DEPARTMENT OF ECOLOGY
State of Washington

Quality Assurance Project Plan

May Creek Landfill Groundwater Assessment Monitoring

November 2020
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Publication Information

Each study conducted by the Washington State Department of 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/2003115.html

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

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Quality Assurance Project Plan

May Creek Landfill
Groundwater Assessment Monitoring

November 2020

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NWRO: Northwest Regional Office
EAP: Environmental Assessment Program

1.0 Table of Contents

Page

List of Figures

List of Tables

2.0 Abstract

The May Creek Landfill, also known as the Pillon Property, is the site of an unpermitted solid waste landfill east of Renton, Washington. In January 2003, King County notified the Washington State Department of Ecology (Ecology) of potential contamination at the site. In August 2003, Ecology placed the May Creek Landfill on the Confirmed and Suspected Contaminated Sites List. The site was listed as confirmed for metals in surface water and suspected for petroleum, antifreeze, metals, and gasoline in soil and groundwater.

In 2016, EPA's Region IV Superfund Technical Assessment and Response Team took responsibility for identifying and removing hazardous wastes and materials. Soil samples collected in 2018 during removal activities identified soil contamination, including petroleum hydrocarbons, dioxins, and metals. Samples of transient surface water collected from locations around the site demonstrated that diesel and motor oil were present at concentrations greater than applicable state cleanup levels.

In July 2019, EPA installed and sampled 7 groundwater monitoring wells on the site. EPA analyzed the samples for a wide range of contaminants of potential concern. The results of EPA groundwater sampling positively identified diesel range organics, metals, and semi-volatile organic compounds at concentrations above applicable cleanup levels in one or more monitoring wells.

Ecology will continue the groundwater monitoring for 2 years on a quarterly basis. The sampling program is designed to collect representative groundwater monitoring data to assess concentrations of the contaminants of potential concern at the May Creek Landfill site. This information will assist Ecology in determining if additional cleanup actions are needed at the site to protect groundwater quality.

3.0 Background

3.1 Introduction and problem statement

The approximately 10-acre May Creek Landfill has operated as an unpermitted solid waste landfill in eastern King County since the 1990s. The site, also known as the Pillon Property, has a long history of investigations and citations by county and state regulatory agencies. Despite numerous notices of violations and penalties, there is no record of any cleanup activities prior to 2016. Beginning in 2016 EPA's Region IV Superfund Technical Assessment and Response Team (START) was tasked with identifying and removing hazardous wastes and materials. Removal activities were completed in July 2019. Soil samples collected during removal activities indicated that the site soils were contaminated with petroleum hydrocarbons, dioxins, and metals (Woodke and Wing, 2019). EPA also installed 7 monitoring wells and conducted one round of sampling to determine if the contaminated soil has resulted in contamination of the shallow groundwater.

3.2 Study area and surroundings

The May Creek Landfill is located in a semi-rural area of unincorporated King County east of Renton (Figure 1). It is about 10 acres in size and surrounded by residential and agricultural land. May Valley Park is adjacent to the northwest corner of the property. Renton-Issaquah Road (Route 900) is adjacent to the northeast corner of the property. The property is located about 370-490 feet above mean sea level. It is hilly, with approximately 120 feet of relief.

The property sits within the May Creek Watershed. The creek flows west into Lake Washington and is part of the Cedar-Sammamish Water Resource Inventory Area (WRIA 08). The annual precipitation in the watershed ranges from 30 to 35 inches per year. Most of the precipitation falls during the winter months (Ecology, 2016a).

Geology of the May Creek Watershed is described as high-relief sedimentary and volcanic bedrock on the northeastern side of the valley. Vashon glacial sediments infilled a surface trough of bedrock through the remainder of the valley. A majority of the glacial sediments observed at the surface are from the Vashon Stade. Till material deposited by the ice and compacted during glacial occupation underlies the valley bottom and is present at the surface throughout much of the basin. The valley bottom is filled with recessional outwash deposits (Anchor QEA, 2010).

In July 2019, Holt Services drilled 7 monitoring wells (Figure 2) completed to depths between 17 and 31 feet. Well logs indicate near-surface deposits are composed primarily of silt, commonly with sand or sand and gravel (Appendix D). Sand is also a major constituent, commonly with silt or gravel. Relatively minor amounts of gravel are present compared to silt and sand deposits. Fill material is present at all monitoring well locations except MW-01. Depth of fill ranges from 1.5 to 9.5 feet below ground surface (bgs). Various types of debris and waste material were encountered at up to 9.5 feet in some on-site boreholes. Groundwater was encountered between approximately 9 and 21 feet bgs. Groundwater flow in May Creek Valley is likely to the northwest, following the direction of the valley. Based on topography and the observed depths to water during drilling, groundwater beneath the site likely flows east-northeast toward May Creek.

Surface water on the site presumably flows downhill toward May Creek, which lies about 1,000 feet northeast of the site. Two ponds are located at the southwest corner of the property, but there is no information regarding whether they are connected to the drainage ditches that drain off the property (Ecology, 2015).

3.2.1 History of study area

It has been reported that the May Creek Landfill has operated as an unpermitted solid waste landfill since the early 1990s. The property owner has claimed to be operating a composting material recovery, waste reduction and recycling business at the site.

The site has a long history of investigations and citations by county and state regulatory agencies. An overview of the issues that have been observed or investigated on the property can be found in the Site Hazard Assessment Summary Score Sheet (Ecology, 2015) and EPA's May Creek Landfill Sample Plan and are summarized here (Woodke and Wing, 2019).

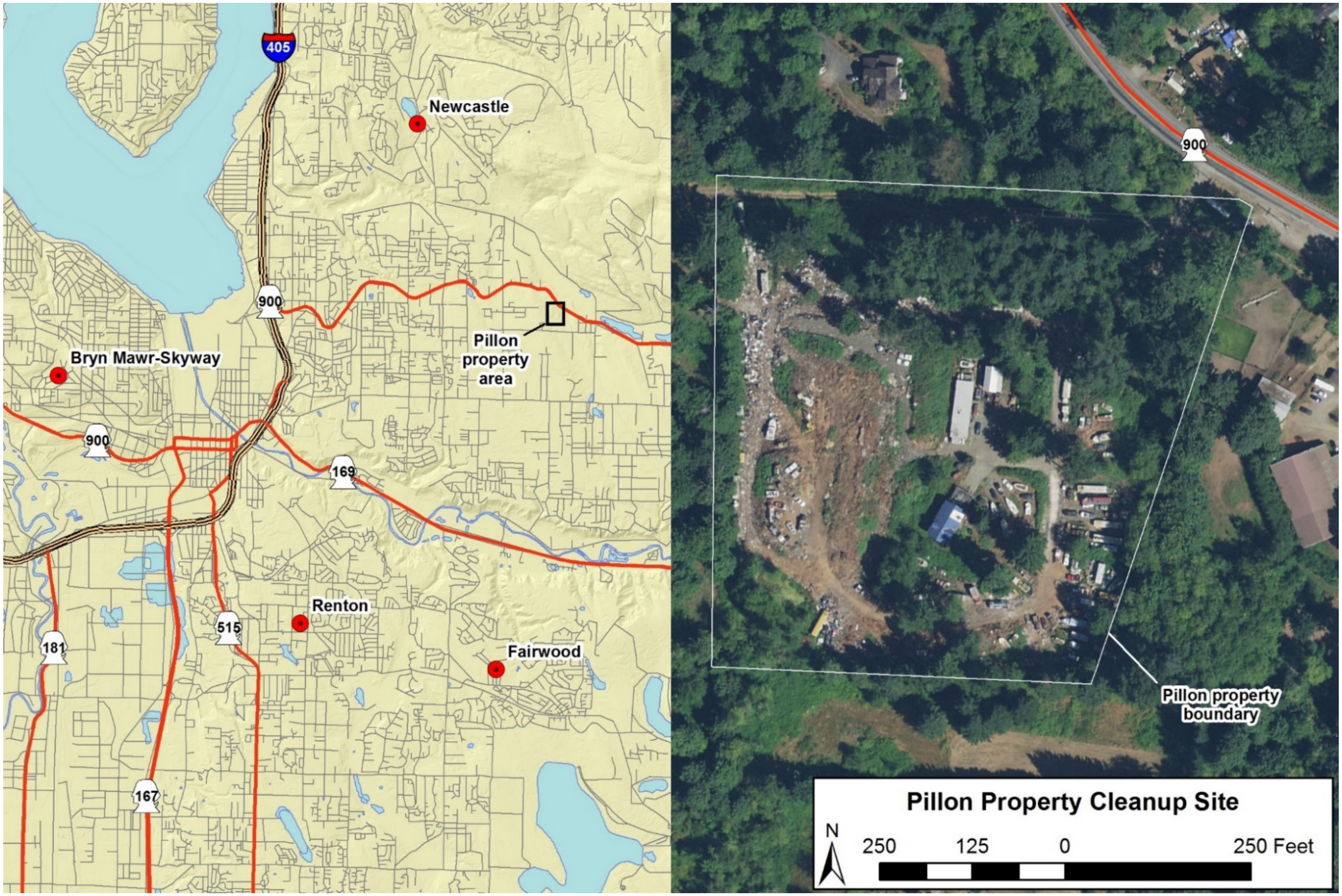

Figure 1. Area maps of the May Creek Landfill cleanup site in King County, WA.

Unpermitted activities observed on the property have included:

- Receiving construction, demolition, and land clearing debris
- Scrapping metals
- Auto wrecking
- Incinerating waste
- Smelting of metals
- Storing asphalt trucks in active use
- Producing biodiesel

In January 2003, King County Hazardous Waste staff submitted an environmental report (ERTS 531727) to Ecology noting that it was being used as a wrecking yard, a landfill and, allegedly, a composting business, all without licenses or permits. The ERTS report included allegations of vehicles being buried and large areas of oil- and solvent-contaminated soils from vehicle dismantling. In August 2003, the Ecology listed the May Creek Landfill on its Confirmed and Suspected Contaminated Sites List as confirmed for metals in surface water and suspected for petroleum, antifreeze, metals, and gasoline in soil and groundwater.

Despite numerous notices of violations and penalties over the years, there is no record of any cleanup activities at the site until 2016. In February 2016 EPA/START was tasked with identifying and removing hazardous wastes and materials. Results from an initial site visit and sampling indicated that Resource Conservation and Recovery Act (RCRA) characteristic waste were present on the site. Hundreds of containers were also observed on the site.

In November and December 2018, EPA performed the following removal activities:

- Recovery, characterization, and disposal of 1,659 containers of hazardous substances. The contents of the containers included gasoline and other fuels, motor oil and other automotive fluids, oil-based and latex paints, paint thinners, pesticides and herbicides, and compressed gas cylinders.
- Excavation of 15 test pits to determine the presence of buried hazardous materials and the extent of soil contamination.
- Collection surface water samples to determine if surface water transiting the site was contaminated.

Samples collected from the test pits indicated that the site soils were contaminated with petroleum hydrocarbons, dioxins, and metals. Surface water samples collected from transient locations around the site contained diesel and motor oil at concentrations greater than applicable state cleanup levels.

