2017 SECOND SEMI-ANNUAL GROUNDWATER MONITORING REPORT

BNSF Former Cummings Oil Lease Site
Winlock, Washington

Prepared for:

BNSF Railway Company
605 Puyallup Avenue South
Tacoma, Washington 98421

Prepared by:

TRC

January 2018

2017 SECOND SEMI-ANNUAL GROUNDWATER MONITORING REPORT

January 22, 2018

BNSF Former Cummings Oil Lease Site
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TRC Project No. 278114

Prepared For:

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1.0 INTRODUCTION

On behalf of the BNSF Railway Company (BNSF), TRC presents this *Second Semi-Annual 2017 Groundwater Monitoring Report.* This report summarizes the groundwater monitoring activities conducted at the Former Cummings Oil Lease (Site) in Winlock, Washington on August 31, 2017.

2.0 SITE BACKGROUND

2.1 Site Description

The Site is located at 908 Northwest Kerron Avenue in Winlock, Lewis County, Washington (Figure 1). The Site was used as a bulk fuel storage plant from approximately 1925 through 1976. Shell Oil Company leased the Site from BNSF for use as a bulk fuel storage facility when the Site was developed in 1925. Cummings Oil Company served as operators of the bulk fuel storage facility from 1970 until approximately 1976. All buildings and other features have been removed and the Site is currently undeveloped and unoccupied (Figure 2).

The previous remedial activities at the Site were performed under the Voluntary Cleanup Program (VCP) in accordance with the Model Toxics Control Act (MTCA), as established in Chapter 173-340 of the Washington Administrative Code, and the *Cleanup Action Work Plan, Former Cummings Oil Lease Site, 908 Northwest Kerron Avenue, Winlock, Washington* dated December 18, 2008, (Farallon, 2008). The Site was entered into the VCP in 2006 and assigned VCP Identification No. SW0775 under Washington State Department of Ecology's (Ecology) Toxics Cleanup Program.

2.2 Previous Investigations

Previous site investigations and remedial actions, including tank removal and soil excavation, confirmed that concentrations of the following Site-related contaminants were released to the subsurface as a result of historical activities at the Site:

- Total petroleum hydrocarbons (TPH) as gasoline-range organics (GRO);
    - *GRO was detected consistently in one Site monitoring well (MW-2), however, concentrations were always below MTCA Method A cleanup levels. Analyses for GRO were discontinued in 2014*.
- TPH as diesel-range organics (DRO);
- TPH as oil-range organics (ORO); and
- Benzene, toluene, ethylbenzene, and total xylenes (BTEX).
    - *Benzene is the only BTEX constituent that has been detected above MTCA Method A cleanup levels*.

A *Cleanup Action Work Plan* was approved in 2008 (Farallon, 2008) that outlined the selected remedial approach and specified the standards and associated requirements for the remedial activities. The selected remedial activities for the Site were implemented by Farallon in conjunction with tank closure activities conducted at the Site between March 10 and August 1, 2008.

The tank closure and remedial activities included removal of two underground storage tanks (USTs) and four aboveground storage tanks (ASTs), excavation and off-site disposal of soil containing petroleum hydrocarbon constituents at concentrations exceeding MTCA cleanup levels, and installation of monitoring wells to delineate the extent of Site-related contaminants in the groundwater and to monitor natural attenuation processes (Figure 2). A summary of the tank closure and remedial actions are included the *Tank Closure Report, Former Cummings Oil Lease Site, 908 Northwest Kerron Avenue, Winlock, Washington* (Farallon, 2010). Farallon concluded from the initial natural attenuation assessment that the groundwater chemistry was favorable for natural attenuation.

On December 27, 2010, Farallon conducted an additional assessment of the potential for natural attenuation to reduce residual concentrations of Site-related contaminants in the groundwater (Farallon, 2011). The additional geochemical indicators that were analyzed during the groundwater monitoring event were evaluated against the criteria established in Ecology's *Guidance on Remediation of Petroleum Contaminated Groundwater by Natural Attenuation* (Ecology, 2005). Farallon concluded from the assessment that natural attenuation was occurring. Additionally, Farallon evaluated concentration trends using the Mann-Kendall statistical test, a log-linear regression analysis, to develop an estimated timeline for the decrease of Site-related contaminant concentrations. Based on the statistical analysis, Farallon determined that DRO, ORO, and benzene concentrations were stable or decreasing. Farallon projected with an 85 percent confidence interval that DRO concentrations would be below MTCA Method A cleanup levels by March 2013. ORO and benzene projections were not evaluated, as more data was required to support regression analysis.

Continued groundwater monitoring activities were performed annually after 2010 as part of an ongoing assessment of natural attenuation of Site-related contaminants. Site-related contaminant concentrations continued to fluctuate and did not attenuate as rapidly as predicted in the assessment. On August 1, 2013, past the projected date of MTCA Method A cleanup level compliance, DRO and/or ORO were detected at concentrations exceeding the cleanup levels in groundwater samples collected from monitoring wells MW-2 and MW-3. Benzene was also detected at concentrations exceeding MTCA Method A cleanup levels in groundwater samples collected from monitoring well MW-2 on August 1, 2013.

On August 12, 2013, Ecology issued an *Opinion on Proposed Cleanup of the BNSF – Winlock Site, 908 Northwest Kerron Avenue, Winlock, Washington*, stating that further remedial action would be necessary to clean up contamination at the Site. Ecology concluded that there was inadequate Site characterization to support selection of monitored natural attenuation as the cleanup alternative or to meet the full requirements of a cleanup action under MTCA.

In August 2014, a supplemental subsurface investigation was performed in response to Ecology's Opinion letter, in addition to the routine annual groundwater monitoring event (Farallon, 2014). The purpose of the subsurface investigation was to further delineate the western extent of the plume, to evaluate potential for natural attenuation, and to evaluate the potential for preferential pathways to transport Site-related contaminants via groundwater flow diversion through the sanitary sewer or storm water conveyance line backfill materials. The conclusions of the supplemental subsurface investigation and annual groundwater monitoring event were as follows:

- No preferential pathways were directing groundwater to the south away from Site monitoring wells,
- Natural attenuation was still occurring, and
- Site-related contaminants were not being transported west of Northwest Kerron Avenue.

Annual groundwater monitoring for DRO, ORO, and BTEX has been conducted at the Site from 2010 through 2015 to assess the progress of natural attenuation of Site-related contaminants and to estimate a restoration time frame for monitoring well locations at the Site. The sampling locations include monitoring wells MW-1 through MW-7. Based on cumulative historical analytical groundwater data, BNSF discontinued analysis of monitoring well MW-4 for Site-related contaminants after 2014 due to the consistent absence of the contaminants in groundwater.

Beginning in the third quarter of 2015, and based on results from the August 2015 annual monitoring event, BNSF temporarily increased the sampling frequency to quarterly monitoring to document achieved reductions in Site-related contaminant concentrations and evaluate if the concentrations of those Site-related contaminants remained below MTCA Method A cleanup levels during seasonal variations in groundwater elevation.

As of August 2016, TRC has been conducting semi-annual groundwater monitoring events to continue assessment of natural attenuation of Site-related contaminants.

3.0 GROUNDWATER MONITORING

TRC conducted the groundwater monitoring and sampling activities described below on August 31, 2017. Groundwater monitoring was conducted in accordance with TRC Standard Operating Procedures (SOPs). A copy of TRC's General Field Procedures and Groundwater Sampling SOPs are included as Appendix A.

3.1 Groundwater Elevations

Depth to water and total well depth were measured in each of the wells using an oil/water interface probe accurate to 0.01 feet. At a minimum of 15 minutes prior to measuring and recording depth to water, monitoring wells MW-1 through MW-7 were opened to allow water levels to equilibrate with atmospheric pressure. For consistency, the measurement reference point for each well is the northern edge of each well casing. Prior to measurement at each well, the interface probe was decontaminated with an Alconox solution wash and rinsed with deionized water. Groundwater measurements and calculated groundwater elevations for each well are summarized in Table 1.

Groundwater elevations have been relatively consistent from the beginning of the investigations in 2005 to the most current monitoring event in August 2017. Based on groundwater elevations recorded during the August 2017 monitoring event, the groundwater flow direction is generally to the west-southwest in the western area of the Site and to the northeast in the eastern area of the Site (Figure 3). The west-southwest groundwater flow is consistent with previous monitoring events, however, the northeasterly groundwater flow direction observed at MW-4 is anomalous.

The groundwater flow direction trends are consistent with previous monitoring results and the groundwater gradient across the Site is approximately 0.04.

3.2 Groundwater Sampling Activities

During the August 2017 monitoring event, samples were collected from all seven (7) of the Site monitoring wells using low flow sampling techniques in accordance with the TRC SOP. As noted in Section 2.2, BNSF discontinued sampling of monitoring well MW-4 for analysis of Site-related contaminants after 2014, however, a groundwater sample was collected from MW-4 during this event for analysis of natural attenuation parameters as discussed below.

Site wells were purged using a peristaltic pump and dedicated polyethylene tubing at flow rates between 100 and 150 milliliters per minute. During the purging process, temperature, pH, conductivity, dissolved oxygen (DO), oxidation reduction potential (ORP), and turbidity parameters were recorded using a YSI Pro DSS water quality meter equipped with a flow-through cell. Following parameter stabilization in accordance with United States Environmental Protection Agency (EPA) guidelines for low flow sampling, the discharge tubing was disconnected from the flow-through cell and groundwater samples were collected in laboratory provided bottles. Groundwater monitoring field data sheets are included in Appendix B.

A duplicate sample was collected from monitoring well MW-2 and submitted to the laboratory under the sample identification MW-2D. The groundwater samples were sealed, labeled, immediately packed on ice, and submitted to ESC Lab Sciences of Mt. Juliet, Tennessee for analysis of the following Site-related contaminants:

- DRO and ORO by Northwest Method NWTPH-Dx, and
- BTEX by EPA Method 8260C.

Additionally, groundwater samples collected from wells MW-2, MW-3, MW-4, and MW-6 were also analyzed for the following natural attenuation/geochemical parameters:

- Total Iron, Total Manganese, and Dissolved Manganese (after field filtering) by EPA Method 6020;
- Nitrate-Nitrite by EPA Method 353.2;
- Sulfate by EPA Method 9056;
- Sulfide by EPA Method 4500;
- Methane, Ethane, and Ethene by Method RSK175;
- Alkalinity by EPA Method 2320; and

- Ferrous Iron by colorimetric analysis in the field using a Hach(R) Model IR-18C after sample preparation with 1.10 Phenanthroline.

Copies of the laboratory analytical reports and chain-of-custody documentation are provided in Appendix C and results are summarized in Table 2, Table 3, and Figure 4.

3.3 Groundwater Monitoring Results

3.3.1 Analytical Results

DRO, ORO, and BTEX were not detected at or above laboratory reporting limits any of the groundwater samples collected during the August 2017 monitoring event.

3.3.2 Site-Related Contaminant Concentration Trends

Trend graphs showing groundwater elevations and dissolved phase concentrations for DRO, ORO, and benzene over time for monitoring wells with historical exceedances of MTCA Method A cleanup levels (MW-1, MW-2, MW-3, and MW-6) are presented in Figures 5 through 10.

DRO and ORO concentrations in the wells generally exhibit an overall decreasing trend in wells MW-1 and MW-3 and a generally stable trend in wells MW-2 and MW-6.

Of the BTEX constituents analyzed, only benzene has exceeded its respective MTCA Method A cleanup level. However, benzene exceedances have only been reported in groundwater samples collected from monitoring wells MW-2 and MW-6. Benzene concentrations in monitoring well MW-2 exhibit a decreasing trend while benzene concentrations in MW-6 have not been detected above laboratory reporting limits with the exception of the March 2016 event.

3.3.3 Natural Attenuation and Quality Parameters

Natural attenuation is a remediation process that relies on naturally occurring destructive processes (i.e., biodegradation and abiotic degradation) or non-destructive processes (i.e., advection, diffusion, sorption, dilution, and volatilization) for the reduction of contaminant mass.

Biodegradation is typically the most prevalent destructive mechanism for the natural attenuation of petroleum hydrocarbons and is facilitated via biological oxidation, where electron donors, electron acceptors, carbon source, and nutrients are utilized by microorganisms to produce metabolic by-products and energy for microbial growth. Petroleum hydrocarbons biodegrade naturally when an indigenous population of hydrocarbon-degrading microorganisms is present in the aquifer and sufficient concentrations of electron acceptors and nutrients are available. Biodegradation of petroleum hydrocarbons can occur under aerobic or anaerobic conditions (i.e., in the presence or absence of dissolved oxygen), where hydrocarbons may be used by microbes as an electron donor and carbon source in both degradation pathways.

Microbial metabolic processes generate energy via oxidation of the electron donor and reduction of the electron acceptor. Aerobic degradation of petroleum hydrocarbons occurs when DO is used as a terminal electron acceptor by hydrocarbon-degrading microbes that respire aerobically. Reduction of molecular oxygen is the most energetically favorable oxidation-reduction reaction involved in petroleum hydrocarbon degradation. However, if the groundwater is devoid of oxygen, hydrocarbons can be degraded by microbes that respire anaerobically utilizing nitrate, ferric iron [Fe(III)], manganese [Mn(IV)], sulfate, or carbon dioxide.

Site monitoring wells MW-2, MW-3, MW-4, and MW-6 were sampled for geochemical parameters to evaluate whether the conditions were favorable at the Site for natural attenuation processes to promote the degradation of petroleum hydrocarbons.

Monitoring wells MW-2, MW-3, and MW-6 are located within the footprint of the dissolved-phase TPH plume (Figure 4) and exhibited field water quality values during the August 2017 monitoring event generally indicative of anaerobic conditions.

Elevated alkalinity concentrations in monitoring wells MW-2, MW-3, and MW-6 relative to MW-4 suggest that microbial processes are enhanced within the footprint of the dissolved-phase TPH plume. Additionally, generally elevated methane concentrations in these wells suggest methanogenic bacteria are enhanced within the dissolved-phase TPH plume and may be facilitating hydrocarbon degradation via methanogenesis.

Water quality and geochemical parameters reported for Site monitoring wells are provided on Table 3. A detailed interpretation of the baseline natural attenuation and water quality parameters is presented on Table 4.

4.0 SUMMARY AND FUTURE MONITORING

4.1 Trend Summary

Concentrations of DRO, ORO, and benzene in Site groundwater are generally stable or decreasing. This conclusion is based on the following observations:

- Despite short-term fluctuations in dissolved-phase concentrations of DRO, ORO, and benzene resulting in concentrations exceeding the MTCA Method A cleanup levels (possibly due to increased groundwater elevations during those months), concentrations in key wells (MW-1, MW-2, MW-3, and MW-6) exhibit long-term stable and/or decreasing trends (Figures 5 through 10).
- The Ecology Statistical Tool Package Mann- Kendall trend analysis confirmed that concentrations of DRO, ORO, and benzene in impacted wells are stable and/or decreasing (Appendix D). The restoration timeframe calculator included in the tool package projected with a 90 percent confidence interval that benzene concentrations will be below MTCA Method A cleanup levels in December 2018 and DRO concentrations will be below MTCA Method A cleanup levels in May 2018.

- Sentry monitoring well MW-5 has had only two reported detections of Site-related contaminants above laboratory reporting limits since monitoring began in 2008, however, both detections of DRO were below the MTCA Method A cleanup levels.
- Decreasing concentration trends and natural attenuation/geochemical data support the previous conclusion that petroleum hydrocarbon degradation is occurring at the Site under natural and biological conditions.

4.2 Future Monitoring Activities

Future groundwater monitoring events will include sample collection from MW-2, MW-3, and MW-6 based on historic data trends. Sampling of MW-7 will also be included in future events in order to monitor groundwater conditions downgradient of onsite well MW-3. As noted in Section 2.2, sampling of up-gradient well MW-4 for analysis of site contaminants was discontinued following the 2014 annual groundwater monitoring event due to the consistent absence of the Site contaminants in that well. Sampling of wells MW-1 and MW-5 will be discontinued beginning in January 2018 as recommended in the *2017 First Semi-Annual Groundwater Monitoring Report* (TRC, 2017).

Sampling of wells MW-2, MW-3, MW-4, and MW-6 for natural attenuation parameters will continue in order to evaluate ongoing hydrocarbon degradation in Site groundwater.

5.0 REFERENCES

Farallon, 2008, *Cleanup Action Work Plan, Former Cummings Oil Lease Site, 908 Northwest Kerron Avenue, Winlock, Washington.* December 18.

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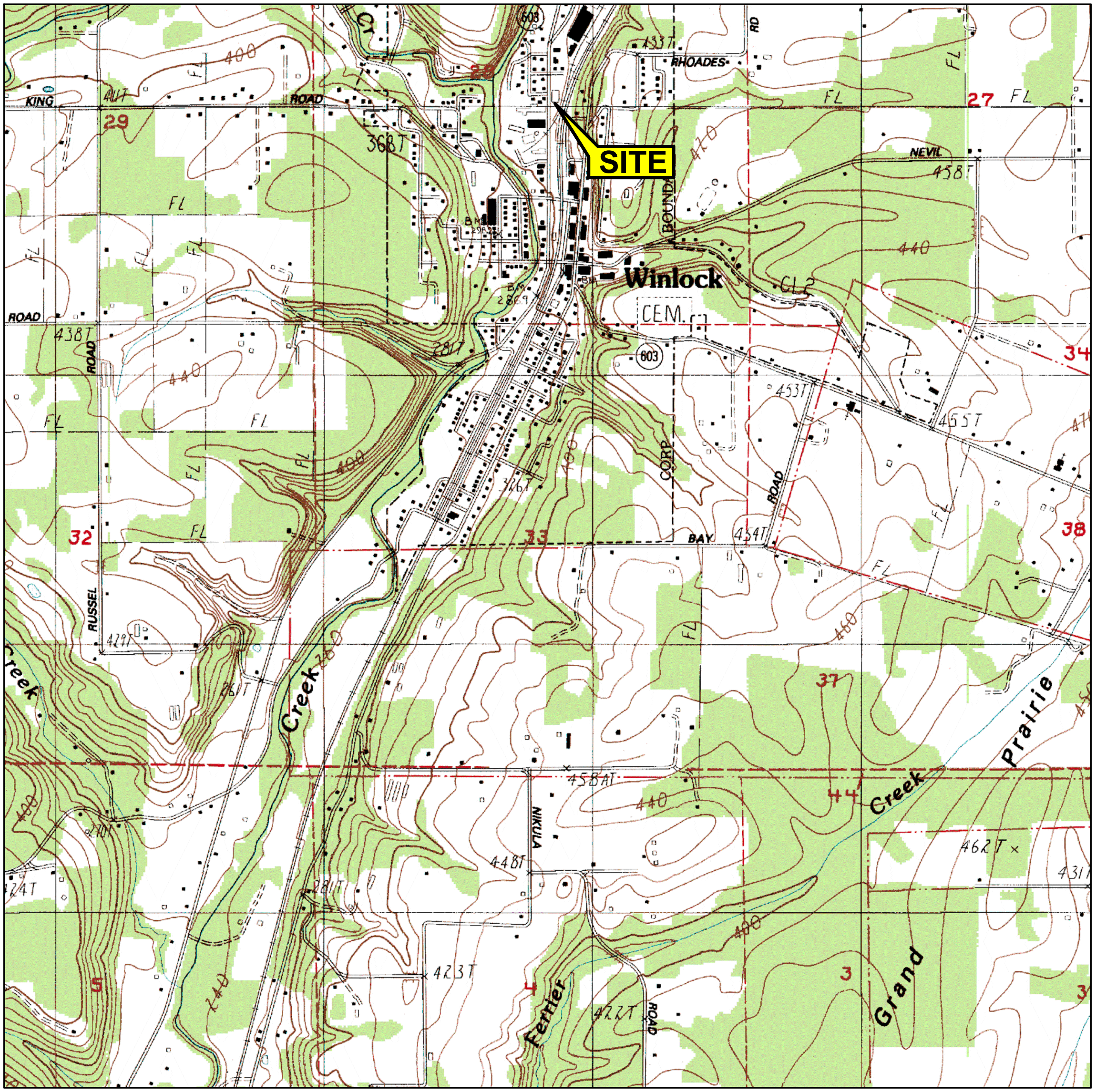
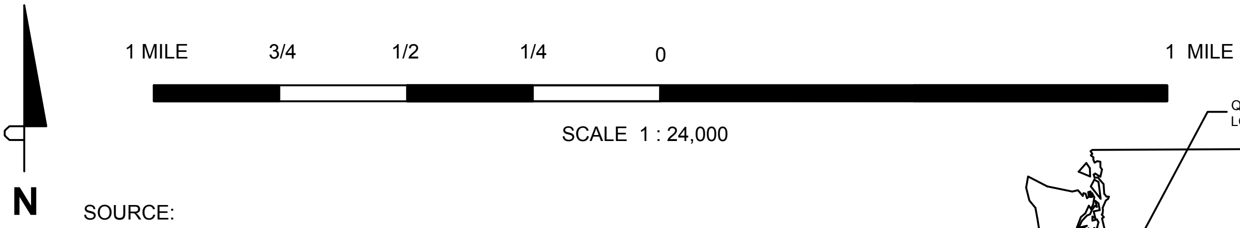
FIGURES





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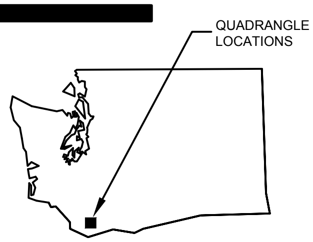
SOURCE:

United States Geological Survey
7.5 Minute Topographic Maps:
Winlock Quadrangles, Washington



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Phone: 425.489.1938
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PROJECT:

FORMER CUMMINGS OIL LEASE SITE
908 NORTHWEST KERRON AVENUE
WINLOCK, WASHINGTON

TITLE:

VICINITY MAP

DRAWN BY:	R. Collins
CHECKED BY:	K. Newman
APPROVED BY:	K. Newman
DATE:	September 2017
PROJ. NO.:	278114
FILE:	Winlock_Fig1_Vicinity Map.dwg

FIGURE 1

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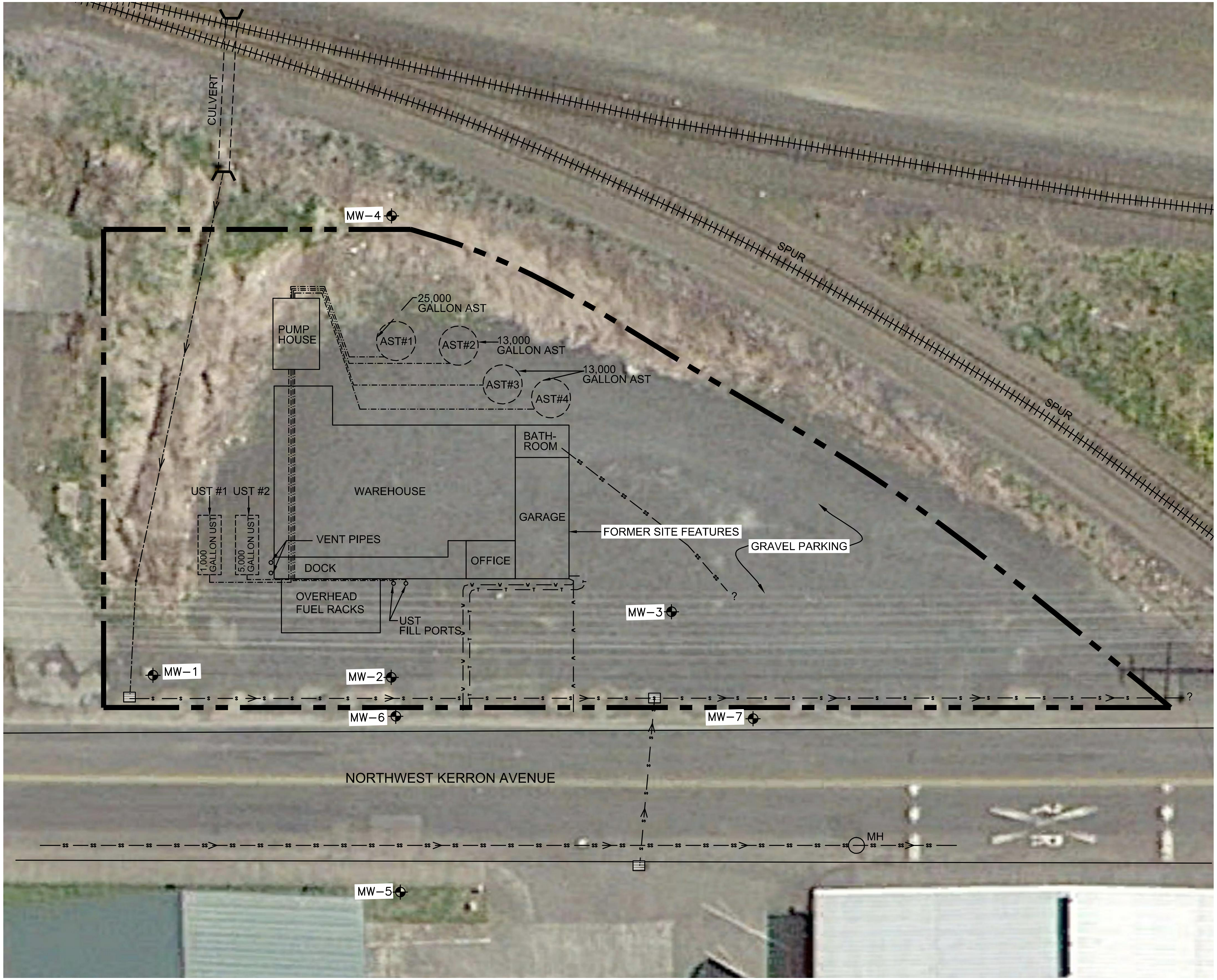

LEGEND

▬ ▪ ▬	PROPERTY BOUNDARY
┼┼┼┼┼┼┼┼	RAILROAD TRACKS
— s — s — s —	STORM LINE
— ss — ss — ss —	SANITARY SEWER
— v — v — v —	FORMER LOCATION OF WATER LINE
— T — T — T —	FORMER LOCATION OF TELEPHONE LINE
— · — · — · —	FORMER LOCATION OF APPROXIMATE LOCATION OF ABOVE GROUND PIPING AT SITE
— — ← — —	DITCH AND DIRECTION OF FLOW
MW–3 ⌖	MONITORING WELL
1,000 GALLON UST	FORMER UNDERGROUND STORAGE TANK LOCATIONS
AST#1	FORMER LOCATION OF ABOVEGROUND STORAGE TANK
☐	CATCH BASIN

SOURCE:
Aerial base map provided by Google Earth Professional, dated 7/5/2012. Base map provided by Farallon Consulting, 12/10/2015. Survey provided by Bluhm & Associates Land Surveyors Inc., 8/14/2014.

N

SCALE (FEET)
0 20 40

PROJECT:
FORMER CUMMINGS OIL LEASE SITE
908 NORTHWEST KERRON AVENUE
WINLOCK, WASHINGTON

TITLE:
SITE PLAN

DRAWN BY:	R. Collins	PROJ NO.:	278114
CHECKED BY:	K. Newman		**FIGURE 2**
APPROVED BY:	K. Newman		
DATE:	September 2017		

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FILE NO.: Winlock_Fig2_Site Plan.dwg

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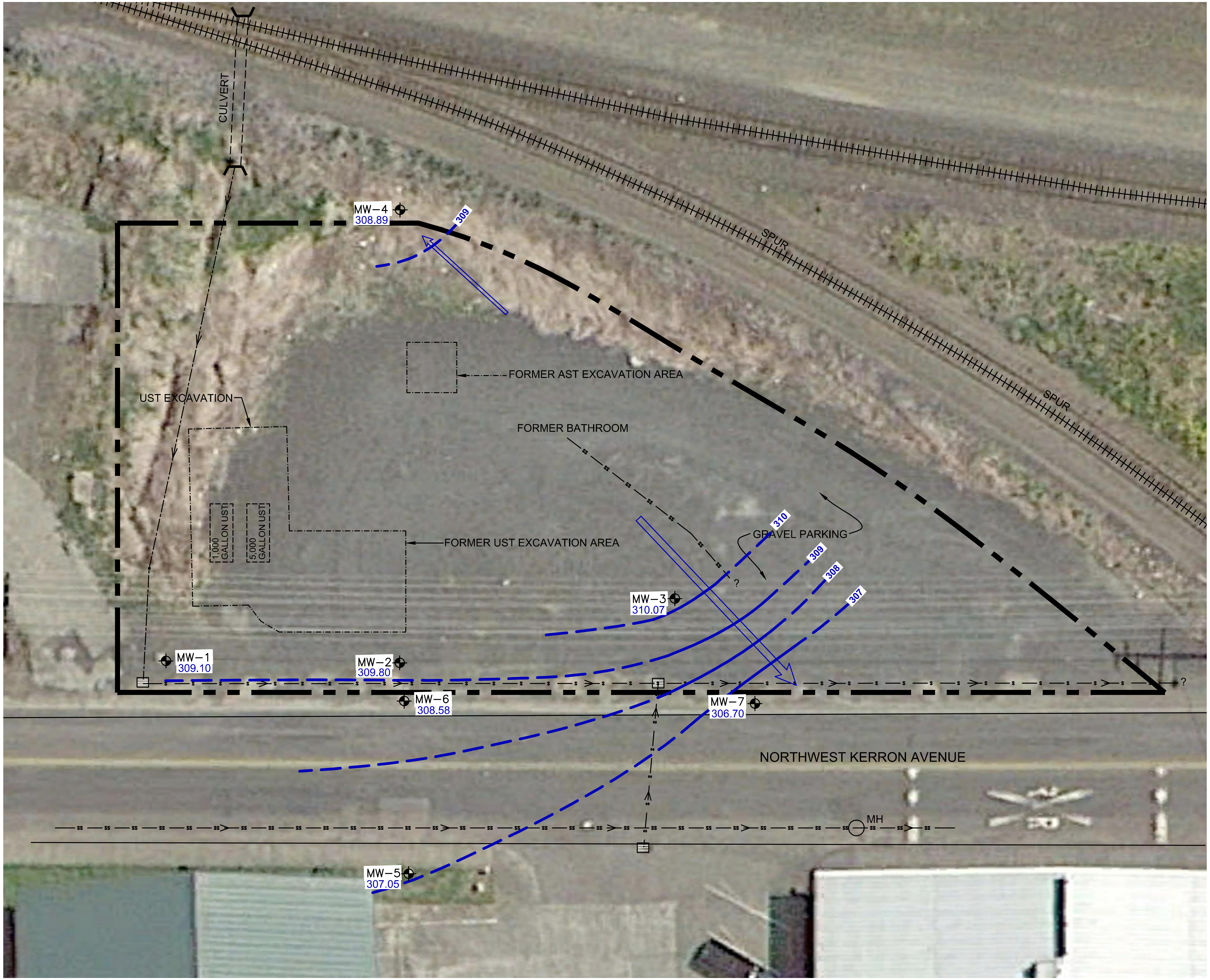

LEGEND

▬ ▪ ▬	PROPERTY BOUNDARY
┼┼┼┼┼┼┼┼	RAILROAD TRACKS
— · ◄ · —	DRAINAGE DITCH AND DIRECTION OF FLOW
— ss ◄ ss — ss —	STORM SEWER LINE AND DIRECTION OF FLOW
— ss ◄ ss — ss —	SANITARY SEWER AND DIRECTION OF FLOW
MH ○	MANHOLE
MW–3 ⌖	MONITORING WELL (FARALLON 2006 AND 2014)
310.07	GROUNDWATER ELEVATION (AUGUST 2017)
310 ▬ ▬	GROUNDWATER ELEVATION CONTOUR LINE, DASHED WHERE INFERRED
⇘	GENERAL DIRECTION OF GROUNDWATER GRADIENT
□	CATCH BASIN
BGS	BELOW GROUND SURFACE

SOURCE:
Aerial base map provided by Google Earth Professional, dated 7/5/2012. Base map provided by Farallon Consulting, 12/10/2015. Survey provided by Bluhm & Associates Land Surveyors Inc., 8/14/2014.

N

SCALE (FEET)
0 20 40

PROJECT:
FORMER CUMMINGS OIL LEASE SITE
908 NORTHWEST KERRON AVENUE
WINLOCK, WASHINGTON

TITLE:
GROUNDWATER ELEVATION CONTOUR MAP AUGUST 2017

DRAWN BY:	R. Collins	PROJ NO.:	278114
CHECKED BY:	K. Newman		
APPROVED BY:	K. Newman	**FIGURE 3**	
DATE:	September 2017		

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FILE NO.: Winlock_Fig3_GW_Aug2017.dwg

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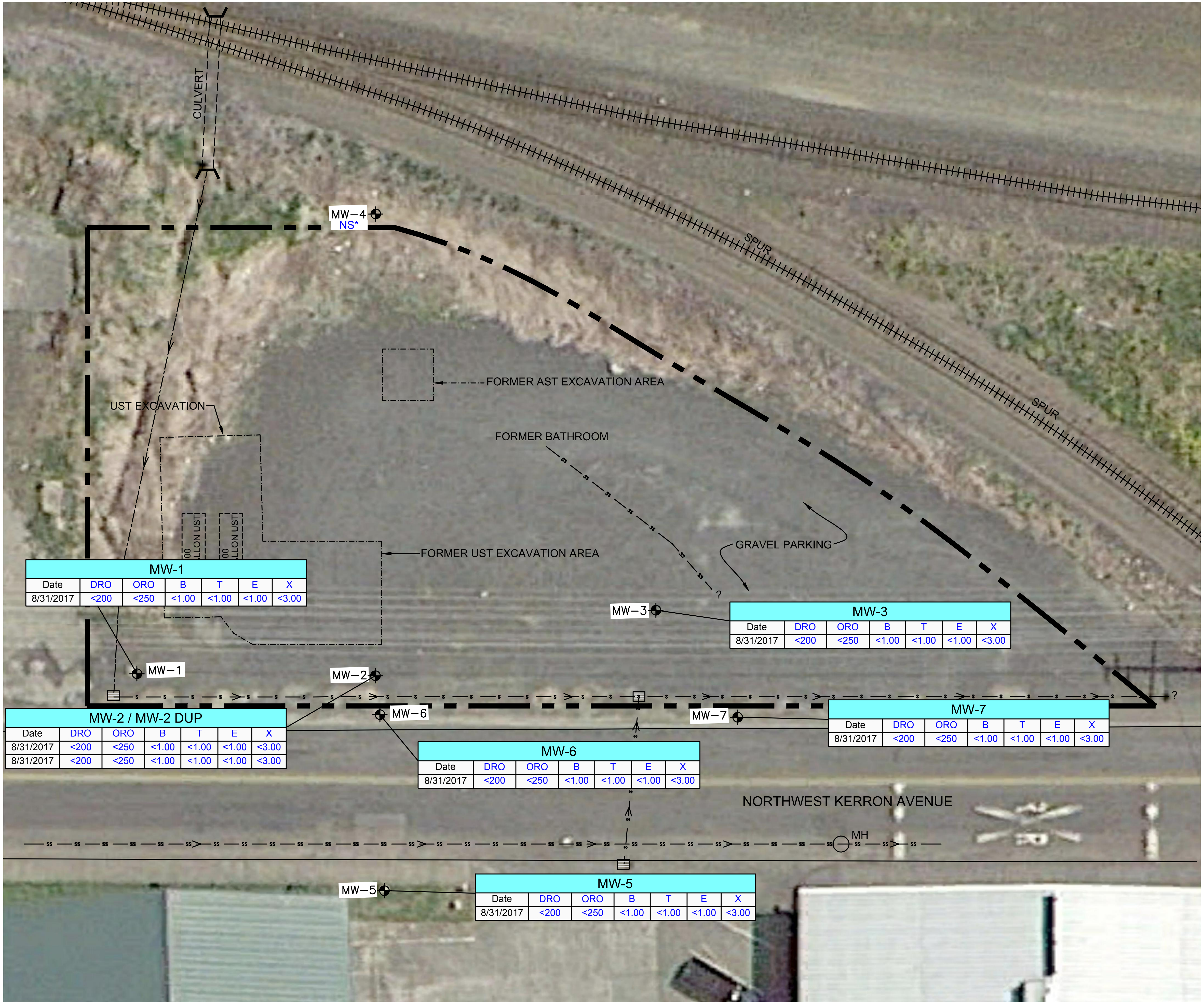

MW-1

Date	DRO	ORO	B	T	E	X
8/31/2017	<200	<250	<1.00	<1.00	<1.00	<3.00

MW-2 / MW-2 DUP

Date	DRO	ORO	B	T	E	X
8/31/2017	<200	<250	<1.00	<1.00	<1.00	<3.00
8/31/2017	<200	<250	<1.00	<1.00	<1.00	<3.00

MW-3

Date	DRO	ORO	B	T	E	X
8/31/2017	<200	<250	<1.00	<1.00	<1.00	<3.00

MW-6

Date	DRO	ORO	B	T	E	X
8/31/2017	<200	<250	<1.00	<1.00	<1.00	<3.00

MW-7

Date	DRO	ORO	B	T	E	X
8/31/2017	<200	<250	<1.00	<1.00	<1.00	<3.00

MW-5

Date	DRO	ORO	B	T	E	X
8/31/2017	<200	<250	<1.00	<1.00	<1.00	<3.00

LEGEND

▬ ▪ ▪ ▬	PROPERTY BOUNDARY
┼┼┼┼┼┼┼┼	RAILROAD TRACKS
— - ← - —	DRAINAGE DITCH AND DIRECTION OF FLOW
—ss ←ss —ss —	STORM SEWER LINE AND DIRECTION OF FLOW
—ss ←ss —ss —	SANITARY SEWER AND DIRECTION OF FLOW
MH ○	MANHOLE
MW–3 ⊕	MONITORING WELL (FARALLON 2006 AND 2014)
☐	CATCH BASIN
BGS	BELOW GROUND SURFACE

ALL RESULTS IN MICROGRAMS PER LITER (µg/L)

DRO = TOTAL PETROLEUM HYDROCARBONS (TPH) AS DIESEL-RANGE ORGANICS.

