2018 FIRST 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

August 2018

2018 FIRST SEMI-ANNUAL GROUNDWATER MONITORING REPORT

August 30, 2018

BNSF Former Cummings Oil Lease Site

Winlock, Washington

TRC Project No. 296308

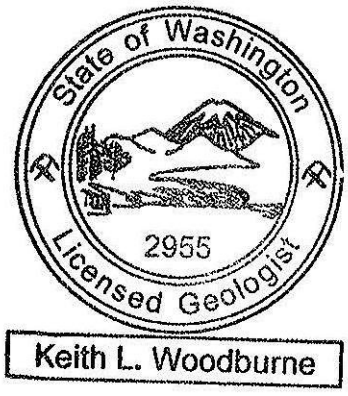
Prepared For:

BNSF Railway Company
605 Puyallup Avenue South
Tacoma, Washington 98421

By:

Amanda Meugniot, LG
Senior Geologist

Keith Woodburne L.G.
Senior Project Manager



TRC
19874 141st Place NE
Woodinville, Washington
(425) 489-1938

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1.0 INTRODUCTION

On behalf of the BNSF Railway Company (BNSF), TRC has prepared this *First Semi-Annual 2018 Groundwater Monitoring Report.* This report summarizes the groundwater monitoring activities conducted between January 17 and 18, 2018 at the Former Cummings Oil Lease Site (Site) located in Winlock, Washington.

2.0 SITE BACKGROUND

2.1 Site Description

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

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

2.2 Previous Investigations

Previous site investigations and remedial actions, including the removal of USTs and excavation of contaminated soil, confirmed releases to the subsurface had occurred as a result of historical activities at the Site. The following contaminants were identified 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*.

Various work was conducted at the Site from 2008 to 2010 and 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 January 17 – 18, 2018. Groundwater monitoring was conducted in accordance with TRC Standard Operating Procedures (SOPs), which 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 January 2018. Based on groundwater elevations recorded during the January 2018 monitoring event, the groundwater flow direction is generally to the west-southwest (Figure 3).

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

3.2 Groundwater Sampling Activities

During the January 2018 monitoring event, samples were collected from five (5) Site monitoring wells using low flow sampling techniques in accordance with TRC SOPs. Sampling of monitoring well MW-4 for analysis of Site-related contaminants was discontinued after 2014, however, a groundwater sample was collected from MW-4 during this event for analysis of natural attenuation parameters as discussed below. Sampling of wells MW-1 and MW-5 was discontinued beginning with this sampling event, as recommended in the *2017 First Semi-Annual Groundwater Monitoring Report* (TRC,

2017).

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 water quality parameters (temperature, pH, conductivity, dissolved oxygen [DO], oxidation reduction potential [ORP], and turbidity) were measured 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 (US EPA) guidelines for low-flow sampling, the discharge tubing was disconnected from the flow-through cell and groundwater samples were collected directly into 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 US 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 6020A;
- Nitrate-Nitrite by EPA Method 353.2;
- Sulfate by EPA Method 9056A;
- Sulfide by EPA Method 4500S2 D-2011;
- Methane, Ethane, and Ethene by Method RSK175;
- Alkalinity by EPA Method 2320 B-2011; 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 was detected in the groundwater samples from MW-2, MW-3, and MW-6 with reported concentrations between 201 and 302 micrograms per liter (µg/L). Benzene was detected in the duplicate groundwater sample from MW-2 with a reported concentration of 1.26 µg/L. The reported concentrations of DRO and benzene did not exceed their respective MTCA Method A cleanup levels of 500 µg/L and 5 µg/L. There were no other reported detections of site contaminants in the samples.

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 the 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 the only detection of benzene in well MW-6 was during 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 at the Site were favorable for natural attenuation processes to promote petroleum hydrocarbon degradation.

Monitoring wells MW-2, MW-3, and MW-6 are located within the footprint of the dissolved-phase TPH plume; MW-4 is inferred to be located beyond the extent of the plume (Figure 4). Wells within the plume exhibited field water quality values during the January 2018 monitoring event that were 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 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 TERRESTRIAL ECOLOGICAL EVALUATION (TEE)

TRC evaluated the eligibility of the Site for exclusion from Terrestrial Ecological Evaluation (TEE) under the criteria set forth in Washington Administrative Code (WAC) 173-340-7491 utilizing the Primary Exclusion documentation form. The Site does not qualify for exclusion from the TEE process because of the presence of soil contamination above the 15 foot point of compliance, the lack of physical barriers (i.e. buildings, paved roads, pavement) that would prevent exposure of plants or wildlife, the insufficient habitat surrounding the site to endanger ecological receptors, and the Site contaminants in soil at concentrations that exceed the natural background levels.

TRC performed a Simplified TEE following the procedure outlined in WAC 173-340-7492. An exposure analysis was completed using Ecology's Simplified TEE Table 4.2. The estimated area of contiguous, undeveloped land within 500 feet of the extent of the Site is approximately 0.50 acres which corresponds to a score of 5 for question 1 on Table 749-1. The combined score for questions 2 through 5 for the Site is 9 (greater than the score for question 1), therefore, the simplified evaluation is complete at the exposure analysis step per WAC 173-340-7492 (2) (a) (ii). Wildlife exposure to contamination at the Site and surrounding area is considered unlikely and the Site does not pose an ecological threat.

Supporting documentation for the TEE activities described above is provided in Appendix D.

5.0 SUMMARY AND FUTURE MONITORING

5.1 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 E). The restoration timeframe calculator included in the tool package projected with a 90 percent confidence interval that benzene concentrations will be consistently below MTCA Method A cleanup levels in December 2018 and DRO concentrations will be consistently 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.

5.3 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 be included in future events in order to monitor groundwater conditions downgradient of onsite well MW-3. Sampling of up-gradient well MW-4 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 was discontinued beginning with this sampling event, as recommended in the *2017 First Semi-Annual Groundwater Monitoring Report* (TRC, 2017).

Wells MW-2, MW-3, MW-4, and MW-6 will continue to be sampled for natural attenuation parameters in order to evaluate ongoing hydrocarbon degradation in Site groundwater

Semi-annual groundwater monitoring is scheduled to continue with the August 2018 event. After the completion of the second semi-annual sampling event in August 2018, impacts and observed trends will be evaluated. Recommendations for future monitoring activities will be included report summarizing the August 2018 sampling event.

6.0 REFERENCES

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

Farallon, 2010, *Tank Closure Report, Former Cummings Oil Lease Site, 908 Northwest Kerron Avenue, Winlock, Washington.* March 11.