In May 2019, EPA received a Summary Judgement from the U.S. District Court of Washington providing EPA access to install groundwater monitoring wells throughout the property and to remove contaminated soil. By the end of July 2019, 7 monitoring wells had been installed (Figure 2) and sampled for a wide range of contaminants of potential concern. EPA demobilized from the site on August 8, 2019.

Ecology has committed to continue the groundwater monitoring for 2 years. King County Solid Waste Division will work with the property owner to remove and properly dispose of the remaining solid waste.

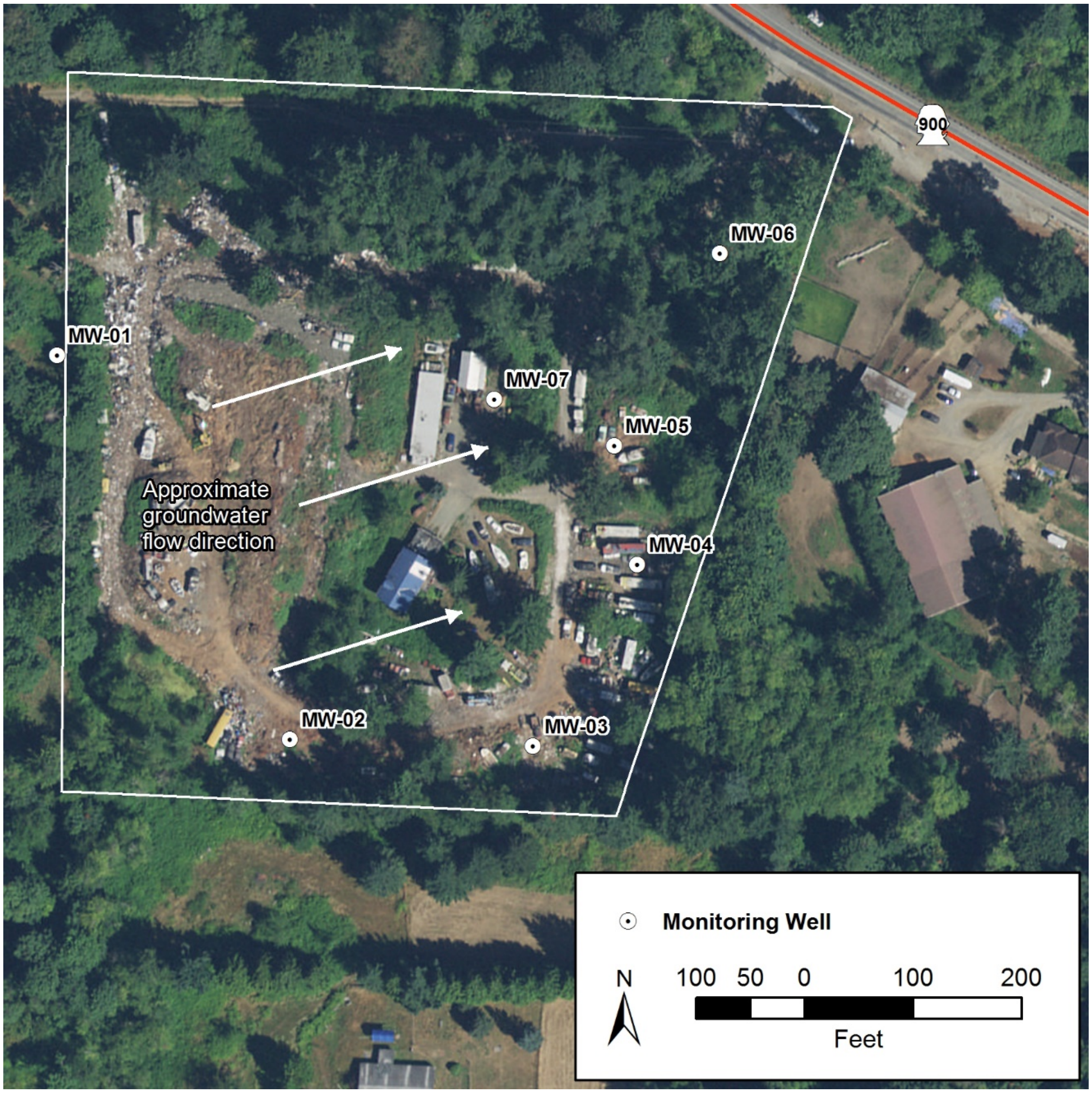

Figure 2. Map of monitoring well locations.

3.2.2 Summary of previous studies and existing data

EPA/START installed 7 monitoring wells on the site in July 2019. One round of sampling was conducted for a wide range of contaminants of potential concern.

3.2.3 Parameters of interest and potential sources

Due to the nature of the unpermitted landfill, there is a wide-ranging list of contaminants of potential concern related to the activities observed on the property listed in section 3.2.1. These contaminants include:

- Metals
- Volatile Organic Compounds (VOC)
- Semi-Volatile Organic Compounds (SVOC)
- Gasoline Range Organics (GRO)
- Diesel Range Organics (DRO)
- Pesticides
- PCBs

Dioxins and furans are of concern in soil but are not expected to be detected in ground water. However, there is potential for mobilization of dioxins due to co-solvency with petroleum products.

3.2.4 Regulatory criteria or standards

This site is regulated under Washington's Model Toxics Control Act (MTCA) (WAC 173-340). Results will be compared to MTCA method B groundwater cleanup levels as listed in Appendix B. As of publication of this Quality Assurance Project Plan (QAPP)**,** the values shown in Appendix B represent preliminary cleanup levels (PCULs). For PCULs, the most stringent method B cleanup or screening level applies, unless the most stringent level is below natural background; if natural background is higher than the most stringent cleanup level, the PCUL is set at the natural background value. For some analytes, the PCUL falls below the reporting limit associated with the analytical methods this project will use (see Appendix C).

The project team will use initial results to decide whether to use higher resolution methods for specific groups of analytes (e.g. PCBs) in future rounds of sampling. Any additional analytical methods will be addressed in an addendum to this QAPP. After 2 years of quarterly sampling, Ecology's Toxics Cleanup Program (TCP) will evaluate the results and determine what, if any, additional work is needed at this site in order to set final cleanup levels (e.g. a Remedial Investigation and Feasibility Study). Additional work beyond 2 years of quarterly sampling will be addressed in an addendum to this QAPP or a new QAPP. If formal cleanup levels are warranted, TCP will consider laboratory capabilities of sensitivity and precision for specific analytes when setting the cleanup levels.

4.0 Project Description

The Director of Ecology's Northwest Regional Office requested that EAP collect groundwater samples from the 7 newly installed wells on the May Creek Landfill site. Groundwater data are needed to assess whether land activities on the site have impacted the shallow groundwater. This information will assist Ecology in determining if further actions are needed at this site as related to groundwater quality.

4.1 Project goals

The project goal is to procure groundwater 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 whether contaminants of concern are present in the project area, and at what concentration.

4.2 Project objectives

The project objective is to collect groundwater samples quarterly for 2-years beginning in early 2020 for analysis of the contaminants of potential concern from the 7 newly installed site monitoring wells.

4.3 Information needed and sources

Groundwater quality data for this project is needed to assess whether the site's groundwater has been impacted by site activities. The property owner of the May Creek Landfill has been cited for numerous waste violations. Soil samples collected during EPA's removal activities confirmed the presence of petroleum hydrocarbons and metals contamination. Groundwater quality data will be collected from the 7 recently installed monitoring wells for the contaminants of potential concern discussed in Section 3.2.3.

4.4 Tasks required

- Measure depth to water in the 7 site monitoring wells, quarterly.
- Sample the site monitoring wells for water quality parameters and contaminants of potential concern quarterly for 2-years beginning in early 2020.
- Evaluate results for quality assurance (QA) using EAP QA procedures.
- Compare analytical data for contaminants of potential concern to MTCA Method B groundwater cleanup levels.
- Enter project data into Ecology's Environmental Information Management database (EIM)
- Prepare a final project report at the end of 2 years of monitoring that includes results of the above 5 activities.

4.5 Systematic planning process

This QAPP serves as the planning document for the project.

5.0 Organization and Schedule

5.1 Key individuals and their responsibilities

Table 1. Organization of project staff and responsibilities.

Staff	Title	Responsibilities
Tom Buroker Regional Director Northwest Regional Office	EAP Client	Clarifies scope of the project. Provides internal review of the QAPP and approves the final QAPP.
Jacob Carnes EAP GFFU SCS	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.
Pam Marti EAP GFFU SCS	Unit Supervisor for the Project Manager/ Licensed Hydrogeologist	Reviews the project scope and budget, tracks progress, reviews the draft QAPP, and approves the final QAPP. Reviews draft report and final report.
Eric Daiber EAP GFFU SCS	Field Assistant	Helps collect samples and records field information.
Rick Thomas TCP Northwest Regional Office	TCP Project Management Assistant	Provides internal review of the QAPP and approves the final QAPP. Provides TCP management support.
Bob Warren TCP Northwest Regional Office	TCP Northwest Regional Office Section Manager	Reviews and approves the final QAPP.
Jessica Archer EAP SCS	Section Manager for the Project Manager	Reviews the project scope and budget, tracks progress, reviews the draft QAPP, and approves the final QAPP.
Stacy Polkowski EAP Western Operations Section	Section Manager for the Study Area	Reviews the project scope and budget, tracks progress, reviews the draft QAPP, and approves the final QAPP.
Alan Rue Manchester Environmental Laboratory	Manchester Lab Director	Reviews and approves the final QAPP.
Arati Kaza	Ecology Quality Assurance Officer	Reviews and approves the draft QAPP and the final QAPP.

EAP Environmental Assessment Program
GFFU: Groundwater/Forests & Fish Unit
SCS: Statewide Coordination Section
EIM Environmental Information Management database
QAPP Quality Assurance Project Plan
TCP Toxics Cleanup Program

5.2 Special training and certifications

A hydrogeologist license is required for the person overseeing hydrogeologic studies (Chapter 18.220.020 RCW). This project is being conducted under the supervision of a licensed hydrogeologist.

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 1.

5.4 Proposed project schedule

Table 2. Proposed schedule for completing field and laboratory work, data entry into EIM, and reports.

Task	Due date	Lead staff
Field work completed	October 2021	Jacob Carnes
Laboratory analyses completed	December 2021	MEL Staff
EIM data loaded	January 2022	Jacob Carnes
EIM data entry review	February 2022	Eric Daiber
EIM complete	March 2022	Jacob Carnes
Draft due to supervisor	March 2022	Jacob Carnes
Draft due to client/peer reviewer	May 2022	Jacob Carnes
Final (all reviews done) due to publications coordinator	June 2022	Jacob Carnes
Final report due on web	October 2022	Publications Coordinator

5.5 Budget and funding

Tables 3 and 4 present the estimated analytical costs for a single round of sampling. Ecology's Manchester Environmental Laboratory will perform all analyses shown in Table 3. The per round cost of sampling will change if analyses are added or removed during the course of this project.