ORO = TPH AS OIL RANGE ORGANICS.

BTEX = BENZENE, TOLUENE, ETHYLBENZENE, AND XYLENES.

< = DENOTES ANALYTE NOT DETECTED AT OR EXCEEDING LABORATORY REPORTING LIMIT LISTED.

RESULTS IN **BOLD** DENOTE CONCENTRATIONS EXCEEDING APPLICABLE CLEANUP LEVELS.

NS* = NOT SAMPLED. SAMPLING MONITORING WELL MW-4 DISCONTINUED IN 2014.

SOURCE:
Aerial base map provided by Google Earth Professional, dated 7/16/2014. Base map provided by Farallon Consulting, 12/10/2015. Survey provided by Bluhm & Associates Land Surveyors Inc., 8/14/2014.

N

SCALE (FEET)
0 20 40

PROJECT:
FORMER CUMMINGS OIL LEASE SITE
908 NORTHWEST KERRON AVENUE
WINLOCK, WASHINGTON

TITLE:
DISSOLVED-PHASE CONCENTRATIONS AUGUST 2017

DRAWN BY:	R. Collins	PROJ NO.:	278114
CHECKED BY:	K. Newman	**FIGURE 4**	
APPROVED BY:	K. Newman		
DATE:	September 2017		

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FILE NO.: Winlock_Fig4_TPHd_Aug2017.dwg

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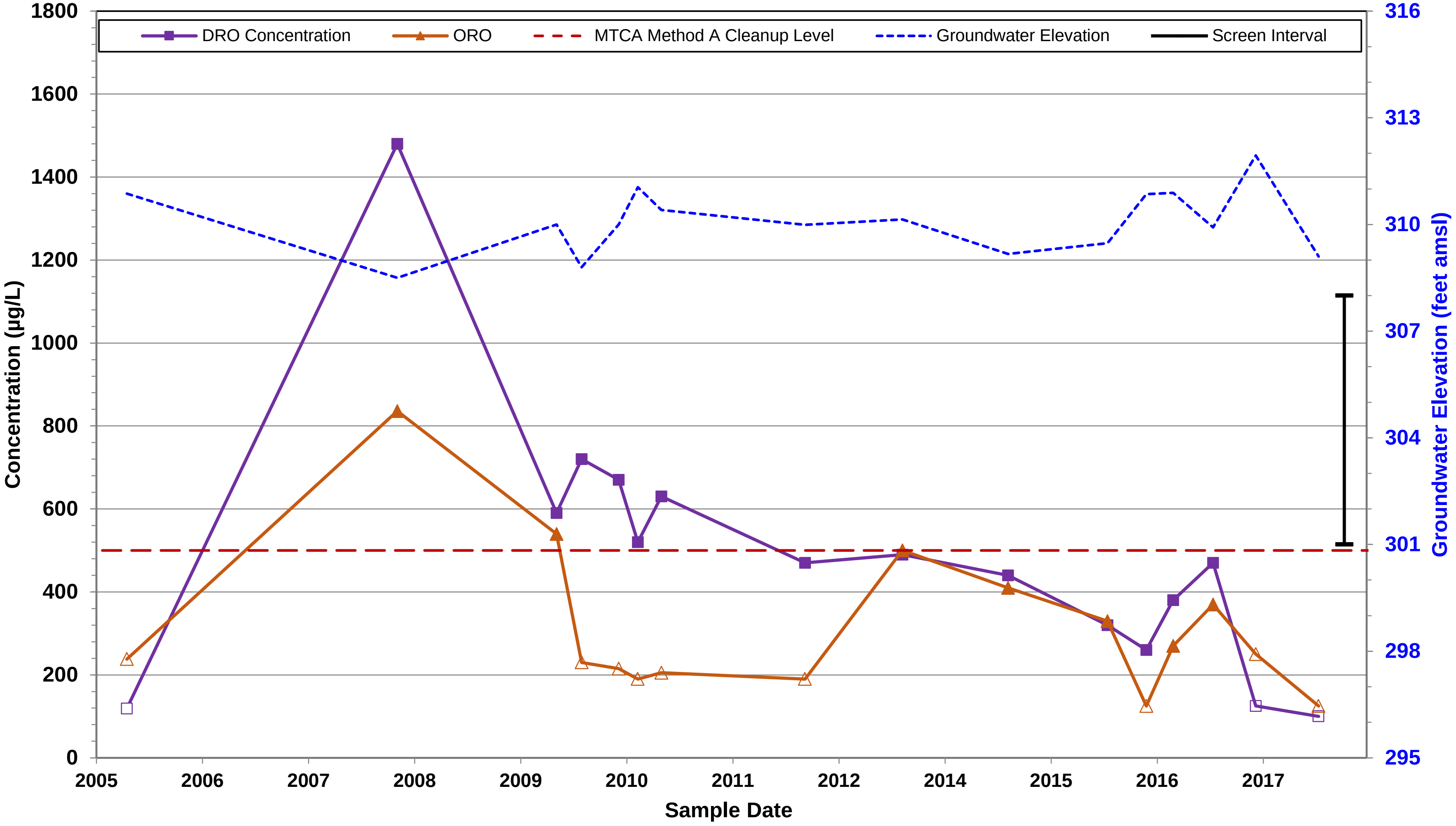
Figure 5
Groundwater Elevation versus DRO and ORO - MW-1
Former Cummings Oil Lease Site
Winlock, Washington

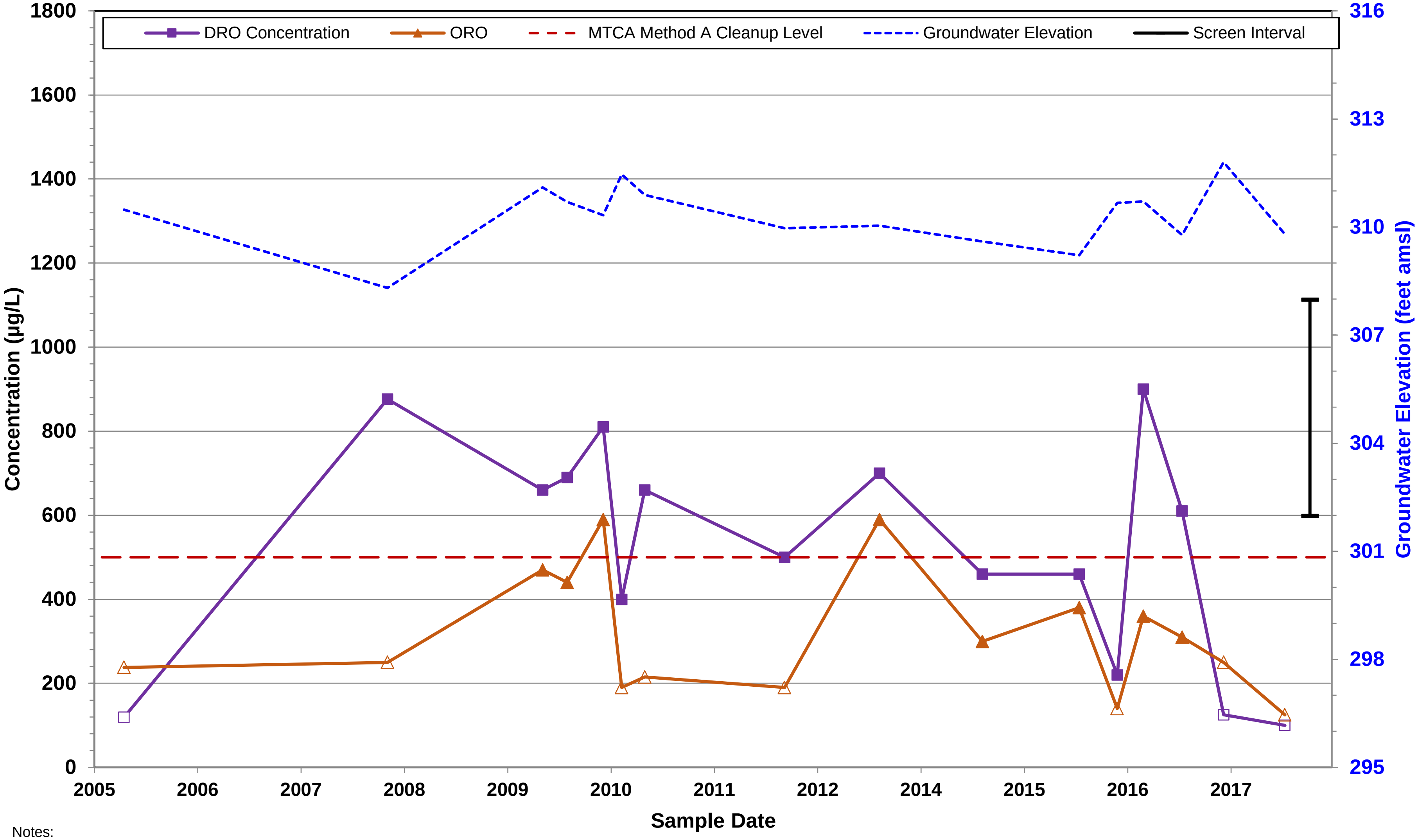


Notes:
1. Non-detect (ND) results are shown as a white box or triangle at half the laboratory reporting limit.
2. Model Toxics Control Act (MTCA) Cleanup level for diesel-range organics (DRO) and oil-range organics (ORO) is 500 micrograms per liter (µg/L).
3. amsl = above mean sea level

Figure 6

Groundwater Elevation versus DRO and ORO - MW-2

Former Cummings Oil Lease Site
Winlock, Washington

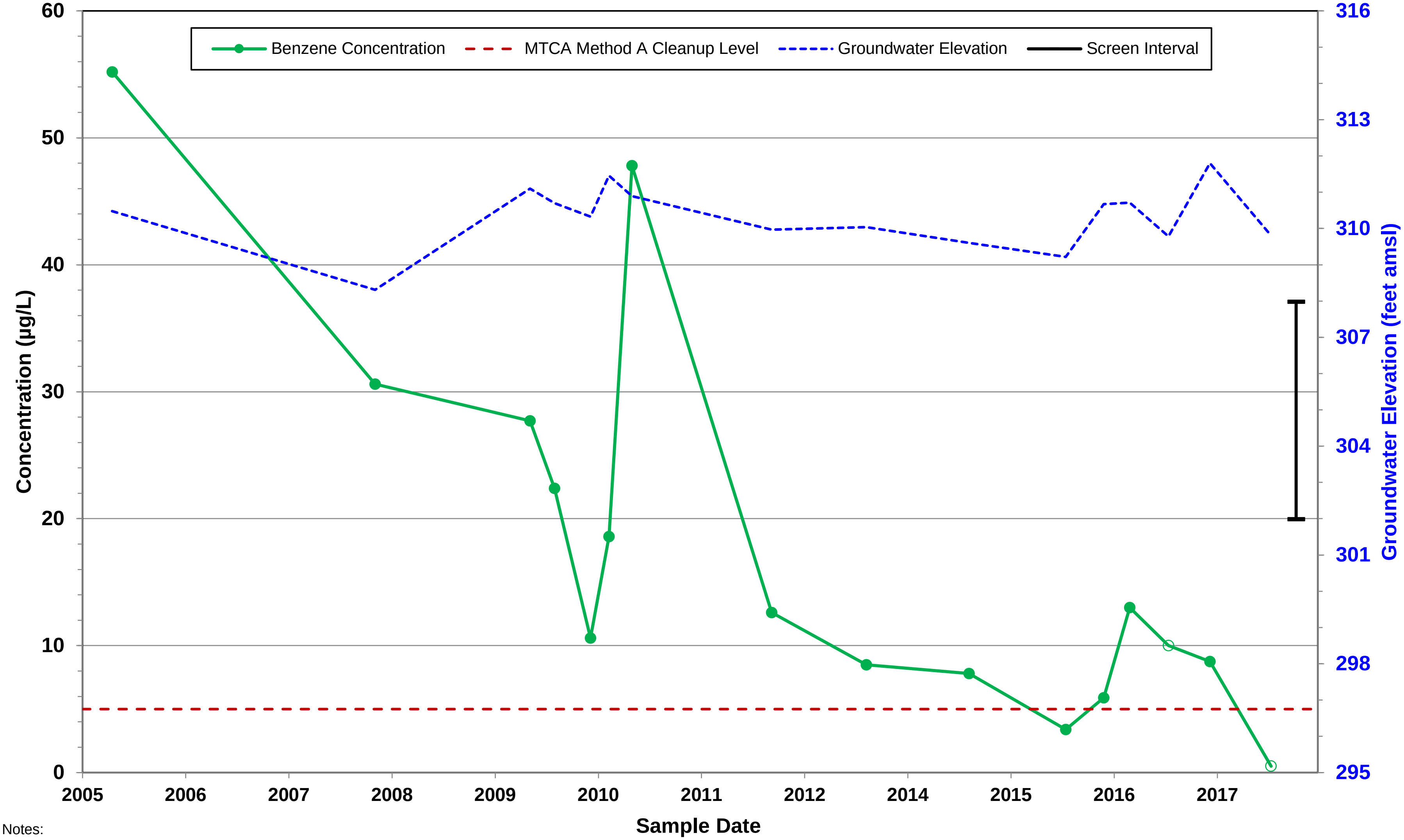


Notes:
1. Non-detect (ND) results are shown as a white box or triangle at half the laboratory reporting limit.
2. Model Toxics Control Act (MTCA) Cleanup level for diesel-range organics (DRO) and oil-range organics (ORO) is 500 micrograms per liter (µg/L).
3. amsl = above mean sea level

Figure 7

Groundwater Elevation versus Benzene - MW-2

Former Cummings Oil Lease Site
Winlock, Washington

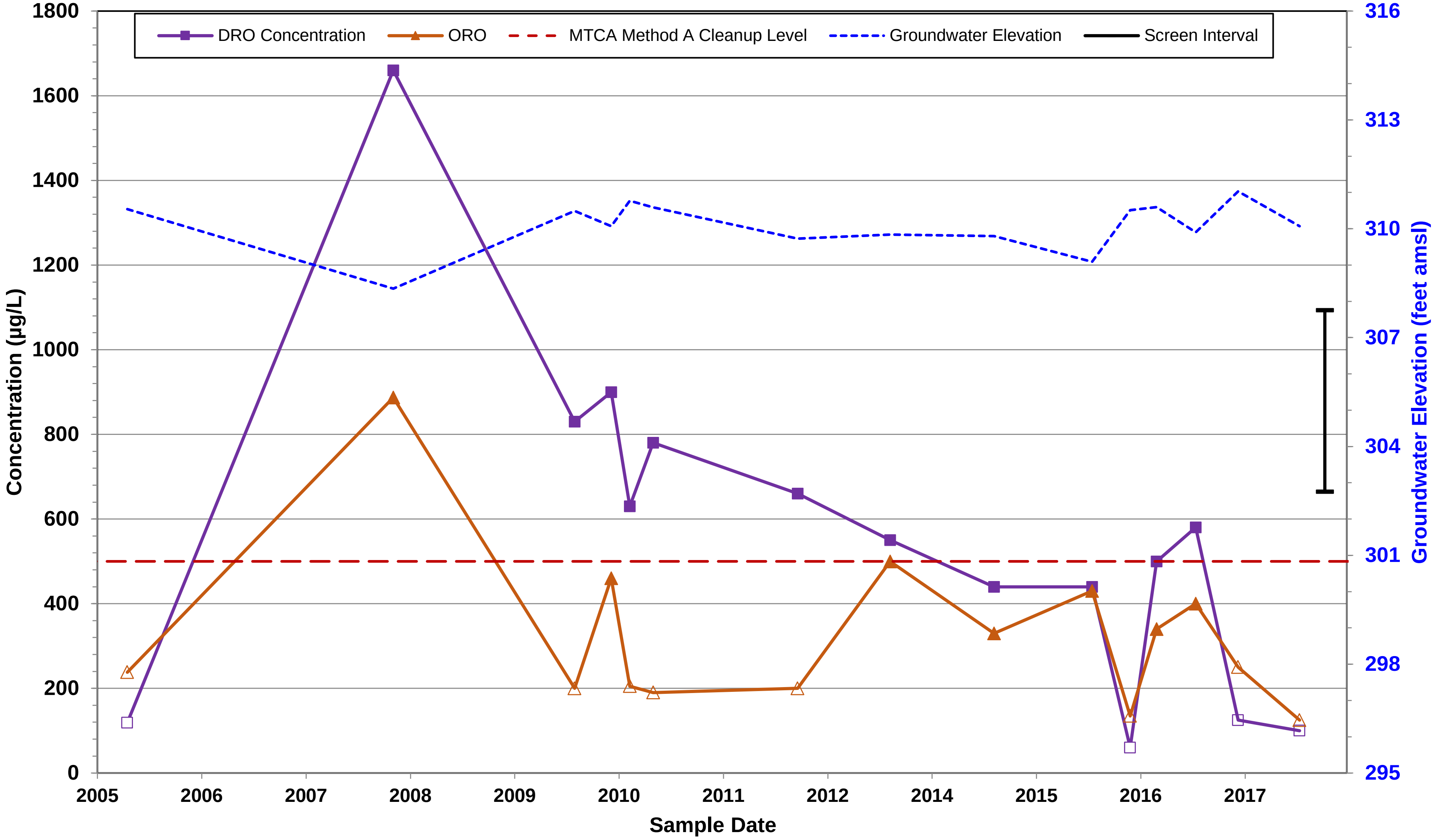


Notes:
1. Non-detect (ND) results are shown as a white circle at half the laboratory reporting limit.
2. Model Toxics Control Act (MTCA) Cleanup level for benzene is 5 micrograms per liter (µg/L).
3. amsl = above mean sea level

Figure 8

Groundwater Elevation versus DRO and ORO - MW-3

Former Cummings Oil Lease Site
Winlock, Washington

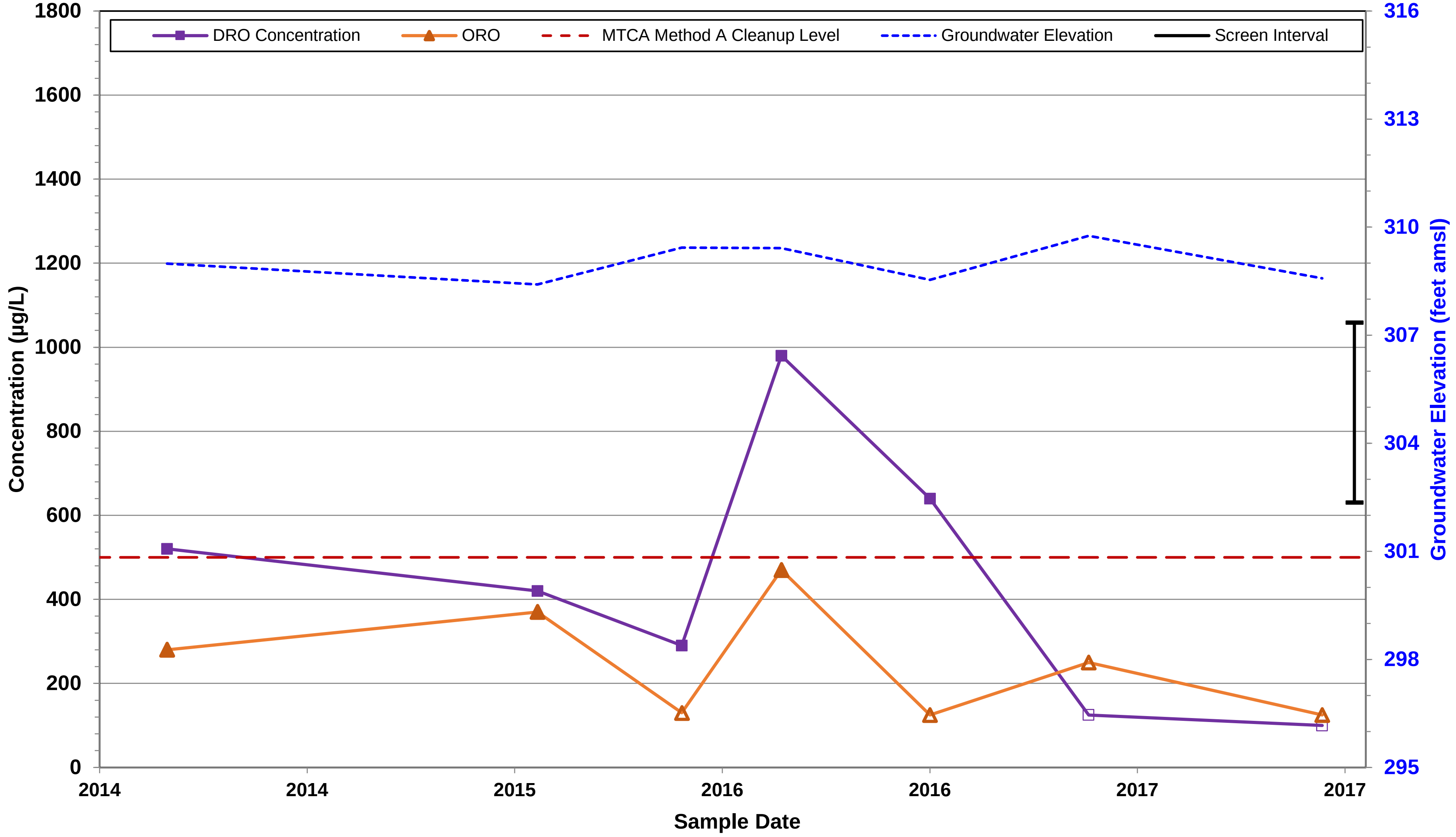


Notes:
1. Non-detect (ND) results are shown as a white box or triangle at half the laboratory reporting limit.
2. Model Toxics Control Act (MTCA) Cleanup level for diesel-range organics (DRO) and oil-range organics (ORO) is 500 micrograms per liter (µg/L).
3. amsl = above mean sea level

Figure 9

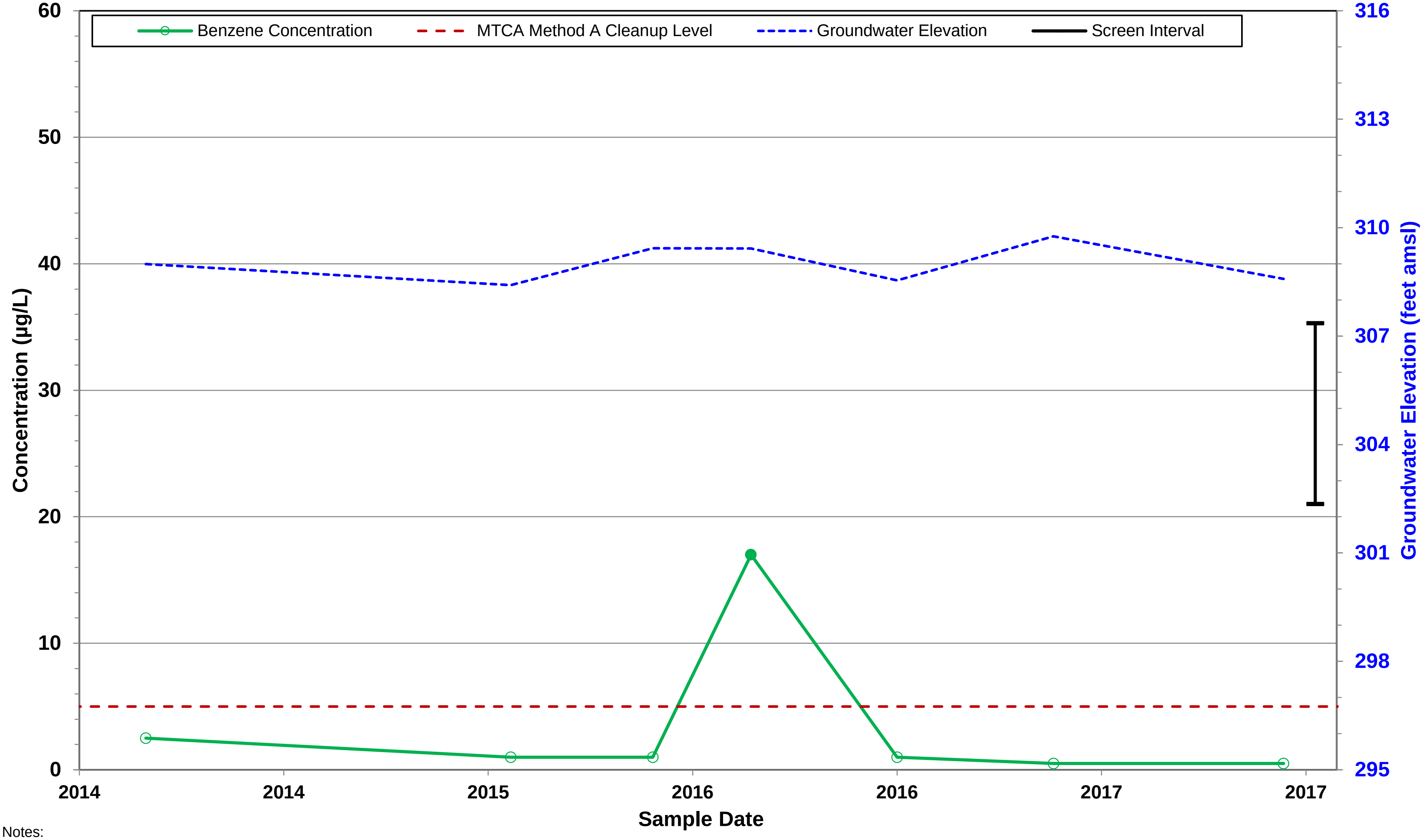
Groundwater Elevation versus DRO and ORO - MW-6

Former Cummings Oil Lease Site
Winlock, Washington



Notes:
1. Non-detect (ND) results are shown as a white box or triangle at half the laboratory reporting limit.
2. Model Toxics Control Act (MTCA) Cleanup level for diesel-range organics (DRO) and oil-range organics (ORO) is 500 micrograms per liter (µg/L).
3. amsl = above mean sea level

Figure 10
Groundwater Elevation versus Benzene - MW-6
Former Cummings Oil Lease Site
Winlock, Washington



Notes:
1. Non-detect (ND) results are shown as a white circle at half the laboratory reporting limit.
2. Model Toxics Control Act (MTCA) Cleanup level for benzene is 5 micrograms per liter (µg/L).
3. amsl = above mean sea level

TABLES

Table 1
Summary of Groundwater Elevation Data
Former Cummings Oil Lease Site
Winlock, Washington

Monitoring Well	Wellhead Elevation[a] (feet amsl)	Date	Monitoring Well Screen Interval (feet bgs)	Depth of Monitoring Well (feet bgs)	Depth to Water (feet btoc)	Water Elevation (feet amsl)
MW-1	313.00	12/23/2005	5-12	12	2.13	310.87
		8/18/2008			4.50	308.50
		3/11/2010			3.00	310.00
		6/8/2010			4.20	308.80
		10/20/2010			3.00	310.00
		12/27/2010			1.95	311.05
		3/22/2011			2.59	310.41
		8/17/2012			3.01	309.99
		8/1/2013			2.86	310.14
		8/14/2014			3.83	309.17
		8/6/2015			3.53	309.47
		12/23/2015			2.15	310.85
		3/28/2016			2.11	310.89
		8/18/2016			3.08	309.92
		1/18/2017			1.06	311.94
		8/31/2017			3.90	309.10
MW-2	312.98	12/23/2005	5-11	11	2.50	310.48
		8/18/2008			4.67	308.31
		3/11/2010			1.88	311.10
		6/8/2010			2.28	310.70
		10/20/2010			2.65	310.33
		12/27/2010			1.52	311.46
		3/22/2011			2.09	310.89
		8/17/2012			3.01	309.97
		8/1/2013			2.94	310.04
		8/14/2014			3.38	309.60
		8/6/2015			3.76	309.22
		12/23/2015			2.31	310.67
		3/28/2016			2.27	310.71
		8/18/2016			3.20	309.78
		1/18/2017			1.18	311.80
		8/31/2017			3.18	309.80

Table 1
Summary of Groundwater Elevation Data
Former Cummings Oil Lease Site
Winlock, Washington

Monitoring Well	Wellhead Elevation[a] (feet amsl)	Date	Monitoring Well Screen Interval (feet bgs)	Depth of Monitoring Well (feet bgs)	Depth to Water (feet btoc)	Water Elevation (feet amsl)
MW-3	312.75	12/23/2005	5-10	10	2.21	310.54
		8/18/2008			4.40	308.35
		3/11/2010			--	--
		6/8/2010			2.26	310.49
		10/20/2010			2.68	310.07
		12/27/2010			1.98	310.77
		3/22/2011			2.16	310.59
		8/29/2012			3.02	309.73
		8/1/2013			2.91	309.84
		8/14/2014			2.95	309.80
		8/6/2015			3.66	309.09
		12/23/2015			2.24	310.51
		3/28/2016			2.15	310.60
		8/18/2016			2.85	309.90
		1/18/2017			1.72	311.03
		8/31/2017			2.68	310.07
MW-4	314.89	12/23/2005	5-12	12	0.50	314.39
		8/18/2008			5.02	309.87
		3/11/2010			1.9	312.99
		6/8/2010			1.45	313.44
		10/20/2010			2.40	312.49
		12/27/2010			0.48	314.41
		3/22/2011			1.33	313.56
		8/29/2012			3.48	311.41
		8/1/2013			3.31	311.58
		8/14/2014			4.24	310.65
		8/6/2015			4.13	310.76
		12/23/2015			0.33	314.56
		3/28/2016			1.07	313.82
		8/18/2016			--	--
		1/18/2017			0.10	314.79
		8/31/2017			6.00	308.89

Table 1
Summary of Groundwater Elevation Data
Former Cummings Oil Lease Site
Winlock, Washington

Monitoring Well	Wellhead Elevation[a] (feet amsl)	Date	Monitoring Well Screen Interval (feet bgs)	Depth of Monitoring Well (feet bgs)	Depth to Water (feet btoc)	Water Elevation (feet amsl)
MW-5	312.45	8/18/2008	5-10	10	5.54	306.91
		3/11/2010			3.29	309.16
		6/8/2010			4.00	308.45
		10/20/2010			5.25	307.20
		12/27/2010			3.17	309.28
		3/22/2011			4.51	307.94
		8/17/2012			5.47	306.98
		8/1/2013			5.52	306.93
		8/14/2014			5.12	307.33
		8/6/2015			5.68	306.77
		12/23/2015			3.63	308.82
		3/28/2016			4.65	307.80
		8/18/2016			5.31	307.14
		1/18/2017			2.68	309.77
		8/31/2017			5.40	307.05
MW-6	312.35	8/14/2014	5-10	10	3.36	308.99
		8/6/2015			3.94	308.41
		12/23/2015			2.92	309.43
		3/28/2016			2.93	309.42
		8/18/2016			3.81	308.54
		1/18/2017			2.59	309.76
		8/31/2017			3.77	308.58
MW-7	312.41	8/14/2014	5-9	9	5.51	306.90
		8/6/2015			5.67	306.74
		12/23/2015			4.75	307.66
		3/28/2016			5.00	307.41
		8/18/2016			5.56	306.85
		1/18/2017			4.70	307.71
		8/31/2017			5.71	306.70

Notes:

amsl = above mean sea level
bgs = below ground surface
btoc = below top of casing
-- denotes depth not measured

Footnotes:

[a] Elevations based on survey completed 8/14/14 Blum & Associates Land Surveyors, Inc. to Washington State Plane Coordinate System South Zone NAD 83, NAVD 88 elevations.

Table 2
Summary of Groundwater Analytical Results
Former Cummings Oil Lease Site
Winlock, Washington

Analytical results in micrograms per liter (µg/L).