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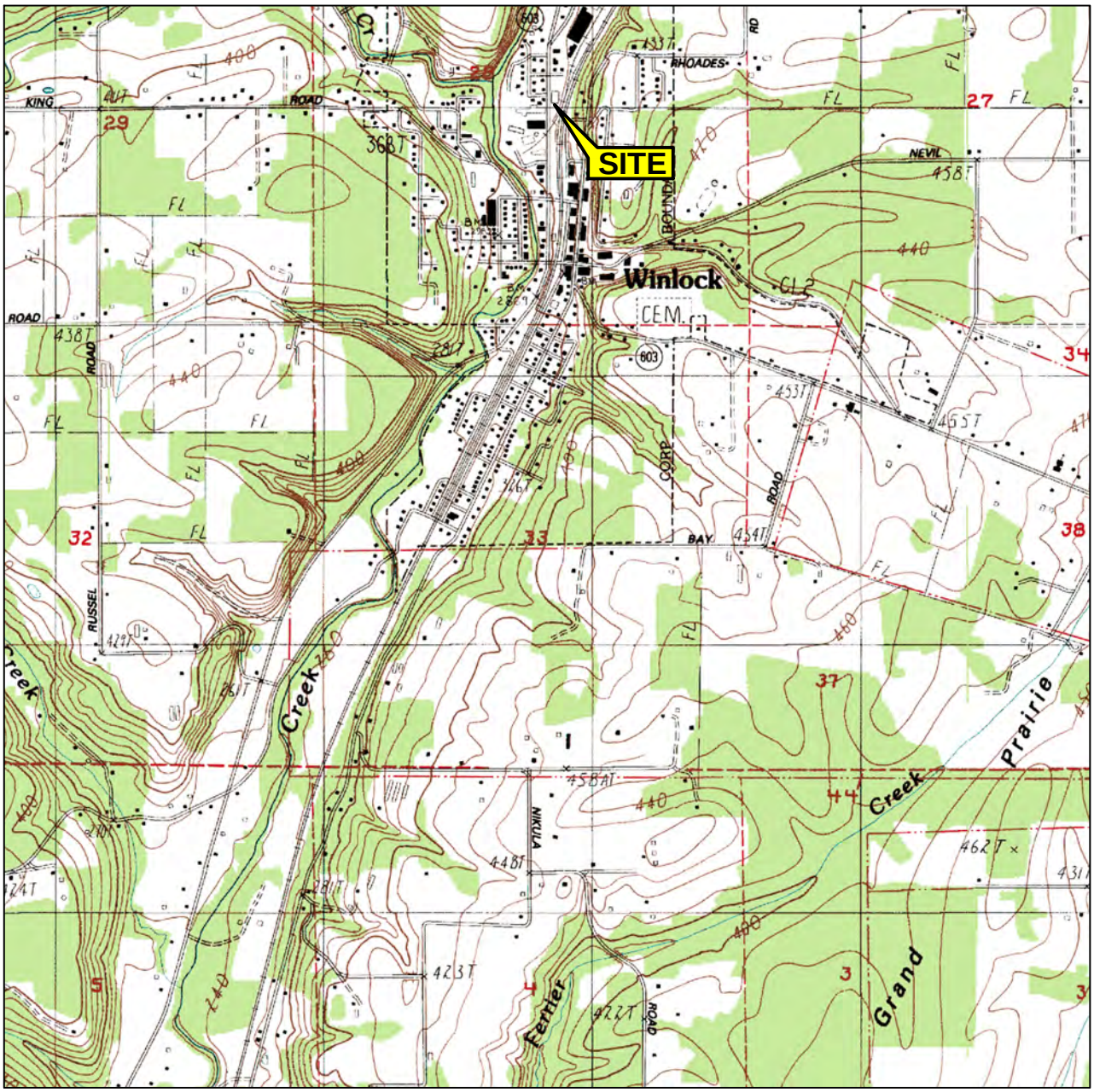
FIGURES



1 MILE 3/4 1/2 1/4 0 1 MILE

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SOURCE:

United States Geological Survey
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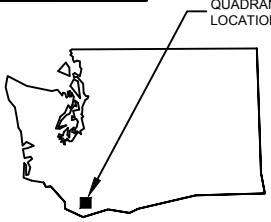
Winlock Quadrangles, Washington



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19874 141st Place N.E.
Woodinville, WA 98072
Phone: 425.489.1938
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PROJECT:

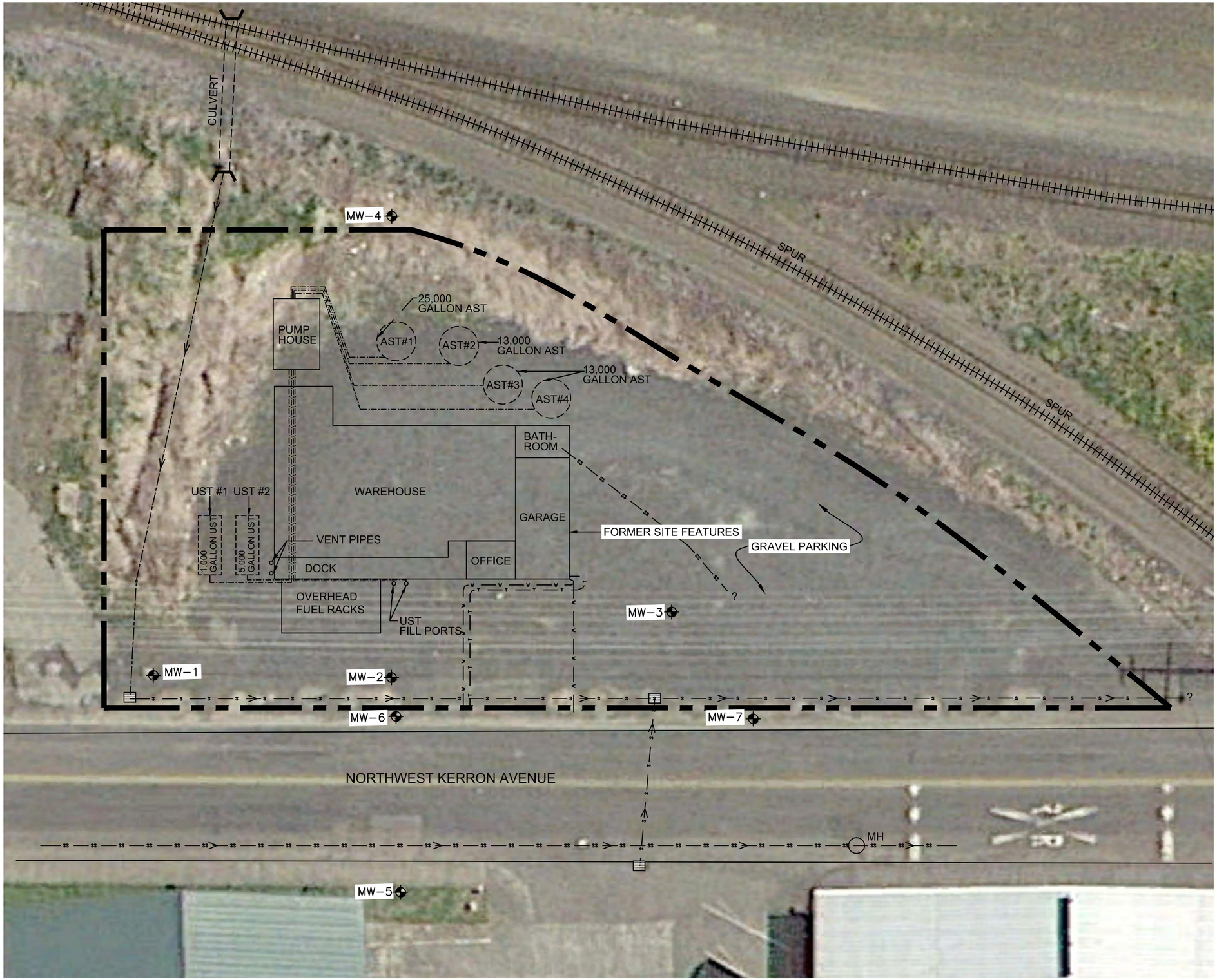
FORMER CUMMINGS OIL LEASE SITE
908 NORTHWEST KERRON AVENUE
WINLOCK, WASHINGTON

TITLE:

VICINITY MAP

DRAWN BY:	R. Collins
CHECKED BY:	K. Newman
APPROVED BY:	A. Meugniot
DATE:	January 2018
PROJ. NO.:	296308
FILE:	Winlock_Fig1_Vicinity Map.dwg

FIGURE 1



LEGEND

- PROPERTY BOUNDARY
- RAILROAD TRACKS
- STORM LINE
- SANITARY SEWER
- FORMER LOCATION OF WATER LINE
- 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.:	296308
CHECKED BY:	K. Newman		
APPROVED BY:	A. Meugniot		**FIGURE 2**
DATE:	January 2018		