Table 3. Project budget for lab analyses per round of sampling

Parameter	Number of Samples	Number of QA Samples	Total Number of Samples	Cost Per Sample	Lab Subtotal
TAL Metals	7	3	10	$262	$2620
VOC	7	3	10	$185	$1850
SVOC	7	3	10	$310	$3100
GRO	7	2	9	$95	$855
DRO	7	2	9	$160	$1440
Pesticides/PCB	7	3	10	$200	$2000
Per Round Lab Total					**$11,865**

DRO Diesel range organics
GRO Gasoline range organics
PCB Polychlorinated biphenyls
SVOC Semivolatile organic compounds
TAL Total analyte list
VOC Volatile organics compounds

Table 4. Total project budget per round of sampling

Budget Item	Amount
Equipment	$250
Travel and other	$250
Laboratory	$11,865
Per Round Grand Total	**$12,365**

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 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 groundwater samples for the contaminants of potential concern that are representative of current concentrations at 7 monitoring well locations (Figure 2), quarterly for 2 years. Fieldwork to collect samples will be conducted following SOPs EAP052 for depth to water measurements (Marti, 2018), and EAP078 for purging and sampling monitoring wells (Marti, 2016). Samples will be analyzed using accredited methods (see Appendix C) to obtain data that meet the Measurement Quality Objectives (MQOs) that are described below and that are comparable to previous study 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 5 and 6.

Table 5. Measurement quality objectives for field measurements of water purged from wells 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 6. Measurement quality objectives for laboratory analyses of water samples.

Parameter	Duplicate Samples (*Relative % Difference)*	Matrix Spike-Duplicates (*Relative % Difference)*	Verification Standards (LCS, CRM, CCV) (% Recovery)	Matrix Spikes (% Recovery)	Surrogate Standards (% Recovery)	MRL or Lowest Conc. of Interest
TAL Metals [a]	≤ 20	≤ 20	85 - 115	75-125	n/a	0.01 - 250 µg/L
Mercury	≤ 20	≤ 20	90 - 110	75-125	n/a	0.05 µg/L
VOC [a]	≤ 30 or ≤ 40	≤ 30 or ≤ 40	75 - 125 or 60 - 140	75 - 130 or 60 - 140	80 - 120	1.00 µg/L
SVOC w/BNA [a]	≤ 40	≤ 40	Various	Various	Various	0.25 - 5.0 µg/L
GRO	≤ 50	≤ 40	70 - 130	n/a	70 - 130	0.07 mg/L
DRO	≤ 40	≤ 40	70 - 130	n/a	50-150	0.15 mg/L
Pesticides [a]	≤ 40	≤ 40	Various	Various	Various	0.0025 - 0.025 µg/L
PCB [a]	≤ 40	≤ 40	50 - 150	50 - 150	50-150	0.025 µg/L

[a] Analyte groups are listed here with the range of MQOs of each group. Appendix C lists individual analytes and MQOs.
BNA Base/neutrals and acids
CCV Continuing calibration verification
CRM Certified Reference Material
LCS Laboratory Control Sample
MRL Method reporting limit
DRO Diesel range organics
GRO Gasoline range organics
PCB Polychlorinated biphenyls
SVOC Semivolatile organic compounds
TAL Total analyte list
VOC Volatile organic compounds

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).

One duplicate sample will be collected per sampling trip. Duplicate samples will be collected by filling 2 sets of bottles at the same time from a pre-selected well. The most recently available analytical results from previous sampling will be used to select an appropriate well, based on the highest concentration of contaminants.

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. For this project, 2 measures of sensitivity that take into account are applicable: 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 TAL metals (EPA methods 200.7, 200.8, and 245) 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 VOCs, SVOCs, Pesticides, and PCBs (EPA methods 8260D, 8270E, 8081B, and 8082A) have LLOQs. Targets for lab measurement sensitivity required for the project are listed in Table 6 and Appendix C.

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 are expected to 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 quarterly to account for seasonal variability. Samples are assumed to be representative of site conditions at the time they are collected. 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.

6.3 Acceptance criteria for quality of existing data

Previous groundwater monitoring results related to this project are limited to those collected by EPA/START in July 2019. EPA's data quality criteria are acceptable for this project.

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 monitoring data to assess concentrations of the contaminants of potential concern at the May Creek Landfill. This information will assist Ecology in determining if additional cleanup actions are needed at the site to protect groundwater quality.

7.1 Study boundaries

The study boundaries will be defined by the locations of existing site monitoring wells as shown in Figure 2.

7.2 Field data collection

7.2.1 Sampling locations and frequency

Groundwater samples will be collected quarterly for 2 years from the 7 recently installed site monitoring wells. Quarterly sampling will account for seasonal variability.

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)
- Target Analyte List (TAL) Metals and Mercury (Laboratory)
- Volatile Organic Compounds (Laboratory)
- Semi-Volatile Organic Compounds including Base/Neutrals/Acids (Laboratory)
- Gasoline Range Organics (Laboratory)
- Diesel Range Organics (Laboratory)
- Pesticides (Laboratory)
- PCBs (Laboratory)

Appendix C lists all individual analytes along with analyte specific MQOs and analytical methods. The TAL is a list of inorganic analytes with specified analytical methods developed by the EPA. Manchester Environmental Lab offers GRO and DRO as single analytes, using methods NWTPH-Gx and NWTPH-Dx, respectively. These methods provide semi-quantitative analysis of volatile (GRO) and semi-volatile (DRO) petroleum products (Ecology, 1997).

The initial round of samples will be analyzed for PCB Aroclors using Method 8082. If PCB Aroclors are not detected by Method 8082 during the first quarter of sampling, the project team will consider analyzing for PCB congeners using Method 1668 (USEPA, 2008) in future sampling rounds. The MQOs for the EPA method 1668B analyses will be included in an addendum to this QAPP, if added to the project.

Ecology's Toxic Cleanup Program has requested that analyses for dioxins and furans also be added to this sampling program. These compounds will be analyzed by EPA method 1613B (USEPA, 1994). MQOs for the method used will be included in an addendum to this QAPP.

If an entire class of analytes (e.g., pesticides) or if individual metals produce results that are not of concern (detected below cleanup levels or not detected) during the first year of sampling, the project team will consider whether these analytes must be included in the second year of sampling.

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 7 recently installed site monitoring wells will provide information representative of site conditions.
- Sampling on a quarterly basis will provide information on seasonal variation when comparing results. This assumes that seasonal climate factors that affect sample results are consistent each year (i.e., precipitation, temperature). A related assumption is that precipitation events during or shortly before sampling will not significantly bias results.

7.5 Possible challenges and contingencies

7.5.1 Logistical problems

The primary challenge of this study relates to accessing the site to sample the newly installed monitoring wells over the course of the project. To install the wells EPA was granted a summary judgement to gain access to the property for a period of 120 days. That agreement ended in September 2019. The property owner, Mr. Charles Pillon, will be contacted prior to any site visits and sampling. If Mr. Pillon denies access for any reason, the EAP project manager will consult with the TCP and NWRO personnel to decide on additional actions.

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

7.5.2 Practical constraints

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

During the July 2019 well installation and sampling, EPA described the groundwater bearing units having very low transmissivity and were therefore slow to recharge. Due to these site conditions, wells will be pumped at a rate that minimizes this potential impact. The pumping rate for purging and sampling is discussed in more detail in section 8.2.

The short holding time for the semi-volatile and pesticide/PCB analysis (7 days from time of sampling) requires planning and advance arrangement with the analytical laboratory.

Any practical constraints will be discussed in the final report.

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).

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

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, 2018)
- EAP078 for purging and sampling monitoring wells (Marti, 2016)

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, 2018).

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. Sample order will be based on previous sample results and professional judgment.

The monitoring wells at this site are described as low-yielding and slow to recover. Because of these conditions, they 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. If higher resolution analytical techniques are used in future sampling events, tubing material may be changed to decrease the potential for sample contamination. Any changes in sampling equipment will be addressed in an addendum to this QAPP.

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). A YSI Professional Plus or Hydrolab MS5 multiparameter sonde will be used to measure pH, temperature, specific conductance, dissolved oxygen, and oxidation reduction potential. A Hach 2100Q turbidimeter will be used to measure turbidity.

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 final report.

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 at MEL for the laboratory parameters of interest (Table 5). Any deviations from the sample plan will be discussed in the final technical report.

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
TAL Metals	Water	350 mL	500 mL HDPE bottle	Pre-acidified with 1:1 HNO_3 Cool to ≤6°C	6 months
Mercury	Water	350 mL	500 mL HDPE bottle	Pre-acidified with 1:1 HNO_3 Cool to ≤6°C	28 days
VOCs	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
SVOCs w/BNA	Water	1 gallon	1 gallon clear glass bottle	Cool to ≤6°C	7 days
GRO	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
DRO	Water	1 L	1 L narrow-mouth amber glass jar	1:1 HCl, Cool to ≤6°C	14 days
Pesticides	Water	1 L	1 L amber glass bottle	Cool to ≤6°C	7 days
PCBs	Water	1 L	1 L amber glass bottle	Cool to ≤6°C	1 year

BNA Base/neutrals and acids
DRO Diesel range organics
GRO Gasoline range organics
PCB Polychlorinated biphenyls
SVOC Semivolatile organic compounds
TAL Total analyte list
VOC Volatile organic compounds

8.4 Equipment decontamination

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 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

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 3 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 this project, along with the expected number of samples and an expected range of results are listed in Table 8. If the project team decides to analyze for PCB congeners by method 1668 in future rounds of sampling, the laboratory procedures for that method will be addressed in an addendum to this QAPP.

Table 8. Laboratory measurement methods (laboratory).

See Appendix C for methods used for individual analytes.

Analyte Group	Sample Matrix	Samples (Number/ Arrival Date)	Expected Range of Results	Method Reporting Limit/Lower Limit of Quantitation	Analytical (Instrumental) Method
TAL Metals	Water	10/quarterly	<1-50,000 µg/L	0.1 - 250 µg/L	EPA 200.7 (Martin et al, 1994)/ EPA 200.8 (Creed et al., 1994)
Mercury	Water	10/quarterly	<1-50,000 µg/L	0.05 µg/L	EPA 245.1 (O'Dell et al., 1994)
VOCs	Water	10/quarterly	<1-1,000 µg/L	1.00 - 2.00 µg/L	EPA 8260D (USEPA, 2018a)
SVOCs w/BNA	Water	10/quarterly	<1-1,000 µg/L	0.25 - 5.0 µg/L	EPA 8270E (USEPA, 2018b)
GRO	Water	9/quarterly	<0.1-10 mg/L	0.07 mg/L	NWTPH-Gx (Ecology, 1997)
DRO	Water	9/quarterly	< 0.1 – 7 mg/L	0.15 - 0.375 mg/L	NWTPH-Dx (Ecology, 1997)
Pesticides	Water	10/quarterly	<1-100 µg/L	0.0025 - 0.025 µg/L	EPA 8081B (USEPA, 2007a)
PCBs	Water	10/quarterly	<0.1-1 µg/L	0.025 µg/L	EPA 8082A (USEPA, 2007b)

BNA Base/neutrals and acids
CCV Continuing calibration verification
CRM Certified Reference Material
LCS Laboratory Control Sample
DRO Diesel range organics
GRO Gasoline range organics
PCB Polychlorinated biphenyls
SVOC Semivolatile organic compounds
TAL Total analyte list
VOC Volatile organic compounds

9.2 Sample preparation method(s)

The laboratory will follow sample preparation procedures described in the analytical 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

Ecology's Manchester Environmental Laboratory will perform all analyses for the analytes listed in Appendix C.