Monitoring Well	Date Sampled[a]	Total Petroleum Hydrocarbons			Volatile Organic Compounds[d]									
		Diesel Range[b]	Heavy Oil Range[b]	Gasoline Range[c]	Benzene	Toluene	Ethyl-benzene	Total Xylenes	Naph-thalene	1-Methyl-naphthalene[g]	2-Methyl-naphthalene[g]	Methyl tert-butyl ether	1,2-Dichloro-ethane	1,2 Dibromo-ethane[h]
MTCA Method A CLs[e]		500	500	800	5	1,000	700	1,000	160	--	--	20	5	0.01
MTCA Method B CLs[f]		--	--	--	--	--	--	--	--	1.51	32	--	--	--
MW-1	12/23/2005	<238	<476	<50.0	<0.500	<0.500	<0.500	<1.00	--	--	--	--	--	--
	8/18/2008	**1,480**	**836**	<50.0	<0.500	<0.500	<0.500	<1.00	--	--	--	--	--	--
	3/11/2010	**590**	**540**	<50.0	<1.0	<1.0	<1.0	<6.0	--	--	--	--	--	--
	6/9/2010	**720**	<460	<50.0	<1.0	<1.0	<1.0	<3.0	--	--	--	--	--	--
	10/20/2010	**670**	<430	<50.0	<1.0	<1.0	<1.0	<3.0	--	--	--	--	--	--
	12/27/2010	**520**	<380	<50.0	<1.0	<1.0	<1.0	<3.0	--	--	--	--	--	--
	3/22/2011	**630**	<410	<50.0	<1.0	<1.0	<1.0	<3.0	--	--	--	--	--	--
	8/17/2012	470	<380	<50.0	<1.0	<1.0	3.1	4.2	--	--	--	--	--	--
	8/1/2013	490	500	<50.0	<1.0	<1.0	<1.0	<3.0	--	--	--	--	--	--
	8/14/2014	440	410	<50.0	<5.0	<5.0	<5.0	<10.0	<15.0	<0.094	<0.094	<5.0	<5.0	<0.010
	8/6/2015	320	330	--	<2.0	<2.0	<3.0	<3.0	--	--	--	--	--	--
	12/23/2015	260	<250	--	<2.0	<2.0	<3.0	<3.0	--	--	--	--	--	--
	3/28/2016	380	270	--	<2.0	--	--	--	--	--	--	--	--	--
	8/18/2016	470	370	--	<2.0	<2.0	<3.0	<3.0	--	--	--	--	--	--
	1/18/2017	<250	<500	--	<1.00	<1.00	<1.00	<3.00	--	--	--	--	--	--
	8/31/2017	<200	<250	--	<1.00	<1.00	<1.00	<3.00	--	--	--	--	--	--
MW-2	12/23/2005	<238	<476	465	**55.2**	2.84	3.46	35.6	--	--	--	--	--	--
	8/18/2008	**876**	<500	606	**30.6**	1.12	2.56	30.9	--	--	--	--	--	--
	3/11/2010	**660**	470	150	**27.7**	<1.0	<1.0	<6.0	--	--	--	--	--	--
	6/9/2010	**690**	440	116	**22.4**	<1.0	<1.0	<3.0	--	--	--	--	--	--
	10/20/2010	**810**	**590**	95.2	**10.6**	<1.0	<1.0	<3.0	--	--	--	--	--	--
	12/27/2010	400	<380	130	**18.6**	<1.0	<1.0	<3.0	--	--	--	--	--	--
	3/22/2011	**660**	<430	196	**47.8**	<1.0	<1.0	<3.0	--	--	--	--	--	--
	8/17/2012	**500**	<380	158	**12.6**	<1.0	5.2	9.6	--	--	--	--	--	--
	8/1/2013	**700**	**590**	260	**8.5**	<1.0	<1.0	4.1	--	--	--	--	--	--
	8/14/2014	460	300	220	**7.8**	<5.0	<5.0	<10.0	<15.0	**1.8**	0.81	<5.0	<5.0	<0.010
	8/6/2015	460	380	--	3.4	<3.0	<3.0	<3.0	--	**--**	--	--	--	--
	12/23/2015	220	<280	--	**5.9**	<2.0	<3.0	<3.0	--	**--**	--	--	--	--
	3/28/2016	**900**	360	--	**13**	--	--	--	--	**--**	--	--	--	--
	8/18/2016	**610**	310	--	**<20**	27	<30	36	--	**--**	--	--	--	--
	8/18/2016 (dup)	**650**	360	--	<2.0	<2.0	<3.0	<3.0	--	**--**	--	--	--	--

Table 2
Summary of Groundwater Analytical Results
Former Cummings Oil Lease Site
Winlock, Washington

Monitoring Well	Date Sampled[a]	Total Petroleum Hydrocarbons			Volatile Organic Compounds[d]									
		Diesel Range[b]	Heavy Oil Range[b]	Gasoline Range[c]	Benzene	Toluene	Ethyl-benzene	Total Xylenes	Naph-thalene	1-Methyl-naphthalene[g]	2-Methyl-naphthalene[g]	Methyl tert-butyl ether	1,2-Dichloro-ethane	1,2 Dibromo-ethane[h]
MTCA Method A CLs[e]		500	500	800	5	1,000	700	1,000	160	--	--	20	5	0.01
MTCA Method B CLs[f]		--	--	--	--	--	--	--	--	1.51	32	--	--	--
MW-2 (cont'd)	1/18/2017	<250	<500	--	**8.75**	<1.00	<1.00	<3.00	--	**--**	--	--	--	--
	1/18/2017 (dup)	<250	<500	--	**9.05**	<1.00	<1.00	<3.00						
	8/31/2017	<200	<250	--	<1.00	<1.00	<1.00	<3.00						
	8/31/2017 (dup)	<200	<250	--	<1.00	<1.00	<1.00	<3.00	--	--	--	--	--	--
MW-3	12/23/2005	<238	<476	<50.0	<0.500	<0.500	<0.500	<1.00	--	--	--	--	--	--
	8/18/2008	**1,660**	**887**	<50.0	<0.500	<0.500	<0.500	<1.00	--	--	--	--	--	--
	3/11/2010	--	--	--	--	--	--	--	--	--	--	--	--	--
	6/9/2010	**830**	<400	<50.0	<1.0	<1.0	<1.0	<3.0	--	--	--	--	--	--
	10/20/2010	**900**	460	<50.0	<1.0	<1.0	<1.0	<3.0	--	--	--	--	--	--
	12/27/2010	**630**	<410	<50.0	<1.0	<1.0	<1.0	<3.0	--	--	--	--	--	--
	3/22/2011	**780**	<380	<50.0	<1.0	<1.0	<1.0	<3.0	--	--	--	--	--	--
	8/29/2012	**660**	<400	<50.0	<1.0	<1.0	<1.0	<3.0	--	--	--	--	--	--
	8/1/2013	**550**	**500**	<50.0	<1.0	<1.0	<1.0	<3.0	--	--	--	--	--	--
	8/14/2014	440	330	<50.0	<5.0	<5.0	<5.0	<10.0	<15.0	<0.094	<0.094	<5.0	<5.0	<0.010
	8/6/2015	440	430	--	<2.0	<2.0	<3.0	<3.0	--	--	--	--	--	--
	12/23/2015	<120	<270	--	<2.0	<2.0	<3.0	<3.0	--	--	--	--	--	--
	3/28/2016	**500**	340	--	<2.0	--	--	--	--	--	--	--	--	--
	8/18/2016	**580**	400	--	<2.0	<2.0	<3.0	<3.0	--	--	--	--	--	--
	1/19/2017	<250	<500	--	<1.00	<1.00	<1.00	<3.00	--	--	--	--	--	--
	8/31/2017	<200	<250	--	<1.00	<1.00	<1.00	<3.00	--	--	--	--	--	--
MW-4	12/23/2005	<238	<476	<50.0	<0.500	<0.500	<0.500	<1.00	--	--	--	--	--	--
	8/18/2008	<243	<485	<50.0	<0.500	<0.500	<0.500	<1.00	--	--	--	--	--	--
	3/11/2010	<78	<390	<50.0	<1.0	<1.0	<1.0	<6.0	--	--	--	--	--	--
	6/9/2010	<82	<410	<50.0	<1.0	<1.0	<1.0	<3.0	--	--	--	--	--	--
	10/20/2010	<86	<430	<50.0	<1.0	<1.0	<1.0	<3.0	--	--	--	--	--	--
	12/27/2010	<83	<420	<50.0	<1.0	<1.0	<1.0	<3.0	--	--	--	--	--	--
	3/22/2011	<85	<430	<50.0	<1.0	<1.0	<1.0	<3.0	--	--	--	--	--	--
	8/29/2012	<78	<390	<50.0	<1.0	<1.0	<1.0	<3.0	--	--	--	--	--	--
	8/1/2013	<120	<240	<50.0	<1.0	<1.0	<1.0	<3.0	--	--	--	--	--	--
	8/14/2014	<120	<240	<50.0	<1.0	<1.0	<1.0	<2.0	<3.0	<0.094	<0.094	<1.0	<1.0	<0.010
	8/6/2015	--	--	--	--	--	--	--	--	--	--	--	--	--
	1/19/2017	--	--	--	--	--	--	--	--	--	--	--	--	--
	8/31/2017	--	--	--	--	--	--	--	--	--	--	--	--	--

Table 2
Summary of Groundwater Analytical Results
Former Cummings Oil Lease Site
Winlock, Washington

Monitoring Well	Date Sampled[a]	Total Petroleum Hydrocarbons			Volatile Organic Compounds[d]									
		Diesel Range[b]	Heavy Oil Range[b]	Gasoline Range[c]	Benzene	Toluene	Ethyl-benzene	Total Xylenes	Naph-thalene	1-Methyl-naphthalene[g]	2-Methyl-naphthalene[g]	Methyl tert-butyl ether	1,2-Dichloro-ethane	1,2 Dibromo-ethane[h]
MTCA Method A CLs[e]		500	500	800	5	1,000	700	1,000	160	--	--	20	5	0.01
MTCA Method B CLs[f]		--	--	--	--	--	--	--	--	1.51	32	--	--	--
MW-5	8/18/2008	433	<481	<50.0	<0.500	<0.500	<0.500	<1.00	--	--	--	--	--	--
	3/11/2010	<82	<410	<50.0	<1.0	<1.0	<1.0	<6.0	--	--	--	--	--	--
	6/9/2010	<84	<420	<50.0	<1.0	<1.0	<1.0	<3.0	--	--	--	--	--	--
	10/20/2010	<85	<430	<50.0	<1.0	<1.0	<1.0	<3.0	--	--	--	--	--	--
	12/27/2010	<87	<430	<50.0	<1.0	<1.0	<1.0	<3.0	--	--	--	--	--	--
	3/22/2011	<75	<380	<50.0	<1.0	<1.0	<1.0	<3.0	--	--	--	--	--	--
	8/17/2012	<76	<380	<50.0	<1.0	<1.0	<1.0	<3.0	--	--	--	--	--	--
	8/1/2013	<120	<240	<50.0	<1.0	<1.0	<1.0	<3.0	--	--	--	--	--	--
	8/14/2014	<120	<240	<50.0	<1.0	<1.0	<1.0	<2.0	<3.0	<0.094	<0.094	<1.0	<1.0	<0.010
	8/6/2015	<100	<240	--	<2.0	<2.0	<3.0	<3.0	--	--	--	--	--	--
	12/23/2015	<110	<250	--	<2.0	<2.0	<3.0	<3.0	--	--	--	--	--	--
	3/28/2016	<110	<250	--	<2.0	--	--	--	--	--	--	--	--	--
	8/18/2016	150	<260	--	<2.0	<2.0	<3.0	<3.0	--	--	--	--	--	--
	1/18/2017	<250	<500	--	<1.00	<1.00	<1.00	<3.00	--	--	--	--	--	--
	8/31/2017	<200	<250	--	<1.00	<1.00	<1.00	<3.00	--	--	--	--	--	--
MW-6	8/14/2014	**520**	280	110	<5.0	<5.0	<5.0	<10.0	<15.0	0.13	<0.094	<5.0	<5.0	<0.010
	8/6/2015	420	370	--	<2.0	<2.0	<5.0	<3.0	--	--	--	--	--	--
	12/23/2015	290	<260	--	<2.0	<2.0	<3.0	<3.0	--	--	--	--	--	--
	3/28/2016	**980**	470	--	**17**	--	--	--	--	--	--	--	--	--
	8/18/2016	**640**	<250	--	<2.0	<2.0	<3.0	<3.0	--	--	--	--	--	--
	1/18/2017	<250	<500	--	<1.00	<1.00	<1.00	<3.00	--	--	--	--	--	--
	8/31/2017	<200	<250	--	<1.00	<1.00	<1.00	<3.00	--	--	--	--	--	--
MW-7	8/14/2014	260	260	<50.0	<1.0	<1.0	<1.0	<2.0	<3.0	<0.094	<0.094	<1.0	<1.0	<0.010
	8/6/2015	120	<240	--	<2.0	<2.0	<3.0	<3.0	--	--	--	--	--	--
	12/23/2015	<110	<250	--	<2.0	<2.0	<3.0	<3.0	--	--	--	--	--	--
	3/28/2016	<110	<250	--	<2.0	--	--	--	--	--	--	--	--	--
	8/18/2016	<110	<250	--	<2.0	<2.0	<3.0	<3.0	--	--	--	--	--	--
	1/18/2017	<250	<500	--	<1.00	<1.00	<1.00	<3.00	--	--	--	--	--	--
	8/31/2017	<200	<250	--	<1.00	<1.00	<1.00	<3.00	--	--	--	--	--	--

Table 2
Summary of Groundwater Analytical Results
Former Cummings Oil Lease Site
Winlock, Washington

Monitoring Well	Date Sampled[a]	Total Petroleum Hydrocarbons			Volatile Organic Compounds[d]									
		Diesel Range[b]	Heavy Oil Range[b]	Gasoline Range[c]	Benzene	Toluene	Ethylbenzene	Total Xylenes	Naphthalene	1-Methylnaphthalene[g]	2-Methylnaphthalene[g]	Methyl tert-butyl ether	1,2-Dichloroethane	1,2 Dibromoethane[h]
MTCA Method A CLs[e]		500	500	800	5	1,000	700	1,000	160	--	--	20	5	0.01
MTCA Method B CLs[f]		--	--	--	--	--	--	--	--	1.51	32	--	--	--

Notes:

Bold indicates concentrations exceed applicable cleanup levels.

< = not detected above laboratory reporting limit

-- = not analyzed

CL = cleanup level

dup = duplicate sample

MTCA = Model Toxics Control Act

Footnotes:

[a] Analytical results prior to 8/18/2016 were collected by other consultants and obtained from Farallon Consulting.

[b] Analyzed by Northwest Method NWTPH-Dx.

[c] Analyzed by Northwest Method NWTPH-Gx.

[d] Analyzed by U.S. Environmental Protection Agency (EPA) Method 8260B or 8260C.

[e] Washington State Department of Ecology MTCA Cleanup Regulation Method A CLs for Groundwater Table 720-1 of Section 900 of Chapter 173-340 of the Washington Administrative Code as revised 2013.

[f] Washington State Model Toxics Control Act Cleanup Regulation Cleanup Levels and Risk Calculations Standard Method B Values for Groundwater, https://fortress.wa.gov/ecy/clarc/CLARCHome.aspx.

[g] Analyzed by EPA Method 8270C SIM

[h] Analyzed by EPA Method 8011

Table 3
Summary of Water Quality and Geochemical Parameters
Former Cummings Oil Lease Site
Winlock, Washington

Monitoring Well	Date Sampled [a]	Water Quality Parameters						Geochemical Parameters											
		Temperature	pH	Conductivity	Turbidity	DO	ORP	Nitrate | Nitrite[b]	Sulfate	Sulfide	Total Iron	Ferrous Iron[c]	Ferric Iron	Methane	Alkalinity	Dissolved Manganese	Total Manganese	Ethane	Ethene
		°C	--	mS/cm	NTU	mg/L	mV	mg/L	mg/L	mg/L	mg/L	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
MW-1	8/18/2008	17.6	6.03	0.221	--	0.92	-7.7	--	--	--	--	--	--	—	--	--	--	--	--
	3/11/2010	10.08	6.7	0.289	--	0.47	117.7	<0.20	74.4	--	--	--	--	289	--	--	--	--	--
	6/9/2010	14.21	6.21	0.348	--	0.42	11.1	0.012	59.4	--	--	9.8	--	520	--	--	--	--	--
	10/20/2010	16.2	6.13	0.234	--	0.64	12.1	<0.20	59.1	--	--	2.3	--	388	--	--	--	--	--
	12/27/2010	10.65	6.16	0.28	--	0.29	-1.2	<0.20	38.3	--	--	15.3	--	668	--	--	--	--	--
	3/22/2011	9.27	7.29	0.308	--	0.15	-61.9	0.0804	34.3	--	--	3.2	--	22	--	--	--	--	--
	12/23/2015	8.52	6.31	0.272	17.3	1.39	-21.4	--	--	--	--	--	--	--	--	--	--	--	--
	3/28/2016	13.06	6.17	0.252	44.2	1.11	-8.1	--	--	--	--	--	--	--	--	--	--	--	--
	8/18/2016	20.08	5.75	0.194	5.03	0.79	-0.4	--	--	--	--	--	--	--	--	--	--	--	--
	1/18/2017	10.1	6.3	0.1889	13.1	1.32	-70.9	--	--	--	--	--	--	--	--	--	--	--	--
	8/31/2017	20.36	6.03	0.136	8.94	2.24	-20.4	--	--	--	--	--	--	--	--	--	--	--	--
MW-2	8/18/2008	17.65	6.64	0.316	--	0.99	-77.2	<0.200	0.4	--	--	--	--	1660	--	--	--	--	--
	3/11/2010	9.93	7.28	0.247	--	0.77	101.2	<0.20	30.3	--	--	--	--	1620	--	--	--	--	--
	6/9/2010	14.48	6.84	0.277	--	1	75.8	<0.050	7.9	--	--	3.2	--	3500	--	--	--	--	--
	10/20/2010	16.76	6.61	0.279	--	0.91	-50.3	<0.20	11.2	--	--	1.3	--	6320	--	--	--	--	--
	12/27/2010	10.39	6.6	0.305	--	0.39	-78.5	<0.20	12.5	--	--	30.2	--	2980	--	--	--	--	--
	3/22/2011	8.97	6.63	0.253	--	0.57	191.6	0.104	8.3	--	--	1.8	--	1160	--	--	--	--	--
	12/23/2015	10.34	6.55	0.189	32.6	3.38	-25.3	--	--	--	--	--	--	--	--	--	--	--	--
	3/28/2016	12.27	6.48	0.368	19.7	1.25	-88.5	--	--	--	--	--	--	--	--	--	--	--	--
	8/18/2016	21.45	5.96	0.273	5.21	0.3	-73.7	--	--	--	--	--	--	--	--	--	--	--	--
	1/18/2017	10.1	6.47	0.2124	45.6	2.25	-60.6	--	--	--	--	--	--	--	--	--	--	--	--
	8/31/2017	19.12	6.59	0.193	10.6	0.90	-64.2	<0.100	<5	<0.05	20.9	6.5	14	3,650	125,000	377	372	<13.0	<13.0
MW-3	8/18/2008	17.38	6.34	0.382	--	1.08	-75.6	--	--	--	--	--	--	—	--	--	--	--	--
	3/11/2010	--	--	--	--	--	--	--	--	--	--	--	--	—	--	--	--	--	--
	6/9/2010	13.87	6.36	0.387	--	0.50	-6.8	<0.050	13.4	--	--	3.9	--	380	--	--	--	--	--
	10/20/2010	17.26	6.57	0.321	--	0.87	-33.4	<0.20	14.6	--	--	1.5	--	338	--	--	--	--	--
	12/27/2010	11.09	6.48	0.378	--	0.45	-50.8	<0.20	13.9	--	--	23.2	--	339	--	--	--	--	--
	3/22/2011	9.72	8.06	0.416	--	0.25	-78.2	0.0734	17.8	--	--	4.2	--	224	--	--	--	--	--
	12/23/2015	8.4	6.91	0.304	64.6	1.96	12.1	--	--	--	--	--	--	--	--	--	--	--	--
	3/28/2016	12.04	6.2	0.450	75.8	0.45	-14.7	--	--	--	--	--	--	--	--	--	--	--	--
	8/18/2016	23.04	6.08	0.392	52.2	0.34	-47.2	--	--	--	--	--	--	--	--	--	--	--	--
	1/19/2017	9.2	6.23	0.189	239.3	3.06	-4.5	--	--	--	--	--	--	--	--	--	--	--	--
	8/31/2017	21.10	6.22	0.285	33	1.51	-14.6	<0.100	32.9	<0.05	18.1	6.0	12	137	131,000	571	574	<13.0	<13.0

Table 3
Summary of Water Quality and Geochemical Parameters
Former Cummings Oil Lease Site
Winlock, Washington

Monitoring Well	Date Sampled [a]	Water Quality Parameters						Geochemical Parameters											
		Temperature	**pH**	**Conductivity**	**Turbidity**	**DO**	**ORP**	**Nitrate | Nitrite[b]**	**Sulfate**	**Sulfide**	**Total Iron**	**Ferrous Iron[c]**	**Ferric Iron**	**Methane**	**Alkalinity**	**Dissolved Manganese**	**Total Manganese**	**Ethane**	**Ethene**
		°C	**--**	**mS/cm**	**NTU**	**mg/L**	**mV**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**
MW-4	8/18/2008	13.78	6.75	0.241	--	0.97	-74.9	<0.200	16.7	--	--	--	--	22.8	--	--	--	--	--
	3/11/2010	9.59	7.92	0.255	--	0.57	85.6	<0.20	17.6	--	--	--	--	47.6	--	--	--	--	--
	6/9/2010	12.42	7.16	0.26	--	0.51	85.5	0.011	12.5	--	--	1.2	--	93	--	--	--	--	--
	10/20/2010	12.96	7.42	0.206	--	0.66	-77.8	<0.20	14.1	--	--	0.52	--	16.9	--	--	--	--	--
	12/27/2010	10.84	6.11	0.205	--	0.49	53.5	<0.20	9.1	--	--	19.5	--	51.6	--	--	--	--	--
	3/22/2011	9.2	6.01	0.196	--	0.91	211.2	0.124	14.3	--	--	2.2	--	<10.0	--	--	--	--	--
	12/23/2015	*Not Sampled*																	
	3/28/2016																		
	8/18/2016																		
	1/19/2017																		
	8/31/2017	15.31	6.79	0.163	41.3	1.13	-44.2	<0.100	15.7	<0.05	12.4	5.0	7	27.2	89,500	504	499	<13.0	<13.0
MW-5	8/18/2008	17.57	6.62	0.466	--	1.45	-31.6	--	8.0	--	--	--	--	40.6	--	--	--	--	--
	3/11/2010	10.3	7.63	0.067	--	5.66	107.9	0.61	3.2	--	--	--	--	<10.0	--	--	--	--	--
	6/9/2010	14.74	5.76	0.074	--	2.27	213.5	0.87	4.7	--	--	<0.17	--	<2.3	--	--	--	--	--
	10/20/2010	17.59	6.03	0.085	--	1.34	75.5	0.65	6.3	--	--	<0.20	--	<10.0	--	--	--	--	--
	12/27/2010	10.69	5.72	0.073	--	5.62	140.7	1.2	3.9	--	--	<0.20	--	<10.0	--	--	--	--	--
	3/22/2011	8.89	5.62	0.072	--	6.02	47.2	0.484	7.0	--	--	0.5	--	<10.0	--	--	--	--	--
	12/23/2015	11.53	5.75	0.277	7.8	4.1	126.6	--	--	--	--	--	--	--	--	--	--	--	--
	3/28/2016	11.13	5.91	0.27	7.7	1.47	28.4	--	--	--	--	--	--	--	--	--	--	--	--
	8/18/2016	22.78	5.81	0.275	2.60	0.42	98.8	--	--	--	--	--	--	--	--	--	--	--	--
	1/18/2017	9.7	6.08	0.1609	10.50	7.92	31.1	--	--	--	--	--	--	--	--	--	--	--	--
	8/31/2017	19.71	5.88	0.182	2.07	1.09	64.8	--	--	--	--	--	--	--	--	--	--	--	--
MW-6	12/23/2015	9.8	6.59	0.332	11.60	1.11	-81.1	--	--	--	--	--	--	--	--	--	--	--	--
	3/28/2016	12.66	6.53	0.399	10.20	4.34	-99.1	--	--	--	--	--	--	--	--	--	--	--	--
	8/18/2016	21.17	6.29	0.309	8.84	0.29	-101.7	--	--	--	--	--	--	--	--	--	--	--	--
	1/18/2017	10.1	6.49	0.299	27.80	1.00	-72.8	--	--	--	--	--	--	--	--	--	--	--	--
	8/31/2017	20.00	6.66	0.211	9.24	0.78	-79.0	<0.100	<5	<0.05	20.6	6.0	15	3,070	121,000	442	425	<13.0	<13.0
MW-7	12/23/2015	9.35	7.12	0.254	16.00	1.66	-30.9	--	--	--	--	--	--	--	--	--	--	--	--
	3/28/2016	11.48	6.34	0.201	25.10	2.08	12.5	--	--	--	--	--	--	--	--	--	--	--	--
	8/18/2016	22.37	5.81	0.217	11.80	1.85	63.2	--	--	--	--	--	--	--	--	--	--	--	--
	1/18/2017	9.1	6.21	0.2261	19.40	3.50	13.2	--	--	--	--	--	--	--	--	--	--	--	--
	8/31/2017	20.33	6.28	0.232	7.76	1.15	24.9	--	--	--	--	--	--	--	--	--	--	--	--

Notes:
°C = degrees Celcius
DO = dissolved oxygen
mS/cm = millisiemens per centimeter
mg/L = milligrams per liter
mV = millivolts
NTU = nephalometric turbidity units
ORP = oxidation reduction potential
-- = not analyzed
* = indicates possible sensor malfunction
< = not detected above laboratory reporting limit
µg/L = micrograms per liter
LNAPL = light non-aqueous phase liquid

Footnotes:
[b] Total Nitrate/Nitrite analyzed by EPA Method 353.2.
[c] Ferrous Iron measured in the field.

Table 4
Evaluation of Natural Attenuation
Former Cummings Oil Lease Site
Winlock, Washington

PARAMETER	CATEGORY	RESULTS	INTERPRETATION[a]
pH	Water Quality	6.22 to 6.79	pH is between 6 and 7, which is within the range considered suitable for hydrocarbon-degrading microorganisms.
Dissolved Oxygen (DO)	Electron Acceptor	0.78 to 1.51 mg/L	DO concentrations are low within site groundwater which is indicative that conditions are suboxic trending to anaerobic.
Nitrate (NO_3^-) / Nitrite (NO2-)	Electron Acceptor	Non-detect (<100 µg/L)	Nitrate and nitrite concentrations are below reporting limits, suggesting that these compound ions, which can serve as terminal electron acceptors for nitrate-reducing bacteria, are not widely present in site groundwater.
Total Manganese / Dissolved Manganese	Electron Acceptor	372 / 377 µg/L to 574 / 571 µg/L	Manganese appears to be present primarily in the dissolved form (speciated as Mn^{2+}), which is indicative of reduced conditions.
Ferric Iron (Fe3+)	Electron Donor	7 µg/L to 15 µg/L	Within site groundwater, iron appears to be primarily speciated as Ferric Iron (Fe^{3+}), which indicates that anaerobic hydrocarbon degradation may be occurring at the Site. Continued monitoring of groundwater for increases in Ferrous Iron (Fe^{2+}) is necessary to determine if anaerobic degradation of hydrocarbons is occurring.
Oxidation-Reduction Potential (ORP)	Water Quality	-79.0 mV to -14.6 mV	ORP values in site groundwater are negative which is indicative of reduced condtions.
Methane (CH_4)	Metabolic By-Product	27.2 µg/L to 3,650 µg/L	Methane concentrations are slightly elevated in groundwater from wells within the dissolved-phase TPH plume, suggesting that anaerobic bacteria may be active at those locations.
Alkalinity	Other Parameters	89,500 µg/L to 131,000 µg/L	Alkalinity concentrations are slightly elevated in groundwater from wells within the dissolved-phase TPH plume, suggesting that bioactivity may be enhanced within the footprint of the plume.

Notes:

[a] Results for monitoring wells MW-2, MW-3, and MW-6 are considered to be representative of conditions within the footprint of the dissolved-phase TPH plume; results for monitoring well MW-4 are considered to be representative of conditions up-gradient of the TPH plume.

[b] Ferric Iron concentrations are estimated by subtracting the field-measured concentration of ferrous iron from the reported concentration of total iron.

APPENDIX A

GENERAL FIELD PROCEDURES AND GROUNDWATER SAMPLING STANDARD OPERATING PROCEDURES

Title: **Groundwater Sampling**	Procedure Number: **ECR 009**
	Revision Number: **2**
	Effective Date: **November 2016**

Authorization Signatures

Cinnamon Smith		Elizabeth Denly	
Technical Reviewer	Date	ECR Practice Quality Coordinator	Date
Cinnamon Smith	11/14/16	Elizabeth Denly	11/14/16

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ATTACHMENTS

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Attachment B	Example Groundwater Field Data Records
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Attachment D	SOP Modifications for PFAS

1.0 INTRODUCTION

1.1 Scope & Applicability

This Standard Operating Procedure (SOP) was prepared to provide TRC personnel with general guidance in performing groundwater sampling activities. This SOP details equipment and sampling procedures for low-flow sampling, multi-volume purge sampling and passive diffusion bag sampling from monitoring wells. Various regulatory agencies and project-specific work plans may have specific requirements (e.g., equipment/instrument, flow rate, etc.) that may be applicable and take precedence, depending on the program.

The objective of groundwater sampling is to obtain a representative sample of water from a saturated zone or groundwater-bearing unit (i.e., aquifer) with minimal disturbance of groundwater chemistry. This requires that the sample being collected is representative of groundwater within the formation surrounding the well bore as opposed to stagnant water within the well casing or within the filter pack immediately surrounding the well casing.

1.2 Summary of Method

There are three general approaches to groundwater purging/sampling that can be used to obtain a representative groundwater sample for analysis: 1) the low-flow or micropurge method where the mixing of the stagnant water is minimized using low-flow pumping rates during the collection of the groundwater sample; 2) the multiple well volume removal approach in which the stagnant water is removed from the well and the filter pack prior to sample collection; and 3) the passive sampler procedure where water quality equilibration with the surroundings is achieved through deployment of the passive sampler for a sufficient amount of time prior to sampling.

For low-flow and multiple well volume removal, there are various types of equipment available to perform groundwater sampling. The most common of these are the submersible pump, peristaltic pump, and bailer. However, the equipment selected and the purge method used, if any, will depend on project goals, data quality objectives (DQOs), hydrogeologic conditions, and regulatory requirements. Care should be taken when choosing the sampling procedures and device(s), as some procedures have the potential to affect the representativeness of the sample more than others. For repeated monitoring events, the sampling methodology and operating equipment employed should be consistent to minimize potential variability due to sampling procedures. The type of sampling method utilized is dependent upon site-specific conditions and it is not within the scope of this document to recommend a specific methodology. For specialized sampling programs involving per- and polyfluorinated alkyl substances (PFAS), refer to Attachment D for further details. Information on applicability of sampling methods can be found on Interstate Technology & Regulatory Council (ITRC) and United States Environmental Protection Agency (EPA) websites.

1.3 Equipment

The following equipment is commonly used to collect groundwater samples from a monitoring well. Site-specific conditions may warrant the use of additional equipment or deletion of items from this list.

- Appropriate level of personal protective equipment (PPE) as specified in the site-specific Health and Safety Plan (HASP)
- Electronic water level indicator capable of measuring to 0.01 foot accuracy
- Oil/water interface probe
- Extra batteries for water level/interface probe
- Submersible pump with low-flow capabilities (less than 1 liter/min) constructed of inert materials (e.g., stainless steel and Teflon®), such as a bladder pump (with sufficient quantity of bladders, o-rings, grab plates, etc.)
- Peristaltic pump
- Source of power for use with submersible or peristaltic pump (e.g., 12-volt battery, compressor, generator, compressed gas tanks, etc.)
- Flow controller for use with submersible pump (varies depending on type of pump used)
- Bottom-filling bailer constructed of inert materials (i.e., polyethylene, polyvinyl chloride [PVC], stainless steel or Teflon®)
- Bailer cord or wire (recommended Teflon®-coated, stainless steel cable; bailer wire; or contaminant-free rope with a Teflon®-coated stainless steel leader to connect bailer and rope)
- Tubing (Teflon®, Teflon®–lined polyethylene, or high density polyethylene [HDPE], type dependent upon project objectives)
- Silicone tubing (only used for peristaltic pump head and/or flow-through cell connections)
- Water quality meter(s) capable of measuring parameters, such as pH, temperature, specific conductivity, oxidation-reduction potential (ORP), and dissolved oxygen (DO)
- Flow-through cell
- T-connector
- Turbidity meter
- Passive sampling device (and any device-specific accessories)
  - Passive diffusion bags (PDBs)
  - Tether (stainless steel cable or marine-grade polyethylene rope), well cap, and weights, unless already installed
  - Funnel (Fill kit)
  - PVC cable ties
  - Tool to cut cable ties
  - PVC discharge tubes
  - Tether reel
- Well lock keys
- Bolt cutters

- Appropriate tools for equipment and to open well box (e.g., socket wrench, pry bar, etc.)
- Containers with lids for purge water (i.e., 5-gallon buckets, drums, etc.)
- Stopwatch or timer
- Graduated measuring container appropriately sized to measure flow rate
- Sample bottle labels
- Laboratory-grade water (can request from lab – for equipment blanks)
- Chain-of-custody (COC) forms
- Sample cooler(s)
- Photoionization detector (PID) or flame ionization detector (FID) for well head monitoring
- Sample containers (may be supplied by the laboratory depending upon the regulatory program): The proper containers should be determined in conjunction with the analytical laboratory in the planning stages of the project. If not included in sample containers provided by laboratory, sample preservatives will need to be kept with sample containers, and added to sample containers prior to sample collection.
- Field book and/or Groundwater Field Data Record (multiple copies)
- Filtration equipment
- In-line filter (0.45 micron [µm]) or as otherwise required by the project-specific work plan.
- Bubble wrap/Bubble wrap bags
- Lint-free, non-abrasive, disposable towels (e.g., Kimwipes®)
- Indelible marking pens
- Plastic bags (e.g., Ziploc®)
- Ice
- Teflon® tape
- Plastic sheeting or large trash bags which can be cut open
- Umbrella, tent, or equivalent for shading equipment (particularly the flow-through cell) from sunlight or blocking rain
- Equipment decontamination supplies
- Container for bailing water out of water-logged road boxes or well vaults
- Map of well locations and well construction data
- Copy of field notes from previous sampling event for reference
- Project-specific work plan

1.4 Definitions

Bailer	A cylindrical device suspended from a rope or cable, which is used to remove water, non-aqueous phase liquid (NAPL), sediment or other materials from a well or open borehole. Usually equipped with some type of check valve at the base to allow water, NAPL, and/or sediment to enter the bailer and be retained as it is lifted to the surface. A bailer may be made in varying diameters; however a bailer that fits in a two-inch well is the most common. In some instances a < 1-inch diameter bailer (a.k.a. pencil bailer) is used for small diameter wells.
Borehole	A hole drilled into the soil or bedrock using a drill rig or similar equipment.
Dense Non-aqueous Phase Liquid (DNAPL)	Separate-phase product that is denser than water and, therefore, sinks to the bottom of the water column.
Depth To Water (DTW)	The distance to the groundwater surface from an established measuring point.
Drawdown	The response to purging/pumping a well resulting in the lowering of groundwater within the water column in the well or in a water-bearing zone.
FID	An instrument that uses a flame to break down volatile organic compounds (VOCs) into ions that can be measured.
Flow-Through Cell	The container used to immerse the multi-parameter probes in well purge water during pre-sampling well purging. The flow-through cell is usually made of transparent acrylic and is connected to the end of the discharge tubing creating an in-line, sealed container in which purge water circulates around the measurement probes. The discharge from the pump prior to the flow-through cell may be fitted with a check valve or T-connector for collection of water for turbidity measurement.
Flush Mount	The type of well completion where the riser terminates at or below grade. Flush-mounted wells are typically completed with a “curb box” which is an “at-grade” enclosure designed to protect the well riser.
Light Non-aqueous Phase Liquid (LNAPL)	Separate-phase product that is less dense than water and therefore floats on the surface of the water.

Monitoring Well	A well made from a PVC pipe, or other appropriate material, with slotted screen installed across or within a saturated zone. A monitoring well is typically constructed with a PVC or stainless steel pipe in unconsolidated deposits and with steel casing in bedrock.
PID	An instrument that uses an ultraviolet light source to break down VOCs into ions that can be measured.
Piezometer	A well made from PVC or metal with a slotted screen installed across or within a saturated zone. Piezometers are primarily installed to monitor changes in the potentiometric surface elevation.
Potentiometric Surface	A surface representing the hydraulic head of groundwater.
Protective Casing	The pipe installed around the well riser that sticks up from the ground (above-grade completions) or is flush with the ground (at-grade completions, e.g., curb box) in order to protect the well integrity. Protective casings are typically constructed of steel or aluminum and usually closeable with a locking cover/hasp to maintain well integrity between sampling events.
Recharge Rate	The rate at which groundwater returns to the water column in the well.
Separate-Phase Product	A liquid that does not easily dissolve in water. Separate-phase product can be more dense (i.e., DNAPL) or less dense (i.e., LNAPL) than water and, therefore, can be found at different depths in the water column.
Static Water Level	Level at which water resides in a well when the water level is at equilibrium with atmospheric pressure.
Well Cover	The cap or lid constructed at the end of the protective casing (above-grade completions) or flush-mounted curb box (ground surface completions) to secure access to the well. Well covers for stick-up wells are often equipped with a hasp to accommodate a padlock. Well covers for flush-mounted road boxes or vaults are opened and closed using a threaded bolt.
Well Filter Pack	A material composed of clean silica sand or sand and gravel of selected grain size and gradation that is placed in the annulus between the screened interval and the borehole wall in a well for the purpose of retaining and stabilizing the formation material.
Well Plug/Expansion Plug	The plug fashioned into a cap placed into the top of the well riser (e.g., J-Plug). Well plugs are usually designed with an expandable gasket that is activated by turning a locking wing nut or removable key latch, closing a snap cap or engaging a magnetic clutch cap to seal the well riser.

Well Riser	Sections of blank (non-slotted) pipe that extend from the well screen to or above the ground surface.
Well Screen	Pipe (typically PVC or stainless steel) used to retain the formation or filter pack materials outside of the well. The pipe has openings/slots of a uniform width, orientation, and spacing. The openings/slots can vary based on formation and filter pack material specifications.