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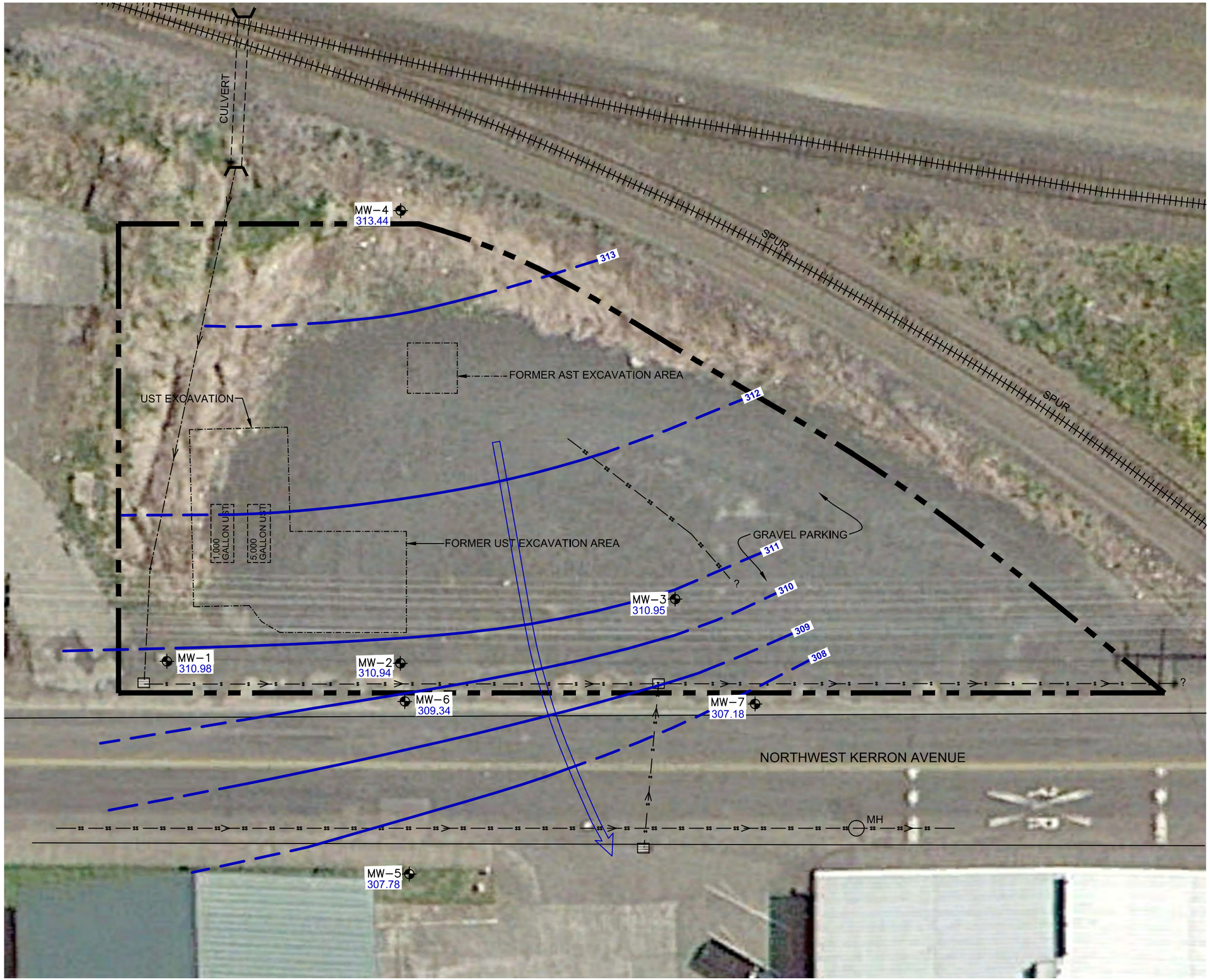
FILE NO.: Winlock_Fig2_Site Plan.dwg



LEGEND

- PROPERTY BOUNDARY
- RAILROAD TRACKS
- DRAINAGE DITCH AND DIRECTION OF FLOW
- STORM SEWER LINE AND DIRECTION OF FLOW
- SANITARY SEWER AND DIRECTION OF FLOW
- MH — MANHOLE
- MW–3 — MONITORING WELL (FARALLON 2006 AND 2014)
- 310.95 — GROUNDWATER ELEVATION (JANUARY 2018)
- 313 — GROUNDWATER ELEVATION CONTOUR LINE, DASHED WHERE INFERRED
- GENERAL DIRECTION OF GROUNDWATER GRADIENT
- 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:
GROUNDWATER ELEVATION CONTOUR MAP JANUARY 2018

DRAWN BY:	R. Collins	PROJ NO.:	296308
CHECKED BY:	K. Newman		
APPROVED BY:	A. Meugniot		**FIGURE 3**
DATE:	January 2018		

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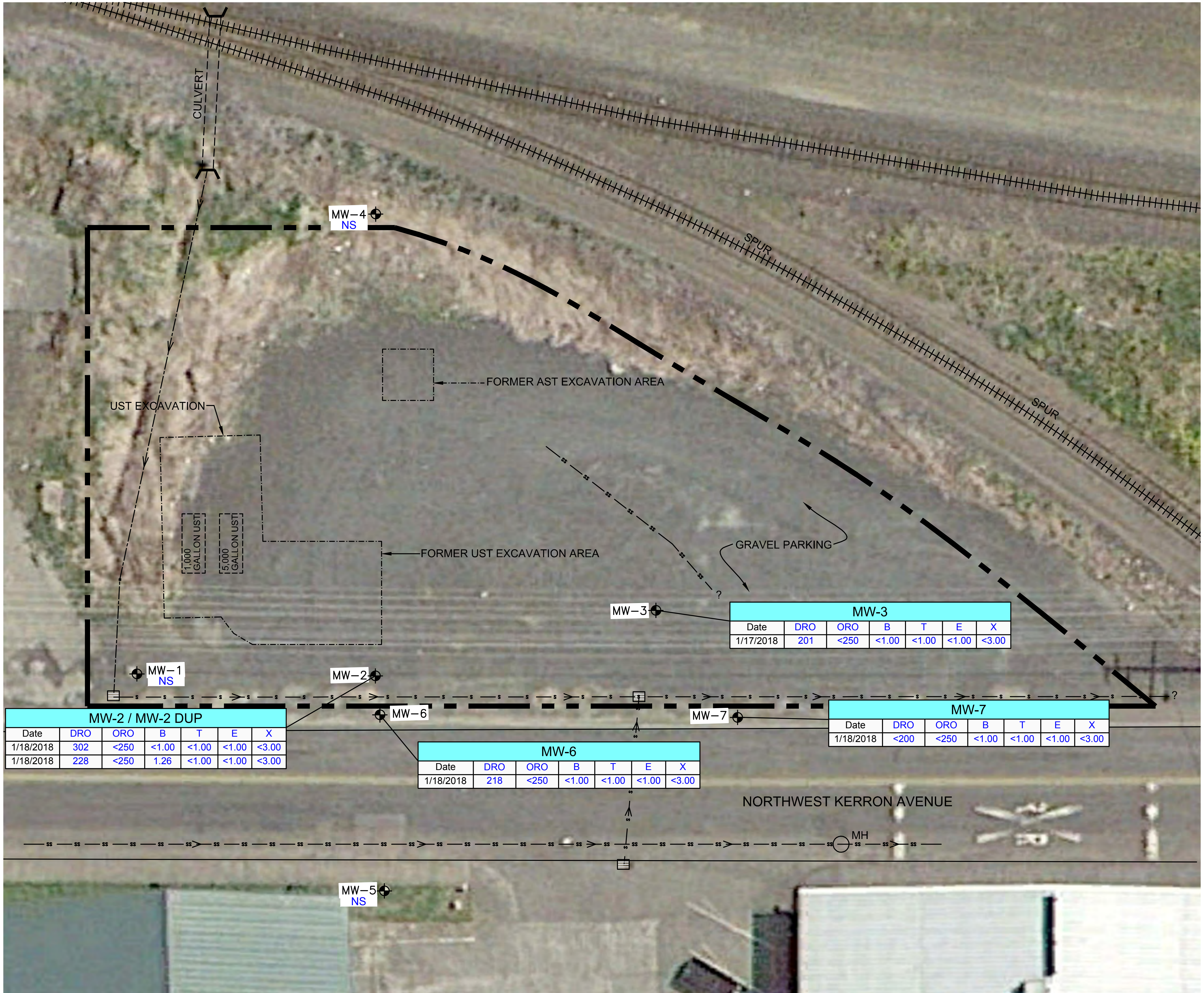
FILE NO.: Winlock_Fig3_GW_Jan2018.dwg



MW-3

Date	DRO	ORO	B	T	E	X
1/17/2018	201	<250	<1.00	<1.00	<1.00	<3.00

MW-2 / MW-2 DUP

Date	DRO	ORO	B	T	E	X
1/18/2018	302	<250	<1.00	<1.00	<1.00	<3.00
1/18/2018	228	<250	1.26	<1.00	<1.00	<3.00

MW-6

Date	DRO	ORO	B	T	E	X
1/18/2018	218	<250	<1.00	<1.00	<1.00	<3.00

MW-7

Date	DRO	ORO	B	T	E	X
1/18/2018	<200	<250	<1.00	<1.00	<1.00	<3.00

LEGEND

- PROPERTY BOUNDARY
- RAILROAD TRACKS
- DRAINAGE DITCH AND DIRECTION OF FLOW
- STORM SEWER LINE AND DIRECTION OF FLOW
- SANITARY SEWER AND DIRECTION OF FLOW
- MH — MANHOLE
- MW–3 — MONITORING WELL (FARALLON 2006 AND 2014)
- CATCH BASIN

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.