10.0 Quality Control Procedures

Quality control (QC) procedures provide the information needed to assess the quality of the collected data. 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 the variability in field duplicates and the variability in laboratory duplicates is an estimate of the 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 (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 9. Quality control samples, types, and frequency.

Parameter	Field Equipment Blanks	Field Replicate Samples	Verification Standards (LCS,CRM, CCV)[a]	Method Blanks[a]	Analytical Duplicates[a]	Matrix Spike/Matrix Spike Duplicate[a]
TAL Metals	1	1/10 samples	1/batch	1/batch	--	1 pair/batch
VOC	1	1/10 samples	1/batch	1/batch	--	1 pair/ batch
SVOC w/BNA	1	1/10 samples	1/batch	1/batch	--	1 pair/ batch
GRO	1	1/10 samples	1/batch	1/batch	1/10 samples	--
DRO	1	1/10 samples	1/batch	1/batch	1/10 samples	--
Pesticides	1	1/10 samples	1 pair / batch	1/batch	--	1 pair / batch
PCB	1	1/10 samples	1 pair / batch	1/batch	--	1 pair / batch

[a] A batch is defined as up to 20 samples analyzed together.
BNA Base/neutrals and acids
CCV Continuing calibration verification
CRM Certified Reference Material
LCS Laboratory Control Sample
DRO Diesel range organics
GRO Gasoline range organics
PCB Polychlorinated biphenyls
SVOC Semivolatile organic compounds
TAL Total analyte list
VOC Volatile organic compounds

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 the Laboratory Information Management System (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 laboratory 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 quality assurance program.

12.2 Responsible personnel

See Section 12.1.

12.3 Frequency and distribution of reports

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

Validated interim results will be communicated to the project client and TCP 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

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.

13.4 Model quality assessment

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 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 treated in the method described in MTCA [WAC 173-340-709(5)].

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 report.

The final technical 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 final technical 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

BNA	Base/Neutral and Acid
DO	(see Glossary above)
DRO	Diesel range organics
e.g.	For example
Ecology	Washington State Department of Ecology
EIM	Environmental Information Management database
EPA	U.S. Environmental Protection Agency
et al.	And others
GRO	Gasoline range organics
i.e.	In other words
MEL	Manchester Environmental Laboratory
MQO	Measurement quality objective
PCB	polychlorinated biphenyls
QA	Quality assurance
QC	Quality control
RPD	Relative percent difference
RSD	Relative standard deviation
SOP	Standard operating procedures
SRM	Standard reference materials
SVOC	Semivolatile organic compounds

TAL	Total analyte list
TPH-D	Total petroleum hydrocarbons as diesel
TPH-G	Total petroleum hydrocarbons as gasoline
USGS	United States Geological Survey
VOC	Volatile organic compounds
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)
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, 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 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 4 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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Appendix B. Preliminary Groundwater Cleanup Levels

Table B-1. Preliminary Cleanup Levels (PCUL) for Groundwater at May Creek Landfill determined by TCP.

All values are in ug/L. The cleanup level GW-1 is intended to protect drinking water, GW-2 protects surface water, GW-3 protects sediment. GW-4 is a screening level to protect indoor air quality. GW-5 is natural background. The most stringent PCUL is the minimum of GW-1 through GW-4. If the minimum value is less than GW-5, it is adjusted up to GW-5. For some compounds the PCUL is below the practical quantitation limit achievable by accredited labs. In such instances, before final cleanup levels are determined, values of sensitivity and precision typical for accredited labs meet TCP's expectations. TCP considers laboratory capabilities when setting final cleanup levels. The measurement quality objectives for this project are presented in Appendix C.

Chemical	Most Stringent PCUL (GW-1 – GW-5)	GW-1	GW-2	GW-3	GW-4	GW-5
PCBs						
Total PCB Aroclors	7.00E-06	4.38E-01	7.00E-06	7.12E-02	na	na
Total PCB congeners	7.00E-06	4.38E-01	7.00E-06	2.26E-03	na	na
Total PCB TEQ	4.43E-10	6.73E-06	4.43E-10	4.53E-07	na	na
Dioxins/Furans						
2,3,7,8-TCDD	5.00E-09	6.73E-06	5.00E-09	TBD	na	na
Total dioxin/furan TEQ	2.76E-09	6.73E-06	2.76E-09	na	na	na
Total chlorinated dioxins	na	na	na	na	na	na
Total chlorinated furans	na	na	na	na	na	na
Metals						
Aluminum	5.00E+01	5.00E+01	8.70E+01	na	na	na
Antimony	5.60E+00	6.00E+00	5.60E+00	na	na	na
Arsenic	5.00E+00	5.83E-01	1.80E-02	3.52E+02	na	5.00E+00
Barium	1.00E+03	2.00E+03	1.00E+03	2.28E+06	na	na
Beryllium	4.00E+00	4.00E+00	7.56E+01	1.19E+01	na	na
Cadmium	4.88E-01	5.00E+00	7.18E-01	4.88E-01	na	na
Chromium, total	1.00E+02	1.00E+02	na	na	na	na
Chromium, trivalent	7.41E+01	2.40E+04	7.41E+01	2.08E+02	na	na
Chromium, hexavalent	1.00E+01	4.80E+01	1.00E+01	1.25E+05	na	na
Cobalt	4.80E+00	4.80E+00	na	na	na	na
Copper	1.14E+01	6.40E+02	1.14E+01	1.40E+01	na	na
Iron	3.00E+02	3.00E+02	1.00E+03	na	na	na
Lead	2.52E+00	1.50E+01	2.52E+00	1.55E+01	na	na
Manganese	5.00E+01	5.00E+01	5.00E+01	na	na	na
Mercury, inorganic	1.20E-02	2.00E+00	1.20E-02	9.99E-01	2.92E-01	na
Methylmercury	7.70E-01	1.60E+00	7.70E-01	na	na	na
Molybdenum	8.00E+01	8.00E+01	na	na	na	na

Chemical	Most Stringent PCUL (GW-1 – GW-5)	GW-1	GW-2	GW-3	GW-4	GW-5
Nickel	2.63E+01	1.00E+02	5.20E+01	2.63E+01	na	na
Selenium	5.00E+00	5.00E+01	5.00E+00	4.42E+03	na	na
Silver	3.22E+00	8.00E+01	3.22E+00	5.17E+00	na	na
Thallium	6.19E-02	1.60E-01	6.19E-02	6.20E+01	na	na
Tin	9.60E+03	9.60E+03	na	na	na	na
Vanadium	1.44E+02	1.44E+02	na	na	na	na
Zinc	1.05E+02	4.80E+03	1.05E+02	1.75E+02	na	na
SVOCs – PAHs						
Acenaphthene	3.00E+01	9.60E+02	3.00E+01	1.10E+06	na	na
Acenaphthylene	na	na	na	na	na	na
Anthracene	1.00E+02	4.80E+03	1.00E+02	1.15E+06	na	na
Benzo(a)anthracene	1.60E-04	na	1.60E-04	na	na	na
Benzo(b)fluoranthene	1.60E-04	na	1.60E-04	na	na	na
Benzo(k)fluoranthene	1.60E-03	na	1.60E-03	na	na	na
Total benzofluoranthenes	na	na	na	na	na	na
Benzo(g,h,i)perylene	na	na	na	na	na	na
Benzo(a)pyrene	1.60E-05	2.00E-01	1.60E-05	5.57E-02	na	na
Chrysene	1.60E-02	na	1.60E-02	na	na	na
Dibenz(a,h)anthracene	1.60E-05	na	1.60E-05	na	na	na
Dibenzofuran	1.60E+01	1.60E+01	na	na	na	na
Fluoranthene	6.00E+00	6.40E+02	6.00E+00	7.36E+04	na	na
Fluorene	1.00E+01	6.40E+02	1.00E+01	4.66E+05	na	na
Indeno(1,2,3-cd)pyrene	1.60E-04	na	1.60E-04	na	na	na
Methyl isopropyl phenanthrene	na	na	na	na	na	na
1-Methylnaphthalene	1.51E+00	1.51E+00	na	na	na	na
2-Methylnaphthalene	3.20E+01	3.20E+01	na	na	na	na
Naphthalene	8.92E+00	1.60E+02	1.37E+03	1.45E+06	8.92E+00	na
Phenanthrene	na	na	na	na	na	na
Pyrene	8.00E+00	4.80E+02	8.00E+00	3.99E+04	na	na
Total LPAHs	na	na	na	na	na	na
Total HPAHs	na	na	na	na	na	na
Total PAHs	na	na	na	na	na	na
Total cPAH TEQ	4.33E-03	2.00E-01	1.19E-02	4.33E-03	na	na
Other SVOCs						
Aniline	7.68E+00	7.68E+00	na	na	na	na
Azobenzene	7.95E-01	7.95E-01	na	na	na	na
Benzidine	2.00E-05	3.80E-04	2.00E-05	na	na	na
Benzoic acid	3.69E+03	6.40E+04	na	3.69E+03	na	na