1.5 Health & Safety Considerations

TRC personnel will be on site when implementing this SOP. Therefore, TRC personnel shall follow the site-specific HASP. TRC personnel will use the appropriate level of PPE as defined in the HASP.

The well head should be pre-screened using a PID/FID to avoid inhalation of contaminants venting from the well. If monitoring results indicate sustained elevated concentrations of organic contaminants, the level of PPE may need to be increased in accordance with the HASP or work could be conducted upwind of the well.

When present, special care should be taken to avoid contact with LNAPL or DNAPL. The use of an air monitoring program, as well as the proper PPE designated by the site-specific HASP, can identify and/or mitigate potential health hazards.

Implementing this SOP may require the use of reagents and/or compressed gases for the calibration and operation of field equipment. These substances may be hazardous and TRC personnel must appropriately handle, store, and dispose of them at all times. Skin contact with liquid from preserved sample bottles must be avoided as they may contain strong acids or bases. When filling bottles pre-preserved with acid (e.g., hydrochloric acid, nitric acid, sulfuric acid), vapors may be released and should not be inhaled. Do not allow bottles with acid to be exposed to elevated atmospheric temperatures or sunlight as this will facilitate fumes from the acids.

1.6 Cautions and Potential Problems

The following sections highlight issues that may be encountered and should be discussed with the Project Manager prior to mobilization into the field. Special care should be taken when sampling for PFAS. Please refer to Attachment D for details.

1.6.1 Pre-Sampling Issues

(a) Selection of equipment for groundwater sampling should consider multiple factors, including: DTW, well specifications (e.g., depth and length of well screen intervals), desired flow rate, possible weather conditions, type and concentration of contaminant(s), and remoteness/accessibility to the site. The benefits and limits of each type of groundwater sampling equipment should be fully reviewed during project planning or prior to mobilization if the project-specific work plan does not identify the required equipment. For example, peristaltic pumps are incapable of withdrawing water in wells in which the depth to water is greater than approximately 20-25 feet below ground surface (bgs).

(b) If the screen or open borehole is greater than 10 feet in length, consult the project-specific work plans for the target sampling interval. Generally, pumps are either placed in the middle of the saturated zone if the water level is below the top of the screen or in the middle of the screen interval if the water level is above the top of the screen.

(c) The need for redevelopment of the monitoring wells should be evaluated periodically in accordance with the project-specific requirements. This is assessed by comparing the measured total depth of the well with the constructed depth. If the measured depth is less than the constructed depth, this may indicate siltation of the well and/or the presence of an obstruction in the well. If it is determined that redevelopment is necessary, it should be performed in accordance with RMD SOP 006, *Well Development*. The time necessary for a well to restabilize after redevelopment will be determined on a project-specific basis and may depend on regulatory requirements.

(d) During the total well depth measurement, there is the potential for sediment, if present at the bottom of the well, to be disturbed, thereby increasing the turbidity of the groundwater. Therefore, the total well depth measurement should be collected the day prior to collecting groundwater samples, if possible.

(e) Use caution if using compressed gas cylinders (e.g., nitrogen, carbon dioxide) for purging/sampling of groundwater. Check for leaks around regulator connections by spraying soapy water on the connections. If a leak is discovered, the connection to the regulator should be disassembled, wrapped with Teflon® tape, and reconnected to the cylinder. If the leak continues, the regulator should be replaced. It should be noted that Department of Transportation (DOT) regulations apply to the transportation and handling of compressed gas cylinders (see 49 Code of Federal Regulations [CFR] 171). Never transport cylinders with the regulator attached. Replace the cylinder valve cover on the compressed gas cylinder before transport.

(f) All field personnel must be made aware of the water level measurement reference point being used for each well at a site (i.e., must be clearly marked) in order to ensure collection of comparable data between events.

(g) Bolt cutters may be necessary to remove rusted locks. Dipping rusted locks in a soapy solution may help with opening difficult locks. Oils and other products containing VOCs (e.g., WD-40) should not be used on locks as these compounds may cause contamination of water samples collected at the well. Replace cut locks and note in the field book.

(h) Prior to accessing the well, physical conditions around the well head should be assessed for situations that might result in cross-contamination or the introduction of foreign material/debris into the well. For example, flush-mounted wells may have water or road sand/salt/debris inside the curb box. Rodents and insects (e.g., bees, wasps) have been known to construct nests within the protective casing of a well. If bees, wasps, or other insects are encountered, insecticides should be used with caution as the chemicals may cause contamination of water samples collected at the well. If water or foreign material is introduced into the well, the Project Manager should be immediately notified.

1.6.2 General Purging and Sampling Issues

(a) Prior to installation of a submersible pump into a well, ensure that the tubing is properly sealed to the pump to avoid losing the pump down the well and to prevent escape of air or water from the pump, which could result in poor pump performance and the aeration of the well water. Do not do this by tugging on tubing. Never lower pumps into the well using only tubing; instead a security line attached to the pump is required to prevent potentially losing the pump down the well.

(b) A submersible pump should not be lowered to the bottom of the well to avoid stirring up any sediment at the bottom of the well and prevent getting the pump stuck (fine sediment accumulation in the bottom of the well can create a strong suction with a flat bottom pump such as a bladder pump, which may require jetting to retrieve the pump).

(c) Start with the lowest pumping rate possible and increase until a sustainable rate is reached. Avoid high pumping rates (> 1 liter/min), as this could lead to damage of the well filter pack, if present. Where practical and/or possible, refer to previous sampling events to establish consistent flow rates.

(d) Some regulatory agencies may have concern about the use of peristaltic pumps when sampling for VOCs due to the potential for loss of VOCs during sampling and alteration of other water quality parameters such as pH and alkalinity. Samplers should review the requirements in the project-specific work plan and/or regulatory guidelines prior to performing the work. Explicit approval to use a peristaltic pump for the collection of VOCs may be required by the governing regulatory agency. An option may be to use the “soda straw” method to collect the VOC sample which does not allow the water to go through the pump head:
   (1) After purging the well with the peristaltic pump, collect all fractions except VOCs from the outlet side of the pump (i.e., VOCs will be collected last instead of first).
   (2) Turn the pump off.
   (3) Change into clean gloves.
   (4) Disconnect the tubing coming out of the well from the inlet side of the pump and immediately put a finger over the end of this tubing to prevent water from draining out of the tubing.
   (5) Retrieve tubing from the well, coiling it in one hand as it is being retrieved (maintain finger over end of tubing).
   (6) Open VOC vials. Briefly remove finger from end of tubing to allow water to flow into vial. Replace finger on end of tubing to stop flow. Do this for remaining VOC vials.

(e) In the event that a well cannot be purged and sampled with a pump, the alternative to pumping may be the use of a bottom-filling bailer. The applicable regulatory agency requirements and the Project Manager should be consulted if in doubt about the appropriateness of using a bailer at a site or during a particular sampling event.

(f) During purging and sampling, the tubing should remain filled with water to minimize possible changes in water chemistry due to contact with the atmosphere. All flow-through cells should be shaded from direct sunlight to minimize the potential for off-gassing and temperature fluctuations.

(g) Ensure monitoring instruments (i.e., multi-parameter water quality instrument, turbidity meter, water level measuring device) are maintained in good condition and properly calibrated to ensure accurate readings. Be sure to have appropriate-sized extra batteries on hand.

(h) Adverse weather conditions may present challenges that need to be dealt with on a case-by-case basis. For example, air temperatures below 32°F may cause ice formation in the tubing, flow-through cell, and on the sampling equipment, or heavy rain could cause standing water issues with flush-mounted wells. Heavy rain can also impact electronic sampling equipment; preventative measures should be taken to keep electronic equipment dry.

(i) Observe and avoid any uncontrolled ambient/surrounding air conditions that could affect analytical results (e.g., truck/vehicle exhaust nearby, industrial building vents). Always ensure that vehicles are turned off during sampling to avoid introducing vehicle exhaust into the sample. If uncontrolled ambient/surrounding air conditions cannot be avoided, contact the Project Manager for further instruction; collection of a field blank sample may be warranted in this situation.

(j) Procedures should be established to minimize potential cross-contamination. For example:

- Wrap monitoring and sampling equipment with protective material (e.g., aluminum foil, polyethylene sheeting, Ziploc® bags) after decontamination and between sampling locations to minimize the potential for cross-contamination between well purging events at different locations.
- Use dedicated or disposable sampling equipment or new tubing at each sampling point when appropriate to minimize the need for decontamination.
- Protect sampling equipment and/or the open well head from blowing soil and dust by covering with plastic sheeting as needed.
- If a bailer and rope are used to purge and/or sample the well, then there is the possibility of contamination from the rope used to lower the bailer. New or dedicated rope should be used when appropriate. Alternatively, a decontaminated, Teflon®-coated stainless steel leader can be attached between the rope and the bailer. The leader acts as an extension to the rope and allows for the top of the bailer to enter the water column without immediately placing the rope into the water. It is important to keep the rope clean and not allow contact with the ground surface during bailing.

(k) Disposal of the groundwater collected during purging must be performed in accordance with all applicable regulations and the project-specific work plan.

(l) Clear tape should not be used to cover labels on containers used for certain analyses (e.g., 40-mL vials for VOC analysis) due to potential interference with analytical equipment.

(m) In cases where it is difficult to obtain sufficient sample volume for multiple analytical fractions as well as required quality control (QC) analyses (*e.g.*, field duplicates, matrix spike/matrix spike duplicate [MS/MSD] analyses), discuss this situation with the Project Manager and laboratory prior to sample collection. Laboratories can often "make do" with less volume, especially for inorganic parameters, or increase the reporting limit proportional to the sample volume obtained.

1.7 Personnel Qualifications

Since this SOP will be implemented at sites or in work areas that entail potential exposure to toxic chemicals or hazardous environments, all TRC personnel must be adequately trained. Project- and client-specific training requirements for samplers and other personnel on site should be developed in project planning documents, such as the sampling plan or project-specific work plan. These requirements may include:

- OSHA 40-hour Health and Safety Training for Hazardous Waste Operations and Emergency Response (HAZWOPER) workers
- 8-hour annual HAZWOPER refresher training.

2.0 PROCEDURES

Procedures for collecting groundwater samples from monitoring wells are described below. The project-specific work plan should also be consulted for specific details regarding sampling.

Sampling should always begin at the monitoring well with the least contaminated groundwater and systematically proceed to the well with the most contaminated groundwater, if possible.

2.1 Pre-sampling Activities

(a) It should be determined if there is the requirement to determine static water level measurements on all wells at the site prior to sampling, regardless if the well is being sampled.

(b) Prior to field activities, review historical groundwater sampling logs (if available) to maintain consistency for the current sampling event (e.g., equipment type, pump intake depth setting, flow rate, etc.)

(c) Organize monitoring, purging, and sampling equipment taking care not to allow cross-contamination. This can be accomplished by laying new polyethylene sheeting near the well or using new buckets, etc.

(d) Calibrate (or perform a calibration check on) all field monitoring equipment on the same day before collecting groundwater samples. Refer to TRC SOPs and manufacturer's equipment calibration instructions. A calibration check may also be required during or at the end of each sampling day. Consult the project-specific work plan.

(e) Unlock the well cover on the well.

(f) Record the sample location, time, and date in the field book and/or on the Groundwater Field Data Record.

(g) On the Groundwater Field Data Record, note the physical condition of the well, including damage, deterioration, and signs of tampering, if any. Collect photographic documentation of serious damage to present to the Project Manager.

(h) Open the well cap and expansion plug, and stay upwind of and not directly over the well. Note any unusual odors, sounds, or difficulties in opening the well and, if required, measure the organic vapor reading at the rim of the well with a suitable organic vapor screening device (e.g., PID or FID), and record the reading in the field book and/or on the Groundwater Field Data Record. If pressure or vacuum is noted or suspected in the well, allow sufficient time for the water level elevation in the well to equilibrate.

(i) Gently lower a clean, decontaminated water level measuring device into the well to determine the static water level. If appropriate for site conditions, check for the presence of LNAPL or DNAPL using an oil/water interface probe (refer to ECR SOP 004, *Water Level and Product Measurements*). If LNAPL or DNAPL is detected, contact the Project Manager before proceeding with purging and sampling activities. Record the information on depth to groundwater to the nearest 0.01 feet, depth to LNAPL or DNAPL, and/or thickness of NAPL in the field book and/or the Groundwater Field Data Record. Refer to ECR SOP 004, *Water Level and Product Measurements*, for proper procedures in performing these measurements.

(j) If required in the project-specific work plan, measure the depth to the bottom of the well to assist in calculating the well volume of the well. If possible, avoid making total well depth measurements on the same day as sampling due to the tendency to disturb sediment during this measurement. If NAPL is suspected, use a decontaminated oil/water interface probe. If the measured depth is less than the constructed depth, this may indicate that the well needs to be redeveloped (see RMD SOP 006, *Well Development*). Consult the project-specific work plan or Project Manager for further instructions.

2.2 Groundwater Purging Activities

Purging is conducted to ensure that representative groundwater is obtained from the water-bearing unit for analysis. The multiple-volume or low-flow purging approach may be used to remove water from the well and monitor the water in order to determine when a well has been adequately purged (i.e., stabilized); at a minimum, the pH, specific conductance and temperature of the groundwater removed during purging should be monitored and recorded in the field notes. Other parameters may be required in some regulatory jurisdictions (e.g., turbidity). Additionally, the purge volume should be monitored and recorded. In some instances, such as when monitoring at solid waste disposal facilities, simply removing an adequate volume of water (e.g., three well volumes) may be suitable for adequate purging, and sampling can commence. Check with the project-specific work plan and appropriate regulatory guidance to determine any specific purging requirements.

If the well has been previously sampled consistent with this SOP, then the prior purging strategy (e.g., method, pump intake depth and the flow rates) should be followed during subsequent sampling events to maintain consistency and minimize potential variability due to the sampling procedure.

2.2.1 Multiple-Volume Purging Approach

The multiple-volume purging approach is typically performed using bailers or submersible or peristaltic pumps. In the multiple-volume purging approach, there are two measurements used to determine adequate purge volume removal prior to sample collection: 1) purge volume and 2) field parameter stabilization. The field parameters should be recorded at regular volumetric intervals. There are no set criteria for establishing how many total sets of measurements are adequate to document stability of parameters. If the calculated purge volume is small, the measurements should be taken frequently enough (e.g., every 3 to 5 minutes) to provide a sufficient number of measurements to evaluate stability. If the purge volume is large, measurements taken every 15 minutes may be sufficient.

Purge Volume

Prior to purging a well, the amount of water inside the well riser and well screen (i.e., water column) should be determined, if possible. To do this, the diameter of the well should be determined and the water level and total depth of the well should be measured and recorded. The specific methodology for obtaining these measurements is included in SOP 004 *Water Level and Product Measurements*.

Once this information is known, the well volume can be calculated using Equation 1:

Well Volume (V) = $\pi r^2 h$ (cf) **Equation 1**

where:
π = pi (3.14)
r = radius of well in feet (ft)
h = height of the water column in ft. [This may be determined by subtracting the depth to water from the total depth of the well as measured from the same reference point.]
cf = conversion factor in gallons per cubic foot (gal/ft^3) = 7.48 gal/ft^3.

The volume in gallons/linear foot (gal/ft) and liters/linear foot (L/ft) for common-size wells are as follows:

Well Inside Diameter (inches)	Volume (gal/ft)	Volume (L/ft)
1	0.0408	0.1529
2	0.1631	0.6174
3	0.3670	1.3892
4	0.6524	2.4696
6	1.4680	5.5570

If the volumes for the common-size wells above are utilized, Equation 1 is modified as follows:

Well volume = (h)(f) **Equation 2**

where:
h = height of water column (feet)
f = the volume in gal/ft or L/ft

For volumetric purging, an adequate purge is typically achieved when 3 to 5 well volumes have been removed. The field notes should reflect the single-well volume calculations or determinations according to one of the above methods and a reference to the appropriate multiplication of that volume, (i.e., a minimum of 3 well volumes) clearly identified as a purge volume goal.

For volumetric purging, it is suggested that field readings are collected every ½ well/well screen volume after an initial 1 to ½ well volumes are purged. The volume removed between readings can be adjusted as well-specific information is developed.

If removing a specified volume of water (e.g., 3 well volumes) has been determined to be suitable for purging, sampling can commence immediately upon achieving the required purge volume. In other cases, where specified in the project-specific work plan, stabilization of field parameters must be documented prior to sample collection. If, after 3 well volumes have been removed, the field parameters have not stabilized (see discussion in Section 2.2.3), additional well volumes (up to a total of 5 well volumes), should be removed. If the parameters have not stabilized within five well volumes, it is at the discretion of the Project Manager whether or not to collect a sample or to continue purging. If, after 5 well volumes, pH and conductivity have stabilized and the turbidity is still decreasing and approaching an acceptable level, additional purging should be considered to obtain the best sample possible with respect to turbidity. The conditions of sampling should be noted in the field book.

2.2.2 Low-flow Purging Approach

The low-flow purging approach is typically performed using peristaltic pumps or submersible pumps. Low-flow purging (also referred to as low-stress purging, low-volume purging, or Micropurging®) is a method of well purging/sampling that minimizes the volume of water withdrawn from a well in obtaining a representative sample. The term low-flow refers to the low velocity with which water enters the pump intake during purging and sampling. The objective is to draw representative saturated zone water through the well screen to the pump intake while avoiding disturbance of the stagnant water above the well screen through minimizing drawdown of the water column in the well. To achieve this, the flow rate should be adjusted to less than 1 L/min (usually, this will be a rate less than 500 ml/min and may be as low as 100 ml/min). Once drawdown stabilizes, the sampled water is isolated from the stagnant water in the well casing, thus eliminating the need for its removal. This sampling method is based on the principle that water within the screened zone passes through continuously and does not mix with water above the screen. Water entering the pump can be considered representative of water in the formation after drawdown and indicator parameters have stabilized.

When performing low-flow purging and sampling, it is recommended that the pump intake be set in the center of the well screen interval (or center of the water column within the well screen if the water level is below the top of the well screen) to help prevent disturbance of any sediment at the bottom of the well. If known, the pump can be placed adjacent to the areas with the highest hydraulic conductivity or highest level of contaminants. Dedicated pumps can be utilized to minimize disturbance of the water column. Subsequent sampling events should duplicate as closely as possible the pump intake depth and the stabilized flow rate from the previous events.

To begin purging, the pump should be started at the lowest pressure/power flow rate setting (e.g., 100 mL/min) and then slowly increased until water begins discharging. Monitor the water level and slowly adjust the pump speed until there is little or no drawdown or drawdown has stabilized. The pump pressure/power may need to be increased for discharge to occur.

The stabilization of drawdown should be documented. Measure and record the flow rate and water level every 3 to 5 minutes during purging. The flow rate should be reduced if drawdown is greater than 0.3 feet over three consecutive 3 to 5 minute interval readings. Note any flow rate adjustments on the Groundwater Field Data Record. Once an appropriate purge rate has been achieved, record this information, continue purging until water quality indicator parameters have stabilized (see Section 2.2.3), and then sample the well.

Attempts should be made to avoid pumping a well dry. If drawdown cannot be maintained at less than 0.3 feet and the falling water level is approaching the top of the screened interval (or the top of the pump for sampling that began with the water level below the top of the screen), perform the following steps:

1. Reduce the flow rate, or turn the pump off and allow for recovery. (The pump must have a check valve to prevent backflow if it is shut off).
2. Begin pumping again at a lower flow rate.
3. If water draws down to the top of the screened interval again (or the top of the pump for sampling that began with the water level below the top of the screen), turn the pump off and allow for recovery.
4. If two tubing volumes (including volume of water in the pump and flow-through cell) have been removed during purging, sampling can proceed the next time the pump is turned on without waiting for indicator field parameters to stabilize. The project-specific work plan or Project Manager should be consulted for guidance.
5. If this procedure is used, this should be recorded in the field book and/or on the Groundwater Field Data Record.

2.2.3 Field Parameter Stabilization During Purging

Stabilization criteria may depend on project objectives or regulatory-specific requirements. Refer to Appendix A for some of the regulatory-specific requirements for field parameter stabilization. Generally, an adequate purge with respect to the ground water chemistry is achieved when, stability for at least three consecutive measurements is as follows:

- pH ± 0.1 standard unit (SU)
- specific conductance within 3%
- turbidity within 10% for values greater than 5 nephelometric turbidity units (NTUs). If three turbidity readings are less than 5 NTUs, the values are considered as stabilized

Other parameters, such as DO, may also be used as a stabilization parameter. Typical stabilization goals for DO are within 0.2 mg/L or 10% saturation, whichever is greater. DO measurements should be conducted using either a flow-through cell or an over-topping cell to minimize or reduce potential oxygenation of the sample.

Because groundwater temperature is generally not very sensitive in distinguishing between stagnant casing water and formation water and is subject to rapid changes during purging, its usefulness is subject to question for the purpose of determining parameter stability. Even if temperature is not used to determine stability during well purging, it is still advisable to record the sample temperature, along with the other groundwater chemistry parameters, during well purging, as it may be needed to interpret other parameter results.

ORP is not always used as a stabilization parameter since it may also be subject to rapid changes during the purging process; however, it may be measured and recorded during well purging.

2.2.4 Special Considerations During Purging

Wells Purged Dry/Purge Adequacy

For wells with slow groundwater recovery, attempts should be made to avoid purging the well dry. This may be accomplished by slowing the purge rate. As water enters a well that has been purged dry, the water may cascade down the sand pack and/or the well screen, potentially stripping VOCs that may be present and/or potentially mobilizing soil fines into the re-accumulating water column.

However, even with slower purge rates, in some situations, a well may be pumped or bailed dry (evacuated) during the purging process. In these situations, evacuation generally constitutes an adequate purge and the well may be sampled following sufficient recovery (enough volume to allow filling of all sample containers). **It is not necessary that the well be evacuated three times before it is sampled.** Purging parameters should be measured and recorded during sample collection to serve as the measurements of record for the sampling event.

It is particularly important that wells be sampled as soon as possible after purging to maintain sample representativeness. If adequate volume is available upon completion of purging, the well should be sampled immediately. If not, sampling should occur as soon as adequate volume has recovered. If possible, sampling of wells that have a slow recovery should be scheduled so that they can be purged and sampled in the same day after adequate volume has recovered. Wells of this type should, unless it is unavoidable, not be purged at the end of one day and sampled the following day.

Temporary Monitoring Wells

Procedures used to purge temporary groundwater monitoring wells may differ from permanent wells, because temporary wells are installed with different DQOs for immediate sample acquisition. Wells of this type may include standard well screens and risers placed in boreholes created by hand augering, power augering, or by drilling. Alternatively, they may consist of a rigid rod and screen that is pushed, driven, or hammered into place to the desired sampling interval, such as a direct push Wellpoint®, a Geoprobe® Screen Point 15/16 sampler, or a Hydropunch® sampler.

Purging to address stagnant water may not necessarily apply to temporary wells, because stagnant water is not typically present. It is important to note, however, that the longer a temporary well is in place and not sampled, the more stagnant the water column may become, and the more appropriate it may be to apply, to the extent possible, standard permanent monitoring well purging criteria.

In cases where the temporary well is to be sampled immediately after installation, purging is conducted primarily to mitigate the impacts of installation. In most cases, temporary well installation procedures disturb the existing saturated conditions, resulting primarily in increased turbidity. Therefore, the goal of purging, if conducted, may be to reduce the turbidity and remove the volume of water in the area directly impacted by the installation procedure. Low turbidity conditions in these types of wells that are completed within the limit of suction are typically and routinely achieved by the use of low-flow/low-stress purging techniques using variable-speed peristaltic pumps.

2.2.5 Equipment Considerations for Purging

Monitoring well purging is accomplished by using in-place plumbing and dedicated pumps or by using portable pumps/equipment when dedicated systems are not present. The pump of choice is usually a function of the purging approach (e.g., multiple-volume vs. low-flow), well diameter, the DTW, the total depth of the well, the amount of water that is to be removed during purging, the specific analytical testing program for the well, and the equipment previously used during purging and sampling of the well. A peristaltic pump is appropriate for purging whenever the head difference between the sampling location and the water level is less than the limit of suction (approximately 25’ to 30’) and the volume to be removed is reasonably small. For wells where the water level is below the limit of suction, and/or where there is a large volume of water to be purged, the variable-speed electric submersible pump or adjustable-rate bladder pumps would be appropriate. Bailers may also be used for purging in appropriate situations (e.g., shallow wells with small purge volumes); bailers are not suitable for low-flow purging.

The following subsections describe well evacuation devices that are most commonly used. Other devices are available but are not discussed in this SOP due to their limited use. Site-specific operating procedures should be developed in the case that an uncommon purge device is used.

2.2.5.1 Purging with a Suction Pump

There are many different types of suction pumps. They commonly include: centrifugal, peristaltic and diaphragm. Diaphragm pumps can be used for well evacuation at a fast pumping rate and sampling at a low pumping rate. The peristaltic pump is a low-volume pump that incorporates a roller to squeeze flexible tubing, thereby creating suction. This tubing can be dedicated to a well for re-use or discarded. It is recommended that 1/4 inch or 3/8 inch (inner diameter) tubing be used to help ensure that the sample tubing remains filled with water and to prevent water from being aerated as it flows through the tubing. Purging procedures are as follows.

(a) Determine the volume of water to be purged as described in Section 2.2.1 or follow the low-flow approach described in Section 2.2.2 (applicable to peristaltic pumps only).
(b) Take necessary precautions (e.g., laying plastic sheeting around the well) to prevent contamination of pumps, tubing or other purging/sampling equipment with foreign materials.
(c) Assemble the pump, tubing and power source, if necessary, in accordance with manufacturer’s specifications.
(d) Ensure that the pump tubing is set at the pre-determined pump intake depth.
(e) Connect the discharge line from the pump to the flow-through cell for parameter measurements. Use a T-connection or valve prior to the flow-through cell to allow for collection of water for turbidity measurements. Direct the discharge line from the flow-through cell to a 5-gallon bucket (or equivalent) to contain the purge water for proper disposal. Verify the end of the tubing is not submerged in the purge bucket. Manage purge water as specified in the project-specific work plan.

(f) Do not allow the pump to run dry. If the pumping rate exceeds the well recharge rate, adjust the rate accordingly or, if consistent with the purging and sampling objectives, lower the tubing further into the well and continue pumping.

(g) Using the water quality meter, take an initial reading of the required indicator parameters. All measurements, except turbidity, must be obtained using a transparent flow-through cell unless an unforeseen situation makes this impractical or inadvisable. Initially, turbidity may be elevated. Once turbidity has decreased to a measurable range, begin monitoring indicator parameters at approximately every 3-5 minutes, or as appropriate. Please note that flow-through cell size should be taken into account in conjunction with the flow rate to determine the length of time between water quality parameter readings. At least one flow-through cell volume should be turned over between readings. For example, if the flow through cell size is 500 mL and the flow rate is 100 mL/min, then it would be appropriate to measure water quality parameters every 5 minutes.

(h) Record the readings on the Groundwater Field Data Record. The monitoring probes must be submerged in water at all times. Record the indicator parameters, along with the water level, as described in Step (g) above. If removing a specified volume of water (e.g., 3-5 well volumes) has been determined to be suitable for purging, sampling can commence immediately upon achieving the required purge volume. In other cases, where specified in the project-specific work plan, stabilization of field parameters must be documented prior to sample collection. Stabilization criteria are discussed in Section 2.2.3.

Particulate build-up in the flow-through cell may impact indicator parameters. If the cell must be cleaned during pumping operations, continue pumping and disconnect the cell for cleaning, then reconnect and continue monitoring. Record the start and stop times, and describe the cleaning steps in the field book.

If indicator parameter stabilization is required and parameters have not stabilized after 2-hours of purging (or other pre-determined length of time), one of three options may be taken after consultation with the Project Manager:

1) continue purging until stabilization is achieved;
2) discontinue purging, do not collect any samples, and record in the field book and/or on the Groundwater Field Data Record the stabilization conditions and steps taken to attempt to achieve stabilization; or,
3) discontinue purging, collect samples and document attempts to achieve stabilization.

NOTE: If parameters do not stabilize, or turbidity remains greater than 5 NTU within the project-determined time range (EPA recommends up to 2 hours), contact the Project Manager to develop a modified sampling approach.

(i) Record the volume of water purged on the Groundwater Field Data Record. Record the disposal method used for purge water in the field book.

(j) Once the required volume of water is removed (typically 3 to 5 well volumes) from the well and/or parameters are stabilized to the satisfaction of the project-specific work plan, proceed to Section 2.3, Post-purging Groundwater Sample Collection.

2.2.5.2 Purging with a Submersible Pump

Submersible pumps generally use one of two types of power supplies, either electric or compressed gas. Electric pumps can be powered by a 12-volt DC rechargeable battery, or a 110-

or 220-volt AC power supply. Those units powered by compressed gas (e.g., bladder pump) normally use a small electric controller that also needs a 12-volt DC battery or 110-volt AC power. They may also utilize compressed gas from bottles. Pumps differ according to the depth and diameter of the monitoring wells and the height of the potentiometric surface/water table (e.g., pressure head). It is recommended that 1/4-inch or 3/8-inch (inner diameter) tubing be used to help ensure that the sample tubing remains filled with water and to prevent water from being aerated as it flows through the tubing. Purging procedures are as follows.

(a) Determine the volume of water to be purged as described in Section 2.2.1 or follow the low-flow approach described in Section 2.2.2.

(b) Take necessary precautions (e.g., laying plastic sheeting around the well) to prevent contamination of pumps, tubing or other purging/sampling equipment with foreign materials.

(c) Assemble the pump, tubing and power source, if necessary, in accordance with manufacturer's specifications. If the pump itself is being lowered into the well, ensure a safety line is attached.

(d) Non-dedicated purge/sampling vs. dedicated purge/sampling systems.

Dedicated systems: Pump has already been installed. Refer to historical monitoring well information, and record the depth of the pump intake in the field book and/or on the Groundwater Field Data Record.

Non-dedicated systems: Determine the target depth of the pump intake. Note that this may be a historical intake depth; see well construction data or the project-specific work plan. If there is not an established intake depth, the center of the screened interval should be targeted. If the measured water level is lower than the top of the well screen, position the pump intake at the midpoint of the water column. The intake should be generally 1 to 2 feet above the bottom of the well to minimize potential mobilization of any settled sediment, the risk of the pumping suction being broken, or the entrainment of air in the pump tubing and resulting sample. Slowly lower the pump, safety line, and tubing into the well to the pre-determined pump intake depth. The tubing should be cut to the desired length to assist in installing the pump. Measure the depth of the pump intake while lowering the tubing/pump into location. Record the pump intake depth in the field book and/or on the Groundwater Field Data Record. For deeper wells and large diameter wells, two staff members may be necessary to accomplish this task.

(e) Connect the discharge line from the pump to the flow-through cell for parameter measurements. Use a T-connection or valve prior to the flow-through cell to allow for collection of water for turbidity measurements. Direct the discharge line from the flow-through cell to a 5-gallon bucket (or equivalent) to contain the purge water for proper disposal. Verify the end of the tubing is not submerged in the purge bucket. Manage purge water as specified in the project-specific work plan.

(f) Measure the flow rate of the pump with a graduated container and stop watch. The pump pressure may need to be increased for discharge to occur. Record the volume of water collected for a period of 1 minute and calculate the flow rate as follows.

$$Flowrate\,(mL\ /\ min) = \frac{volume\ collected\ (mL)}{1\,minute}$$

(g) Measure the water level and record the flow rate and the water level. This should be performed every 3 to 5 minutes during purging. For low-flow purging, the flow rate should be adjusted to result in a rate between 100 to 500 mL/min; however, if drawdown of the well is observed, a slower flow rate may be necessary. If using a bladder pump, it is recommended that the pump be set to deliver long pulses of water so that one pulse will fill a 40 mL volatile organic analysis (VOA) vial, if possible.

(h) Prior to recording the water quality indicator parameters, a minimum of one tubing volume should be purged. Note that this includes the volume of the flow-through cell.

(i) Proceed to steps (g) through (j) in Section 2.2.5.1.

2.2.5.3 Purging with a Bailer

(a) Determine the volume of water to be purged as described in Section 2.2.1.

(b) Take necessary precautions (e.g., laying plastic sheeting around the well) to prevent contamination of tubing or other purging/sampling equipment with foreign materials.

(c) Use a well-dedicated bailer (i.e., used exclusively for that well only), a decontaminated bailer or an unused, disposable bailer.

(d) Attach an appropriate length of (a) bailing line, (b) Teflon®-coated bailing wire or (c) rope with Teflon®-coated stainless steel leader to reach the bottom of the well. Secure a knot or series of knots to the top of the bailer. Be sure to have additional length of line to facilitate handling of the bailer at the surface (typically 10 ft).

(e) Lower the bailer gently into the well until it reaches the water column and fills with water from the bottom. Note: It is recommended that the bailer be lowered into the water to a depth that prevents the water from entering the top of the bailer. This is done to prevent excess turbulence caused by filling from the bottom and the top simultaneously. Controlling the line attached to the bailer as it is lowered into the well is also important to prevent degassing of the water as the bailer impacts the water. In shallow wells, controlling the line is not too difficult; however, for wells of greater depths it is common to utilize a hand-over-hand (windmill) approach using both hands to control longer lengths of line and prevent the loops in the line from tangling with one another. This procedure is simple to learn and saves a good deal of time by preventing tangles. Do not allow the bailing line or rope to become contaminated by surface soil.

(f) Once the bailer is full of water, gently withdraw the bailer from the well until it comes out of the top of the well. Be sure to control excess line in your hands to prevent the rope and bailer from touching the ground, and then grasp the bailer as it appears at the top of the well.

(g) Immediately pour the water into a vessel for water quality measurements, and record the measurements in the field book or on the Groundwater Field Data Record (at the project-required frequency). Otherwise, pour water into a 5-gallon bucket or other vessel to track the volume purged. As a general rule, standard 2-inch bailers are able to hold about 1 liter of water when full. This process will have to be repeated several times to complete adequate purging of the well (e.g., three to five well volumes).

(h) Record the volume of water purged on the Groundwater Field Data Record. Record the disposal method used for purge water in the field book.

(i) Once the required volume of water is removed (typically 3 to 5 well volumes) from the well and/or parameters are stabilized to the satisfaction of the project-specific work plan, proceed to Section 2.3, Post-purging Groundwater Sample Collection.

2.3 Post-purging Groundwater Sample Collection

(a) New, disposable gloves should be donned immediately prior to sample collection and should be changed at any point that their cleanliness becomes compromised during sample collection.

(b) If using a submersible or peristaltic pump, maintain the same flow rate as used during purging. Disconnect the pump tubing from the flow-through cell or sample from the T-connector, if used. Samples must be collected directly from the discharge port of the pump tubing prior to passing through the flow-through cell. This is critically important to avoid cross-contamination between wells.

(c) If using bottom-filling bailers,

- Slowly lower the bailer into the well until it is submerged to the point where water does not enter the top (i.e., bottom-filling).
- Retrieve the bailer. The first bailer recovered after well purging must be used for sample collection.

2.3.1 Sample Collection Order

Fractions of the groundwater sample should be collected in the following order (i.e., decreasing volatility) unless otherwise specified in the project-specific work plan:

1. VOCs;
2. Semivolatile organic compounds (SVOCs);
3. Other organic parameters;
4. Unfiltered inorganic constituents (e.g., total metals);
5. Filtered inorganic constituents (e.g., dissolved metals); and
6. Other constituents.

During sample collection, allow the water to flow directly down the side of the sample container without allowing the tubing to touch the inside of the sample container or lid in order to minimize aeration and turbulence and maintain sample integrity. The tubing should remain filled with water.

2.3.2 VOC Sample Collection

Collection of VOCs/Volatile Petroleum Hydrocarbons (VPH): Samples for VOCs will be collected first unless they are being collected by the "straw" method described in Section 1.6.2 (d), and the sample vial must be filled so a meniscus forms over the mouth of the vial. This ensures no air bubbles or headspace will be formed after it has been capped. Ensure the lack of air bubbles and headspace by turning the vial upside down and tapping it lightly. If any bubbles are observed, the vial should be topped off using a minimal amount of sample to re-establish the meniscus. Care should be taken to not flush any preservative out of the vial when topping off. If, after topping off and capping the vial, bubbles are still present, a new vial should be obtained and the sample re-collected. Note: Extra VOC vials should be obtained prior to the sampling event in case this situation occurs.