NS = NOT SAMPLED.

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
JANUARY 2018

DRAWN BY:	R. Collins	PROJ NO.:	296308
CHECKED BY:	K. Newman	**FIGURE 4**	
APPROVED BY:	A. Meugniot		
DATE:	January 2018		

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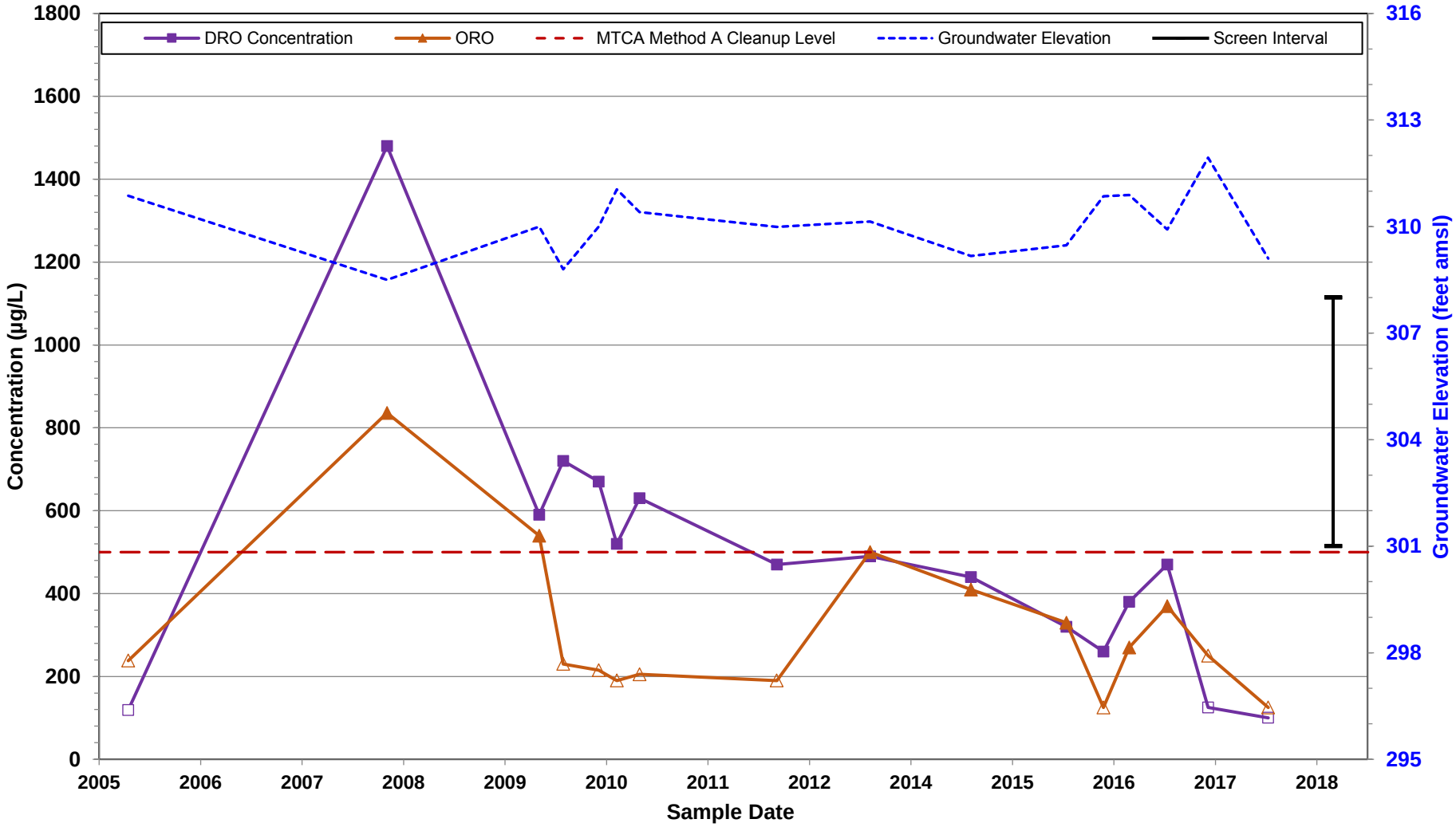
FILE NO.: Winlock_Fig4_TPHd_Jan2018.dwg

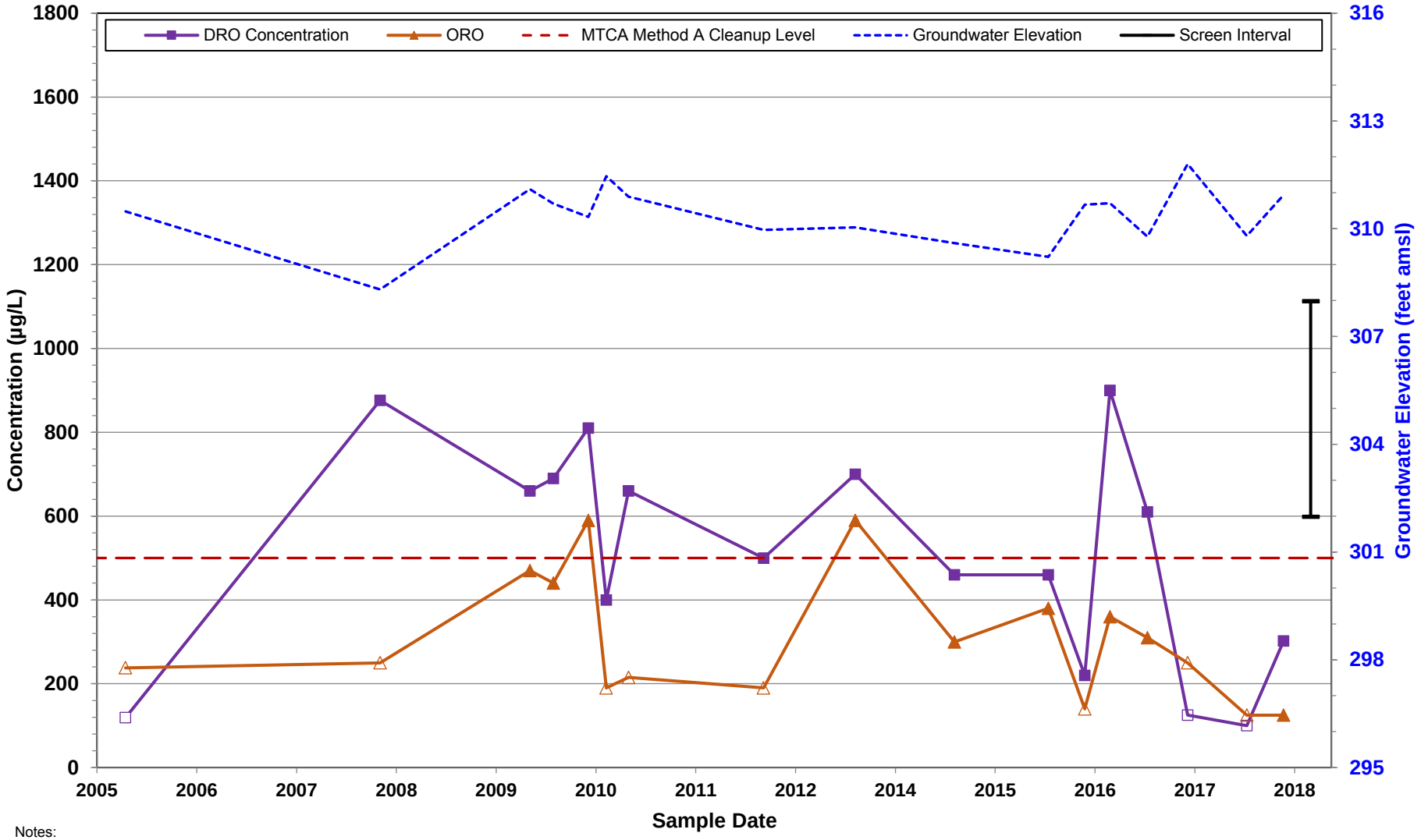
DRAWING NAME: L:\Graphics\Projects by Name\BNSF Winlock\296308\ Winlock_Fig4_TPHd_Jan2018.dwg -- PLOT DATE: February 21, 2018 - 11:46AM -- LAYOUT: 11x17_L