Chemical	Most Stringent PCUL (GW-1 – GW-5)	GW-1	GW-2	GW-3	GW-4	GW-5
Benzyl alcohol	8.00E+02	8.00E+02	na	na	na	na
Bis(2-chloroethoxy)methane	na	na	na	na	na	na
Bis(2-chloroethyl)ether	2.00E-02	3.98E-02	2.00E-02	4.98E+02	2.57E+01	na
Bis(2-chloro-1-methylethyl)ether	2.00E+02	3.20E+02	2.00E+02	na	na	na
2,6-Bis(1,1-dimethylethyl) phenol	na	na	na	na	na	na
Bis(2-ethylhexyl) phthalate	4.50E-02	6.00E+00	4.50E-02	9.00E-01	na	na
4-Bromophenyl phenyl ether	na	na	na	na	na	na
Butyl benzyl phthalate	1.30E-02	4.61E+01	1.30E-02	2.80E+03	na	na
Butyl diphenyl phosphate	na	na	na	na	na	na
Carbazole	5.22E+01	na	na	5.22E+01	na	na
4-Chloroaniline	2.19E-01	2.19E-01	na	2.96E+03	na	na
4-Chloro-3-methylphenol	3.60E+01	na	3.60E+01	na	na	na
2-Chloronaphthalene	1.00E+02	6.40E+02	1.00E+02	na	na	na
2-Chlorophenol	1.50E+01	4.00E+01	1.50E+01	7.90E+03	na	na
4-Chlorophenyl phenyl ether	na	na	na	na	na	na
Dibutyl phthalate	8.00E+00	1.60E+03	8.00E+00	1.26E+01	na	na
Dibutyl phenyl phosphate	na	na	na	na	na	na
1,2-Dichlorobenzene	6.00E+02	6.00E+02	7.00E+02	5.44E+06	2.58E+03	na
1,3-Dichlorobenzene	2.00E+00	na	2.00E+00	na	na	na
1,4-Dichlorobenzene	4.93E+00	7.50E+01	5.98E+01	5.64E+03	4.93E+00	na
3,3'-Dichlorobenzidine	3.10E-03	1.94E-01	3.10E-03	5.78E+01	na	na
2,4-Dichlorophenol	1.00E+01	2.40E+01	1.00E+01	1.88E+04	na	na
Di(2-ethylhexyl)adipate	4.00E+02	4.00E+02	na	na	na	na
Diethyl phthalate	2.00E+02	1.28E+04	2.00E+02	5.20E+08	na	na
Dimethyl phthalate	6.00E+02	na	6.00E+02	na	na	na
2,4-Dimethylphenol	8.50E+01	1.60E+02	8.50E+01	6.80E+06	na	na
1,2-Dinitrobenzene	1.60E+00	1.60E+00	na	na	na	na
1,3-Dinitrobenzene	1.60E+00	1.60E+00	na	na	na	na
1,4-Dinitrobenzene	1.60E+00	1.60E+00	na	na	na	na
4,6-Dinitro-2-methylphenol	2.00E+00	na	2.00E+00	na	na	na
2,4-Dinitrophenol	1.00E+01	3.20E+01	1.00E+01	3.05E+06	na	na
2,4-Dinitrotoluene	3.90E-02	2.82E-01	3.90E-02	1.54E+03	na	na
2,6-Dinitrotoluene	5.83E-02	5.83E-02	na	3.85E+02	na	na
Di-n-octyl phthalate	9.37E-05	1.60E+02	na	9.37E-05	na	na
1,4-Dioxane	4.38E-01	4.38E-01	na	na	na	na

Chemical	Most Stringent PCUL (GW-1 – GW-5)	GW-1	GW-2	GW-3	GW-4	GW-5
1,2-Diphenylhydrazine	1.00E-02	1.09E-01	1.00E-02	na	na	na
Hexachlorobenzene	5.00E-06	5.47E-01	5.00E-06	2.50E-03	na	na
Hexachlorobutadiene	1.00E-02	5.61E-01	1.00E-02	1.74E+01	8.06E-01	na
Hexachlorocyclopentadiene	1.00E+00	4.80E+01	1.00E+00	2.71E+03	na	na
Hexachloroethane	2.00E-02	1.09E+00	2.00E-02	9.94E+02	3.14E+00	na
Isophorone	2.70E+01	4.61E+01	2.70E+01	7.39E+05	na	na
2-Methoxynaphthalene	na	na	na	na	na	na
2-Methylphenol	4.00E+02	4.00E+02	na	3.05E+07	na	na
3-Methylphenol	4.00E+02	4.00E+02	na	na	na	na
4-Methylphenol	8.00E+02	8.00E+02	na	na	na	na
2-Nitroaniline	1.60E+02	1.60E+02	na	na	na	na
3-Nitroaniline	na	na	na	na	na	na
4-Nitroaniline	6.40E+01	6.40E+01	na	na	na	na
Nitrobenzene	1.00E+01	1.60E+01	1.00E+01	1.03E+06	1.58E+02	na
2-Nitrophenol	na	na	na	na	na	na
4-Nitrophenol	na	na	na	na	na	na
n-Nitrosodimethylamine	6.50E-04	8.58E-04	6.50E-04	na	na	na
n-Nitrosodiphenylamine	6.20E-01	1.79E+01	6.20E-01	1.11E+04	na	na
n-Nitrosodi-n-propylamine	4.40E-03	1.25E-02	4.40E-03	1.28E+02	na	na
Pentachlorophenol	2.00E-03	1.00E+00	2.00E-03	8.65E-01	na	na
Phenol	2.79E+02	2.40E+03	4.00E+03	2.79E+02	na	na
Pyridine	8.00E+00	8.00E+00	na	na	na	na
2,3,4,6-Tetrachlorophenol	4.80E+02	4.80E+02	na	na	na	na
1,2,4-Trichlorobenzene	3.60E-02	1.51E+01	3.60E-02	1.47E+03	3.85E+01	na
2,4,5-Trichlorophenol	3.00E+02	8.00E+02	3.00E+02	1.52E+05	na	na
2,4,6-Trichlorophenol	2.50E-01	3.98E+00	2.50E-01	2.53E+02	na	na
Volatile Organic Compounds						
Acetone	7.20E+03	7.20E+03	na	na	na	na
Acrolein	1.00E+00	4.00E+00	1.00E+00	na	2.94E+00	na
Acrylonitrile	1.90E-02	8.10E-02	1.90E-02	na	1.57E+01	na
Benzaldehyde	1.09E+01	1.09E+01	na	na	na	na
Benzene	4.40E-01	5.00E+00	4.40E-01	na	2.41E+00	na
Bromobenzene	6.40E+01	6.40E+01	na	na	na	na
Bromochloromethane	na	na	na	na	na	na
Bromoethane	na	na	na	na	na	na
Bromoform	4.60E+00	5.54E+01	4.60E+00	na	1.96E+02	na
Bromomethane	1.12E+01	1.12E+01	1.00E+02	na	1.29E+01	na

Chemical	Most Stringent PCUL (GW-1 – GW-5)	GW-1	GW-2	GW-3	GW-4	GW-5
2-Butoxyethanol	8.00E+02	8.00E+02	na	na	na	na
n-Butylbenzene	4.00E+02	4.00E+02	na	na	na	na
sec-Butylbenzene	8.00E+02	8.00E+02	na	na	na	na
tert-Butylbenzene	8.00E+02	8.00E+02	na	na	na	na
Carbon disulfide	3.99E+02	8.00E+02	na	na	3.99E+02	na
Carbon tetrachloride	2.00E-01	5.00E+00	2.00E-01	na	5.62E-01	na
Chlorobenzene	1.00E+02	1.00E+02	1.00E+02	na	2.91E+02	na
Chloroethane	1.85E+04	na	na	na	1.85E+04	na
2-Chloroethyl vinyl ether	na	na	na	na	na	na
Chloroform	1.19E+00	1.41E+01	6.00E+01	na	1.19E+00	na
Chloromethane	1.53E+02	na	na	na	1.53E+02	na
3-Chloro-1-propene	2.08E+00	2.08E+00	na	na	na	na
2-Chlorotoluene	1.60E+02	1.60E+02	na	na	na	na
4-Chlorotoluene	na	na	na	na	na	na
Dibromochloromethane	6.00E-01	5.21E+00	6.00E-01	na	na	na
1,2-Dibromo-3-chloropropane	2.00E-01	2.00E-01	na	na	na	na
Dibromomethane	8.00E+01	8.00E+01	na	na	na	na
Dichlorobromomethane	7.30E-01	7.06E+00	7.30E-01	na	1.82E+00	na
trans-1,4-Dichloro-2-butene	na	na	na	na	na	na
Dichlorodifluoromethane	5.65E+00	1.60E+03	na	na	5.65E+00	na
1,1-Dichloroethane	7.68E+00	7.68E+00	na	na	1.11E+01	na
1,2-Dichloroethane	4.22E+00	4.81E+00	8.90E+00	na	4.22E+00	na
1,1-Dichloroethylene	7.00E+00	7.00E+00	3.00E+02	na	1.29E+02	na
cis-1,2-Dichloroethylene	1.60E+01	1.60E+01	na	na	na	na
trans-1,2-Dichloroethylene	1.00E+02	1.00E+02	1.00E+02	na	na	na
1,2-Dichloroethylene (mixed isomers)	7.20E+01	7.20E+01	na	na	na	na
1,2-Dichloropropane	7.10E-01	5.00E+00	7.10E-01	na	1.04E+01	na
1,3-Dichloropropane	na	na	na	na	na	na
2,2-Dichloropropane	na	na	na	na	na	na
1,1-Dichloropropene	na	na	na	na	na	na
cis-1,3-Dichloropropene	2.20E-01	4.38E-01	2.20E-01	na	na	na
trans-1,3-Dichloropropene	2.20E-01	4.38E-01	2.20E-01	na	na	na
Ethane	na	na	na	na	na	na
Ethylbenzene	2.90E+01	7.00E+02	2.90E+01	na	2.82E+03	na
Ethylene	na	na	na	na	na	na
Ethyl ether	1.60E+03	1.60E+03	na	na	na	na
Ethylene dibromide	5.00E-02	5.00E-02	na	na	2.71E-01	na

Chemical	Most Stringent PCUL (GW-1 – GW-5)	GW-1	GW-2	GW-3	GW-4	GW-5
Formaldehyde	2.08E+00	2.08E+00	na	na	na	na
2-Hexanone	4.00E+01	4.00E+01	na	na	na	na
Isopropylbenzene	8.00E+02	8.00E+02	na	na	na	na
4-Isopropyltoluene	na	na	na	na	na	na
Methane	na	na	na	na	na	na
Methyl ethyl ketone	4.80E+03	4.80E+03	na	na	1.75E+06	na
Methyl iodide	na	na	na	na	na	na
Methyl isobutyl ketone	6.40E+02	6.40E+02	na	na	4.70E+05	na
Methyl tert-butyl ether	2.43E+01	2.43E+01	na	na	6.05E+02	na
Methylene chloride	5.00E+00	5.00E+00	1.00E+01	na	4.41E+03	na
2-Pentanone	na	na	na	na	na	na
n-Propylbenzene	8.00E+02	8.00E+02	na	na	na	na
Styrene	1.00E+02	1.00E+02	na	na	8.19E+03	na
1,1,1,2-Tetrachloroethane	1.68E+00	1.68E+00	na	na	7.36E+00	na
1,1,2,2-Tetrachloroethane	1.00E-01	2.19E-01	1.00E-01	na	6.19E+00	na
Tetrachloroethylene	2.40E+00	5.00E+00	2.40E+00	na	2.42E+01	na
Toluene	5.70E+01	6.40E+02	5.70E+01	na	1.55E+04	na
1,2,3-Trichlorobenzene	na	na	na	na	na	na
1,1,1-Trichloroethane	2.00E+02	2.00E+02	1.00E+04	na	5.46E+03	na
1,1,2-Trichloroethane	3.50E-01	3.00E+00	3.50E-01	na	4.64E+00	na
Trichloroethylene	3.00E-01	4.00E+00	3.00E-01	na	1.55E+00	na
Trichlorofluoroethane	na	na	na	na	na	na
Trichlorofluoromethane	1.20E+02	2.40E+03	na	na	1.20E+02	na
1,2,3-Trichloropropane	1.46E-03	1.46E-03	na	na	na	na
Trichlorotrifluoroethane	1.83E+02	2.40E+05	na	na	1.83E+02	na
1,2,3-Trimethylbenzene	8.00E+01	8.00E+01	na	na	na	na
1,2,4-Trimethylbenzene	8.00E+01	8.00E+01	na	na	2.39E+02	na
1,3,5-Trimethylbenzene	8.00E+01	8.00E+01	na	na	na	na
Vinyl acetate	7.81E+03	8.00E+03	na	na	7.81E+03	na
Vinyl chloride	2.00E-02	2.92E-01	2.00E-02	na	3.50E-01	na
Total xylenes	3.32E+02	1.60E+03	na	na	3.32E+02	na
Petroleum Hydrocarbons						
Gasoline range hydrocarbons	8.00E+02	8.00E+02	na	na	na	na
Diesel range hydrocarbons	5.00E+02	5.00E+02	na	na	na	na
Oil range hydrocarbons	5.00E+02	5.00E+02	na	na	na	na
Total diesel & oil range hydrocarbons	5.00E+02	5.00E+02	na	na	na	na
Pesticides						