Note: When using a bladder pump, it is recommended that the pump be set to deliver long pulses of water so that one pulse will fill a 40 ml VOA vial, if possible.

When acid preservation is used for the collection of VOCs, the acid must be added to the vials before sample collection. However, in most cases 40-ml VOA vials come pre-preserved. If a pre-preserved vial effervesces upon the addition of sample, the acid preservative can be rinsed out of the vial with sample water and then used to collect the sample. The laboratory should be made aware that the affected sample will not be acid-preserved as this may affect the sample holding time. Note effervescence in the field book for future reference.

2.3.3 Non-VOC Sample Collection

Completely fill the remaining sample containers for all non-VOC analyses.

Preserve the non-VOC samples in accordance with method and project-specific requirements following sample collection if the sample containers are not pre-preserved. (**NOTE:** Pre-preserved vials may be supplied by the laboratory, depending on the program).

2.3.4 Field Filtering

Depending upon project requirements, field filtering may be performed for non-VOC analyses. An in-line filter should be fitted at the end of the discharge tubing and the sample should be collected after the filter. Pre-rinse the in-line filter by allowing a minimum of 0.5 to 1 liter of groundwater from the well to pass through the filter prior to sampling. Ensure the filter is free of air bubbles prior to collecting samples. Preserve the filtered water sample immediately or directly fill pre-preserved containers (if provided). Clearly note “filtered” or “dissolved” on sample label and COC document.

2.4 Groundwater Sample Collection Without Purging (Passive Sampling)

Passive sampling can be defined as the free flow of contaminants from the media being sampled to a receiving phase in a sampling device. Depending upon the sampler, the receiving phase can be a solvent (e.g., water), chemical reagent, or porous adsorbent (e.g., activated carbon). While there are many different types of passive samplers, most have a barrier between the medium being sampled and the receiving phase. The barrier determines the sampling rate that contaminants are collected at a given concentration and can be used to selectively permit or restrict various classes of chemicals from entering the receiving phase.

There are three generic forms of passive (no purge) samplers: thief (grab) samplers, diffusion (equilibrium) samplers, and integrating (kinetic) samplers. However, this SOP focuses on the more commonly used diffusion (equilibrium) samplers.

Passive samplers are deployed down a well to the desired depth within the screened interval or open borehole to obtain a discrete sample without using pumping or a purging technique. Most samplers are able to be stacked to obtain samples at multiple depths. Some samplers can also be used to measure contaminants in groundwater as it enters a surface water body.

Diffusion, or equilibrium, samplers are devices that rely on diffusion of the analytes to reach equilibrium between the sampler fluid and the well water. Samples are time-weighted toward conditions at the sampling point during the latter portion of the deployment period. The degree of weighting depends on analyte and device-specific diffusion rates. Typically, conditions during only the last few days of sampler deployment are represented. Depending upon the contaminant of concern, equilibration times range from a few days to several weeks. Diffusion samplers are less versatile than grab samplers as they are not generally effective for all chemical classes.

Both the diffusion and integrating samplers depend upon permeation or diffusion through barriers that hold the receiving phase. This diffusion process is chemical and barrier specific. Diffusion samplers are commonly known as PDBs or rigid porous polyethylene (RPP) samplers. PDBs may be used to sample for VOCs, and RPPs may be used to sample for various organic and inorganic constituents. PDBs must be allowed to remain in the well for a sufficient period of time to allow the deionized water in the sampler to come into equilibrium with the constituents in the ambient groundwater.

Some regulatory agencies allow groundwater samples to be collected without purging the well. This may be accomplished by suspending a passive sampler in the well for a period of time appropriate for the type of passive sampler being used. It is important to confirm that the chosen sampler is compatible with the contaminants of concern including all VOCs of interest at the site.

Diffusion passive samplers are used most commonly and the procedure for their use is as follows:

(a) Passive samplers are deployed at a predetermined depth across the well screen. Typically, the initial sampling event may deploy multiple passive samplers across 5-foot intervals of saturated well screen to observe any potential stratification. Long-term sampling depths typically target a zone of higher concentration, if present.

(b) New passive samplers are attached via PVC cable ties to a tether (a pre-made marine-grade polyethylene rope or stainless steel cable with a weight at the bottom) that is then suspended within the well. There should be sufficient well screen saturation within the well to completely cover the passive sampler. For VOCs, it is recommended that there should be several feet of groundwater above the top of the PDB.

(c) The passive sampler should be allowed to equilibrate with groundwater for an appropriate period of time (e.g., at least 2 weeks for PDB samplers). Longer equilibration times may be necessary in lower permeability formations. Once sufficient time for equilibration has passed, the PDB samplers can be retrieved when convenient.

(d) Raise the passive sampler to the surface using a tether reel. Examine the surface of the passive sampler for evidence of algae, iron, or other coatings, and for tears to the membrane. Note observations in the field book. If tears are present and water is leaking out, the sample is not considered viable. Contact the Project Manager.

(e) Detach the passive sampler from the tether.

(f) Remove excess beaded water from the passive sampler with a clean gloved hand, running top to bottom; this is to minimize the contact of beaded water with water in the passive sampler.

(g) Use a small diameter discharge tube (<0.15 inch diameter to reduce volatilization) and pierce near the bottom, allowing water to smoothly flow into the VOA vial. Tilting the passive sampler will control the flow rate. The VOA vials must be filled within the first several minutes of passive sampler retrieval. (Note that sample vials should be prepared and opened on a stable surface or holding device such as a foam pack. Decanting sample from passive samplers into containers requires techniques that may require some practice and patience.) Refer to Section 2.3.2 for special circumstances regarding the filling of VOA vials.

(h) A small amount of water may remain within the passive sampler after filling the VOA vials and can be used for field parameter measurements if required.

(i) Dispose of the passive sampler after use.

2.5 Post-sampling Activities

(a) Cease pumping and, if system is non-dedicated, disassemble and decontaminate the purging and sampling equipment. Verify the end of the tubing is not submerged in the purge bucket prior to turning off the pump.

(b) Dispose of the bailer (if disposable) and/or rope and/or other disposable equipment in accordance with the project-specific work plan, or store the bailer in a plastic bag for transport to the site decontamination area.

(c) Dispose of the empty passive sampler and/or rope and/or other disposable equipment in accordance with the project-specific work plan, or store the empty passive sampler in a plastic bag for transport to the site decontamination area

(d) Replace the well cap and well cover on the well and lock the outer casing (if present).

(e) Label each sample. If the labels are covered with clear tape, ensure this is not performed for VOA vials.

(f) Place all samples in a cooler with ice.

(g) Ensure samples are delivered to the laboratory well before the required holding time expires.

(h) Consult the project-specific work plan to determine if a calibration check is required at the end of the day for the water quality parameters.

3.0 INVESTIGATION-DERIVED WASTE DISPOSAL

Field personnel should discuss specific documentation and containerization requirements for investigation-derived waste disposal with the Project Manager.

Each project must consider investigation-derived waste disposal methods and have a plan in place prior to performing the field work. Provisions must be in place as to what will be done with investigation-derived waste. If investigation-derived waste cannot be returned to the site, consider material containment, such as a composite drum, proper labeling, on-site storage by the client, testing for disposal approval of the materials, and ultimately the pickup and disposal of the materials by appropriately licensed vendors.

4.0 QUALITY ASSURANCE/QUALITY CONTROL

The collection of QC samples is dependent upon the DQOs. Project-specific work plans should be consulted to determine the required frequency of QC sample collection.

4.1 *Field Duplicates*

The following procedures should be used for collecting field duplicates of groundwater samples:

(a) For QC purposes, each duplicate sample will be typically submitted to the laboratory as a "blind" duplicate sample, in that a unique sample identification not tied to the primary sample identification will be assigned to the duplicate (e.g., DUP-01). Standard labeling procedures used for groundwater sampling will be employed. However, a sample collection time will not be included on the sample label or the COC form. The actual source of the duplicate sample will be recorded in the field book and/or on the Groundwater Field Data Record.

(b) Each duplicate sample will be collected simultaneously with the actual sample by alternately filling sample and duplicate bottles. Following the order of collection specified for each set of containers (VOCs, SVOCs, other organic parameters, unfiltered inorganic constituents, and filtered inorganic constituents), the duplicate sample containers will be alternately filled with groundwater for each parameter.

(c) All collection and preservation procedures outlined for groundwater sampling will be followed for each duplicate sample.

4.2 *Equipment Blanks*

Equipment blanks include reagent water that is run through the bailer (if not disposable), rope, leader line, decontaminated pump, a representative section of the pump's tubing, or any other piece of sampling equipment that may have come in contact with the sample. The equipment blanks are collected and preserved in the same sample containers as field samples. If dedicated or disposable systems are used, equipment blanks are not required, although an initial blank could be performed to demonstrate that the dedicated equipment is clean prior to use. If only dedicated tubing is used, the equipment blank will include only the pump in subsequent sampling events. A passive sampler is considered a dedicated device and no equipment blank is required.

Ideally, the reagent water should come from the laboratory and be certified clean. If not certified and/or if not from the laboratory performing the analyses, a separate water blank that has not run through the sampling equipment should be sent to the laboratory for analysis.

4.3 *Trip Blanks*

Trip blanks will be used to check for potential contamination of VOCs via migration during storage and shipping. Trip blanks typically consist of two to three 40 mL VOA vials filled with analyte-free water and preserved with hydrochloric acid (HCl) to pH <2 SU. Trip blank containers are usually supplied pre-filled by the laboratory. Trip blanks are typically submitted to the laboratory at a frequency of one per cooler for coolers that contain samples for VOC and/or VPH analysis. Trip blanks are analyzed by the laboratory for VOCs and/or VPH, depending on field sample analyses.

4.4 MS/MSDs and MS/Duplicates

MSs are an additional analysis of a sample spiked by the laboratory with a subset or all of the target analytes and are used to demonstrate the accuracy of analytical methods for a given matrix. MSDs are an additional analysis of a sample spiked with a subset or all of the target analytes and are also used to demonstrate the accuracy of analytical methods for a given matrix. MS/MSDs also provide a measure of analytical precision for a given matrix. Duplicates are an additional analysis of a sample and are used to demonstrate the precision of analytical methods for a given matrix.

Triplicate volumes of a field sample must be collected in order for the laboratory to have enough volume to perform the MS/MSD analyses for organic parameters. Duplicate volumes of a field sample must be collected in order for the laboratory to have enough volume to perform MS/Duplicate analyses for inorganic parameters. The sample designated for MS/MSD or MS/Duplicate analyses should be noted in the Comments column of the COC document.

4.5 Temperature Blanks

Temperature blanks consist of a sample container filled with non-preserved water (potable or distilled) and typically are included in all coolers that contain samples that require temperature preservation. These may be added to the coolers by the field team if not provided by the laboratory. Temperature blanks must remain inside the coolers on ice during the sampling process.

5.0 DATA MANAGEMENT AND RECORDS MANAGEMENT

Record the sample location, sample identification, and date and time of collection in the field book and/or the Groundwater Field Data Record. The Groundwater Field Data Record (Attachment B) should be used to record the following information:

- Volume of each sample
- Sample identification number
- Sample location (sketch of the sample point)
- Time and date sample was collected
- Personnel performing the task
- Volume of water removed
- Purging time
- Flow rate during purging and sampling
- Weather conditions during sampling
- Field parameters such as water level, pH, temperature, conductivity, turbidity, ORP, and DO
- Sample collection equipment and method used
- Decontamination procedures
- Analytical parameters
- Preservation method and amount of preservative

All sample numbers must be documented on the COC form that accompanies the samples during shipment. Any deviations from the records management procedures specified in the project-specific work plan must be approved by the Project Manager and documented in the field book.

6.0 REFERENCES

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7.0 SOP REVISION HISTORY

REVISION NUMBER	REVISION DATE	REASON FOR REVISION
0	AUGUST 2014	NOT APPLICABLE
1	JULY 2016	ADDED ATTACHMENT D TO ACCOMMODATE SOP MODIFICATIONS REQUIRED WHEN SAMPLING FOR PFCS; CHANGED NAMING CONVENTION FOR SOP FROM RMD TO ECR.
2	NOVEMBER 2016	ADDED ADDITIONAL INFORMATION REGARDING PFAS.

Attachment A:

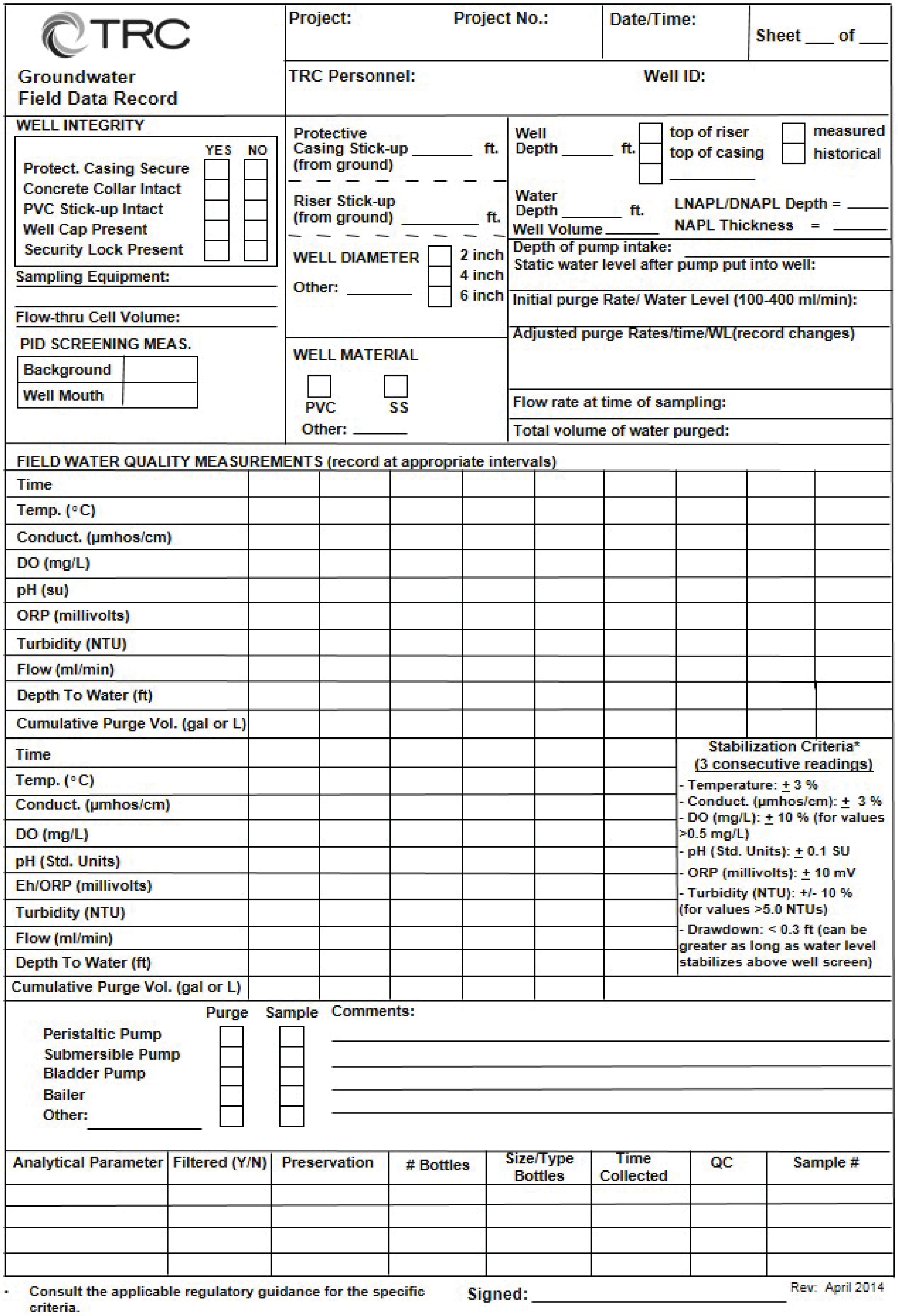
Groundwater Field Parameter Stabilization Criteria for Selected Jurisdictions

Jurisdiction	Information Source	Applicable Stabilization Criteria
USEPA Region 1	Low Stress (low flow) Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells; U.S. Environmental Protection Agency Region 1, January 19, 2010. http://www.epa.gov/region1/lab/qa/pdfs/EQASOP-GW001.pdf (for low flow PDF) http://www.epa.gov/region1/lab/qa/qualsys.html (for EPA's Quality System Documents)	pH: ±0.1 unit Specific Conductance: ±3% Temperature: ±3% Turbidity: ±10% if >5 NTUs; if three Turbidity values are <5 NTU, consider the values as stabilized Dissolved Oxygen: ±10% if >0.5 mg/L, if three Dissolved Oxygen values are <0.5 mg/L, consider the values as stabilized Oxidation/Reduction Potential: ±10 millivolts
USEPA Region 2	Groundwater Sampling Procedure: Low Stress (Low Flow) Purging and Sampling, SOP # SST-7, Revision No. 1, November 2010.	Same as above
USEPA Region 4	USEPA Region 4 SOPs: http://www.epa.gov/region4/sesd/fbqstp/index.html See Chemical Parameter Stabilization Criteria (section 3.2.1.1.2 of Groundwater Sampling SOP, revision 3/6/2013: http://www.epa.gov/region4/sesd/fbqstp/Groundwater-Sampling.pdf	pH: ±0.1 unit Specific Conductance: ±5% Temperature: Not used Turbidity: "Stabilized" (no criteria specified) if >10 NTUs ; if three Turbidity values are <10 NTUs, consider the values as stabilized Dissolved Oxygen (optional parameter): ±0.2 mg/L or ±10% of saturation, whichever is greater Oxidation/Reduction Potential: Not used
USEPA Region 5	Ground Water Forum Issue Paper (May 2002, Yeskis and Zavala) http://www.epa.gov/superfund/remedytech/tsp/download/gw_sampling_guide.pdf A minimum set of parameters would include pH, conductivity, and turbidity or DO. Puls and Barcelona, 1996 (pH, specific conductance, ORP, turbidity) Wilde et al., 1998 (pH, turbidity, DO)	pH: ±0.1 unit Specific Conductance: ±3% Temperature: Not used Turbidity: ±10% if >10 NTUs Dissolved Oxygen: ±0.3 mg/L Oxidation/Reduction Potential: ±10 millivolts
USEPA Region 9	See USEPA Region 1 (above)	
USEPA Region 10	See USEPA Region 5 (above)	
Alabama	Alabama Environmental Investigation and Remediation Guidance (section C.3.1) http://www.adem.state.al.us/MoreInfo/pubs/AEIRGInvestigation.pdf	pH: ±0.1 unit Specific Conductance: ±10% Temperature: "Constant" (no criteria specified) Turbidity: Stabilized (no criteria specified), or <10 NTUs Dissolved Oxygen: No criteria specified Oxidation/Reduction Potential: No criteria specified

Jurisdiction	Information Source	Applicable Stabilization Criteria
Indiana	Indiana Department of Environmental Management The Micro-Purge Sampling Option http://www.in.gov/idem/files/remediation_tech_guidance_micro-purge.pdf The parameters normally measured for stability (listed in increasing order of sensitivity) are pH, temperature, specific conductivity, oxidation-reduction potential, DO and turbidity. At least one of the last three listed must be used.	pH: ±0.1 unit Specific Conductance: ±3% Temperature: ±3% Turbidity: ±10% Dissolved Oxygen: ±10% Oxidation/Reduction Potential: ±10 millivolts (document says microvolts, but that may be an error)
Michigan	MDEQ Part 201 Op Memo 2, Attachment 5 http://www.michigan.gov/documents/deq/deq-rrd-OpMemo_2_Attachment5_249853_7.pdf	No specific values to determine stabilization are listed, but the Op Memo lists several other groundwater sampling guidance documents. If a valid reference exists, then it can be used to justify a sampling approach and stabilization parameters.
New Jersey	New Jersey Department of Environmental Protection http://www.state.nj.us/dep/srp/guidance/fspm/	pH: ± 0.1 unit Specific Conductance: ± 3% Temperature: ± 3% Dissolved Oxygen: ± 10% Turbidity: ± 10% for values greater than 1 NTU ORP/Eh: ± 10 millivolts
Ohio	Ohio EPA SOPs: http://www.epa.state.oh.us/portals/30/rules/FSOPs.pdf See Purging Stabilization Criteria (SOP 2.2.4, dated January 2, 2007, review in progress)	pH: ±0.1 unit Specific Conductance: ±3% Temperature: No criteria specified Turbidity: Below 10 NTUs ideal; ±10% if greater than 10 NTUs Dissolved Oxygen: ±0.3 mg/L Oxidation/Reduction Potential: ±10 millivolts
This table was last updated in July 2014.		

Attachment B:

Example Groundwater Field Data Records



Groundwater Field Data Record

Project:
Project No.:
Date/Time:
Sheet ___ of ___
TRC Personnel:
Well ID:

WELL INTEGRITY

	YES	NO
Protect. Casing Secure	☐	☐
Concrete Collar Intact	☐	☐
PVC Stick-up Intact	☐	☐
Well Cap Present	☐	☐
Security Lock Present	☐	☐

Sampling Equipment:

Flow-thru Cell Volume:

PID SCREENING MEAS.

Background	
Well Mouth	

Protective Casing Stick-up (from ground) _______ ft.

Riser Stick-up (from ground) _________ ft.

WELL DIAMETER ☐ 2 inch ☐ 4 inch ☐ 6 inch
Other: ________

WELL MATERIAL
☐ PVC ☐ SS
Other: ______

Well Depth ______ ft. ☐ top of riser ☐ top of casing ☐ __________ ☐ measured ☐ historical

Water Depth _______ ft.
Well Volume ______
LNAPL/DNAPL Depth = _____
NAPL Thickness = ______

Depth of pump intake: ______________
Static water level after pump put into well:
Initial purge Rate/ Water Level (100-400 ml/min):
Adjusted purge Rates/time/WL(record changes)
Flow rate at time of sampling:
Total volume of water purged:

FIELD WATER QUALITY MEASUREMENTS (record at appropriate intervals)

Time									
Temp. (°C)									
Conduct. (µmhos/cm)									
DO (mg/L)									
pH (su)									
ORP (millivolts)									
Turbidity (NTU)									
Flow (ml/min)									
Depth To Water (ft)									
Cumulative Purge Vol. (gal or L)									

Time					
Temp. (°C)					
Conduct. (µmhos/cm)					
DO (mg/L)					
pH (Std. Units)					
Eh/ORP (millivolts)					
Turbidity (NTU)					
Flow (ml/min)					
Depth To Water (ft)					
Cumulative Purge Vol. (gal or L)					

Stabilization Criteria*
(3 consecutive readings)
- Temperature: ± 3 %
- Conduct. (µmhos/cm): ± 3 %
- DO (mg/L): ± 10 % (for values >0.5 mg/L)
- pH (Std. Units): ± 0.1 SU
- ORP (millivolts): ± 10 mV
- Turbidity (NTU): +/- 10 % (for values >5.0 NTUs)
- Drawdown: < 0.3 ft (can be greater as long as water level stabilizes above well screen)

	Purge	Sample
Peristaltic Pump	☐	☐
Submersible Pump	☐	☐
Bladder Pump	☐	☐
Bailer	☐	☐
Other: __________	☐	☐

Comments:

Analytical Parameter	Filtered (Y/N)	Preservation	# Bottles	Size/Type Bottles	Time Collected	QC	Sample #

- Consult the applicable regulatory guidance for the specific criteria.

Signed: ____________________________

Rev: April 2014

WATER SAMPLE LOG

PROJECT NAME:		PREPARED				CHECKED			
PROJECT NUMBER:		BY:		DATE:		BY:		DATE:	

SAMPLE ID:		WELL DIAMETER:	☐ 2"	☐ 4"	☐ 6"	☐ OTHER	________
WELL MATERIAL:	☐ PVC	☐ SS	☐ IRON	☐ GALVANIZED STEEL		☐ OTHER	________
SAMPLE TYPE:	☑ GW	☐ WW	☐ SW	☐ DI	☐ LEACHATE	☐ OTHER	________

PURGING	TIME:	DATE:	
PURGE METHOD:	☐ PUMP ________		
	☐ BAILER ________		
DEPTH TO WATER:	________	T/ PVC	FLOW-THRU CELL VOLUME
DEPTH TO BOTTOM:	________	T/ PVC	
PUMP INTAKE DEPTH:	________	T/ PVC	________ LITERS
WELL VOLUME:	________	☐ LITERS	☐ GALLONS
VOLUME REMOVED:	________	☐ LITERS	☐ GALLONS
COLOR:	________	ODOR: ________	
TURBIDITY			
☐ NONE	☐ SLIGHT	☐ MODERATE	☐ VERY
DISPOSAL METHOD:	☐ GROUND	☐ DRUM	☐ OTHER

SAMPLE	TIME:	DATE:	
PH: ________ SU	CONDUCTIVITY: ________ umhos/cm		
ORP: ________ mV	DO: ________ mg/L		
TURBIDITY: ________ NTU			
☐ NONE	☐ SLIGHT	☐ MODERATE	☐ VERY
TEMPERATURE: ________ °C	OTHER: ________		
COLOR: ________	ODOR: ________		
FILTRATE (0.45 um)	☐ YES	☐ NO	
FILTRATE COLOR: ________	FILTRATE ODOR: ________		
QC SAMPLE:	☐ MS/MSD	☐ DUP- ________	
COMMENTS:			

TIME	PURGE RATE (ML/MIN)	PH (SU)	CONDUCTIVITY (umhos/cm)	ORP (mV)	D.O. (mg/L)	TURBIDITY (NTU)	TEMPERATURE (°C)	WATER LEVEL (FEET)	CUMULATIVE PURGE VOLUME (GAL OR L)
									INITIAL

NOTE: STABILIZATION TEST IS COMPLETE WHEN 3 SUCCESSIVE READINGS ARE WITHIN THE FOLLOWING LIMITS:

pH: +/- **10 %** COND.: +/- **10 %** ORP: +/- **10 %** D.O.: +/- **10 %** TURB: +/- **10 %** or </= **5** TEMP.: +/- **0.5°C**

BOTTLES FILLED	PRESERVATIVE CODES	A - NONE	B - HNO3	C - H2SO4	D - NaOH	E - HCL	F - ________		
NUMBER	SIZE	TYPE	PRESERVATIVE	FILTERED	NUMBER	SIZE	TYPE	PRESERVATIVE	FILTERED
				☐ Y ☐ N					☐ Y ☐ N
				☐ Y ☐ N					☐ Y ☐ N
				☐ Y ☐ N					☐ Y ☐ N
				☐ Y ☐ N					☐ Y ☐ N

SHIPPING METHOD:	________	DATE SHIPPED:	________	AIRBILL NUMBER:	________
COC NUMBER:	________	SIGNATURE:	________	DATE SIGNED:	________

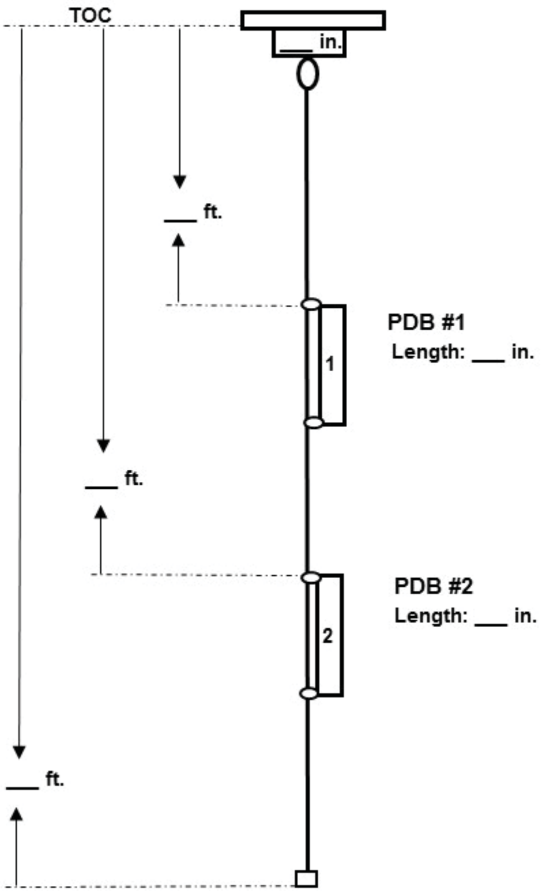
Groundwater Sampling Record for Organics (For Wells with Passive Diffusion Bags)	**Project Name/No:**	**Well ID:**

Installation of PDBs:

TRC Personnel: ______________________
Date: ______________________
Time: ______________________
DTW (ft): ______________________

Sampling of PDBs:

TRC Personnel: ______________________
Date: ______________________
DTW (ft): ______________________



PDB #1

Sample ID: ______________________
Sample Time: ______________________
Evidence of algae, iron or other coatings?: ______________

PDB #2

Sample ID: ______________________
Sample Time: ______________________
Evidence of algae, iron or other coatings?: ______________

Measured well depth during tether installation: ___ ft.

Field Notes:

Rev: April 2014

Attachment C: SOP Fact Sheet

GROUNDWATER SAMPLING

PURPOSE AND OBJECTIVE

The objective of groundwater sampling is to obtain a representative sample of water from a saturated zone or groundwater-bearing unit (i.e., aquifer) with minimal disturbance of groundwater chemistry. This requires that the sample being collected is representative of groundwater within the formation surrounding the well bore as opposed to stagnant water within the well casing or within the filter pack immediately surrounding the well casing.

There are three general approaches to groundwater purging/sampling that can be used to obtain a representative groundwater sample for analysis: 1) the low-flow or micropurge method where the mixing of the stagnant water is minimized using low-flow pumping rates during the collection of the groundwater sample; 2) the multiple well volume removal approach in which the stagnant water is removed from the well and the filter pack prior to sample collection; and 3) the passive sampler procedure where water quality equilibration with the surroundings is achieved through deployment of the passive sampler for a sufficient amount of time prior to sampling. All three approaches are summarized in this document.

WHAT TO BRING

- Site-specific HASP and field book
- Project-specific work plan
- Figure or site map showing well locations and table showing well construction details
- Field data sheets from previous sampling event
- Well wrenches, ratchet set, and turkey baster to remove standing water from flushmount manholes
- Bolt cutters, padlocks and keys
- Water level meter of sufficient length
- Decontaminated pump, control box, power source (i.e., battery, generator, etc.)
- Tubing (Teflon®, Teflon®–lined polyethylene, or HDPE, type dependent upon project objectives)
- Multi-parameter instrument and flow-through cell (typically should include: pH, temperature, conductivity, ORP, and DO)
- Turbidity meter
- Equipment decontamination supplies (refer to RMD SOP 010, *Equipment Decontamination*)
- Appropriate PPE
- Field book
- Sample bottleware, labeled cooler, ice, temperature blank and blank COC forms; may also need field blank bottles and reagent-grade water
- Zip-loc® plastic bags
- Groundwater field data records
- Graduated cylinder and stop-watch
- Rope for tying off pump at desired intake
- Indelible marking pens
- Bubble wrap
- 5-gallon bucket(s)

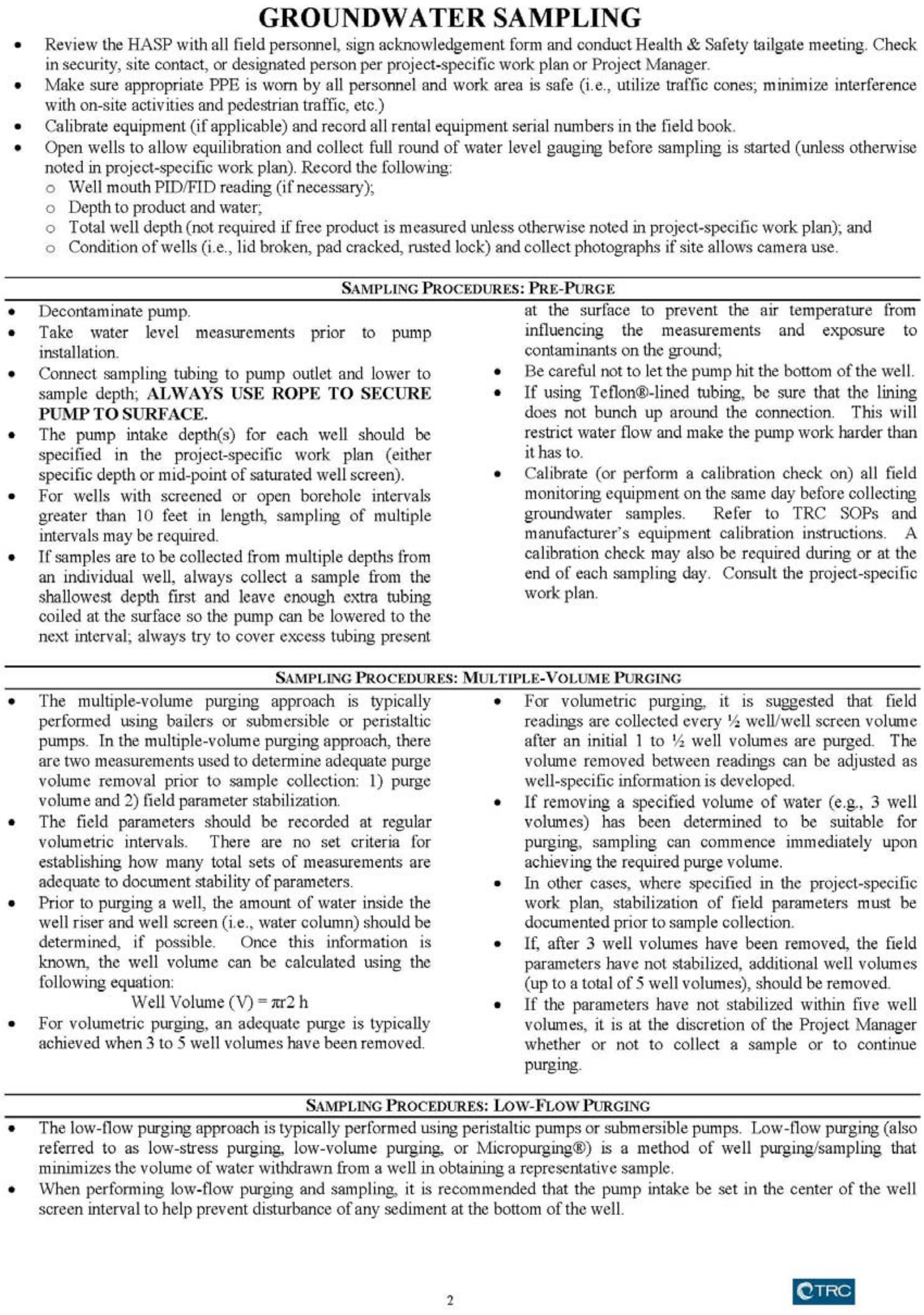
As Needed:

- Calibrated PID or FID for well mouth readings
- Oil/water interface probe of sufficient length
- Drums for purge water, grease pen and adhesive drum labels; appropriate crescent or socket wrench
- Filtration equipment, if required (0.45 micron filters, or as otherwise required for the project)
- Other non-routine PPE such as Tyvek coveralls or respirators
- Traffic cones
- Field calibration sheets and calibration solutions

OFFICE

- Prepare/update the site-specific HASP; make sure the field team is familiar with the most recent version.
- Review the project-specific work plan with the Project Manager and/or the field team leader. Discuss the following:
  - Communication procedures;
  - Sampling order and designation;
  - Collection and sample method;
  - Analytical parameters, holding times and turn-around times;
  - Laboratory (contact/shipping info, COC, billing references);
  - Purge water management (Drums? Discharge to ground?);
  - QC sample collection; and
  - Decontamination procedures.
- Verify that monitoring wells will be accessible and/or coordinate to have a site contact available to assist.
- Make sure that monitoring well sample designations and QC sample designations/frequency are understood.
- Confirm that all necessary equipment is available in-house or has been ordered. Rental equipment is typically delivered the day before fieldwork is scheduled. Prior to departure or mobilization to site, test equipment and make sure it is in proper working order. Have rental equipment supplier contact information available for use in field.
- Review sample bottle order for accuracy and completeness and damaged bottles.
- Discuss specific documentation and containerization requirements for investigation-derived waste disposal with the Project Manager

ON-SITE



GROUNDWATER SAMPLING

- Review the HASP with all field personnel, sign acknowledgement form and conduct Health & Safety tailgate meeting. Check in security, site contact, or designated person per project-specific work plan or Project Manager.
- Make sure appropriate PPE is worn by all personnel and work area is safe (i.e., utilize traffic cones; minimize interference with on-site activities and pedestrian traffic, etc.)
- Calibrate equipment (if applicable) and record all rental equipment serial numbers in the field book.
- Open wells to allow equilibration and collect full round of water level gauging before sampling is started (unless otherwise noted in project-specific work plan). Record the following:
    - Well mouth PID/FID reading (if necessary);
    - Depth to product and water;
    - Total well depth (not required if free product is measured unless otherwise noted in project-specific work plan); and
    - Condition of wells (i.e., lid broken, pad cracked, rusted lock) and collect photographs if site allows camera use.