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



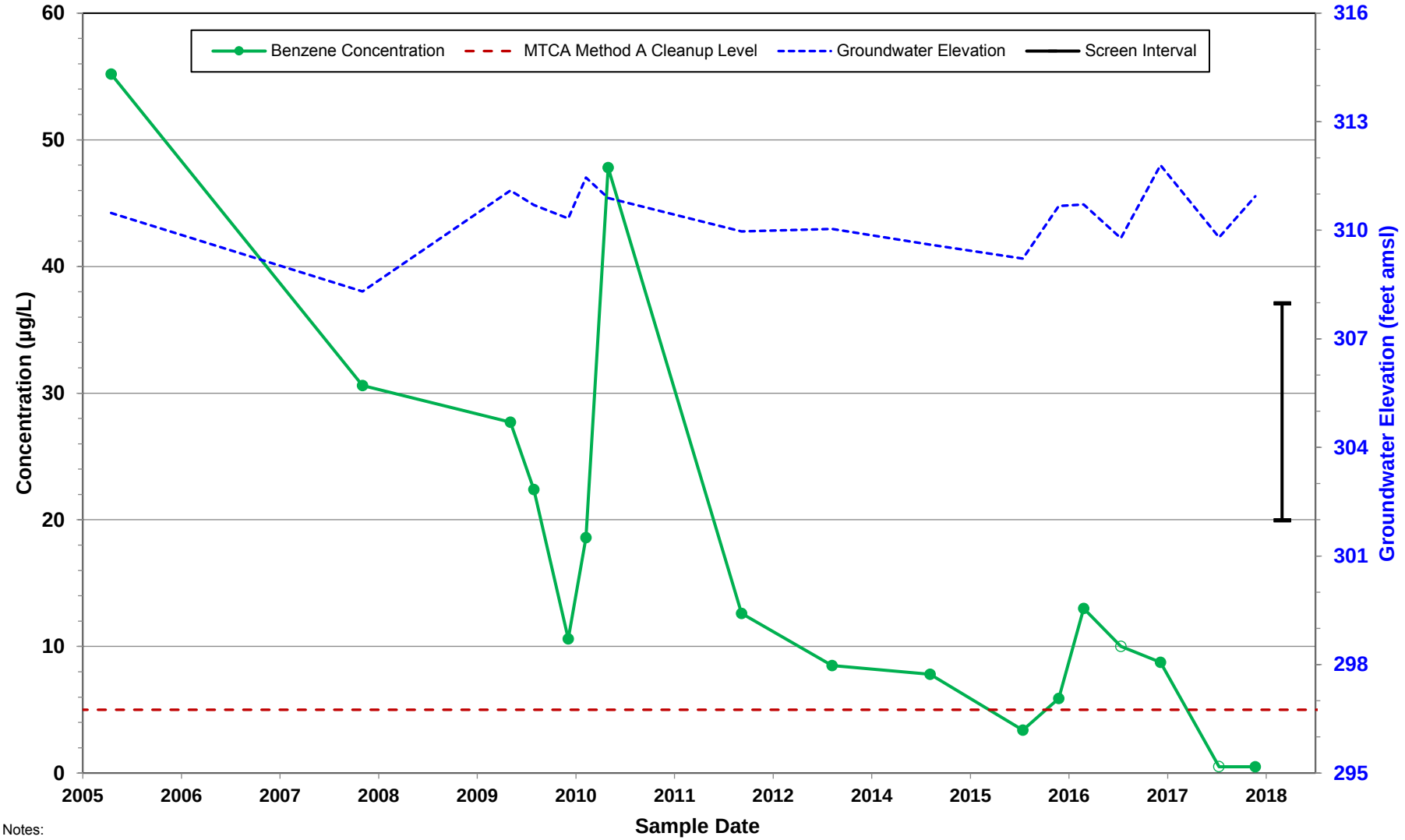
Notes:
1. Non-detect (ND) results are shown as a white box or triangle at half the laboratory reporting limit.
2. Model Toxics Control Act (MTCA) Cleanup level for diesel-range organics (DRO) and oil-range organics (ORO) is 500 micrograms per liter (µg/L).
3. amsl = above mean sea level

Figure 6
Groundwater Elevation versus DRO and ORO - MW-2
Former Cummings Oil Lease Site
Winlock, Washington



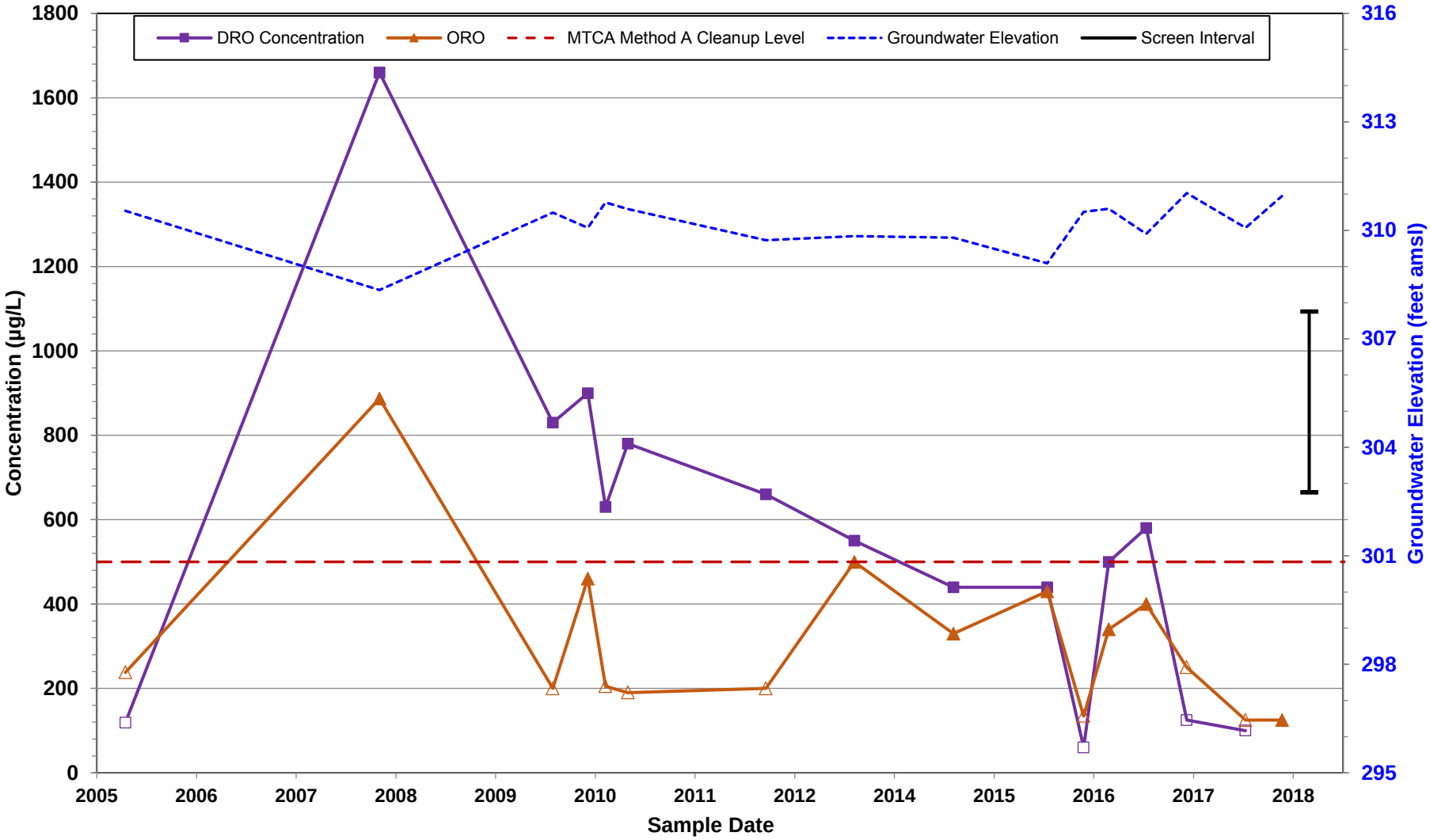
Notes:
1. Non-detect (ND) results are shown as a white box or triangle at half the laboratory reporting limit.
2. Model Toxics Control Act (MTCA) Cleanup level for diesel-range organics (DRO) and oil-range organics (ORO) is 500 micrograms per liter (µg/L).
3. amsl = above mean sea level