Chemical	Most Stringent PCUL (GW-1 – GW-5)	GW-1	GW-2	GW-3	GW-4	GW-5
Aldrin	4.10E-08	2.57E-03	4.10E-08	4.10E-04	3.18E-01	na
alpha-BHC	4.80E-05	1.39E-02	4.80E-05	6.38E+00	na	na
beta-BHC	1.30E-03	4.86E-02	1.30E-03	6.55E-01	na	na
delta-BHC	na	na	na	na	na	na
gamma-BHC	8.00E-02	2.00E-01	8.00E-02	4.72E+01	na	na
cis-Chlordane	1.03E-04	2.50E-01	3.64E-04	1.03E-04	na	na
trans-Chlordane	1.03E-04	2.50E-01	3.64E-04	1.03E-04	na	na
Chlordane	2.20E-05	2.00E+00	2.20E-05	TBD	na	na
Chlorpyrifos	4.10E-02	1.60E+01	4.10E-02	na	na	na
4,4'-DDD	7.90E-06	3.65E-01	7.90E-06	6.64E+00	na	na
4,4'-DDE	8.80E-07	2.57E-01	8.80E-07	2.49E+00	na	na
4,4'-DDT	1.20E-06	2.57E-01	1.20E-06	2.95E-05	na	na
Total DDD	3.65E-01	3.65E-01	na	1.35E+00	na	na
Total DDE	4.86E-02	2.57E-01	na	4.86E-02	na	na
Total DDT	2.57E-01	2.57E-01	na	TBD	na	na
Diazinon	1.70E-01	1.12E+01	1.70E-01	na	na	na
Dieldrin	7.00E-08	5.47E-03	7.00E-08	7.83E-04	na	na
Endosulfan I	5.60E-02	9.60E+01	5.60E-02	2.59E+05	na	na
Endosulfan II	5.60E-02	9.60E+01	5.60E-02	2.59E+05	na	na
Endosulfan sulfate	9.00E+00	9.60E+01	9.00E+00	na	na	na
Endrin	2.00E-03	2.00E+00	2.00E-03	2.50E+03	na	na
Endrin aldehyde	3.40E-02	na	3.40E-02	na	na	na
Endrin ketone	na	na	na	na	na	na
Heptachlor	3.40E-07	1.94E-01	3.40E-07	2.09E-03	na	na
Heptachlor epoxide	2.40E-06	4.81E-02	2.40E-06	TBD	na	na
Malathion	1.00E-01	3.20E+02	1.00E-01	na	na	na
Methoxychlor	2.00E-02	4.00E+01	2.00E-02	5.65E+03	na	na
Mirex	1.00E-03	4.86E-03	1.00E-03	na	na	na
Nonachlor	na	na	na	na	na	na
Toxaphene	3.20E-05	7.95E-01	3.20E-05	6.93E-01	na	na
na - not available or not applicable						

Appendix C. Analytes, Analytical Methods, and Measurement Quality Objectives

Analytes included in Table C-1 will be analyzed by MEL using the methods shown.

Abbreviation for quality control criteria in Table C-1:

- **BSRPD** Blank spike relative percent difference
- **BSLL** Blank spike lower limit
- **BSUL** Blank spike upper limit
- **DUPRPD** Duplicate relative percent difference
- **LLOQ** Lower limit of quantitation
- **MDL** Method detection limit
- **MSRPD** Matrix spike relative percent difference
- **MSLL** Matrix spike lower limit
- **MSUL** Matrix spike upper limit
- **MRL** Method reporting limit

Table C-1. List of analytes that MEL will analyze for in May Creek Landfill groundwater samples.

Analytical methods and analyte-specific MQOs are included. Personnel in TCP have determined that the sensitivity and precision values for the analytes in this table sufficiently meet project goals and are comparable to the values available from other accredited laboratories.

Analyte Group	Analyte	Analytical Method	MDL (µg/L)	MRL/ LLOQ (µg/L)	BSLL (%)	BSUL (%)	BSRPD (%)	MSLL (%)	MSUL (%)	MSRPD (%)	DUPRPD (%)
VOC	1,1,1,2-Tetrachloroethane	EPA 8260D	0.1500	1	75	125	30	70	130	30	30
VOC	1,1,1-Trichloroethane	EPA 8260D	0.0790	1	75	125	30	70	130	30	30
VOC	1,1,2,2-Tetrachloroethane	EPA 8260D	0.0800	1	75	125	30	70	130	30	30
VOC	1,1,2-Trichloroethane	EPA 8260D	0.0610	1	75	125	30	70	130	30	30
VOC	1,1,2-Trichlorotrifluoroethane	EPA 8260D	0.1200	1	75	125	30	70	130	30	30
VOC	1,1-Dichloroethane	EPA 8260D	0.0820	1	75	125	30	70	130	30	30
VOC	1,1-Dichloroethene	EPA 8260D	0.1300	1	75	125	30	70	130	30	30
VOC	1,1-Dichloropropene	EPA 8260D	0.0790	1	75	125	30	70	130	30	30
VOC	1,2,3-Trichlorobenzene	EPA 8260D	0.0780	1	75	125	30	70	130	30	30
VOC	1,2,3-Trichloropropane	EPA 8260D	0.0500	1	75	125	30	70	130	30	30
VOC	1,2,4-Trichlorobenzene	EPA 8260D	0.0390	1	75	125	30	70	130	30	30

Analyte Group	Analyte	Analytical Method	MDL (µg/L)	MRL/ LLOQ (µg/L)	BSLL (%)	BSUL (%)	BSRPD (%)	MSLL (%)	MSUL (%)	MSRPD (%)	DUPR PD (%)
VOC	1,2,4-Trimethylbenzene	EPA 8260D	0.0580	1	75	125	30	70	130	30	30
VOC	1,2-Dibromo-3-Chloropropane	EPA 8260D	0.1400	1	75	125	30	70	130	30	30
VOC	1,2-Dibromoethane	EPA 8260D	0.0770	1	75	125	30	70	130	30	30
VOC	1,2-Dichlorobenzene	EPA 8260D	0.0650	1	75	125	30	70	130	30	30
VOC	1,2-Dichloroethane	EPA 8260D	0.0840	1	75	125	30	70	130	30	30
VOC	1,2-Dichloropropane	EPA 8260D	0.0840	1	75	125	30	70	130	30	30
VOC	1,3,5-Trimethylbenzene	EPA 8260D	0.0320	1	75	125	30	70	130	30	30
VOC	1,3-Dichlorobenzene	EPA 8260D	0.0380	1	75	125	30	70	130	30	30
VOC	1,3-Dichloropropane	EPA 8260D	0.0730	1	75	125	30	70	130	30	30
VOC	1,4-Dichlorobenzene	EPA 8260D	0.0790	1	75	125	30	70	130	30	30
VOC	2,2-Dichloropropane	EPA 8260D	0.1900	1	75	125	30	70	130	30	30
VOC	2-Butanone	EPA 8260D	0.2400	1	60	140	40	60	140	40	40
VOC	2-Chlorotoluene	EPA 8260D	0.1000	1	75	125	30	70	130	30	30
VOC	2-Hexanone	EPA 8260D	0.0670	1	60	140	40	60	140	40	40
VOC	4-Chlorotoluene	EPA 8260D	0.0650	1	60	140	40	60	140	40	40
VOC	4-Methyl-2-pentanone	EPA 8260D	0.0610	1	60	140	40	60	140	40	40
VOC	Acetone	EPA 8260D	0.5100	1	60	140	40	60	140	40	40
VOC	Benzene	EPA 8260D	0.0690	1	75	125	30	70	130	30	30
VOC	Bromobenzene	EPA 8260D	0.0480	1	75	125	30	70	130	30	30
VOC	Bromochloromethane	EPA 8260D	0.1500	1	75	125	30	70	130	30	30
VOC	Bromodichloromethane	EPA 8260D	0.0990	1	75	125	30	70	130	30	30
VOC	Bromoform	EPA 8260D	0.0910	1	75	125	30	70	130	30	30
VOC	Bromomethane	EPA 8260D	0.1000	1	60	140	40	60	140	40	40
VOC	Carbon Disulfide	EPA 8260D	0.0690	1	75	125	30	70	130	30	30
VOC	Carbon Tetrachloride	EPA 8260D	0.3600	1	75	125	30	70	130	30	30
VOC	Chlorobenzene	EPA 8260D	0.0550	1	75	125	30	70	130	30	30
VOC	Chloroethane	EPA 8260D	0.0550	1	75	125	30	70	130	30	30
VOC	Chloroform	EPA 8260D	0.0530	1	75	125	30	70	130	30	30

Analyte Group	Analyte	Analytical Method	MDL (µg/L)	MRL/ LLOQ (µg/L)	BSLL (%)	BSUL (%)	BSRPD (%)	MSLL (%)	MSUL (%)	MSRPD (%)	DUPR PD (%)
VOC	Chloromethane	EPA 8260D	0.1110	1	60	140	40	60	140	40	40
VOC	Cis-1,2-Dichloroethene	EPA 8260D	0.1100	1	75	125	30	70	130	30	30
VOC	Cis-1,3-Dichloropropene	EPA 8260D	0.0570	1	75	125	30	70	130	30	30
VOC	Dibromochloromethane	EPA 8260D	0.1800	1	75	125	30	70	130	30	30
VOC	Dibromomethane	EPA 8260D	0.1100	1	75	125	30	70	130	30	30
VOC	Dichlorodifluoromethane	EPA 8260D	0.0500	1	60	140	40	60	140	40	40
VOC	Ethyl Ether	EPA 8260D	0.1200	1	75	125	30	70	130	30	30
VOC	Ethylbenzene	EPA 8260D	0.0510	1	75	125	30	70	130	30	30
VOC	Hexachlorobutadiene	EPA 8260D	0.1800	1	75	125	30	70	130	30	30
VOC	Hexachloroethane	EPA 8260D	0.5500	1	75	125	30	70	130	30	30
VOC	Isopropylbenzene (Cumene)	EPA 8260D	0.0450	1	75	125	30	70	130	30	30
VOC	m,p-Xylene	EPA 8260D	0.1900	2	75	125	30	70	130	30	30
VOC	Methyl Iodide	EPA 8260D	0.2700	1	75	125	30	70	130	30	30
VOC	Methyl t-butyl ether	EPA 8260D	0.0950	1	75	125	30	70	130	30	30
VOC	Methylene Chloride	EPA 8260D	0.2300	1	60	140	40	60	140	40	40
VOC	Naphthalene	EPA 8260D	0.0490	1	75	125	30	70	130	30	30
VOC	n-Butylbenzene	EPA 8260D	0.0600	1	75	125	30	70	130	30	30
VOC	n-Propylbenzene	EPA 8260D	0.0910	1	75	125	30	70	130	30	30
VOC	o-Xylene	EPA 8260D	0.0510	1	75	125	30	70	130	30	30
VOC	Pentachloroethane	EPA 8260D	0.0980	1	75	125	30	70	130	30	30
VOC	p-Isopropyltoluene	EPA 8260D	0.0550	1	75	125	30	70	130	30	30
VOC	Sec-Butylbenzene	EPA 8260D	0.1000	1	75	125	30	70	130	30	30
VOC	Styrene	EPA 8260D	0.0700	1	75	125	30	70	130	30	30
VOC	Tert-Butylbenzene	EPA 8260D	0.0620	1	75	125	30	70	130	30	30
VOC	Tetrachloroethene	EPA 8260D	0.1300	1	75	125	30	70	130	30	30
VOC	Tetrahydrofuran	EPA 8260D	0.2600	1	75	125	30	70	130	30	30
VOC	Toluene	EPA 8260D	0.0880	1	75	125	30	70	130	30	30
VOC	Trans-1,2-Dichloroethene	EPA 8260D	0.1100	1	75	125	30	70	130	30	30