SAMPLING PROCEDURES: PRE-PURGE

- Decontaminate pump.
- Take water level measurements prior to pump installation.
- Connect sampling tubing to pump outlet and lower to sample depth; **ALWAYS USE ROPE TO SECURE PUMP TO SURFACE.**
- The pump intake depth(s) for each well should be specified in the project-specific work plan (either specific depth or mid-point of saturated well screen).
- For wells with screened or open borehole intervals greater than 10 feet in length, sampling of multiple intervals may be required.
- If samples are to be collected from multiple depths from an individual well, always collect a sample from the shallowest depth first and leave enough extra tubing coiled at the surface so the pump can be lowered to the next interval; always try to cover excess tubing present at the surface to prevent the air temperature from influencing the measurements and exposure to contaminants on the ground;
- Be careful not to let the pump hit the bottom of the well.
- If using Teflon®-lined tubing, be sure that the lining does not bunch up around the connection. This will restrict water flow and make the pump work harder than it has to.
- Calibrate (or perform a calibration check on) all field monitoring equipment on the same day before collecting groundwater samples. Refer to TRC SOPs and manufacturer's equipment calibration instructions. A calibration check may also be required during or at the end of each sampling day. Consult the project-specific work plan.

SAMPLING PROCEDURES: MULTIPLE-VOLUME PURGING

- The multiple-volume purging approach is typically performed using bailers or submersible or peristaltic pumps. In the multiple-volume purging approach, there are two measurements used to determine adequate purge volume removal prior to sample collection: 1) purge volume and 2) field parameter stabilization.
- The field parameters should be recorded at regular volumetric intervals. There are no set criteria for establishing how many total sets of measurements are adequate to document stability of parameters.
- Prior to purging a well, the amount of water inside the well riser and well screen (i.e., water column) should be determined, if possible. Once this information is known, the well volume can be calculated using the following equation:

  Well Volume (V) = $\pi r2$ h
- For volumetric purging, an adequate purge is typically achieved when 3 to 5 well volumes have been removed.
- For volumetric purging, it is suggested that field readings are collected every ½ well/well screen volume after an initial 1 to ½ well volumes are purged. The volume removed between readings can be adjusted as well-specific information is developed.
- If removing a specified volume of water (e.g., 3 well volumes) has been determined to be suitable for purging, sampling can commence immediately upon achieving the required purge volume.
- In other cases, where specified in the project-specific work plan, stabilization of field parameters must be documented prior to sample collection.
- If, after 3 well volumes have been removed, the field parameters have not stabilized, additional well volumes (up to a total of 5 well volumes), should be removed.
- If the parameters have not stabilized within five well volumes, it is at the discretion of the Project Manager whether or not to collect a sample or to continue purging.

SAMPLING PROCEDURES: LOW-FLOW PURGING

- The low-flow purging approach is typically performed using peristaltic pumps or submersible pumps. Low-flow purging (also referred to as low-stress purging, low-volume purging, or Micropurging®) is a method of well purging/sampling that minimizes the volume of water withdrawn from a well in obtaining a representative sample.
- When performing low-flow purging and sampling, it is recommended that the pump intake be set in the center of the well screen interval to help prevent disturbance of any sediment at the bottom of the well.

GROUNDWATER SAMPLING

- To begin purging, the pump should be started at the lowest pressure/power flow rate setting (e.g., 100 mL/min) and then slowly increased until water begins discharging. Monitor the water level and slowly adjust the pump speed until there is little or no drawdown or drawdown has stabilized. The pump pressure/power may need to be increased for discharge to occur.
- The stabilization of drawdown should be documented. Measure and record the flow rate and water level every 3 to 5 minutes during purging. The flow rate should be reduced if drawdown is greater than 0.3 feet over three consecutive 3 to 5 minute interval readings.
- Attempts should be made to avoid pumping a well dry.

Field Parameter Stabilization During Purging

- Generally, an adequate purge with respect to the groundwater chemistry is achieved when stability for at least three consecutive measurements is achieved. See stability requirements in Appendix A of this SOP.

POST-PURGE GROUNDWATER SAMPLE COLLECTION

- New, disposable gloves should be donned immediately prior to sample collection and should be changed at any point that their cleanliness becomes compromised during sample collection.
- If using a submersible or peristaltic pump, maintain the same flow rate as used during purging. Disconnect the pump tubing from the flow-through cell. Samples must be collected directly from the discharge port of the pump tubing prior to passing through the flow-through cell. This is critically important to avoid cross-contamination between wells.
- If using bottom-filling bailers, slowly lower the bailer into the well until it is submerged to the point where water does not enter the top (i.e., bottom-filling). Retrieve the bailer. The first bailer recovered after well purging must be used for sample collection.
- Collect groundwater samples in the following order:
    - VOCs;
    - SVOCs;
    - Other organic parameters;
    - Unfiltered inorganic constituents; and
    - Filtered inorganic constituents.
- Note that sample vials for VOCs must be filled so a meniscus forms over the mouth of the vial. This ensures no air bubbles or headspace will be formed after it has been capped. Ensure the lack of air bubbles and headspace by turning the vial upside down and tapping it lightly. If any bubbles are observed, see Section 2.3.2 of this SOP.
- Preserve the non-VOC samples in pre-preserved vials supplied by the laboratory or if the sample containers are not pre-preserved, preserve the non-VOC samples in accordance with method and project-specific requirements.
- Depending upon project requirements, filtering may be performed. See procedures listed in Section 2.3.4 of this SOP. Clearly note "filtered" on the sample label and the COC.
- Make sure all sample bottles are appropriately labeled.
- Package the samples with bubble wrap and/or organic absorbent, as necessary. Place into shipping container and cool to 4°C and complete the COC.
- Decontaminate non-disposable sampling equipment between uses.

PASSIVE SAMPLING

- There are three generic forms of passive (no purge) samplers: thief (grab) samplers, diffusion (equilibrium) samplers, and integrating (kinetic) samplers. However, this SOP focuses on the more commonly used diffusion (equilibrium) samplers. Be aware of sample holding times, and arrange for samples to be in the laboratory's possession accordingly.
- Passive samplers are deployed at a predetermined depth across the well screen. Typically, the initial sampling event may deploy multiple passive samplers across 5-foot intervals of saturated well screen to observe any potential stratification. Long-term sampling depths typically target a zone of higher concentration, if present.
- New passive samplers are attached via PVC cable ties to a tether (pre-made marine-grade polyethylene rope or stainless steel cable with a weight at the bottom) that is then suspended within the well.
- The passive sampler should be allowed to equilibrate with groundwater for an appropriate period of time (e.g., at least 2 weeks for PDB samplers).
- Raise the passive sampler to the surface using a tether reel. Examine the surface of the passive sampler for evidence of algae, iron, or other coatings, and for tears to the membrane. Note observations in the field book. If tears are present and water is leaking out, the sample is not considered viable. Contact the Project Manager.
- Detach the passive sampler from the tether.
- Remove excess beaded water from the passive sampler with a clean gloved hand, running top to bottom; this is to minimize the contact of beaded water with water in the passive sampler.

GROUNDWATER SAMPLING

- Use a small diameter discharge tube (<0.15 inch diameter to reduce volatilization) and pierce near the bottom, allowing water to smoothly flow into the VOA vial. The VOA vials must be filled within the first several minutes of passive sampler retrieval.
- A small amount of water may remain within the passive sampler after filling the VOA vials and can be used for field parameter measurements if required.
- Dispose of the passive sampler after use.
- Note that sample vials for VOCs must be filled so a meniscus forms over the mouth of the vial. This ensures no air bubbles or headspace will be formed after it has been capped. Ensure the lack of air bubbles and headspace by turning the vial upside down and tapping it lightly. If any bubbles are observed, see Section 2.3.2 of this SOP.
- Make sure all sample bottles are appropriately labeled.
- Package the samples with bubble wrap and/or organic absorbent, as necessary. Place into shipping container and cool to 4ºC and complete the COC.

DOs AND DO NOTs OF GROUNDWATER PURGING AND SAMPLING

DOs:

- DO have the following items when going into the field: site-specific work plan; site-Specific HASP; appropriate PPE (steel-toed boots, safety glasses, etc.) as required by the Site-Specific HASP; field book and a water-proof ball-point pen; business cards; nitrile gloves; well keys; copies of well installation forms and field data forms from previous sampling event.
- DO make sure that the equipment is set up properly and the bottleware is nearby and ready to be filled. There is little time between taking parameters.
- DO look at the water quality parameters from the previous round of sampling. If there is a large deviation from the previous round's measurements, make sure the meters are properly calibrated and the parameter units are the same. Otherwise, consult the Project Manager or field team leader.
- DO fill sample bottles slowly to make sure that they are not overfilled and that preservative does not become diluted. If collecting filtered samples, fill all non-filtered first, then fill filtered samples - if water is very silty, more than one filter might be required to fill sample bottles.
- DO record the time that purging begins and ends. "Purge Stop" and sample start time are the same.
- DO call your Project Manager or field team leader if unexpected conditions are encountered or at least daily to update them. It is also recommended to call when sampling is winding down for the day to make sure that the project-specific work plan has been fully implemented and there are no additional tasks to complete. Provide shipping tracking numbers to the Project Manager and laboratory contact.
- DO have the numbers for laboratory, vehicle rental and equipment rental providers readily available while in the field.
- DO record sample locations and parameters in the field book and the Groundwater Field Data Records as you purge.
- DO check on the purging setup frequently to make sure proper equipment function is maintained.
- DO bring ice to the site in the morning so that samples are kept cool throughout the entire event. Storing samples in a warm cooler can invalidate sample results and may result in re-sampling on your own time.

DO NOTs:

- DO NOT sign anything in the field. This includes disposal documentation, statements, etc.; call the Project Manager if this is an issue.
- DO NOT allow the pump or sampling equipment to hit the bottom of the well - If the pump hits the bottom of the well, it can stir up mud. Remember, the goal of low-flow sampling is to collect non-turbid samples.
- DO NOT use non-indelible ink to label samples or record field notes – if the field book gets wet, notes become illegible.
- DO NOT leave air bubbles in VOA vials.
- DO NOT pour any extracted water back down into the well.
- DO NOT lean over wells with pens, keys, cell phones, tools, etc. in your pocket.
- DO NOT use clear tape to cover labels on certain analyses (e.g., 40-mL vials for VOC analysis) due to potential interference with analytical equipment.

Attachment D: SOP Modifications for PFAS

Due to the pervasive nature of PFAS in various substances routinely used during sampling and the need to mitigate potential cross-contamination or sampling bias to ensure representative data are collected, special care should be taken when sampling for PFAS. The following table highlights the required modifications to this SOP when sampling for PFAS.

PFAS Sampling Protocols	
SOP Section Number	**Modifications to SOP**
1.3	• Do not use equipment utilizing Teflon® or low density polyethylene (LDPE)[1] during sample handling or mobilization/demobilization. This includes bailers, tubing, bladders, bailer cord/wire, waterproof/resistant paper products, certain personal protective equipment (PPE) (see below), and Teflon® tape. High density polyethylene (HDPE) or silicone tubing should be used in lieu of Teflon® or Teflon®-lined tubing. • Passive diffusion bags (PDBs) should not be used due to the presence of LDPE material in PDBs. • Blue Ice® (chemical ice packs) must not be used to cool samples or be used in sample coolers. Regular ice in Ziploc® bags can be used. • Do not use LDPE or glass sample containers or containers with Teflon-lined lids. HDPE or polypropylene containers are acceptable for sample storage. HDPE or polypropylene caps are acceptable. • Do not use aluminum foil. • Field notes should be recorded on loose paper field forms maintained in aluminum or Masonite clipboards. Waterproof field books, plastic clipboards and spiral bound notebooks should not be used. • Do not use Post-It Notes during sample handling or mobilization/demobilization. • Refer to TRC's SOP ECR-010 Equipment Decontamination for PFAS-specific decontamination protocols. Ensure that PFAS-free water is used during the decontamination procedure.
1.5	Always consult the Site Specific Health and Safety Plan prior to conducting field work. The following considerations should be made with regards to field preparation during PFAS sampling: • Tyvek® suits should not be worn during PFAS sampling events. Cotton coveralls may be worn. • Boots and other field clothing containing Gore-Tex™ or other waterproof/resistant material should not be worn. This includes rain gear. Boots made with polyurethane and polyvinyl chloride (PVC) are acceptable. • Stain resistant clothing should not be worn. • Food and drink should not be allowed within the exclusion area. Pre-wrapped food or snacks should not be in the possession of sampling personnel during sampling. Bottled water and hydration drinks (e.g., Gatorade®) may be consumed in the staging area only. • Personnel involved with sample collection and handling should wear

PFAS Sampling Protocols

SOP Section Number	Modifications to SOP
	nitrile gloves at all times while collecting and handling samples or sampling equipment. Avoid handling unnecessary items with nitrile gloves. A new pair of gloves must be donned prior to collecting each sample. • Wash hands with Alconox or Liquinox and deionized water after leaving vehicle before setting up to sample a well.
1.6.1	• Avoid wearing clothing laundered with fabric softeners. • Avoid wearing new clothing (recommended 6 washings since purchase). Clothing made of cotton is preferred. • Avoid using cosmetics, moisturizers, hand creams, or other related products as part of cleaning/showering on the day of sampling. • Avoid using sunscreens or insect repellants that are not natural or chemical free.
2.2.5	Tubing used to purge and sample groundwater for PFAS must not be LDPE or Teflon®. HDPE and silicone are acceptable.
2.3 and 2.3.3	LDPE and/or glass containers should not be used for sampling. Teflon®-lined caps should also not be used during sample collection. Instead, HDPE or polypropylene containers are acceptable for sample storage. HDPE or polypropylene caps are acceptable.
2.4	Due to LDPE material in PDBs, PDBs cannot be used for PFAS sampling.
2.5 (e)	Avoid using waterproof labels for sample bottles. The use of paper labels covered with clear tape or placed in Ziploc® bags to avoid moisture on the sample label is acceptable.
2.5 (f)	Samples for PFAS analysis must be shipped at <10°C. Standard coolers are acceptable.
4.3	Due to low reporting limit requirements for PFAS, trip blanks for PFAS analysis should be included in sample coolers if PFAS are being analyzed for in the associated groundwater samples.

Notes:

[1] – PFAS have been used as an additive in the manufacturing of LDPE to smooth rough surfaces and, in the case of LDPE tubing, to allow for less turbulent flow along the surface of the tubing.

GENERAL FIELD PROCEDURES

A description of the general field procedures used during monitoring activities is presented below. For an overview of protocol, refer to the appropriate section(s).

FLUID LEVEL MONITORING

Fluid levels are monitored in the wells using an electronic interface probe with conductance sensors. The presence of liquid-phase hydrocarbons is verified using a hydrocarbon-reactive paste. The depth to liquid-phase hydrocarbons and water is measured relative to the top of casing. Well boxes or casing elevations are surveyed to within 0.01 foot relative to a county or city bench mark.

LOW-FLOW PURGING AND SAMPLING

This procedure is designed to assist the user in taking representative groundwater samples from *groundwater monitoring wells. Samples will be collected using low-flow (minimal drawdown) purging and sampling methods* as discussed in U.S. EPA, Ground Water Issue, Publication Number EPA/540/S-95/504, April 1996 by Puls, R.W. and M.J. Barcelona - "Low-Flow (Minimal Drawdown) Ground-water Sampling Procedures."

The field sampler's objective is to purge and sample the well so that the water that is discharged from the pump, and subsequently collected, is representative of the formation water from the aquifer's identified zone of interest.

The wells to be sampled are equipped with QED Well Wizard™ bladder (squeeze-type) pumps or Peristaltic Pumps Each bladder pump or the suction inlet tubing of the peristaltic pump is positioned with its inlet located within the desired portion of the screened interval of the well. The down well equipment includes a bladder pump and/or Teflon-lined PE (polyethylene) tubing.

Initial Pump Flow Test Procedures

If possible, the optimum flow rate for each well will be established during well development or redevelopment, or in advance of the actual sampling event. The monitoring well must be gauged for Static Water Level (SWL) prior to the installation of the pump and before pumping of any water from the well. The measurement will be documented on a Low Flow Ground Water Sample Collection Record, or field data sheet.

After pump/tubing installation, and confirmation that the SWL has returned to its original level (as determined prior to pump installation), the bladder pump or peristaltic pump should be started at a discharge rate between 100 ml to 300 ml per minute without any in-line flow cell connected. The water level in the well casing must be monitored continuously for any change from the original measurement. If significant drawdown is observed, the pump's flow rate should be incrementally reduced until the SWL drawdown ceases and stabilizes. Total drawdown from the initial (static) water level should not exceed 25% of the distance between pump inlet location and the top of the well screen. (For example, if a well has a 10-foot screen zone and the pump inlet is located mid-screen; the maximum drawdown should be 1.25 feet.) In any case, the water level in the well should not be lowered below the top of the screen/intake zone of the well.

Once the specific well's optimum discharge rate, without an in-line flow cell connected, has been determined and documented, the in-line flow cell system to be used is connected to the well discharge and the control settings required to achieve the well's optimum discharge rate are determined with the in-line flow cell connected. (Due to the system's back-pressure, the discharge rate will be decreased by 10-20%). All control settings are to be documented on the gauging and sampling sheet as specific to that particular well's ID and will be utilized for its subsequent purging and sampling events.

Purge and Sampling Events

Prior to the initiation of purging a well, the SWL will be measured and documented. The pump will be started utilizing its documented control settings and its discharge rate will be confirmed by volumetric discharge measurement with the in-line flow cell connected. If necessary, any minor modifications to the control settings to achieve the well's optimum discharge rate will be documented on the gauging sheet. When the optimum pump flow rate has been established, the SWL draw down has stabilized within the required range and at least one pump system volume (bladder volume + discharge tubing volume) has been purged, begin taking field measurements for pH, temperature (T), conductivity (Ec), oxygen reduction potential (ORP) and dissolved oxygen (DO) using a "QED" Model MP-20 in-line flow cell, or other multi-parameter meter. All water chemistry field measurements will be documented on the field data sheet. Measurements should be taken every three to five minutes until stabilization has been achieved. Stabilization is achieved after all parameters have stabilized for three consecutive readings. In lieu of measuring all five parameters, a minimum subset would include pH, conductivity and dissolved oxygen. Three consecutive measurements indicating stability should be within:

Temperature	± 10%
pH	± 0.1 units
Conductance	± 03

When water quality parameters have stabilized, and there has been no change in the stabilized SWL (i.e., no continuous draw down), sample collection may begin.

Equipment List

The following equipment is needed to conduct low flow purging and sampling:

- Bladder pump installed within the well's screened interval
- Pump controller and air source set to operate at the specific well's documented optimum discharge rate
- In-line flow cell and meter(s) with connection fittings and tubing to measure water quality
- Water level probe or installed dedicated water level measurement system
- Sample containers appropriate for the analytical requirements
- Low Flow Ground Water Sample Collection Record, or field data sheets
- 300-500 milliliter graduated cylinder or measuring cup
- 5 gallon bucket(s) for collecting purge water
- Wristwatch with second hand or stopwatch
- Sufficient cleaning and decontamination supplies if portable water level probe is utilized
- Peristaltic pump & tubing, in place of bladder pump, if applicable
- Multi-parameter meter, in place of in-line flow cell, if applicable

Procedure QED Bladder Pumps

1. Calibrate all field instruments at the start of each day's deployment per the instrument manufacturer's instructions. Record calibration data on the "Field Instruments Calibration Documentation Form."
2. Drive to the first well scheduled to be sampled (typically the least contaminated). Make notes in the field logbook, describing the well condition and activity in the vicinity of the well. Decontaminate the portable water gauging probe by washing with phosphate-free detergent, rinsing with potable water.
3. Measure the depth to water from the surveyed reference mark on the wellhead and record the measurement on the gauging and sampling sheet. Lock the water level meter in place so that the level can be monitored during purging and sampling. When placing the probe in the well, take precautions to not disturb or agitate the water.
4. Connect the compressed air source's airline to the pump controller's "AIR IN" connection (If utilizing a gas-engine operated compressor, locate the compressor at least 25 feet, down wind from the wellhead).
5. Connect the pump controller "AIR OUT" air-line to the bladder pump's air supply fitting at the wellhead.
6. Connect the pump discharge line to the in-line flow cell's "IN" fitting.
7. Connect the flow cell's "OUT" line and secure to drain the purge water into the purge water collection container.
8. Start the air supply to the pump. Set the pump controller settings to the documented settings for the specific well. Confirm the flow rate is equal to the well's established optimum flow rate. Modify as necessary (documenting any required modifications).
9. Monitor the water level and confirm that the SWL draw down has stabilized within the well's allowable limits.
10. After a single pump-system's volume (bladder volume + discharge tubing volume) has been adequately purged, read and record water quality field measurements every three to five minutes until all parameters have stabilized within their allowable ranges for at least three consecutive measurements. When stabilization has been achieved, sample collection may begin.
11. Disconnect the flow cell, and it's tubing, from the pump discharge line before collecting samples. Decrease the pump rate to 100 milliliters per minute or less by lowering the controller's air pressure setting prior to collecting samples for volatiles. Utilize the QED Model 400 Controller's 'MANUAL SAMPLE' button to ensure minimized sample exposure to the ambient air. Refer to the task instructions for the correct order and procedures for filling sample containers. Place the samples in a cooler with enough ice to keep them at 4 degrees Centigrade.
12. Once samples for volatiles have been collected, re-establish pump flow rate to the original purge flow rate by inputting the documented controller settings for the well without the in-line flow cell connected and collect remaining samples.
13. When all sample containers have been filled, make a final measurement of the well's SWL and record the measurement on the gauging and sampling sheet. If the well has a "QED" dedicated bottom sounder, measure the well's total depth and record the measurement, as well.

14. Measure and record total purge volume collected. Consolidate generated purge water.
15. Remove and decontaminate the portable water level probe with phosphate-free detergent, rinsing with potable water.
16. Disconnect the controller air supply to the pump.
17. Secure the pump's discharge line/discharge adapter in the wellhead.
18. Secure the wellhead cover and secure with its lock. Move equipment to next well to be sampled.
19. At the end of each day, post calibrate all field instruments and record the measurements on the "Field Calibration Documentation Form".
20. Clean and decontaminate the in-line flow cell with phosphate-free detergent, rinsing with potable water.

Procedure Peristaltic Pump

1. Record all depth to water readings on field data sheets
2. Calibrate all field instruments according to manufacturer's directions.
3. Setup pump and install silicone tubing in the roller head.
4. Place suction tubing at desired intake level in well, (mid screen) and attach to pump silicone tubing.
5. Attach tubing at discharge side of pump head and place in collection container.
6. Start pump and adjust flow rate to achieve flow without depressing water level more than necessary (approx. 0.30').
7. Record parameter readings after parameters have stabilized (3 consecutive readings that fall within the acceptance criteria).
8. Decrease the flow rate of the pump to achieve approximately 100 ml/min. when collecting samples.
9. Change all tubing between wells and repeat procedure.

CHAIN OF CUSTODY PROTOCOL

Chain of custody protocol is followed for all groundwater samples selected for laboratory analysis. The chain of custody form(s) accompanies the samples from the sampling locality to the laboratory, providing a continuous record of possession prior to analysis.

DECONTAMINATION

Groundwater Sampling

Purging and sampling equipment that could contact well fluids is either dedicated to a particular well or cleaned prior to each use in a soap solution followed by two tap water rinses.

APPENDIX B

GROUNDWATER MONITORING FIELD DATA SHEETS

FIELD REPORT FORM

Project No.: 278114
Date: 8/31/17
Project Name: Winlock
Personnel: KRN
Weather: Sunny, 80's
Page: 1 of 1

0915 Arrived onsite, put on PPE, went over Health and Safety.

0925 Open all well monuments to allow a minimum of 15 mins of equilibration.

0940 Gauge Wells MW-1 through MW-7 (See depth to water field form dated 08/31/17).

1025 Begin purging MW-1 (see groundwater sampling record dated 08/31/17.

1050 Sample MW-1.

1156 Sample MW-4.

1319 Sample MW-3.

1422 Sample MW-7.

1456 Sample MW-2 and duplicate MW-2D.

1606 Sample, MW-6.

1708 Sample MW-5.

1730 Cleanup site, depart site. No IDW drum was onsite so purge water taken back to office.

DEPTH TO WATER FIELD FORM

Project No.: 278114

Site Name: Winlock

TRC Personnel: KRN

Date: 8/31/17

Well Number	Screen Interval	Depth to Water	Depth to Product	Free Product Thickness (ft)	Free Product Recovery	Total Depth	Comments
MW-1	5-12	3.90	—	—	—	11.29	
MW-2	5-11	3.18	—	—	—	10.92	
MW-3	5-10	2.68	—	—	—	9.60	
MW-4	5-12	6.00	—	—	—	11.98	
MW-5	5-10	5.40	—	—	—	10.30	
MW-6	5-10	3.77	—	—	—	12.15	
MW-7	5-9	5.71	—	—	—	9.06	

TRC Results you can rely on

WELL ID
MW-1

GROUNDWATER SAMPLING RECORD

TRC

Sheet 1 **of** 1

Project Number: 278114

Project Name: Winlock

Date: 8/31/17

Personnel: KRN

Weather:

Well Construction	
Casing Material:	PVC
Casing Diameter:	2"
Completion Type:	
Screened Interval:	5-12

Well Integrity	
Concrete Collar:	good
Well Cap:	good
Security Lock:	good
Standing Water:	no

Well Volume	
Initial DTW (ft btoc)	3.90
Measured Total Depth (ft btoc)	
Height of water Column	
Casing Volume (gal)	

Sampling Method:	peristaltic pump
Pump Intake Depth: (ft)	7

monument cover is broken (metal)

Field Water Quality Measurements

Time	DTW (ft/btoc)	Temp. (C°)	pH	Specific Cond. (mS/cm)	DO (mg/L)	ORP (mV)	Turbidity (NTU)	Turbidity (visual)	Color (visual)	Flow Rate (mL/min)	Cum. Vol. (mL)
1032	3.99	20.95	5.88	~~0.14~~ 138 KN	6.18	-11.9	8.89	Clear	clear	125	~~125~~ KN
1035	4.29	20.61	5.87	0.139	3.86	-14.4	9.42	↓	↓	↓	↓
1038	4.48	21.06	5.90	0.136	2.82	-12.5	9.23				
1041	4.62	20.64	5.92	0.129	2.56	-16.8	9.06				
1044	4.66	20.40	6.00	0.134	2.55	-18.2	8.02				
1047	4.69	20.55	6.01	0.135	2.54	-19.1	9.29				
1050	4.70	20.36	6.03	0.136	2.24	-20.4	8.94				

Sample Name	MW1-0817
SampleTime	1050

Comments:

WELL ID

MW-2

GROUNDWATER SAMPLING RECORD

TRC

Sheet 1 of 1

Project Number:

Date: 8/31/17

Project Name:

Personnel: KRN

Weather:

Well Construction	
Casing Material:	PVC
Casing Diameter:	2"
Completion Type:	
Screened Interval:	5-11

Well Integrity	
Concrete Collar:	good
Well Cap:	good
Security Lock:	no
Standing Water:	no

Well Volume	
Initial DTW (ft btoc)	3.18
Measured Total Depth (ft btoc)	10.92
Height of water Column	
Casing Volume (gal)	

Sampling Method:	peri pump
Pump Intake Depth: (ft)	7

Field Water Quality Measurements

Time	DTW (ft/btoc)	Temp. (C°)	pH	Specific Cond. (mS/cm)	DO (mg/L)	ORP (mV)	Turbidity (NTU)	Turbidity (visual)	Color (visual)	Flow Rate (mL/min)	Cum. Vol. (mL)
1456	4.01	18.75	6.59	0.195	0.97	-57.9	14.0	clear	clear	125	
1459	4.10	19.00	6.57	0.195	1.00	-60.5	10.4	↓	↓	↓	
1502	4.32	19.15	6.56	0.194	0.87	-59.0	8.57				
1505	4.51	19.15	6.59	0.193	0.90	-60.7	11.0				
1508	4.58	19.12	6.59	0.193	0.90	-64.2	10.6				

Sample Name	MW2-0817	MW2D-0817
SampleTime	1508	1456

duplicate

Comments:

- ferrous iron field filtering: ~6.5 mg/L

WELL ID

MW-3

GROUNDWATER SAMPLING RECORD

TRC

Sheet ___ of ___

Project Number:

Date: 8/31/17

Project Name:

Personnel: KRN

Weather:

Well Construction	
Casing Material:	PVC
Casing Diameter:	2"
Completion Type:	
Screened Interval:	5-10

Well Integrity	
Concrete Collar:	good
Well Cap:	good
Security Lock:	no
Standing Water:	no

missing screw

Well Volume	
Initial DTW (ft btoc)	2.68
Measured Total Depth (ft btoc)	
Height of water Column	
Casing Volume (gal)	

Sampling Method:	peri pump
Pump Intake Depth: (ft)	7

Field Water Quality Measurements

Time	DTW (ft/btoc)	Temp. (C°)	pH	Specific Cond. (mS/cm)	DO (mg/L)	ORP (mV)	Turbidity (NTU)	Turbidity (visual)	Color (visual)	Flow Rate (mL/min)	Cum. Vol. (mL)
1249	3.34	20.97	6.22	0.284	4.81	-21.0	80.3	clear	clear	150	
1252	3.43	21.61	6.21	0.287	3.49	-17.2	75.5			↓	
1255	3.54	21.77	6.21	0.288	3.27	-15.9	71.8	↓	↓		
1258	3.62	21.60	6.21	0.286	2.50	-15.2	68.2				
1301	3.70	21.42	6.21	0.286	2.33	-15.2	60.7				
1304	3.75	21.45	6.22	0.285	2.14	-15.1	51.8				
1307	3.80	21.44	6.22	0.286	2.00	-15.0	41.4				
1310	3.86	21.37	6.22	0.286	1.85	-15.0	38.9				
1313	3.91	21.21	6.22	0.285	1.69	-14.6	35.3				
1316	3.92	21.16	6.22	0.285	1.65	-14.6	36.4				
1319	3.92	21.10	6.22	0.285	1.51	-14.6	33.0				

Sample Name	MW3-0817
Sample Time	~~1313~~ KN 1319

Comments:

ferrous iron field sample: ~ 6 mg/L

WELL ID

MW-4

GROUNDWATER SAMPLING RECORD

TRC

Sheet ___ of ___

Project Number:

Date:

Project Name:

Personnel:

Weather:

Well Construction	
Casing Material:	PVC
Casing Diameter:	
Completion Type:	
Screened Interval:	5-12

Well Integrity	
Concrete Collar:	good
Well Cap:	good
Security Lock:	~~ye~~ KN no
Standing Water:	no

Well Volume	
Initial DTW (ft btoc)	6.00
Measured Total Depth (ft btoc)	
Height of water Column	
Casing Volume (gal)	

Sampling Method:	peri pump
Pump Intake Depth: (ft)	7

Field Water Quality Measurements

Time	DTW (ft/btoc)	Temp. (C°)	pH	Specific Cond. (mS/cm)	DO (mg/L)	ORP (mV)	Turbidity (NTU)	Turbidity (visual)	Color (visual)	Flow Rate (mL/min)	Cum. Vol. (mL)
1135	6.26	14.92	6.72	0.163	3.11	-8.6	101	clear	clear	125	
1138	6.33	15.17	6.67	0.162	1.57	-21.0	93.7	slightly yellow	↓	↓	
1141	6.37	15.21	6.58	0.162	1.42	-21.6	80.3	↓			
1144	6.49	15.43	6.70	0.162	1.29	-26.8	75.1				
1147	6.52	15.54	6.75	0.163	1.32	-32.2	63.3				
1150	6.60	15.49	6.77	0.162	1.26	-38.2	55.3				
1153	6.68	15.34	6.80	0.163	1.15	-43.4	47.6				
1156	6.71	15.31	6.79	0.163	1.13	-44.2	41.3				

Sample Name	MW4-0817
Sample Time	1156

Comments:

- turbidity of water visually appears clear with a slight yellow tinge
- ferrous iron in-field was ~5 mg/L

WELL ID

MW-5

GROUNDWATER SAMPLING RECORD

Sheet 1 of ___

Project Number:

Date: 8/31/17

Project Name:

Personnel: KRN

Weather:

Well Construction	
Casing Material:	PVC
Casing Diameter:	2"
Completion Type:	
Screened Interval:	5-10

Well Integrity	
Concrete Collar:	good
Well Cap:	good
Security Lock:	no
Standing Water:	yes

Well Volume	
Initial DTW (ft btoc)	5.40
Measured Total Depth (ft btoc)	10.30
Height of water Column	
Casing Volume (gal)	

Sampling Method:	peri pump
Pump Intake Depth: (ft)	7

Field Water Quality Measurements

Time	DTW (ft/btoc)	Temp. (C°)	pH	Specific Cond. (mS/cm)	DO (mg/L)	ORP (mV)	Turbidity (NTU)	Turbidity (visual)	Color (visual)	Flow Rate (mL/min)	Cum. Vol. (mL)
1650	5.65	19.58	5~~0~~.6 KN	0.187	2.37	50.8	5.59	clear	clear	125	
1653	5.70	19.59	5.91	0.183	1.92	56.6	3.13	↓	↓	↓	
1656	5.78	19.69	5.93	0.181	1.60	59.5	3.82	↓	↓	↓	
1659	5.83	19.71	~~4~~5.91	0.181	1.46	60.5	2.63	↓	↓	↓	
1702	5.90	19.74	5.90	0.181	1.28	61.7	2.30	↓	↓	↓	
1705	5.94	19.73	5.89	0.181	1.15	63.7	2.21	↓	↓	↓	
1708	~~4~~5.97	19.71	5.88	0.182	1.09	64.8	2.07	↓	↓	↓	

Sample Name	MWS-0817
Sample Time	1708

Comments:

WELL ID

MW-6

GROUNDWATER SAMPLING RECORD

TRC

Sheet 1 of ___

Project Number:

Date: 8/31/17

Project Name:

Personnel: KRN

Weather:

Well Construction	
Casing Material:	PVC
Casing Diameter:	2"
Completion Type:	
Screened Interval:	5-10

Well Integrity	
Concrete Collar:	good
Well Cap:	good
Security Lock:	no
Standing Water:	yes

Well Volume	
Initial DTW (ft btoc)	3.77
Measured Total Depth (ft btoc)	12.15
Height of water Column	
Casing Volume (gal)	

Sampling Method:	peri pump
Pump Intake Depth: (ft)	7

Field Water Quality Measurements

Time	DTW (ft/btoc)	Temp. (C°)	pH	Specific Cond. (mS/cm)	DO (mg/L)	ORP (mV)	Turbidity (NTU)	Turbidity (visual)	Color (visual)	Flow Rate (mL/min)	Cum. Vol. (mL)
1554	4.50	19.98	7.3	0.201	0.80	-57.9	10.6	clear	clear	150	
1557	4.66	20.00	6.67	0.200	0.83	-61.2	16.2	↓	↓	↓	
1600	4.68	20.03	7.0	0.200	0.72	-68.2	14.1				
1603	4.74	20.09	6.66	0.203	0.68	-71.6	12.5				
1606	4.78	20.00	6.66	0.211	0.78	-79.0	9.24				