Figure 7
Groundwater Elevation versus Benzene - MW-2
Former Cummings Oil Lease Site
Winlock, Washington



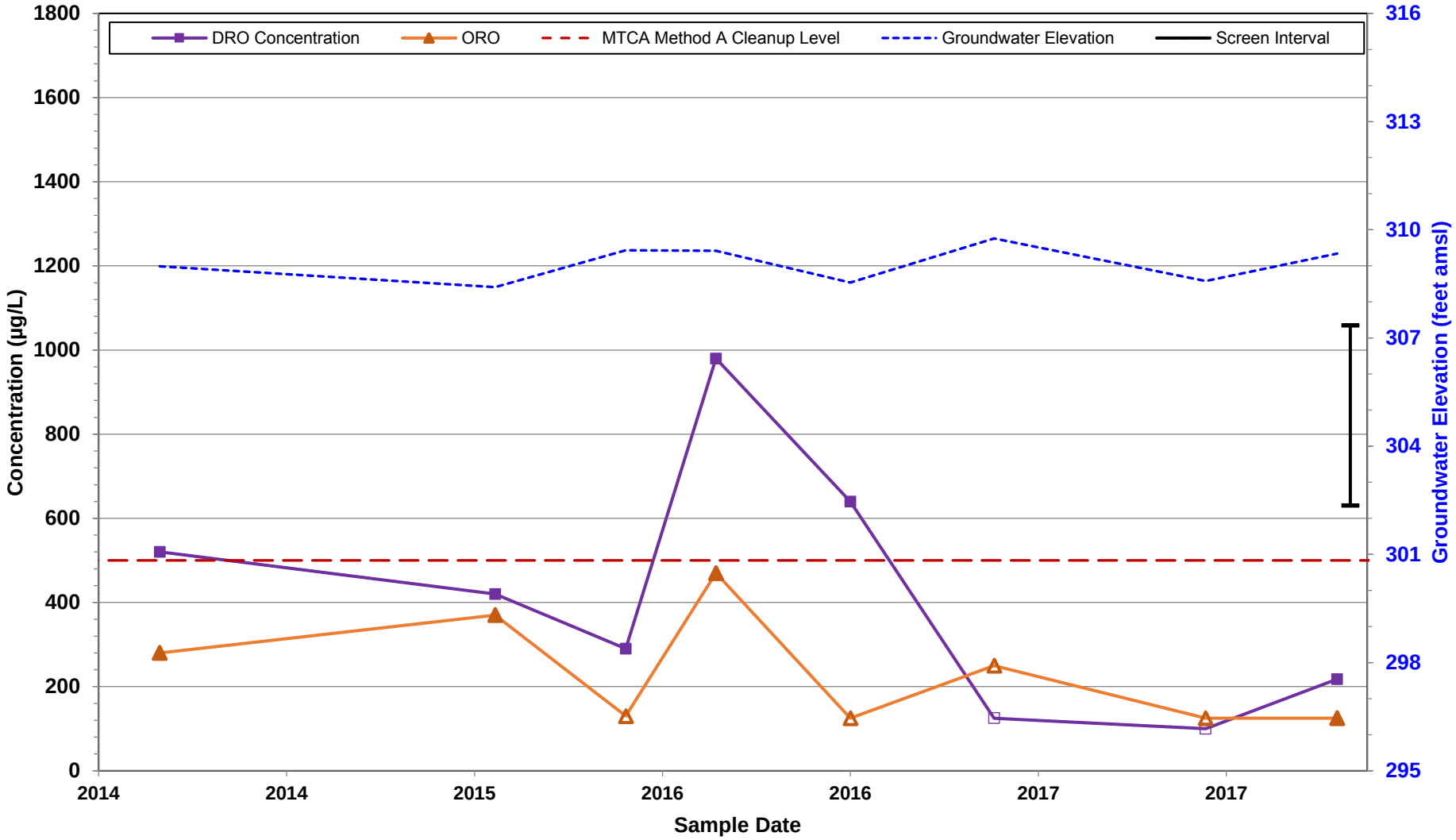
Notes:
1. Non-detect (ND) results are shown as a white circle at half the laboratory reporting limit.
2. Model Toxics Control Act (MTCA) Cleanup level for benzene is 5 micrograms per liter (µg/L).
3. amsl = above mean sea level

Figure 8
Groundwater Elevation versus DRO and ORO - MW-3
Former Cummings Oil Lease Site
Winlock, Washington



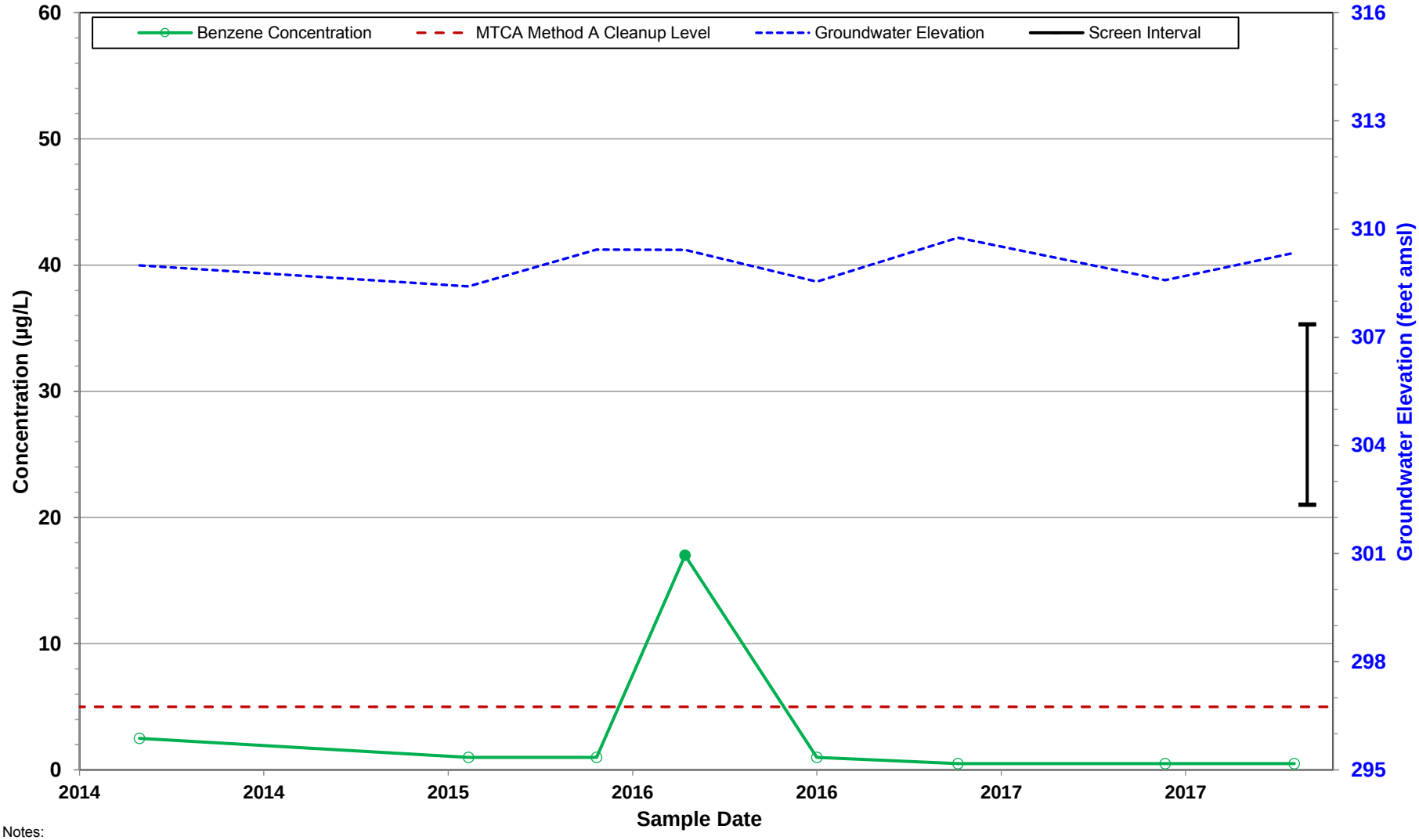
Notes:
1. Non-detect (ND) results are shown as a white box or triangle at half the laboratory reporting limit.
2. Model Toxics Control Act (MTCA) Cleanup level for diesel-range organics (DRO) and oil-range organics (ORO) is 500 micrograms per liter (µg/L).
3. amsl = above mean sea level