Analyte Group	Analyte	Analytical Method	MDL (µg/L)	MRL/ LLOQ (µg/L)	BSLL (%)	BSUL (%)	BSRPD (%)	MSLL (%)	MSUL (%)	MSRPD (%)	DUPRPD (%)
VOC	Trans-1,3-Dichloropropene	EPA 8260D	0.1000	1	75	125	30	70	130	30	30
VOC	Trans-1,4-Dichloro-2-butene	EPA 8260D	0.1800	1	75	125	30	70	130	30	30
VOC	Trichloroethene	EPA 8260D	0.0690	1	75	125	30	70	130	30	30
VOC	Trichlorofluoromethane	EPA 8260D	0.1100	1	75	125	30	70	130	30	30
VOC	Vinyl Chloride	EPA 8260D	0.0450	1	60	140	40	60	140	40	40
SVOC	1,2,4-Trichlorobenzene	EPA 8270E	0.0617	0.25	16	92	40	16	90	40	40
SVOC	1,2-Dichlorobenzene	EPA 8270E	0.0590	0.25	19	90	40	19	84	40	40
SVOC	1,2-Diphenylhydrazine	EPA 8270E	0.1591	0.25	50	150	40	50	150	40	40
SVOC	1,3-Dichlorobenzene	EPA 8270E	0.0510	0.25	13	90	40	16	84	40	40
SVOC	1,4-Dichlorobenzene	EPA 8270E	0.0547	0.25	14	92	40	17	85	40	40
SVOC	1-Methylnaphthalene	EPA 8270E	0.1617	0.25	33	110	40	33	110	40	40
SVOC	2,4,5-Trichlorophenol	EPA 8270E	0.1978	1	46	141	40	56	130	40	40
SVOC	2,4,6-Trichlorophenol	EPA 8270E	0.1515	1	51	141	40	66	118	40	40
SVOC	2,4-Dichlorophenol	EPA 8270E	0.1308	2.5	66	115	40	49	125	40	40
SVOC	2,4-Dimethylphenol	EPA 8270E	0.1475	2.5	59	127	40	58	122	40	40
SVOC	2,4-Dinitrotoluene	EPA 8270E	0.1412	1	64	136	40	71	118	40	40
SVOC	2,6-Dinitrotoluene	EPA 8270E	0.1702	1	65	131	40	71	130	40	40
SVOC	2-Chloronaphthalene	EPA 8270E	0.1584	0.5	21	127	40	21	127	40	40
SVOC	2-Chlorophenol	EPA 8270E	0.1303	1	66	109	40	46	104	40	40
SVOC	2-Methylnaphthalene	EPA 8270E	0.1492	0.25	29	112	40	29	112	40	40
SVOC	2-Methylphenol	EPA 8270E	0.1262	2.5	55	117	40	28	99	40	40
SVOC	2-Nitroaniline	EPA 8270E	0.1670	5	64	136	40	27	145	40	40
SVOC	2-Nitrophenol	EPA 8270E	0.1124	0.5	64	115	40	51	115	40	40
SVOC	3,3'-Dichlorobenzidine	EPA 8270E	0.0498	0.5	10	178	40	10	178	40	40
SVOC	3B-Coprostanol	EPA 8270E	0.0763	5	10	154	40	10	284	40	40
SVOC	3-Nitroaniline	EPA 8270E	0.1436	1	10	393	40	10	123	40	40
SVOC	4,6-Dinitro-2-Methylphenol	EPA 8270E	1.6704	5	67	133	40	80	128	40	40
SVOC	4-Bromophenyl phenyl ether	EPA 8270E	0.2247	0.5	47	113	40	61	136	40	40

Analyte Group	Analyte	Analytical Method	MDL (µg/L)	MRL/ LLOQ (µg/L)	BSLL (%)	BSUL (%)	BSRPD (%)	MSLL (%)	MSUL (%)	MSRPD (%)	DUPR PD (%)
SVOC	4-Chloro-3-Methylphenol	EPA 8270E	0.1981	2.5	60	129	40	50	133	40	40
SVOC	4-Chloroaniline	EPA 8270E	0.4025	10	10	150	40	10	150	40	40
SVOC	4-Chlorophenyl-Phenylether	EPA 8270E	0.2234	0.25	47	113	40	58	110	40	40
SVOC	4-Methylphenol	EPA 8270E	0.1240	2.5	43	127	40	20	100	40	40
SVOC	4-Nitrophenol	EPA 8270E	0.0509	2.5	10	134	40	10	81	40	40
SVOC	4-nonylphenol	EPA 8270E	0.1000	1	77	215	40	30	262	40	40
SVOC	Acenaphthene	EPA 8270E	0.2434	0.25	17	169	40	17	169	40	40
SVOC	Acenaphthylene	EPA 8270E	0.1896	0.25	46	118	40	46	118	40	40
SVOC	Anthracene	EPA 8270E	0.2557	0.5	66	121	40	66	121	40	40
SVOC	Benz[a]anthracene	EPA 8270E	0.2890	0.5	84	130	40	84	130	40	40
SVOC	Benzo(a)pyrene	EPA 8270E	0.1217	0.25	70	145	40	70	145	40	40
SVOC	Benzo(b)fluoranthene	EPA 8270E	0.1158	0.25	71	140	40	71	140	40	40
SVOC	Benzo(ghi)perylene	EPA 8270E	0.2570	0.5	61	141	40	61	141	40	40
SVOC	Benzo(k)fluoranthene	EPA 8270E	0.2402	0.25	73	141	40	73	141	40	40
SVOC	Benzyl Alcohol	EPA 8270E	0.0882	2.5	10	97	40	10	97	40	40
SVOC	Bis(2-chloro-1-methylethyl) ether	EPA 8270E	0.1669	0.25	63	105	40	63	105	40	40
SVOC	Bis(2-Chloroethoxy)Methane	EPA 8270E	0.2077	0.25	65	116	40	46	124	40	40
SVOC	Bis(2-Chloroethyl)Ether	EPA 8270E	0.1434	0.5	65	110	40	65	110	40	40
SVOC	Bis(2-Ethylhexyl) Phthalate	EPA 8270E	0.1503	5	80	128	40	61	131	40	40
SVOC	Bisphenol A	EPA 8270E	0.1000	1	11	203	40	10	256	40	40
SVOC	Butyl benzyl phthalate	EPA 8270E	0.1165	1	23	183	40	80	150	128	40
SVOC	Caffeine	EPA 8270E	0.1938	0.5	62	114	40	28	91	40	40
SVOC	Carbazole	EPA 8270E	0.0256	0.5	59	139	40	59	139	40	40
SVOC	Cholesterol	EPA 8270E	0.2373	5	10	140	40	10	227	40	40
SVOC	Chrysene	EPA 8270E	0.2979	0.5	82	128	40	82	128	40	40
SVOC	Dibenzo(a,h)anthracene	EPA 8270E	0.2354	0.25	65	130	40	65	130	40	40
SVOC	Dibenzofuran	EPA 8270E	0.2232	0.5	47	126	40	47	126	40	40
SVOC	Diethyl phthalate	EPA 8270E	0.2465	0.5	77	123	40	79	117	40	40

Analyte Group	Analyte	Analytical Method	MDL (µg/L)	MRL/ LLOQ (µg/L)	BSLL (%)	BSUL (%)	BSRPD (%)	MSLL (%)	MSUL (%)	MSRPD (%)	DUPRPD (%)
SVOC	Dimethyl phthalate	EPA 8270E	0.2162	0.5	74	122	40	73	126	40	40
SVOC	Di-N-Butylphthalate	EPA 8270E	0.1827	1	70	156	40	73	148	40	40
SVOC	Di-N-Octyl Phthalate	EPA 8270E	0.2225	2.5	75	135	40	61	148	40	40
SVOC	Fluoranthene	EPA 8270E	0.3050	0.5	72	124	40	72	124	40	40
SVOC	Fluorene	EPA 8270E	0.2428	0.25	50	134	40	50	134	40	40
SVOC	Hexachlorobenzene	EPA 8270E	0.1233	0.25	53	114	40	52	129	40	40
SVOC	Hexachlorobutadiene	EPA 8270E	0.0380	0.5	10	90	40	15	178	40	40
SVOC	Hexachlorocyclopentadiene	EPA 8270E	0.0314	1	10	76	40	10	85	40	40
SVOC	Hexachloroethane	EPA 8270E	0.0584	0.25	12	79	40	13	74	40	40
SVOC	Indeno(1,2,3-cd)pyrene	EPA 8270E	0.2373	0.25	61	139	40	61	139	40	40
SVOC	Isophorone	EPA 8270E	0.2313	0.5	50	103	40	46	92	40	40
SVOC	Naphthalene	EPA 8270E	0.1395	0.5	34	114	40	34	114	40	40
SVOC	Nitrobenzene	EPA 8270E	0.2069	0.25	67	108	40	48	113	40	40
SVOC	N-Nitrosodi-n-propylamine	EPA 8270E	0.2215	0.25	60	128	40	46	124	40	40
SVOC	N-Nitrosodiphenylamine	EPA 8270E	0.1047	0.5	10	209	40	10	185	40	40
SVOC	Phenanthrene	EPA 8270E	0.2703	0.5	63	126	40	63	126	40	40
SVOC	Phenol	EPA 8270E	0.0795	1	41	81	40	10	49	40	40
SVOC	Pyrene	EPA 8270E	0.3406	0.5	64	140	40	64	140	40	40
SVOC	Retene	EPA 8270E	0.2743	0.5	75	135	40	73	136	40	40
SVOC	Triclosan	EPA 8270E	0.1000	1	54	126	40	43	164	40	40
SVOC	Triethyl citrate	EPA 8270E	0.1000	1	27	123	40	35	143	40	40
SVOC	Tris(2-chloroethyl) phosphate (TCEP)	EPA 8270E	0.1000	0.25	50	150	40	50	150	40	40
PCB	PCB-aroclor-1016	EPA 8082A	0.0029	0.025	50	150	40	50	150	40	40
PCB	PCB-aroclor-1221	EPA 8082A	0.0042	0.025	50	150	40	50	150	40	40
PCB	PCB-aroclor-1232	EPA 8082A	0.0073	0.025	50	150	40	50	150	40	40
PCB	PCB-aroclor-1242	EPA 8082A	0.0018	0.025	50	150	40	50	150	40	40
PCB	PCB-aroclor-1248	EPA 8082A	0.0022	0.025	50	150	40	50	150	40	40
PCB	PCB-aroclor-1254	EPA 8082A	0.0043	0.025	50	150	40	50	150	40	40