Sample Name	MW6-0817
Sample Time	1606

Comments:

ferrous iron field filtered: ~ 6 mg/L

WELL ID

MW-7

GROUNDWATER SAMPLING RECORD

Sheet 1 of ___

Project Number:

Project Name:

Date: 8/31/17

Personnel: KRN

Weather:

Well Construction	
Casing Material:	PVC
Casing Diameter:	2"
Completion Type:	
Screened Interval:	5-9

Well Integrity	
Concrete Collar:	good
Well Cap:	good
Security Lock:	no
Standing Water:	yes

~~missing screws~~ KN

Well Volume	
Initial DTW (ft btoc)	5.71
Measured Total Depth (ft btoc)	
Height of water Column	
Casing Volume (gal)	

Sampling Method:	peri pump
Pump Intake Depth: (ft)	7

Field Water Quality Measurements

Time	DTW (ft/btoc)	Temp. (C°)	pH	Specific Cond. (mS/cm)	DO (mg/L)	ORP (mV)	Turbidity (NTU)	Turbidity (visual)	Color (visual)	Flow Rate (mL/min)	Cum. Vol. (mL)
1358	5.90	20.91	6.05	0.161	2.65	36.9	33.0	clear	clear	125	
1401	5.93	21.09	6.03	0.162	2.23	39.8	8.85	↓	↓	↓	
1404	5.98	21.14	6.04	0.164	1.86	42.7	5.63				
1407	6.02	20.96	6.11	0.181	1.70	40.9	4.40				
1410	6.04	20.82	6.17	0.193	1.53	37.0	4.58				
1413	6.06	20.82	6.23	0.212	1.32	32.2	8.14				
1416	6.13	20.64	6.24	0.218	1.23	30.4	8.10				
1419	6.18	20.46	6.27	0.230	1.18	25.9	7.91				
1422	6.18	20.33	6.28	0.232	1.15	24.9	7.76				

Sample Name	MW7-0817
Sample Time	1422

Comments:

APPENDIX C

LABORATORY ANALYTICAL REPORTS
AND
CHAIN-OF-CUSTODY DOCUMENTATION

ANALYTICAL REPORT

September 13, 2017

TRC - BNSF Region 1

Sample Delivery Group:	L933731
Samples Received:	09/02/2017
Project Number:	278114
Description:	BNSF - Former Cummings Oil Lease Site
Report To:	Keith Woodburne 19874 141st Place NE Woodinville, WA 98072

Entire Report Reviewed By:

Mark W. Beasley
Technical Service Representative

12065 Lebanon Rd   Mount Juliet, TN 37122   615-758-5858   800-767-5859   www.esclabsciences.com

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Gl: Glossary of Terms 25
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Sc: Sample Chain of Custody 27

1 Cp
2 Tc
3 Ss
4 Cn
5 Sr
6 Qc
7 Gl
8 Al
9 Sc

MW1-0817 L933731-01 GW

Collected by	Collected date/time	Received date/time
Kaelin Newman	08/31/17 10:50	09/02/17 08:45

Method	Batch	Dilution	Preparation date/time	Analysis date/time	Analyst
Volatile Organic Compounds (GC/MS) by Method 8260C	WG1016545	1	09/03/17 13:59	09/03/17 13:59	BMB
Semi-Volatile Organic Compounds (GC) by Method NWTPHDX-SGT	WG1016941	1	09/07/17 08:52	09/08/17 05:55	TH

MW2-0817 L933731-02 GW

Collected by	Collected date/time	Received date/time
Kaelin Newman	08/31/17 15:08	09/02/17 08:45

Method	Batch	Dilution	Preparation date/time	Analysis date/time	Analyst
Wet Chemistry by Method 2320 B-2011	WG1017245	1	09/09/17 11:53	09/09/17 11:53	MCG
Wet Chemistry by Method 353.2	WG1016935	1	09/07/17 12:41	09/07/17 12:41	JER
Wet Chemistry by Method 4500S2 D-2011	WG1017451	1	09/06/17 21:06	09/06/17 21:06	MZ
Wet Chemistry by Method 9056A	WG1017068	1	09/06/17 22:18	09/06/17 22:18	NJM
Metals (ICPMS) by Method 6020A	WG1017914	1	09/09/17 09:33	09/09/17 13:52	JPD
Metals (ICPMS) by Method 6020A	WG1018475	1	09/11/17 08:41	09/11/17 12:09	LAT
Volatile Organic Compounds (GC) by Method RSK175	WG1016553	1	09/05/17 11:47	09/05/17 11:47	BG
Volatile Organic Compounds (GC) by Method RSK175	WG1016892	5	09/05/17 13:29	09/05/17 13:29	BG
Volatile Organic Compounds (GC/MS) by Method 8260C	WG1016545	1	09/03/17 14:19	09/03/17 14:19	BMB
Semi-Volatile Organic Compounds (GC) by Method NWTPHDX-SGT	WG1016941	1	09/07/17 08:52	09/08/17 06:11	TH

MW2D-0817 L933731-03 GW

Collected by	Collected date/time	Received date/time
Kaelin Newman	08/31/17 14:56	09/02/17 08:45

Method	Batch	Dilution	Preparation date/time	Analysis date/time	Analyst
Volatile Organic Compounds (GC/MS) by Method 8260C	WG1016545	1	09/03/17 14:39	09/03/17 14:39	BMB
Semi-Volatile Organic Compounds (GC) by Method NWTPHDX-SGT	WG1016941	1	09/07/17 08:52	09/08/17 06:27	TH

MW3-0817 L933731-04 GW

Collected by	Collected date/time	Received date/time
Kaelin Newman	08/31/17 13:19	09/02/17 08:45

Method	Batch	Dilution	Preparation date/time	Analysis date/time	Analyst
Wet Chemistry by Method 2320 B-2011	WG1017245	1	09/09/17 12:01	09/09/17 12:01	MCG
Wet Chemistry by Method 353.2	WG1016935	1	09/07/17 12:42	09/07/17 12:42	JER
Wet Chemistry by Method 4500S2 D-2011	WG1017451	1	09/06/17 21:06	09/06/17 21:06	MZ
Wet Chemistry by Method 9056A	WG1017068	1	09/06/17 23:02	09/06/17 23:02	NJM
Metals (ICPMS) by Method 6020A	WG1017914	1	09/09/17 09:33	09/09/17 14:26	JPD
Metals (ICPMS) by Method 6020A	WG1018475	1	09/11/17 08:41	09/11/17 12:23	LAT
Volatile Organic Compounds (GC) by Method RSK175	WG1016553	1	09/05/17 11:49	09/05/17 11:49	BG
Volatile Organic Compounds (GC/MS) by Method 8260C	WG1016545	1	09/03/17 14:59	09/03/17 14:59	BMB
Semi-Volatile Organic Compounds (GC) by Method NWTPHDX-SGT	WG1016941	1	09/07/17 08:52	09/08/17 06:43	TH

MW4-0817 L933731-05 GW

Collected by	Collected date/time	Received date/time
Kaelin Newman	08/31/17 11:56	09/02/17 08:45

Method	Batch	Dilution	Preparation date/time	Analysis date/time	Analyst
Wet Chemistry by Method 2320 B-2011	WG1017245	1	09/10/17 11:24	09/10/17 11:24	MCG
Wet Chemistry by Method 353.2	WG1016935	1	09/07/17 12:43	09/07/17 12:43	JER
Wet Chemistry by Method 4500S2 D-2011	WG1017451	1	09/06/17 21:06	09/06/17 21:06	MZ
Wet Chemistry by Method 9056A	WG1017068	1	09/06/17 23:16	09/06/17 23:16	NJM
Metals (ICPMS) by Method 6020A	WG1017914	1	09/09/17 09:33	09/09/17 14:30	JPD
Metals (ICPMS) by Method 6020A	WG1018475	1	09/11/17 08:41	09/11/17 12:27	LAT
Volatile Organic Compounds (GC) by Method RSK175	WG1016553	1	09/05/17 11:51	09/05/17 11:51	BG

MW5-0817 L933731-06 GW

Collected by	Collected date/time	Received date/time
Kaelin Newman	08/31/17 17:08	09/02/17 08:45

Method	Batch	Dilution	Preparation date/time	Analysis date/time	Analyst
Volatile Organic Compounds (GC/MS) by Method 8260C	WG1016545	1	09/03/17 15:19	09/03/17 15:19	BMB
Semi-Volatile Organic Compounds (GC) by Method NWTPHDX-SGT	WG1016941	1	09/07/17 08:52	09/08/17 06:59	TH

MW6-0817 L933731-07 GW

Collected by	Collected date/time	Received date/time
Kaelin Newman	08/31/17 16:06	09/02/17 08:45

Method	Batch	Dilution	Preparation date/time	Analysis date/time	Analyst
Wet Chemistry by Method 2320 B-2011	WG1017245	1	09/09/17 12:12	09/09/17 12:12	MCG
Wet Chemistry by Method 353.2	WG1016935	1	09/07/17 12:44	09/07/17 12:44	JER
Wet Chemistry by Method 4500S2 D-2011	WG1017451	1	09/06/17 21:07	09/06/17 21:07	MZ
Wet Chemistry by Method 9056A	WG1017068	1	09/06/17 23:30	09/06/17 23:30	NJM
Metals (ICPMS) by Method 6020A	WG1017914	1	09/09/17 09:33	09/09/17 14:33	JPD
Metals (ICPMS) by Method 6020A	WG1018475	1	09/11/17 08:41	09/11/17 12:30	LAT
Volatile Organic Compounds (GC) by Method RSK175	WG1016553	1	09/05/17 11:58	09/05/17 11:58	BG
Volatile Organic Compounds (GC) by Method RSK175	WG1016892	5	09/05/17 13:32	09/05/17 13:32	BG
Volatile Organic Compounds (GC/MS) by Method 8260C	WG1016545	1	09/03/17 15:39	09/03/17 15:39	BMB
Semi-Volatile Organic Compounds (GC) by Method NWTPHDX-SGT	WG1016941	1	09/07/17 08:52	09/08/17 07:15	TH

MW7-0817 L933731-08 GW

Collected by	Collected date/time	Received date/time
Kaelin Newman	08/31/17 14:22	09/02/17 08:45

Method	Batch	Dilution	Preparation date/time	Analysis date/time	Analyst
Volatile Organic Compounds (GC/MS) by Method 8260C	WG1016545	1	09/03/17 16:00	09/03/17 16:00	BMB
Semi-Volatile Organic Compounds (GC) by Method NWTPHDX-SGT	WG1016941	1	09/07/17 08:52	09/08/17 07:31	TH

TRIP BLANK L933731-09 GW

Collected by	Collected date/time	Received date/time
Kaelin Newman	08/31/17 00:00	09/02/17 08:45

Method	Batch	Dilution	Preparation date/time	Analysis date/time	Analyst
Volatile Organic Compounds (GC/MS) by Method 8260C	WG1016545	1	09/03/17 11:38	09/03/17 11:38	BMB

All sample aliquots were received at the correct temperature, in the proper containers, with the appropriate preservatives, and within method specified holding times. All MDL (LOD) and RDL (LOQ) values reported for environmental samples have been corrected for the dilution factor used in the analysis. All radiochemical sample results for solids are reported on a dry weight basis with the exception of tritium, carbon-14 and radon, unless wet weight was requested by the client. All Method and Batch Quality Control are within established criteria except where addressed in this case narrative, a non-conformance form or properly qualified within the sample results. By my digital signature below, I affirm to the best of my knowledge, all problems/anomalies observed by the laboratory as having the potential to affect the quality of the data have been identified by the laboratory, and no information or data have been knowingly withheld that would affect the quality of the data.

Mark W. Beasley
Technical Service Representative

Volatile Organic Compounds (GC/MS) by Method 8260C

Analyte	Result ug/l	Qualifier	RDL ug/l	Dilution	Analysis date / time	Batch
Benzene	ND		1.00	1	09/03/2017 13:59	WG1016545
Toluene	ND		1.00	1	09/03/2017 13:59	WG1016545
Ethylbenzene	ND		1.00	1	09/03/2017 13:59	WG1016545
Total Xylenes	ND		3.00	1	09/03/2017 13:59	WG1016545
(S) Toluene-d8	*109*		*80.0-120*		*09/03/2017 13:59*	WG1016545
(S) Dibromofluoromethane	*91.3*		*76.0-123*		*09/03/2017 13:59*	WG1016545
(S) a,a,a-Trifluorotoluene	*106*		*80.0-120*		*09/03/2017 13:59*	WG1016545
(S) 4-Bromofluorobenzene	*107*		*80.0-120*		*09/03/2017 13:59*	WG1016545

Semi-Volatile Organic Compounds (GC) by Method NWTPHDX-SGT

Analyte	Result ug/l	Qualifier	RDL ug/l	Dilution	Analysis date / time	Batch
Diesel Range Organics (DRO)	ND		200	1	09/08/2017 05:55	WG1016941
Residual Range Organics (RRO)	ND		250	1	09/08/2017 05:55	WG1016941
(S) o-Terphenyl	*81.0*		*52.0-156*		*09/08/2017 05:55*	WG1016941

MW2-0817

Collected date/time: 08/31/17 15:08

SAMPLE RESULTS - 02

L933731

Wet Chemistry by Method 2320 B-2011

Analyte	Result ug/l	Qualifier	RDL ug/l	Dilution	Analysis date / time	Batch
Alkalinity	125000		20000	1	09/09/2017 11:53	WG1017245

Sample Narrative:

L933731-02 WG1017245: Endpoint pH 4.5

Wet Chemistry by Method 353.2

Analyte	Result ug/l	Qualifier	RDL ug/l	Dilution	Analysis date / time	Batch
Nitrate-Nitrite	ND		100	1	09/07/2017 12:41	WG1016935

Wet Chemistry by Method 4500S2 D-2011

Analyte	Result ug/l	Qualifier	RDL ug/l	Dilution	Analysis date / time	Batch
Sulfide	ND		50.0	1	09/06/2017 21:06	WG1017451

Wet Chemistry by Method 9056A

Analyte	Result ug/l	Qualifier	RDL ug/l	Dilution	Analysis date / time	Batch
Sulfate	ND		5000	1	09/06/2017 22:18	WG1017068

Metals (ICPMS) by Method 6020A

Analyte	Result ug/l	Qualifier	RDL ug/l	Dilution	Analysis date / time	Batch
Iron	20900		100	1	09/11/2017 12:09	WG1018475
Manganese	372		5.00	1	09/11/2017 12:09	WG1018475
Manganese,Dissolved	377		5.00	1	09/09/2017 13:52	WG1017914

Volatile Organic Compounds (GC) by Method RSK175

Analyte	Result ug/l	Qualifier	RDL ug/l	Dilution	Analysis date / time	Batch
Methane	3650		50.0	5	09/05/2017 13:29	WG1016892
Ethane	ND		13.0	1	09/05/2017 11:47	WG1016553
Ethene	ND		13.0	1	09/05/2017 11:47	WG1016553

Volatile Organic Compounds (GC/MS) by Method 8260C

Analyte	Result ug/l	Qualifier	RDL ug/l	Dilution	Analysis date / time	Batch
Benzene	ND		1.00	1	09/03/2017 14:19	WG1016545
Toluene	ND		1.00	1	09/03/2017 14:19	WG1016545
Ethylbenzene	ND		1.00	1	09/03/2017 14:19	WG1016545
Total Xylenes	ND		3.00	1	09/03/2017 14:19	WG1016545
(S) Toluene-d8	*109*		*80.0-120*		*09/03/2017 14:19*	WG1016545
(S) Dibromofluoromethane	*91.9*		*76.0-123*		*09/03/2017 14:19*	WG1016545
(S) a,a,a-Trifluorotoluene	*107*		*80.0-120*		*09/03/2017 14:19*	WG1016545
(S) 4-Bromofluorobenzene	*107*		*80.0-120*		*09/03/2017 14:19*	WG1016545

Semi-Volatile Organic Compounds (GC) by Method NWTPHDX-SGT

Analyte	Result ug/l	Qualifier	RDL ug/l	Dilution	Analysis date / time	Batch
Diesel Range Organics (DRO)	ND		200	1	09/08/2017 06:11	WG1016941
Residual Range Organics (RRO)	ND		250	1	09/08/2017 06:11	WG1016941
(S) o-Terphenyl	*81.3*		*52.0-156*		*09/08/2017 06:11*	WG1016941

Volatile Organic Compounds (GC/MS) by Method 8260C

	Result	Qualifier	RDL	Dilution	Analysis	Batch
Analyte	ug/l		ug/l		date / time	
Benzene	ND		1.00	1	09/03/2017 14:39	WG1016545
Toluene	ND		1.00	1	09/03/2017 14:39	WG1016545
Ethylbenzene	ND		1.00	1	09/03/2017 14:39	WG1016545
Total Xylenes	ND		3.00	1	09/03/2017 14:39	WG1016545
(S) Toluene-d8	*109*		*80.0-120*		*09/03/2017 14:39*	WG1016545
(S) Dibromofluoromethane	*92.5*		*76.0-123*		*09/03/2017 14:39*	WG1016545
(S) a,a,a-Trifluorotoluene	*106*		*80.0-120*		*09/03/2017 14:39*	WG1016545
(S) 4-Bromofluorobenzene	*106*		*80.0-120*		*09/03/2017 14:39*	WG1016545

Semi-Volatile Organic Compounds (GC) by Method NWTPHDX-SGT

	Result	Qualifier	RDL	Dilution	Analysis	Batch
Analyte	ug/l		ug/l		date / time	
Diesel Range Organics (DRO)	ND		200	1	09/08/2017 06:27	WG1016941
Residual Range Organics (RRO)	ND		250	1	09/08/2017 06:27	WG1016941
(S) o-Terphenyl	*78.4*		*52.0-156*		*09/08/2017 06:27*	WG1016941

Wet Chemistry by Method 2320 B-2011

Analyte	Result ug/l	Qualifier	RDL ug/l	Dilution	Analysis date / time	Batch
Alkalinity	131000		20000	1	09/09/2017 12:01	WG1017245

Sample Narrative:

L933731-04 WG1017245: Endpoint pH 4.5

Wet Chemistry by Method 353.2

Analyte	Result ug/l	Qualifier	RDL ug/l	Dilution	Analysis date / time	Batch
Nitrate-Nitrite	ND		100	1	09/07/2017 12:42	WG1016935

Wet Chemistry by Method 4500S2 D-2011

Analyte	Result ug/l	Qualifier	RDL ug/l	Dilution	Analysis date / time	Batch
Sulfide	ND		50.0	1	09/06/2017 21:06	WG1017451

Wet Chemistry by Method 9056A

Analyte	Result ug/l	Qualifier	RDL ug/l	Dilution	Analysis date / time	Batch
Sulfate	32900		5000	1	09/06/2017 23:02	WG1017068

Metals (ICPMS) by Method 6020A

Analyte	Result ug/l	Qualifier	RDL ug/l	Dilution	Analysis date / time	Batch
Iron	18100		100	1	09/11/2017 12:23	WG1018475
Manganese	574		5.00	1	09/11/2017 12:23	WG1018475
Manganese,Dissolved	571		5.00	1	09/09/2017 14:26	WG1017914

Volatile Organic Compounds (GC) by Method RSK175

Analyte	Result ug/l	Qualifier	RDL ug/l	Dilution	Analysis date / time	Batch
Methane	137		10.0	1	09/05/2017 11:49	WG1016553
Ethane	ND		13.0	1	09/05/2017 11:49	WG1016553
Ethene	ND		13.0	1	09/05/2017 11:49	WG1016553

Volatile Organic Compounds (GC/MS) by Method 8260C

Analyte	Result ug/l	Qualifier	RDL ug/l	Dilution	Analysis date / time	Batch
Benzene	ND		1.00	1	09/03/2017 14:59	WG1016545
Toluene	ND		1.00	1	09/03/2017 14:59	WG1016545
Ethylbenzene	ND		1.00	1	09/03/2017 14:59	WG1016545
Total Xylenes	ND		3.00	1	09/03/2017 14:59	WG1016545
(S) Toluene-d8	*108*		*80.0-120*		*09/03/2017 14:59*	WG1016545
(S) Dibromofluoromethane	*92.3*		*76.0-123*		*09/03/2017 14:59*	WG1016545
(S) a,a,a-Trifluorotoluene	*107*		*80.0-120*		*09/03/2017 14:59*	WG1016545
(S) 4-Bromofluorobenzene	*107*		*80.0-120*		*09/03/2017 14:59*	WG1016545

Semi-Volatile Organic Compounds (GC) by Method NWTPHDX-SGT

Analyte	Result ug/l	Qualifier	RDL ug/l	Dilution	Analysis date / time	Batch
Diesel Range Organics (DRO)	ND		200	1	09/08/2017 06:43	WG1016941
Residual Range Organics (RRO)	ND		250	1	09/08/2017 06:43	WG1016941
(S) o-Terphenyl	*71.8*		*52.0-156*		*09/08/2017 06:43*	WG1016941

MW4-0817

Collected date/time: 08/31/17 11:56

SAMPLE RESULTS - 05

L933731

Wet Chemistry by Method 2320 B-2011

	Result	Qualifier	RDL	Dilution	Analysis	Batch
Analyte	ug/l		ug/l		date / time	
Alkalinity	89500		20000	1	09/10/2017 11:24	WG1017245

Sample Narrative:

L933731-05 WG1017245: Endpoint pH 4.5

Wet Chemistry by Method 353.2

	Result	Qualifier	RDL	Dilution	Analysis	Batch
Analyte	ug/l		ug/l		date / time	
Nitrate-Nitrite	ND		100	1	09/07/2017 12:43	WG1016935

Wet Chemistry by Method 4500S2 D-2011

	Result	Qualifier	RDL	Dilution	Analysis	Batch
Analyte	ug/l		ug/l		date / time	
Sulfide	ND		50.0	1	09/06/2017 21:06	WG1017451

Wet Chemistry by Method 9056A

	Result	Qualifier	RDL	Dilution	Analysis	Batch
Analyte	ug/l		ug/l		date / time	
Sulfate	15700		5000	1	09/06/2017 23:16	WG1017068

Metals (ICPMS) by Method 6020A

	Result	Qualifier	RDL	Dilution	Analysis	Batch
Analyte	ug/l		ug/l		date / time	
Iron	12400		100	1	09/11/2017 12:27	WG1018475
Manganese	499		5.00	1	09/11/2017 12:27	WG1018475
Manganese,Dissolved	504		5.00	1	09/09/2017 14:30	WG1017914

Volatile Organic Compounds (GC) by Method RSK175

	Result	Qualifier	RDL	Dilution	Analysis	Batch
Analyte	ug/l		ug/l		date / time	
Methane	27.2		10.0	1	09/05/2017 11:51	WG1016553
Ethane	ND		13.0	1	09/05/2017 11:51	WG1016553
Ethene	ND		13.0	1	09/05/2017 11:51	WG1016553

Volatile Organic Compounds (GC/MS) by Method 8260C

Analyte	Result ug/l	Qualifier	RDL ug/l	Dilution	Analysis date / time	Batch
Benzene	ND		1.00	1	09/03/2017 15:19	WG1016545
Toluene	ND		1.00	1	09/03/2017 15:19	WG1016545
Ethylbenzene	ND		1.00	1	09/03/2017 15:19	WG1016545
Total Xylenes	ND		3.00	1	09/03/2017 15:19	WG1016545
(S) Toluene-d8	*109*		*80.0-120*		*09/03/2017 15:19*	WG1016545
(S) Dibromofluoromethane	*90.6*		*76.0-123*		*09/03/2017 15:19*	WG1016545
(S) a,a,a-Trifluorotoluene	*106*		*80.0-120*		*09/03/2017 15:19*	WG1016545
(S) 4-Bromofluorobenzene	*107*		*80.0-120*		*09/03/2017 15:19*	WG1016545

Semi-Volatile Organic Compounds (GC) by Method NWTPHDX-SGT

Analyte	Result ug/l	Qualifier	RDL ug/l	Dilution	Analysis date / time	Batch
Diesel Range Organics (DRO)	ND		200	1	09/08/2017 06:59	WG1016941
Residual Range Organics (RRO)	ND		250	1	09/08/2017 06:59	WG1016941
(S) o-Terphenyl	*79.5*		*52.0-156*		*09/08/2017 06:59*	WG1016941

1 Cp
2 Tc
3 Ss
4 Cn
5 Sr
6 Qc
7 Gl
8 Al
9 Sc

Wet Chemistry by Method 2320 B-2011

Analyte	Result ug/l	Qualifier	RDL ug/l	Dilution	Analysis date / time	Batch
Alkalinity	121000		20000	1	09/09/2017 12:12	WG1017245

Sample Narrative:

L933731-07 WG1017245: Endpoint pH 4.5

Wet Chemistry by Method 353.2

Analyte	Result ug/l	Qualifier	RDL ug/l	Dilution	Analysis date / time	Batch
Nitrate-Nitrite	ND		100	1	09/07/2017 12:44	WG1016935

Wet Chemistry by Method 4500S2 D-2011

Analyte	Result ug/l	Qualifier	RDL ug/l	Dilution	Analysis date / time	Batch
Sulfide	ND		50.0	1	09/06/2017 21:07	WG1017451

Wet Chemistry by Method 9056A

Analyte	Result ug/l	Qualifier	RDL ug/l	Dilution	Analysis date / time	Batch
Sulfate	ND		5000	1	09/06/2017 23:30	WG1017068

Metals (ICPMS) by Method 6020A

Analyte	Result ug/l	Qualifier	RDL ug/l	Dilution	Analysis date / time	Batch
Iron	20600		100	1	09/11/2017 12:30	WG1018475
Manganese	425		5.00	1	09/11/2017 12:30	WG1018475
Manganese,Dissolved	442		5.00	1	09/09/2017 14:33	WG1017914

Volatile Organic Compounds (GC) by Method RSK175

Analyte	Result ug/l	Qualifier	RDL ug/l	Dilution	Analysis date / time	Batch
Methane	3070		50.0	5	09/05/2017 13:32	WG1016892
Ethane	ND		13.0	1	09/05/2017 11:58	WG1016553
Ethene	ND		13.0	1	09/05/2017 11:58	WG1016553

Volatile Organic Compounds (GC/MS) by Method 8260C

Analyte	Result ug/l	Qualifier	RDL ug/l	Dilution	Analysis date / time	Batch
Benzene	ND		1.00	1	09/03/2017 15:39	WG1016545
Toluene	ND		1.00	1	09/03/2017 15:39	WG1016545
Ethylbenzene	ND		1.00	1	09/03/2017 15:39	WG1016545
Total Xylenes	ND		3.00	1	09/03/2017 15:39	WG1016545
(S) Toluene-d8	*108*		*80.0-120*		*09/03/2017 15:39*	WG1016545
(S) Dibromofluoromethane	*91.9*		*76.0-123*		*09/03/2017 15:39*	WG1016545
(S) a,a,a-Trifluorotoluene	*105*		*80.0-120*		*09/03/2017 15:39*	WG1016545
(S) 4-Bromofluorobenzene	*106*		*80.0-120*		*09/03/2017 15:39*	WG1016545

Semi-Volatile Organic Compounds (GC) by Method NWTPHDX-SGT

Analyte	Result ug/l	Qualifier	RDL ug/l	Dilution	Analysis date / time	Batch
Diesel Range Organics (DRO)	ND		200	1	09/08/2017 07:15	WG1016941
Residual Range Organics (RRO)	ND		250	1	09/08/2017 07:15	WG1016941
(S) o-Terphenyl	*77.2*		*52.0-156*		*09/08/2017 07:15*	WG1016941

Volatile Organic Compounds (GC/MS) by Method 8260C

Analyte	Result ug/l	Qualifier	RDL ug/l	Dilution	Analysis date / time	Batch
Benzene	ND		1.00	1	09/03/2017 16:00	WG1016545
Toluene	ND		1.00	1	09/03/2017 16:00	WG1016545
Ethylbenzene	ND		1.00	1	09/03/2017 16:00	WG1016545
Total Xylenes	ND		3.00	1	09/03/2017 16:00	WG1016545
(S) Toluene-d8	*108*		*80.0-120*		*09/03/2017 16:00*	WG1016545
(S) Dibromofluoromethane	*91.7*		*76.0-123*		*09/03/2017 16:00*	WG1016545
(S) a,a,a-Trifluorotoluene	*105*		*80.0-120*		*09/03/2017 16:00*	WG1016545
(S) 4-Bromofluorobenzene	*108*		*80.0-120*		*09/03/2017 16:00*	WG1016545

Semi-Volatile Organic Compounds (GC) by Method NWTPHDX-SGT

Analyte	Result ug/l	Qualifier	RDL ug/l	Dilution	Analysis date / time	Batch
Diesel Range Organics (DRO)	ND		200	1	09/08/2017 07:31	WG1016941
Residual Range Organics (RRO)	ND		250	1	09/08/2017 07:31	WG1016941
(S) o-Terphenyl	*79.2*		*52.0-156*		*09/08/2017 07:31*	WG1016941

Volatile Organic Compounds (GC/MS) by Method 8260C

Analyte	Result ug/l	Qualifier	RDL ug/l	Dilution	Analysis date / time	Batch
Benzene	ND		1.00	1	09/03/2017 11:38	WG1016545
Toluene	ND		1.00	1	09/03/2017 11:38	WG1016545
Ethylbenzene	ND		1.00	1	09/03/2017 11:38	WG1016545
Total Xylenes	ND		3.00	1	09/03/2017 11:38	WG1016545
(S) Toluene-d8	*109*		*80.0-120*		*09/03/2017 11:38*	WG1016545
(S) Dibromofluoromethane	*82.2*		*76.0-123*		*09/03/2017 11:38*	WG1016545
(S) a,a,a-Trifluorotoluene	*107*		*80.0-120*		*09/03/2017 11:38*	WG1016545
(S) 4-Bromofluorobenzene	*105*		*80.0-120*		*09/03/2017 11:38*	WG1016545

Method Blank (MB)

(MB) R3248105-1 09/09/17 09:54

Analyte	MB Result ug/l	MB Qualifier	MB MDL ug/l	MB RDL ug/l
Alkalinity	3580	J	2710	20000

Sample Narrative:

BLANK: Endpoint pH 4.5

L933699-01 Original Sample (OS) • Duplicate (DUP)

(OS) L933699-01 09/09/17 10:02 • (DUP) R3248105-3 09/09/17 10:10

Analyte	Original Result ug/l	DUP Result ug/l	Dilution	DUP RPD %	DUP Qualifier	DUP RPD Limits %
Alkalinity	268000	276000	1	3.00		20

Sample Narrative:

OS: Endpoint pH 4.5

DUP: Endpoint pH 4.5

L933764-01 Original Sample (OS) • Duplicate (DUP)

(OS) L933764-01 09/10/17 11:38 • (DUP) R3248105-8 09/10/17 11:46

Analyte	Original Result ug/l	DUP Result ug/l	Dilution	DUP RPD %	DUP Qualifier	DUP RPD Limits %
Alkalinity	98100	99500	1	1.00		20

Sample Narrative:

OS: Endpoint pH 4.5

DUP: Endpoint pH 4.5

Laboratory Control Sample (LCS) • Laboratory Control Sample Duplicate (LCSD)

(LCS) R3248105-4 09/09/17 11:11 • (LCSD) R3248105-7 09/09/17 12:52

Analyte	Spike Amount ug/l	LCS Result ug/l	LCSD Result ug/l	LCS Rec. %	LCSD Rec. %	Rec. Limits %	LCS Qualifier	LCSD Qualifier	RPD %	RPD Limits %
Alkalinity	100000	107000	103000	107	103	85.0-115			4.00	20

Sample Narrative:

LCS: Endpoint pH 4.5

LCSD: Endpoint pH 4.5

1 Cp
2 Tc
3 Ss
4 Cn
5 Sr
6 Qc
7 Gl
8 Al
9 Sc

Method Blank (MB)

(MB) R3247575-2 09/07/17 12:21

	MB Result	MB Qualifier	MB MDL	MB RDL
Analyte	ug/l		ug/l	ug/l
Nitrate-Nitrite	U		19.7	100

L933589-04 Original Sample (OS) • Duplicate (DUP)

(OS) L933589-04 09/07/17 12:27 • (DUP) R3247575-5 09/07/17 12:28

	Original Result	DUP Result	Dilution	DUP RPD	DUP Qualifier	DUP RPD Limits
Analyte	ug/l	ug/l		%		%
Nitrate-Nitrite	ND	48.0	1	0		20

L933916-01 Original Sample (OS) • Duplicate (DUP)

(OS) L933916-01 09/07/17 14:31 • (DUP) R3247575-10 09/07/17 14:32

	Original Result	DUP Result	Dilution	DUP RPD	DUP Qualifier	DUP RPD Limits
Analyte	ug/l	ug/l		%		%
Nitrate-Nitrite	5600	5660	2	1		20

Laboratory Control Sample (LCS) • Laboratory Control Sample Duplicate (LCSD)

(LCS) R3247575-3 09/07/17 12:22 • (LCSD) R3247575-4 09/07/17 12:23

	Spike Amount	LCS Result	LCSD Result	LCS Rec.	LCSD Rec.	Rec. Limits	LCS Qualifier	LCSD Qualifier	RPD	RPD Limits
Analyte	ug/l	ug/l	ug/l	%	%	%			%	%
Nitrate-Nitrite	5000	4030	4200	101	105	90-110			4	20

L933589-06 Original Sample (OS) • Matrix Spike (MS)

(OS) L933589-06 09/07/17 12:29 • (MS) R3247575-6 09/07/17 12:30

	Spike Amount	Original Result	MS Result	MS Rec.	Dilution	Rec. Limits	MS Qualifier
Analyte	ug/l	ug/l	ug/l	%		%	
Nitrate-Nitrite	2500	ND	4430	177	1	90-110	J5

L933916-02 Original Sample (OS) • Matrix Spike (MS) • Matrix Spike Duplicate (MSD)

(OS) L933916-02 09/07/17 12:52 • (MS) R3247575-7 09/07/17 12:53 • (MSD) R3247575-8 09/07/17 12:54

	Spike Amount	Original Result	MS Result	MSD Result	MS Rec.	MSD Rec.	Dilution	Rec. Limits	MS Qualifier	MSD Qualifier	RPD	RPD Limits
Analyte	ug/l	ug/l	ug/l	ug/l	%	%		%			%	%
Nitrate-Nitrite	2500	4980	7860	7740	115	110	1	90-110	E J5	E	2	20

Method Blank (MB)

(MB) R3247321-1 09/06/17 21:03

Analyte	MB Result ug/l	MB Qualifier	MB MDL ug/l	MB RDL ug/l
Sulfide	U		6.50	50.0

L933731-02 Original Sample (OS) • Duplicate (DUP)

(OS) L933731-02 09/06/17 21:06 • (DUP) R3247321-4 09/06/17 21:06

Analyte	Original Result ug/l	DUP Result ug/l	Dilution	DUP RPD %	DUP Qualifier	DUP RPD Limits %
Sulfide	ND	0.000	1	0		20

Laboratory Control Sample (LCS) • Laboratory Control Sample Duplicate (LCSD)

(LCS) R3247321-2 09/06/17 21:04 • (LCSD) R3247321-3 09/06/17 21:04

Analyte	Spike Amount ug/l	LCS Result ug/l	LCSD Result ug/l	LCS Rec. %	LCSD Rec. %	Rec. Limits %	LCS Qualifier	LCSD Qualifier	RPD %	RPD Limits %
Sulfide	500	521	518	104	104	85-115			1	20

L933731-07 Original Sample (OS) • Matrix Spike (MS) • Matrix Spike Duplicate (MSD)

(OS) L933731-07 09/06/17 21:07 • (MS) R3247321-5 09/06/17 21:07 • (MSD) R3247321-6 09/06/17 21:07

Analyte	Spike Amount ug/l	Original Result ug/l	MS Result ug/l	MSD Result ug/l	MS Rec. %	MSD Rec. %	Dilution	Rec. Limits %	MS Qualifier	MSD Qualifier	RPD %	RPD Limits %
Sulfide	1000	ND	986	1030	99	103	1	80-120			4	20