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
		1/17/2018			2.02	310.98
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
		1/17/2018			2.04	310.94

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
		1/17/2018			1.80	310.95
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
		1/17/2018			1.45	313.44

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
		1/17/2018			4.67	307.78
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
		1/17/2018			3.01	309.34
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
		1/17/2018			5.23	307.18

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	--	--	--	--	--	--
	1/17/2018	--	--	--	--	--	--	--	--	--	--	--	--	--
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	--	**--**	--	--	--	--
	1/18/2018	302	<250	--	<1.00	<1.00	<1.00	<3.00	--	**--**	--	--	--	--
	1/18/18 (dup)	228	<250	--	1.26	<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	--	--	--	--	--	--
	1/17/2018	201	<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	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-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	--	--	--	--	--	--	--	--	--	--	--	--	--
	1/18/2018	--	--	--	--	--	--	--	--	--	--	--	--	--
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	--	--	--	--	--	--
	1/18/2018	--	--	--	--	--	--	--	--	--	--	--	--	--

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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-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	--	--	--	--	--	--
	1/18/2018	218	<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	--	--	--	--	--	--
	1/18/2018	<200	<250	--	<1.00	<1.00	<1.00	<3.00	--	--	--	--	--	--

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	Water Quality Parameters						Geochemical Parameters											
		Temperature	pH	Conductivity	Turbidity	DO	ORP	Nitrate | Nitrite[a]	Sulfate	Sulfide	Total Iron	Ferrous Iron	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	mg/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	-7.70	--	--	--	--	--	--	—	--	--	--	--	--
	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	0.080[c]	34.3	--	--	3.2	--	22.0	--	--	--	--	--
	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	--	--	--	--	--	--	--	--	--	--	--	--
	1/17/2018	9.26	5.30	0.125	15.2	1.57	-166.4	--	--	--	--	--	--	--	--	--	--	--	--
MW-2	8/18/2008	17.65	6.64	0.316	--	0.99	-77.20	<0.200	0.4	--	--	--	--	1,660	--	--	--	--	--
	3/11/2010	9.93	7.28	0.247	--	0.77	101.2	<0.20	30.3	--	--	--	--	1,620	--	--	--	--	--
	6/9/2010	14.48	6.84	0.277	--	1	75.8	<0.050	7.9	--	--	3.2	--	3,500	--	--	--	--	--
	10/20/2010	16.76	6.61	0.279	--	0.91	-50.3	<0.20	11.2	--	--	1.3	--	6,320	--	--	--	--	--
	12/27/2010	10.39	6.6	0.305	--	0.39	-78.5	<0.20	12.5	--	--	30.2	--	2,980	--	--	--	--	--
	3/22/2011	8.97	6.63	0.253	--	0.57	191.6	0.10[c]	8.3	--	--	1.8	--	1,160	--	--	--	--	--
	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	0.9	-64.2	<0.100	<5.0	<0.05	20.9	6.5[b]	14.4	3,650	125,000	377	372	<13.0	<13.0
	1/18/2018	7.57	5.87	0.156	29.3	1.31	-146.4	<0.100	<250	<0.05	22.6	3.0[b]	19.6	2,530	97,300	372	428	<13.0	<13.0
MW-3	8/18/2008	17.38	6.34	0.382	--	1.08	-75.60	--	--	--	--	--	--	—	--	--	--	--	--
	3/11/2010	--	--	--	--	--	--	--	--	--	--	--	--	—	--	--	--	--	--
	6/9/2010	13.87	6.36	0.387	--	0.50	-6.80	<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	0.073[c]	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[b]	12.1	137	131,000	571	574	<13.0	<13.0
	1/17/2018	8.56	5.60	0.201	>1,000	2.73	-74.2	<0.100	<250	<0.05	40.8	3.5[b]	37	140	111,000	511	698	<13.0	<13.0

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

Monitoring Well	Date Sampled	Water Quality Parameters						Geochemical Parameters											
		Temperature	pH	Conductivity	Turbidity	DO	ORP	Nitrate | Nitrite[a]	Sulfate	Sulfide	Total Iron	Ferrous Iron	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	mg/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	-74.90	<0.200	16.7	--	--	--	--	22.8	--	--	--	--	--
	3/11/2010	9.59	7.92	0.255	--	0.57	85.60	<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	0.12[c]	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[b]	7.4	27.2	89,500	504	499	<13.0	<13.0
	1/18/2018	9.09	5.89	0.12	70.1	1.00	-176.3	<0.100	8.28	<0.05	7.8	1.5[b]	6.3	34.6	76,200	412	440	<13.0	<13.0
MW-5	8/18/2008	17.57	6.62	0.466	--	1.45	-31.60	--	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	0.48[c]	7.0	--	--	0.50	--	<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	--	--	--	--	--	--	--	--	--	--	--	--
	1/18/2018	9.34	6.14	0.209	3.33	2.99	-191.8	--	--	--	--	--	--	--	--	--	--	--	--
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	<0.100	<5	<0.05	20.6	6.0[b]	14.6	3,070	121,000	442	425	<13.0	<13.0
	1/18/2018	8.78	5.90	0.201	15.8	1.28	-132.2	<0.100	<5	<0.05	28.4	3.5[b]	25	3,960	131,000	486	574	<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	--	--	--	--	--	--	--	--	--	--	--	--
	1/18/2018	9.14	6.12	0.179	15.1	2.78	-177.4	--	--	--	--	--	--	--	--	--	--	--	--

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

Monitoring Well	Date Sampled	Water Quality Parameters						Geochemical Parameters											
		Temperature	pH	Conductivity	Turbidity	DO	ORP	Nitrate | Nitrite[a]	Sulfate	Sulfide	Total Iron	Ferrous Iron	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	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L

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

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

PARAMETER	CATEGORY	RESULTS	INTERPRETATION[a]
pH	Water Quality	5.30 to 6.14	pH is between 5 and 7, which is within the range considered suitable for hydrocarbon-degrading microorganisms.
Dissolved Oxygen (DO)	Electron Acceptor	1.00 to 2.99 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	428 / 372 µg/L to 698 / 511 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+)[b]	Electron Donor	6.3 mg/L to 37 mg/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	-191.8 mV to -74.2 mV	ORP values in site groundwater are negative which indicate reduced condtions.
Methane (CH_4)	Metabolic By-Product	34.6 µg/L to 3,690 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	76,200 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

TRC STANDARD OPERATING PROCEDURES

Title: **Field Activity Documentation for Environmental Investigations**	Procedure Number: **RMD 001**
	Revision Number: **0**
	Effective Date: **January 2013**

Authorization Signatures

Terrance Hertz 1/25/2013	Elizabeth Denly 1/30/2013
Technical Reviewer Terrance Hertz — Date	Remediation Practice Quality Coordinator Elizabeth Denly — Date

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ATTACHMENTS

1.0 INTRODUCTION

1.1 Scope & Applicability

This Standard Operating Procedure (SOP) guides TRC personnel in the documentation of field activities for environmental investigations.

Field activity documentation is one of the most important activities that occur during field work. There is abundant information available for documenting the details of field work at the time the field work is taking place. It is critical that sufficient detail be documented during field work as it happens to allow others not present during the field activities to fully comprehend the field procedures and conditions at the time of the field work.

The objective of documenting field activities is to ensure that a collection of facts is recorded, the activities can be reconstructed from the documentation, and that the field activities are adequately logged in a manner that will be acceptable if the record is required as evidence in legal proceedings. An additional objective of adequately documenting field activities is to provide complete information that is useful and understandable to someone other than the note taker. Because the field books and field data forms provide the basis for future reports and analysis, facts and observations must be accurately recorded. Some regulatory agencies require that a copy of the field notes be included as part of the report submittal.

This SOP was not intended for use if computer tablets will be used. Consult with the Remediation Practice Quality Coordinator for procedures when tablets will be used.

1.2 Equipment

The following list is an example of items that may be utilized for field activity documentation. Project-specific conditions or requirements may warrant the use of additional items or deletion of items from this list.