Analyte Group	Analyte	Analytical Method	MDL (µg/L)	MRL/ LLOQ (µg/L)	BSLL (%)	BSUL (%)	BSRPD (%)	MSLL (%)	MSUL (%)	MSRPD (%)	DUPR PD (%)
PCB	PCB-aroclor-1260	EPA 8082A	0.0075	0.025	50	150	40	50	150	40	40
PCB	PCB-aroclor-1262	EPA 8082A	0.0020	0.025	50	150	40	50	150	40	40
PCB	PCB-aroclor-1268	EPA 8082A	0.0010	0.025	50	150	40	50	150	40	40
Pesticides	Alpha-BHC	EPA 8081B	0.0012	0.0025	50	150	40	50	150	40	40
Pesticides	Beta-BHC	EPA 8081B	0.00131	0.0025	50	150	40	50	150	40	40
Pesticides	Gamma-BHC	EPA 8081B	0.0013	0.0025	50	150	40	50	150	40	40
Pesticides	Delta-BHC	EPA 8081B	0.00115	0.0025	50	150	40	50	150	40	40
Pesticides	Heptachlor	EPA 8081B	0.0014	0.0025	50	150	40	50	150	40	40
Pesticides	Aldrin	EPA 8081B	0.00127	0.0025	50	150	40	50	150	40	40
Pesticides	Chlorpyriphos	EPA 8081B		0.0025	50	150	40	50	150	40	40
Pesticides	Heptachlor Epoxide	EPA 8081B	0.00128	0.0025	50	150	40	50	150	40	40
Pesticides	trans-Chlordane	EPA 8081B	0.00123	0.0025	50	150	40	50	150	40	40
Pesticides	cis-Chlordane	EPA 8081B	0.0012	0.0025	50	150	40	50	150	40	40
Pesticides	Endosulfan I	EPA 8081B	0.00108	0.0025	50	150	40	50	150	40	40
Pesticides	Dieldrin	EPA 8081B	0.0012	0.0025	50	150	40	50	150	40	40
Pesticides	Endrin	EPA 8081B	0.00124	0.0025	50	150	40	50	150	40	40
Pesticides	Endrin Ketone	EPA 8081B	0.00096	0.0025	50	150	40	50	150	40	40
Pesticides	Endosulfan II	EPA 8081B	0.00129	0.0025	50	150	40	50	150	40	40
Pesticides	Endrin Aldehyde	EPA 8081B	0.00119	0.0025	50	150	40	50	150	40	40
Pesticides	Endosulfan Sulfate	EPA 8081B	0.00105	0.0025	50	150	40	50	150	40	40
Pesticides	4,4'-DDE	EPA 8081B	0.00119	0.0025	50	150	40	50	150	40	40
Pesticides	4,4'-DDD	EPA 8081B	0.00136	0.0025	50	150	40	50	150	40	40
Pesticides	4,4'-DDT	EPA 8081B	0.00116	0.0025	50	150	40	50	150	40	40
Pesticides	2,4'-DDE	EPA 8081B		0.0025	50	150	40	50	150	40	40
Pesticides	2,4'-DDD	EPA 8081B		0.0025	50	150	40	50	150	40	40
Pesticides	2,4'-DDT	EPA 8081B		0.0025	50	150	40	50	150	40	40
Pesticides	Methoxychlor	EPA 8081B	0.0012	0.0025	50	150	40	50	150	40	40
Pesticides	Oxychlordane	EPA 8081B	0.00131	0.0025	50	150	40	50	150	40	40

Analyte Group	Analyte	Analytical Method	MDL (µg/L)	MRL/ LLOQ (µg/L)	BSLL (%)	BSUL (%)	BSRPD (%)	MSLL (%)	MSUL (%)	MSRPD (%)	DUPR PD (%)
Pesticides	DDMU	EPA 8081B		0.0025	50	150	40	50	150	40	40
Pesticides	Cis-Nonachlor	EPA 8081B	0.00104	0.0025	50	150	40	50	150	40	40
Pesticides	Toxaphene	EPA 8081B		0.025	50	150	40	50	150	40	40
Pesticides	Trans-Nonachlor	EPA 8081B	0.00042	0.0025	50	150	40	50	150	40	40
Pesticides	Mirex	EPA 8081B		0.0025	50	150	40	50	150	40	40
Pesticides	Chlordane, technical	EPA 8081B		0.025	50	150	40	50	150	40	40
Pesticides	Hexachlorobenzene	EPA 8081B		0.0025	50	150	40	50	150	40	40
Pesticides	Dacthal	EPA 8081B		0.0025	50	150	40	50	150	40	40
Pesticides	Pentachloroanisole	EPA 8081B		0.0025	50	150	40	50	150	40	40
Petroleum	TPHD	NWTPH-DX		150	70	130	40				40
Petroleum	TPHG	NWTPH-GX		70	70	130	40				40
TAL Metals	Aluminum	EPA 200.7	0.0034	25	85	115	20	75	125	20	20
TAL Metals	Antimony	EPA 200.8	0.0334	0.1	85	115	20	75	125	20	20
TAL Metals	Arsenic	EPA 200.8	0.0171	0.1	85	115	20	75	125	20	20
TAL Metals	Barium	EPA 200.8	0.0234	0.1	85	115	20	75	125	20	20
TAL Metals	Beryllium	EPA 200.8	0.0085	0.1	85	115	20	75	125	20	20
TAL Metals	Cadmium	EPA 200.8	0.0084	0.1	85	115	20	75	125	20	20
TAL Metals	Calcium	EPA 200.7	0.013	25	85	115	20	75	125	20	20
TAL Metals	Chromium	EPA 200.8	0.0643	0.1	85	115	20	75	125	20	20
TAL Metals	Cobalt	EPA 200.8	0.0041	0.1	85	115	20	75	125	20	20
TAL Metals	Copper	EPA 200.8	0.0412	0.1	85	115	20	75	125	20	20
TAL Metals	Iron	EPA 200.7	0.0024	25	85	115	20	75	125	20	20
TAL Metals	Lead	EPA 200.8	0.0172	0.1	85	115	20	75	125	20	20
TAL Metals	Magnesium	EPA 200.7	0.0061	25	85	115	20	75	125	20	20
TAL Metals	Manganese	EPA 200.8	0.0091	0.1	85	115	20	75	125	20	20
TAL Metals	Nickel	EPA 200.8	0.0526	0.1	85	115	20	75	125	20	20
TAL Metals	Potassium	EPA 200.7	0.0334	250	85	115	20	75	125	20	20
TAL Metals	Selenium	EPA 200.8	0.014	0.1	85	115	20	75	125	20	20

Analyte Group	Analyte	Analytical Method	MDL (µg/L)	MRL/ LLOQ (µg/L)	BSLL (%)	BSUL (%)	BSRPD (%)	MSLL (%)	MSUL (%)	MSRPD (%)	DUPRPD (%)
TAL Metals	Silver	EPA 200.8	0.0185	0.1	85	115	20	75	125	20	20
TAL Metals	Sodium	EPA 200.7	0.0032	25	85	115	20	75	125	20	20
TAL Metals	Thallium	EPA 200.8	0.0056	0.1	85	115	20	75	125	20	20
TAL Metals	Vanadium	EPA 200.8	0.085	0.1	85	115	20	75	125	20	20
TAL Metals	Zinc	EPA 200.8	1.19	5	85	115	20	75	125	20	20
Mercury	Mercury	EPA 245.1	0.011	0.05	85	115	20	75	125	20	20

Appendix D. Well Completion Information and Well Logs

Well completion information is presented in Table D-1. Well logs can be viewed via the following links: MW-1, MW-2, MW-3, MW-4, MW-5, MW-6, MW-7.

Table D-1. Monitoring well construction summary

Monitoring Well	Borehole ID	Drilling and Monitoring Well Installation[1,2]	Total Borehole Depth (ft)	Riser Interval (ft bgs)	Surface Seal Interval (ft bgs)[3]	Screened Interval (ft bgs)	Filter Pack Interval (ft bgs)	Sump Interval (ft bgs)	Latitude	Longitude	Measured Well Depth (ft btoic)	Surveyed Well Elevation (toic)[4]	Surveyed Ground Surface Elevation[4]
MW-1	BH-A	7/9/2019	19	+2.5 - 7	1.5 - 5	7 - 17	5 - 19	17 - 18	47.50194472	-122.1327708	20.12	468.08	465.81
MW-2	BH-C	7/10/2019	18.5	+2.5 - 7	0.5 - 5	7 - 17	5 - 18.5	17 - 18	47.50098722	-122.1318725	20.4	469.92	467.27
MW-3	BH-B	7/11/2019	31	+2.5 - 18	0.5 - 14.5	18 - 28	14.5 - 29	28 - 29	47.50098306	-122.1309667	31.5	457.00	454.36
MW-4	BH-D	7/11/2019	21	+2.5 - 10	1 - 8	10 - 20	8 - 21	20 - 21	47.50144667	-122.1305925	23.28	437.87	435.68
MW-5	BH-F	7/12/2019	21	+2.5 - 10	0.5 - 9	10 - 20	9 - 21	20 - 21	47.50174528	-122.1306881	23.17	434.20	431.39
MW-6	BH-E	7/12/2019 - 7/13/2019	24.75	+2.5 - 13.75	0.5 - 12	13.75 - 23.75	12 - 24.75	23.75 - 24.75	47.50223611	-122.1303089	26.71	398.23	395.34
MW-7	BH-G	7/13/2019	17	+2.5 - 6	0.5 - 8	6 - 16	5 - 17	16 - 17	47.50185611	-122.1311367	19.21	446.14	443.56

[1] All borings drilled by Holt Services utilizing a Mobile B58 hollow stem auger with a 6 inch auger bit.
[2] All monitoring wells constructed with 2.0 inch PVC casing, 10-foot 0.010 inch slotted screen, and 1 foot sump.
[3] For all monitoring wells, the surface seal consists of bentonite chips and/or bentonite pellets. The filter pack consists of 12-10 CSS.
[4] NAVD88 Elevation in Feet

bgs Below Ground Surface
btoic Below Top of Inner Casing
ft Feet
ID Identification
PVC Polyvinyl chloride
toic Top of Inner Casing
CSS Colorado Silica Sand