Method Blank (MB)

(MB) R3247492-1 09/06/17 13:25

Analyte	MB Result ug/l	MB Qualifier	MB MDL ug/l	MB RDL ug/l
Sulfate	U		77.4	5000

L933422-01 Original Sample (OS) • Duplicate (DUP)

(OS) L933422-01 09/06/17 17:30 • (DUP) R3247492-4 09/06/17 18:14

Analyte	Original Result ug/l	DUP Result ug/l	Dilution	DUP RPD %	DUP Qualifier	DUP RPD Limits %
Sulfate	25300	25400	1	0		15

L933572-01 Original Sample (OS) • Duplicate (DUP)

(OS) L933572-01 09/06/17 21:35 • (DUP) R3247492-7 09/06/17 21:50

Analyte	Original Result ug/l	DUP Result ug/l	Dilution	DUP RPD %	DUP Qualifier	DUP RPD Limits %
Sulfate	ND	1830	1	0		15

Laboratory Control Sample (LCS) • Laboratory Control Sample Duplicate (LCSD)

(LCS) R3247492-2 09/06/17 13:39 • (LCSD) R3247492-3 09/06/17 13:53

Analyte	Spike Amount ug/l	LCS Result ug/l	LCSD Result ug/l	LCS Rec. %	LCSD Rec. %	Rec. Limits %	LCS Qualifier	LCSD Qualifier	RPD %	RPD Limits %
Sulfate	40000	41300	41400	103	103	80-120			0	15

L933422-01 Original Sample (OS) • Matrix Spike (MS) • Matrix Spike Duplicate (MSD)

(OS) L933422-01 09/06/17 17:30 • (MS) R3247492-5 09/06/17 18:28 • (MSD) R3247492-6 09/06/17 18:42

Analyte	Spike Amount ug/l	Original Result ug/l	MS Result ug/l	MSD Result ug/l	MS Rec. %	MSD Rec. %	Dilution	Rec. Limits %	MS Qualifier	MSD Qualifier	RPD %	RPD Limits %
Sulfate	50000	25300	74800	75200	99	100	1	80-120			1	15

L933572-01 Original Sample (OS) • Matrix Spike (MS)

(OS) L933572-01 09/06/17 21:35 • (MS) R3247492-8 09/06/17 22:04

Analyte	Spike Amount ug/l	Original Result ug/l	MS Result ug/l	MS Rec. %	Dilution	Rec. Limits %	MS Qualifier
Sulfate	50000	ND	52500	101	1	80-120	

Method Blank (MB)

(MB) R3248077-1 09/09/17 13:41

Analyte	MB Result ug/l	MB Qualifier	MB MDL ug/l	MB RDL ug/l
Manganese,Dissolved	0.937	J	0.250	5.00

Laboratory Control Sample (LCS) • Laboratory Control Sample Duplicate (LCSD)

(LCS) R3248077-2 09/09/17 13:45 • (LCSD) R3248077-3 09/09/17 13:49

Analyte	Spike Amount ug/l	LCS Result ug/l	LCSD Result ug/l	LCS Rec. %	LCSD Rec. %	Rec. Limits %	LCS Qualifier	LCSD Qualifier	RPD %	RPD Limits %
Manganese,Dissolved	50.0	50.2	49.5	100	99	80-120			1	20

L933731-02 Original Sample (OS) • Matrix Spike (MS) • Matrix Spike Duplicate (MSD)

(OS) L933731-02 09/09/17 13:52 • (MS) R3248077-5 09/09/17 13:59 • (MSD) R3248077-6 09/09/17 14:03

Analyte	Spike Amount ug/l	Original Result ug/l	MS Result ug/l	MSD Result ug/l	MS Rec. %	MSD Rec. %	Dilution	Rec. Limits %	MS Qualifier	MSD Qualifier	RPD %	RPD Limits %
Manganese,Dissolved	50.0	377	418	416	83	77	1	75-125			1	20

Method Blank (MB)

(MB) R3248300-1 09/11/17 11:59

	MB Result	MB Qualifier	MB MDL	MB RDL
Analyte	ug/l		ug/l	ug/l
Iron	U		15.0	100
Manganese	U		0.250	5.00

Laboratory Control Sample (LCS) • Laboratory Control Sample Duplicate (LCSD)

(LCS) R3248300-2 09/11/17 12:02 • (LCSD) R3248300-3 09/11/17 12:06

	Spike Amount	LCS Result	LCSD Result	LCS Rec.	LCSD Rec.	Rec. Limits	LCS Qualifier	LCSD Qualifier	RPD	RPD Limits
Analyte	ug/l	ug/l	ug/l	%	%	%			%	%
Iron	5000	5140	5020	103	100	80-120			2	20
Manganese	50.0	50.1	48.8	100	98	80-120			3	20

L933731-02 Original Sample (OS) • Matrix Spike (MS) • Matrix Spike Duplicate (MSD)

(OS) L933731-02 09/11/17 12:09 • (MS) R3248300-5 09/11/17 12:16 • (MSD) R3248300-6 09/11/17 12:20

	Spike Amount	Original Result	MS Result	MSD Result	MS Rec.	MSD Rec.	Dilution	Rec. Limits	MS Qualifier	MSD Qualifier	RPD	RPD Limits
Analyte	ug/l	ug/l	ug/l	ug/l	%	%		%			%	%
Iron	5000	20900	25700	25800	96	98	1	75-125			0	20
Manganese	50.0	372	418	418	91	91	1	75-125			0	20

Method Blank (MB)

(MB) R3246780-1 09/05/17 10:28

Analyte	MB Result ug/l	MB Qualifier	MB MDL ug/l	MB RDL ug/l
Methane	U		2.91	10.0
Ethane	U		4.07	13.0
Ethene	U		4.26	13.0

L933703-01 Original Sample (OS) • Duplicate (DUP)

(OS) L933703-01 09/05/17 10:36 • (DUP) R3246780-2 09/05/17 11:29

Analyte	Original Result ug/l	DUP Result ug/l	Dilution	DUP RPD %	DUP Qualifier	DUP RPD Limits %
Methane	ND	0.000	1	0.000		20
Ethane	ND	0.000	1	0.000		20
Ethene	ND	0.000	1	0.000		20

L933731-04 Original Sample (OS) • Duplicate (DUP)

(OS) L933731-04 09/05/17 11:49 • (DUP) R3246780-3 09/05/17 12:00

Analyte	Original Result ug/l	DUP Result ug/l	Dilution	DUP RPD %	DUP Qualifier	DUP RPD Limits %
Methane	137	127	1	7.50		20
Ethane	ND	0.000	1	0.000		20
Ethene	ND	0.000	1	0.000		20

Laboratory Control Sample (LCS) • Laboratory Control Sample Duplicate (LCSD)

(LCS) R3246780-4 09/05/17 12:04 • (LCSD) R3246780-5 09/05/17 12:07

Analyte	Spike Amount ug/l	LCS Result ug/l	LCSD Result ug/l	LCS Rec. %	LCSD Rec. %	Rec. Limits %	LCS Qualifier	LCSD Qualifier	RPD %	RPD Limits %
Methane	67.8	68.4	68.2	101	101	85.0-115			0.230	20
Ethane	129	116	121	89.8	93.5	85.0-115			4.03	20
Ethene	127	112	115	88.4	90.7	85.0-115			2.65	20

Method Blank (MB)

(MB) R3246821-1 09/05/17 12:29

Analyte	MB Result ug/l	MB Qualifier	MB MDL ug/l	MB RDL ug/l
Methane	U		2.91	10.0

L933704-09 Original Sample (OS) • Duplicate (DUP)

(OS) L933704-09 09/05/17 13:08 • (DUP) R3246821-2 09/05/17 13:36

Analyte	Original Result ug/l	DUP Result ug/l	Dilution	DUP RPD %	DUP Qualifier	DUP RPD Limits %
Methane	11500	10800	20	6.15		20

Laboratory Control Sample (LCS) • Laboratory Control Sample Duplicate (LCSD)

(LCS) R3246821-3 09/05/17 13:48 • (LCSD) R3246821-4 09/05/17 13:50

Analyte	Spike Amount ug/l	LCS Result ug/l	LCSD Result ug/l	LCS Rec. %	LCSD Rec. %	Rec. Limits %	LCS Qualifier	LCSD Qualifier	RPD %	RPD Limits %
Methane	67.8	65.2	63.1	96.2	93.1	85.0-115			3.35	20

Method Blank (MB)

(MB) R3247690-2 09/03/17 10:32

Analyte	MB Result ug/l	MB Qualifier	MB MDL ug/l	MB RDL ug/l
Benzene	U		0.331	1.00
Ethylbenzene	U		0.384	1.00
Toluene	U		0.412	1.00
Xylenes, Total	U		1.06	3.00
(S) Toluene-d8	*109*			*80.0-120*
(S) Dibromofluoromethane	*76.9*			*76.0-123*
(S) a,a,a-Trifluorotoluene	*106*			*80.0-120*
(S) 4-Bromofluorobenzene	*107*			*80.0-120*

Laboratory Control Sample (LCS)

(LCS) R3247690-1 09/03/17 09:52

Analyte	Spike Amount ug/l	LCS Result ug/l	LCS Rec. %	Rec. Limits %	LCS Qualifier
Benzene	25.0	26.3	105	69.0-123	
Ethylbenzene	25.0	26.5	106	77.0-120	
Toluene	25.0	27.6	111	77.0-120	
Xylenes, Total	75.0	80.2	107	77.0-120	
(S) Toluene-d8			*108*	*80.0-120*	
(S) Dibromofluoromethane			*78.1*	*76.0-123*	
(S) a,a,a-Trifluorotoluene			*106*	*80.0-120*	
(S) 4-Bromofluorobenzene			*109*	*80.0-120*	

Method Blank (MB)

(MB) R3247880-1 09/07/17 18:11

Analyte	MB Result ug/l	MB Qualifier	MB MDL ug/l	MB RDL ug/l
Diesel Range Organics (DRO)	U		66.7	200
Residual Range Organics (RRO)	U		83.3	250
(S) o-Terphenyl	*77.2*			*52.0-156*

Laboratory Control Sample (LCS) • Laboratory Control Sample Duplicate (LCSD)

(LCS) R3247880-2 09/07/17 18:27 • (LCSD) R3247880-3 09/07/17 18:44

Analyte	Spike Amount ug/l	LCS Result ug/l	LCSD Result ug/l	LCS Rec. %	LCSD Rec. %	Rec. Limits %	LCS Qualifier	LCSD Qualifier	RPD %	RPD Limits %
Diesel Range Organics (DRO)	750	757	746	101	99.4	50.0-150			1.47	20
Residual Range Organics (RRO)	750	762	731	102	97.5	50.0-150			4.02	20
(S) o-Terphenyl				*79.8*	*78.2*	*52.0-156*				

Guide to Reading and Understanding Your Laboratory Report

The information below is designed to better explain the various terms used in your report of analytical results from the Laboratory. This is not intended as a comprehensive explanation, and if you have additional questions please contact your project representative.

Abbreviations and Definitions

MDL	Method Detection Limit.
ND	Not detected at the Reporting Limit (or MDL where applicable).
RDL	Reported Detection Limit.
Rec.	Recovery.
RPD	Relative Percent Difference.
SDG	Sample Delivery Group.
(S)	Surrogate (Surrogate Standard) - Analytes added to every blank, sample, Laboratory Control Sample/Duplicate and Matrix Spike/Duplicate; used to evaluate analytical efficiency by measuring recovery. Surrogates are not expected to be detected in all environmental media.
U	Not detected at the Reporting Limit (or MDL where applicable).
Analyte	The name of the particular compound or analysis performed. Some Analyses and Methods will have multiple analytes reported.
Dilution	If the sample matrix contains an interfering material, or if concentrations of analytes in the sample are higher than the highest limit of concentration that the laboratory can accurately report, the sample may be diluted for analysis. If a value different than 1 is used in this field, the result reported has already been corrected for this factor.
Limits	These are the target % recovery ranges or % difference value that the laboratory has historically determined as normal for the method and analyte being reported. Successful QC Sample analysis will target all analytes recovered or duplicated within these ranges.
Original Sample	The non-spiked sample in the prep batch used to determine the Relative Percent Difference (RPD) from a quality control sample. The Original Sample may not be included within the reported SDG.
Qualifier	This column provides a letter and/or number designation that corresponds to additional information concerning the result reported. If a Qualifier is present, a definition per Qualifier is provided within the Glossary and Definitions page and potentially a discussion of possible implications of the Qualifier in the Case Narrative if applicable.
Result	The actual analytical final result (corrected for any sample specific characteristics) reported for your sample. If there was no measurable result returned for a specific analyte, the result in this column may state “ND” (Not Detected) or “BDL” (Below Detectable Levels). The information in the results column should always be accompanied by either an MDL (Method Detection Limit) or RDL (Reporting Detection Limit) that defines the lowest value that the laboratory could detect or report for this analyte.
Case Narrative (Cn)	A brief discussion about the included sample results, including a discussion of any non-conformances to protocol observed either at sample receipt by the laboratory from the field or during the analytical process. If present, there will be a section in the Case Narrative to discuss the meaning of any data qualifiers used in the report.
Quality Control Summary (Qc)	This section of the report includes the results of the laboratory quality control analyses required by procedure or analytical methods to assist in evaluating the validity of the results reported for your samples. These analyses are not being performed on your samples typically, but on laboratory generated material.
Sample Chain of Custody (Sc)	This is the document created in the field when your samples were initially collected. This is used to verify the time and date of collection, the person collecting the samples, and the analyses that the laboratory is requested to perform. This chain of custody also documents all persons (excluding commercial shippers) that have had control or possession of the samples from the time of collection until delivery to the laboratory for analysis.
Sample Results (Sr)	This section of your report will provide the results of all testing performed on your samples. These results are provided by sample ID and are separated by the analyses performed on each sample. The header line of each analysis section for each sample will provide the name and method number for the analysis reported.
Sample Summary (Ss)	This section of the Analytical Report defines the specific analyses performed for each sample ID, including the dates and times of preparation and/or analysis.

Qualifier	Description
E	The analyte concentration exceeds the upper limit of the calibration range of the instrument established by the initial calibration (ICAL).
J	The identification of the analyte is acceptable; the reported value is an estimate.
J5	The sample matrix interfered with the ability to make any accurate determination; spike value is high.

ACCREDITATIONS & LOCATIONS

ESC Lab Sciences is the only environmental laboratory accredited/certified to support your work nationwide from one location. One phone call, one point of contact, one laboratory. No other lab is as accessible or prepared to handle your needs throughout the country. Our capacity and capability from our single location laboratory is comparable to the collective totals of the network laboratories in our industry. The most significant benefit to our "one location" design is the design of our laboratory campus. The model is conducive to accelerated productivity, decreasing turn-around time, and preventing cross contamination, thus protecting sample integrity. Our focus on premium quality and prompt service allows us to be **YOUR LAB OF CHOICE.**
* Not all certifications held by the laboratory are applicable to the results reported in the attached report.

State Accreditations

Alabama	40660	Nevada	TN-03-2002-34
Alaska	UST-080	New Hampshire	2975
Arizona	AZ0612	New Jersey–NELAP	TN002
Arkansas	88-0469	New Mexico	TN00003
California	01157CA	New York	11742
Colorado	TN00003	North Carolina	Env375
Conneticut	PH-0197	North Carolina [1]	DW21704
Florida	E87487	North Carolina [2]	41
Georgia	NELAP	North Dakota	R-140
Georgia [1]	923	Ohio–VAP	CL0069
Idaho	TN00003	Oklahoma	9915
Illinois	200008	Oregon	TN200002
Indiana	C-TN-01	Pennsylvania	68-02979
Iowa	364	Rhode Island	221
Kansas	E-10277	South Carolina	84004
Kentucky [1]	90010	South Dakota	n/a
Kentucky [2]	16	Tennessee [1,4]	2006
Louisiana	AI30792	Texas	T 104704245-07-TX
Maine	TN0002	Texas [5]	LAB0152
Maryland	324	Utah	6157585858
Massachusetts	M-TN003	Vermont	VT2006
Michigan	9958	Virginia	109
Minnesota	047-999-395	Washington	C1915
Mississippi	TN00003	West Virginia	233
Missouri	340	Wisconsin	9980939910
Montana	CERT0086	Wyoming	A2LA
Nebraska	NE-OS-15-05		

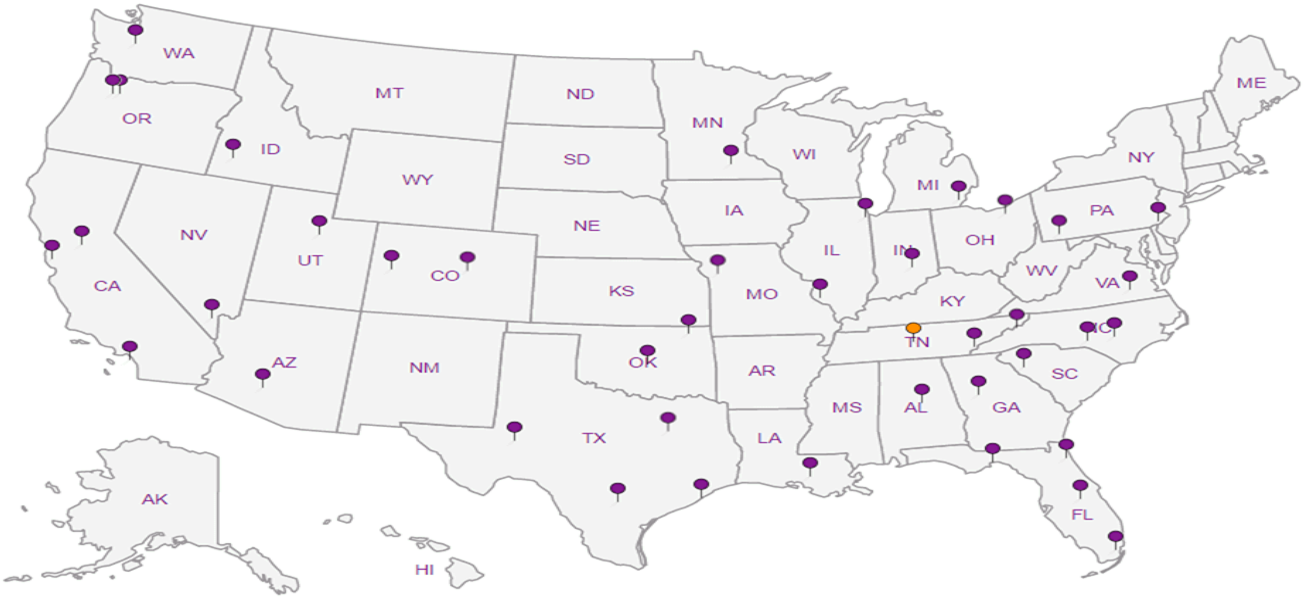
Third Party & Federal Accreditations

A2LA – ISO 17025	1461.01	AIHA-LAP,LLC	100789
A2LA – ISO 17025 [5]	1461.02	DOD	1461.01
Canada	1461.01	USDA	S-67674
EPA–Crypto	TN00003		

[1] Drinking Water [2] Underground Storage Tanks [3] Aquatic Toxicity [4] Chemical/Microbiological [5] Mold n/a Accreditation not applicable

Our Locations

ESC Lab Sciences has sixty-four client support centers that provide sample pickup and/or the delivery of sampling supplies. If you would like assistance from one of our support offices, please contact our main office. **ESC Lab Sciences performs all testing at our central laboratory.**



TRC - BNSF Region 1

19874 141st Place NE
Woodinville, WA 98072

Billing information:

Scott MacDonald
605 Puyallup Avenue South
Tacoma, WA 98421

Chain of Custody Page 1 of 1

ESC
LAB SCIENCES

12065 Lebanon Rd
Mount Juliet, TN 37122
Phone: 615-758-5858
Phone: 800-767-5859
Fax: 615-758-5859

Report to:
Amanda Meugniot

Email To: **ameugniot@trcsolutions.com**

Project Description: **BNSF - Former Cummings Oil Lease Site**

City/State Collected: Winlock, WA

Phone: **425-489-1938**
Fax:

Client Project # 278114

Lab Project # **BNSF1TRC-CUMMINGS**

Collected by (print): Kaelin Newman

Site/Facility ID #

P.O. # 7289

Collected by (signature): Kali Newman

Quote #

Immediately Packed on Ice N___ Y X

Rush? (Lab MUST Be Notified)
___ Same Day ___ Five Day
___ Next Day ___ 5 Day (Rad Only)
___ Two Day ___ 10 Day (Rad Only)
___ Three Day

Date Results Needed

L# 933731

E115

Acctnum: **BNSF1TRC**
Template: **T127006**
Prelogin: **P614566**
TSR: **134 - Mark W. Beasley**
PB:
Shipped Via:

Analysis / Container / Preservative

Sample ID	Comp/Grab	Matrix *	Depth	Date	Time	No. of Cntrs	ALK, Sulfate 250mlHDPE-NoPres	Dissolved Mn 250mlHDPE-NoPres	NO2NO3 250mlHDPE-H2SO4	NWTPHDXLVI[illegible] 40mlAmb-HCl-BT (w/ SGT)	RSK175 40mlAmb HCl	Sulfide 125mlAmb-S-NaOH+ZnAc	Total Fe, Mn 250mlHDPE-HNO3	V8260BTEXC 40mlAmb-HCl		Remarks	Sample # (lab only)
Pres Chk								V	<2				<2				
MW1-0817	Grab	GW	NA	08/31/17	1050	4				X				X			01
MW2-0817		GW			1508	11	X	X	X	X	X	X	X	X			02
MW20-0817		GW			1456	4				X				X			03
MW3-0817		GW			1319	11	X	X	X	X	X	X	X	X			04
MW4-0817		GW			1156	11	X	X	X		X	X	X				05
MW5-0817		GW			1708	4				X				X			06
MW6-0817		GW			1606	11	X	X	X	X	X	X	X	X			07
MW7-0817		GW			1422	4				X				X			08
		GW															6
TRIP BLANK		GW				1								X			09

* Matrix:
SS - Soil AIR - Air F - Filter
GW - Groundwater B - Bioassay
WW - WasteWater
DW - Drinking Water
OT - Other___________

Remarks:

pH _______ Temp _______
Flow _______ Other _______

Samples returned via:
__UPS X FedEx __Courier ___________

Tracking #

Sample Receipt Checklist
COC Seal Present/Intact: __NP Y __N
COC Signed/Accurate: Y __N
Bottles arrive intact: Y __N
Correct bottles used: Y __N
Sufficient volume sent: Y __N
If Applicable
VOA Zero Headspace: Y __N
Preservation Correct/Checked: Y __N

Relinquished by : (Signature) Kali Newman	Date: 09/01/17	Time: 1000	Received by: (Signature)
Relinquished by : (Signature)	Date:	Time:	Received by: (Signature)
Relinquished by : (Signature)	Date:	Time:	Received for lab by: (Signature)

Trip Blank Received: [✓ Yes] / No
[✓ HCL] / MeoH
TBR

Temp: 2.3 °C
Bottles Received: 60

Date: 9-2-17
Time: 845

If preservation required by Login: Date/Time

Hold:

Condition: NCF / [✓ OK]

APPENDIX D

MANN-KENDALL STATISTICAL TREND ANALYSIS OF SELECT WELLS

Module1: Mann-Kendall Trend Test for Plume Stability (Non-parametric Statistical Test)

Site Name: *Former Cummings Oil Lease Site*
Site Address: *Winlock, WA*
Additional Description:

Well (Sampling) Location? **MW-2**
Level of Confidence (Decision Criteria)? **85%**

1. Monitoring Well Information: Contaminant Concentration at a well: Quarterly sampling recommended.

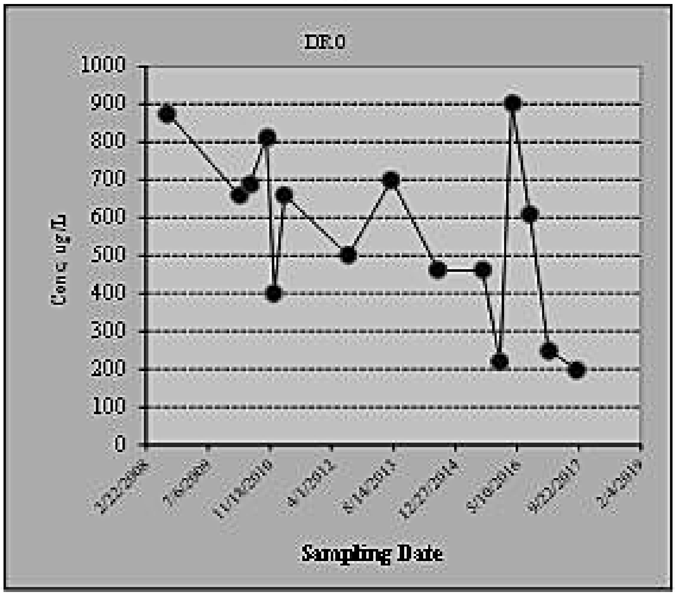
		Hazardous Substances (unit is ug/L)					
Sampling Event	Date Sampled	DRO					
#1	8/18/2008	876					
#2	3/11/2010	660					
#3	6/9/2010	690					
#4	10/20/2010	810					
#5	12/27/2010	400					
#6	3/22/2011	660					
#7	8/17/2012	500					
#8	8/1/2013	700					
#9	8/14/2014	460					
#10	8/6/2015	460					
#11	12/23/2015	220					
#12	3/28/2016	900					
#13	8/18/2016	610					
#14	1/18/2017	250					
#15	8/31/2017	200					
#16							

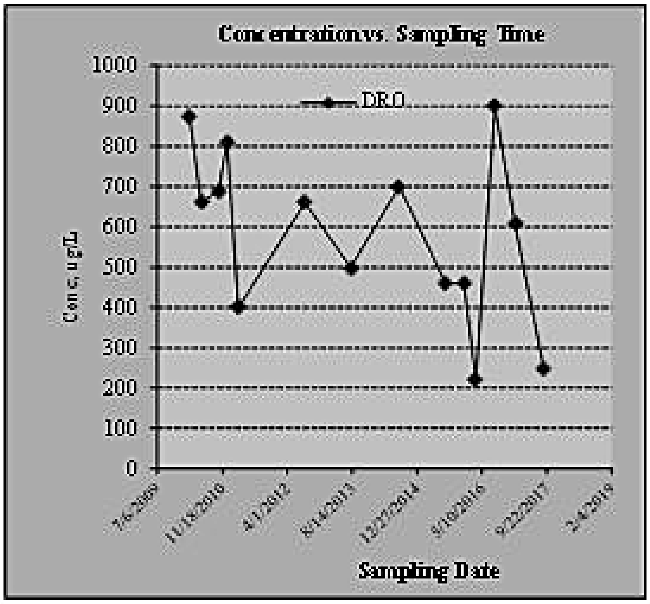
2. Mann-Kendall Non-parametric Statistical Test Results

Hazardous Substance?	**DRO**					
Confidence Level Calculated?	98.60%	NA	NA	NA	NA	NA
Plume Stability?	Shrinking	NA	NA	NA	NA	NA
Coefficient of Variation?		n<4	n<4	n<4	n<4	n<4
Mann-Kendall Statistic "S" value?	-45	0	0	0	0	0
Number of Sampling Rounds?	15	0	0	0	0	0
Average Concentration?	559.73	NA	NA	NA	NA	NA
Standard Deviation?	227.95	NA	NA	NA	NA	NA
Coefficient of Variation?	0.41	NA	NA	NA	NA	NA
Blank if No Errors found		n<4	n<4	n<4	n<4	n<4

3. Temporal Trend: Plot of Concentration vs. Sampling Time

Hazardous substance? **DRO**
Plume Stability? **Shrinking**





Module 2: Temporal Analysis: Concentration of contaminant vs. time (Regression Analysis at each well)

Site Name: *Former Cummings Oil Lease Site*
Site Address: *Winlock, WA*
Additional Description: *0*
Hazardous Substance *DRO*

1. Level of Confidence (Decision Criteria)? 90%

2. Prediction: Calculation of Restoration Time and Predicted Concentration at Wells

Well Location		MW-2	MW-3	MW-6	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
A. Cleanup Level (Criterion) to be achieved?	ug/L	500	500	500													
A.1 Average (@50% CL[1] best-fitting values)																	
Time to reach the criterion	yr	5.00	5.17	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Date when the Criterion to be achieved	date	8/18/13	10/17/13	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
A.2 Boundary (@90% CL)																	
Time to reach the criterion[2]	yr	9.77	7.17	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Date when the Criterion to be achieved	date	5/25/18	10/17/15	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B Date of Prediction?	date	11/16/17	11/16/17	11/16/17													
B.1 Average conc predicted (@50% CL)	ug/L	326.37	234.37	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B.2 Boundary conc predicted (@90% CL)	ug/L	513.61	378.39	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

3. Log-Linear Regression Results

Coefficient of Determination	r^2	0.369	0.661	0.216	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Correlation Coefficient	r	-0.607	-0.813	-0.465	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Number of data points	n	15	14	7	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

4. Statistical Inference on the Slope of the Log-Linear Regression Line with t-statistics

One-tailed Confidence Level calculated, %	98.366%	99.959%	70.650%	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sufficient evidence to support that the slope of the regression line is significantly different from zero?	YES!	YES!	NO!	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Coefficient of Variation?	NA	NA	0.579	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Plume Stability?	Shrinking	Shrinking	Stable	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

5. Calculation of Point Decay Rate Constant (k_{point})

Slope: Point decay rate constant (k_{point})	@50% CL	yr^{-1}	0.100	0.186	0.262	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	@90% CL	yr^{-1}	0.051	0.134	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Half Life for (k_{point})	@50% CL	yr	6.901	3.736	2.646	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	@90% CL	yr	13.479	5.181	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Note: 1. CL : Confidence Level; UD= Undetermined

2. The length of time that will actually be required is estimated to be no more than years calculated (@ 90% of confidence level.)

Module1: Mann-Kendall Trend Test for Plume Stability (Non-parametric Statistical Test)

Site Name: *Former Cummings Oil Lease Site*
Site Address: *Winlock, WA*
Additional Description:

Well (Sampling) Location? **MW-2**
Level of Confidence (Decision Criteria)? **95%**

1. Monitoring Well Information: Contaminant Concentration at a well: Quarterly sampling recommended.

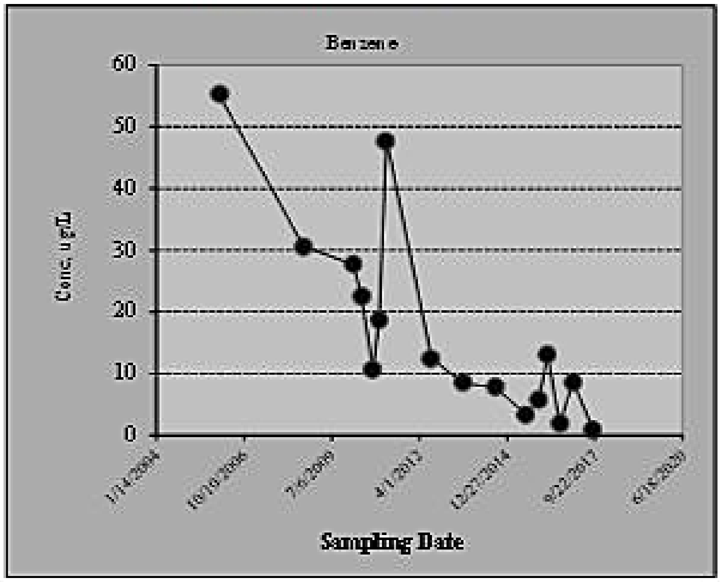
		Hazardous Substances (unit is ug/L)					
Sampling Event	Date Sampled	Benzene					
#1	12/23/2005	55.2					
#2	8/18/2008	30.6					
#3	3/11/2010	27.7					
#4	6/9/2010	22.4					
#5	10/20/2010	10.6					
#6	12/27/2010	18.6					
#7	3/22/2011	47.8					
#8	8/17/2012	12.6					
#9	8/1/2013	8.5					
#10	8/14/2014	7.8					
#11	8/6/2015	3.4					
#12	12/23/2015	5.9					
#13	3/28/2016	13					
#14	8/18/2016	2					
#15	1/18/2017	8.75					
#16	8/31/2017	1					

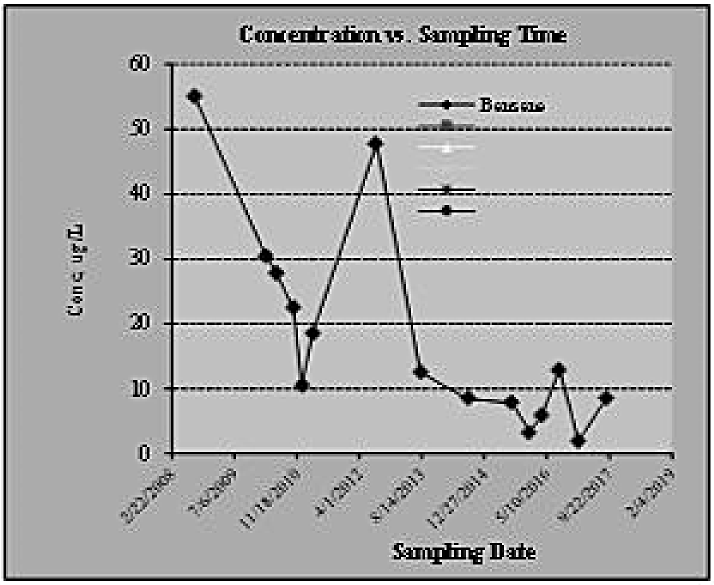
2. Mann-Kendall Non-parametric Statistical Test Results

Hazardous Substance?	**Benzene**					
Confidence Level Calculated?	100.00%					
Plume Stability?	Shrinking					
Coefficient of Variation?						
Mann-Kendall Statistic "S" value?	-82					
Number of Sampling Rounds?	16					
Average Concentration?	17.24					
Standard Deviation?	15.98					
Coefficient of Variation?	0.93					
Blank if No Errors found						

3. Temporal Trend: Plot of Concentration vs. Sampling Time

Hazardous substance? **Benzene**
Plume Stability? **Shrinking**





Module 2: Temporal Analysis: Concentration of contaminant vs. time (Regression Analysis at each well)

Site Name: *Former Cummings Oil Lease Site*
Site Address: *Winlock, WA*
Additional Description: *0*
Hazardous Substance *Benzene*

1. Level of Confidence (Decision Criteria)?

90%

2. Prediction: Calculation of Restoration Time and Predicted Concentration at Wells

Well Location		MW-2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
A. Cleanup Level (Criterion) to be achieved?	ug/L	5															
A.1 Average (@50% CL[1] best-fitting values)																	
Time to reach the criterion	yr	9.93	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Date when the Criterion to be achieved	date	11/24/15	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
A.2 Boundary (@90% CL)																	
Time to reach the criterion[2]	yr	12.96	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Date when the Criterion to be achieved	date	12/6/18	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B Date of Prediction?	date	11/16/17															
B.1 Average conc predicted (@50% CL)	ug/L	2.94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B.2 Boundary conc predicted (@90% CL)	ug/L	6.22	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

3. Log-Linear Regression Results

Coefficient of Determination	r^2	0.700	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Correlation Coefficient	r	-0.837	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Number of data points	n	16	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

4. Statistical Inference on the Slope of the Log-Linear Regression Line with t-statistics

One-tailed Confidence Level calculated, %	99.995%	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sufficient evidence to support that the slope of the regression line is significantly different from zero?	YES!	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Coefficient of Variation?	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Plume Stability?	Shrinking	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

5. Calculation of Point Decay Rate Constant (k_{point})

Slope: Point decay rate constant (k_{point})	@50% CL	yr^{-1}	0.269	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	@90% CL	yr^{-1}	0.206	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Half Life for (k_{point})	@50% CL	yr	2.577	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	@90% CL	yr	3.365	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Note: 1. CL : Confidence Level; UD= Undetermined

2. The length of time that will actually be required is estimated to be no more than years calculated (@ 90% of confidence level.)