Iron	mg/L	0.67	0.17	0.16	3.52	2.62	3.21	1.04	0.84	0.92
Lead	mg/L	1**K**	n/a	n/a	0.0018	0.00009	0.0001	0.0019	0.00031	0.00058
Manganese	mg/L	0.173	0.021	1.09	0.073	1.01	1.25	0.069	0.035	0.224
Mercury	mg/L	n/a	n/a	n/a	0.033	0.0002	0.0002	0.0002	0.0002	0.0002
Nickel	mg/L	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Selenium	mg/L	0.5**U**	n/a	n/a	0.0007	0.0011	0.0029	0.0013	0.0115	0.0030
Silver	mg/L	3**U**	n/a	n/a	0.00052	0.0010	0.0005	0.0005	0.0005	0.0010
Thallium	mg/L	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Vanadium	mg/L	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Parameter	Units	MW-9	MW-11	MW-13	MW-17	MW-19	MW-20	MW-21	MW-22	MW-23
Zinc	mg/L	n/a	n/a	n/a	0.0125	0.005	0.012	0.016	0.014	0.0135
Calcium	mg/L	28.0	n/a	n/a	6.51	64.4	57.8	4.86	26.8	97.1
Magnesium	mg/L	12.0	n/a	n/a	3.74	40.3	24.0	2.50	20.3	36.4
Potassium	mg/L	3.37	n/a	n/a	8.01	5.58	1.79	7.10	3.32	3.98
Sodium	mg/L	23.0	n/a	n/a	272	71.0	35.7	193	49.5	21.2
TDS	mg/L	210	n/a	n/a	795	488	325	516	244	455
TOC	mg/L	2.25	n/a	n/a	3.58	9.52	4.42	6.20	1.00	5.60

U = Analyte was not detected at or above the reported result.

K = Reported result with unknown bias.

Appendix B. 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.

Nutrient: Substance such as carbon, nitrogen, and phosphorus used by organisms to live and grow. Too many nutrients in the water can promote algal blooms and rob the water of oxygen vital to aquatic organisms.

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.

Sediment: Soil and organic matter that is covered with water (for example, river or lake bottom).

Stormwater: The portion of precipitation that does not naturally percolate into the ground or evaporate but instead runs off roads, pavement, and roofs during rainfall or snow melt. Stormwater can also come from hard or saturated grass surfaces such as lawns, pastures, playfields, and from gravel roads and parking lots.

Total Dissolved Solids (TDS): The solids that are capable of passing through a glass fiber filter (1.0 – 1.5 µm) and dried to a constant weight at 180 degrees centigrade.

Total suspended solids (TSS): The particulate material in a sample that does not pass through a glass fiber filter.

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

Acronyms and Abbreviations

BOD	Biochemical oxygen demand
DO	Dissolved Oxygen (see Glossary above)
e.g.	For example
Ecology	Washington State Department of Ecology
EAP	Environmental Assessment Program
EIM	Environmental Information Management database
EPA	U.S. Environmental Protection Agency
et al.	And others

i.e.	In other words
MEL	Manchester Environmental Laboratory
MQO	Measurement quality objective
MTCA	Model Toxic Control Act
NWRO	Northwest Regional Office
ORP	Oxidation-reduction potential
PAHs	Polycyclic aromatic hydrocarbons
QA	Quality assurance
QAPP	Quality Assurance Project Plan
QC	Quality control
RCW	Revised Code of Washington
RPD	Relative percent difference
RSD	Relative standard deviation
SOP	Standard operating procedure
SWM	Solid Waste Management Program
TOC	Total organic carbon
TSS	Total suspended solids (see Glossary above)
TDS	Total dissolved solids (see Glossary above)
WAC	Washington Administrative Code
WQP	Water Quality Program
WRIA	Water Resource Inventory Area

Units of Measurement

°C	degrees centigrade
ft	feet
mg/L	milligrams per liter (parts per million)
mL	milliliter
mV	millivolt, units of oxidation-reduction potential
ng/L	nanograms per liter (parts per trillion)
NTU	nephelometric turbidity units
pg/L	picograms per liter (parts per quadrillion)
s.u.	standard units
µg/L	micrograms per liter (parts per billion)
µmhos/cm	micromhos per centimeter
µS/cm	microsiemens per centimeter, a unit of conductivity

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 sample 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, deionized 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 quality control (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 the 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 40 CFR 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 two values. Percent Relative Standard Deviation is (%RSD) is used if there are results for more than two 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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