- Field book(s) – bound book with water-resistant pages
- Indelible marking pens
- Field data forms – generic or project-specific
- Digital camera
- Pocket ruler
- GPS device

2.0 PROCEDURES

All entries must be legible and must be made in blue or black permanent ink, signed or initialed, and dated. No erasures or obliterations can be made. If an incorrect entry is made, the information must be crossed out with a single strike mark which is signed or initialed and dated by the person recording the information. The correction must be written adjacent to the error.

The original entry should still be legible even though crossed out. Pages should never be removed from a field book.

2.1 Setup of Field Book and Logs

When multiple field personnel are on site, the Field Team Leader should decide the appropriate distribution of field books, field logs or project-specific forms necessary to document field activities. It is not necessary for each participant to take field notes.

1. Each field book assigned to a project should have the following information on the title page (the inside cover of the field book):

    - Project name
    - Site address
    - Site contact, if available
    - Project number(s)
    - TRC's name, address and phone number
    - Start and end dates of field book entries

2. Each field book may have a designated number (i.e., Book #1, Book #2, etc.) listed on the outside front cover.

3. Each field book will be a bound field survey book or notebook, water-resistant, and have sequentially numbered pages.

4. Other field books may or may not be required, dependent on the project needs, at the discretion of the Project Manager.

2.2 Documentation Requirements for Field Books or Daily Field Report Logs

Data collection activities performed during the field effort will be recorded in field books or on Daily Field Report Logs. Entries will be of adequate detail so that others will be able to comprehend a particular situation and it will be possible to reconstruct each activity without reliance on memory.

Entries into the field book or Daily Field Report Log may contain a variety of information. The terminology used in recording all field data should be objective, factual, and free of personal interpretation that may prove inappropriate. At the beginning of each daily entry, the date, start time, weather, and names of all field team members present will be entered. It is good practice to record the date on every page. The start and end of each day's entries in the field book or Daily Field Report Log will be signed or initialed and dated by the person(s) making the entry.

In general, it is expected that field notes will be collected every 15 minutes, as appropriate. Information included in the field book or Daily Field Report Log may include, but need not be limited to, the following:

- Chronology of activities, including entry and exit times;
- Names of all people involved in field activities and organizational affiliations;
- Level of personal protection used (if different from site-specific protocol/plan);

- Any changes made to site-specific protocol/plan
- Names of visitors to the site during field work and reason for their visit (unless in Daily Personnel Log)
- Sample location and identification
- Weather conditions, including temperature and any precipitation
- Day's objectives/scope of work
- Vehicle used (personal, rental) with travel time to site and mileage
- Measurement equipment identification (model/manufacturer) and calibration information
- Summary of equipment brought by subcontractor
- Communications while on site impacting site-specific protocol/plan
- Field screening results
- Site observations
- Sample collection methods and equipment
- Sample collection date (month/day/year) and time (military)
- Sample depths
- Whether grab or composite sample collected
- How sample composited, if applicable
- Sample description (color, odor, texture, etc.)
- Tests or analyses to be performed
- Sample preservation and storage conditions
- Equipment decontamination procedures
- QC sample collection
- Sample shipping methods, including tracking numbers, if applicable
- Unusual events or observations
- Record of photographs (unless in Photograph Log)
- Volume and type of investigation derived waste generated
- Sketches or diagrams
- Signature or initials of person recording the information

Upon receipt of the field book or Daily Field Report Log for a particular activity, the designated person recording the notes will begin recording notes on a new page. The person(s) recording the notes will sign/initial the new page and indicate the date, time, and weather conditions, prior to recording information about the field activity. The field book or Daily Field Report Log should indicate whether any Field Data Forms are being used. When the designated person recording the notes either relinquishes the field book or Daily Field Report Log to another team member or turns the book or log in at the end of the day, the person relinquishing the field book or Daily Field Report Log will affix a signature and date to the bottom of the last page used. If the page is not full, a diagonal line should be struck across the blank portion of the page. An example field book page is provided in Attachment A. An example Daily Field Report Log is provided in Attachment B.

Field data forms may be used to document sampling information for routine activities that have an associated form. A stockpile of blank forms will be kept in the field trailer/office or with the Field Team Leader. The field book or Daily Field Report Log should reference the form used during that event. Examples of TRC field data forms include:

- Sample log sheets (e.g., groundwater, sediment, soil gas, indoor air)
- Groundwater static water level data sheet
- Slug test data sheet

- Monitoring well construction summary/well development
- Monitoring well decommissioning
- Photograph log
- Soil boring/Rock core log
- Equipment log
- Calibration log

2.3 Documentation Requirements for Daily Personnel Logs

If applicable, the Daily Personnel Log will be maintained in the field trailer/office or by the Field Team Leader for the duration of the project to record the identities of all personnel who are on site. The following information will be recorded on Daily Personnel Logs:

- Names of field personnel
- Names of subcontractor personnel
- Names of visitors
- Affiliation of each person on site
- Date/time of entry and exit

2.4 Documentation Requirements for Photograph Logs

A field book/Daily Field Report Log entry or Photograph Log will be used to record the date and time of photographs taken at the project site. Digital cameras that imprint the date and time of the photograph may also be used to document conditions; however, prior to taking any site photographs with a digital camera, the photographer must verify the correct clock and calendar settings in the camera. An appropriate site figure may be used to note the location and direction of photographic documentation and should be referenced and attached to the log, if used. Examples of items that warrant photographic documentation include:

- General site topography
- Sampling and/or drilling locations
- Existing monitoring well locations
- Pre-existing property conditions and conditions following restoration
- Physical appearance of environmental samples
- Evidence of possible contamination
- Well casing or pad damage
- Rock cores

2.5 Documentation Requirements for Equipment Calibration Logs

A field book/Daily Field Report Log entry or Equipment Calibration Log will be completed to record appropriate information for the instruments calibrated each day. This information may include:

- Equipment manufacturer, model number and serial number
- Dates and times of calibration
- Supplies used (e.g., calibration gas)
- Individual who performed the calibration
- Adjustments made to the instrument during calibration

- Notes regarding the maintenance of the instrument

2.6 Documentation Requirements for Health and Safety Logs

A field book/Daily Field Report Log entry or Health and Safety Log will be completed to record Health and Safety issues during field activities. Entries may include:

- Daily health and safety meeting prior to performing work
- Any injuries, illnesses, near-misses, or the use of first aid supplies
- Activity under Level D conditions or the use of specific personal protective equipment (for Levels A, B or C only, if needed)
- Occurrence of possible work-related symptoms
- The date, name(s) of affected individuals and a description of the issue or incident and response
- A record of air monitoring results, any action level exceedances, and actions taken as the result of any action level exceedances

2.7 Documentation Requirements for Air Monitoring Logs

A field book/Daily Field Report Log entry or Air Monitoring Log will be completed to record monitoring results from real-time air monitoring instruments during field activities. The air monitoring devices will be located and operated in accordance with the Air Monitoring Plan. For hand-held instruments without data logging capabilities, readings will be recorded in the field book/Daily Field Report Log or on the Air Monitoring Log. For instruments with data logging capabilities, the instruments will be periodically checked, with results recorded in the field book/Daily Field Report Log or on the Air Monitoring Log. Data will be downloaded at the end of each workday and maintained in the project files.

3.0 QUALITY ASSURANCE/QUALITY CONTROL

The Field Team Leader has the responsibility to maintain the various logs, forms, and books that document daily field activities. Individual responsibilities may be delegated to other field staff, as appropriate.

Quality control procedures will place emphasis on the completeness and accuracy of all information recorded in the field and will be used to confirm that field notes contain statements that are legible, accurate, and comprehensive documentation of project activities. Field books/Daily Field Report Logs should be reviewed on a frequent basis by the Field Team Leader to confirm that:

- Field books/Daily Field Report Logs and standardized forms have been filled out completely and that the information recorded accurately reflects the activities that were performed.

- Records are legible and in accordance with good record-keeping procedures, i.e., entries are signed or initialed and dated, data are not obliterated, and changes are initialed, dated, and explained.

- Sample collection, handling, preservation, and storage procedures were conducted in accordance with the protocols described in the project plans, and that any deviations were documented and approved by the appropriate personnel.

- Instruments were calibrated and operated in accordance with the procedures specified in the project plans.

4.0 INVESTIGATION-DERIVED WASTE DISPOSAL

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

5.0 DATA MANAGEMENT AND RECORDS MANAGEMENT

The Project Manager or Field Team Leader will maintain an inventory of all field books/Daily Field Report Logs used during the program and will be responsible for ensuring that they are archived in the project files following the completion of the field work.

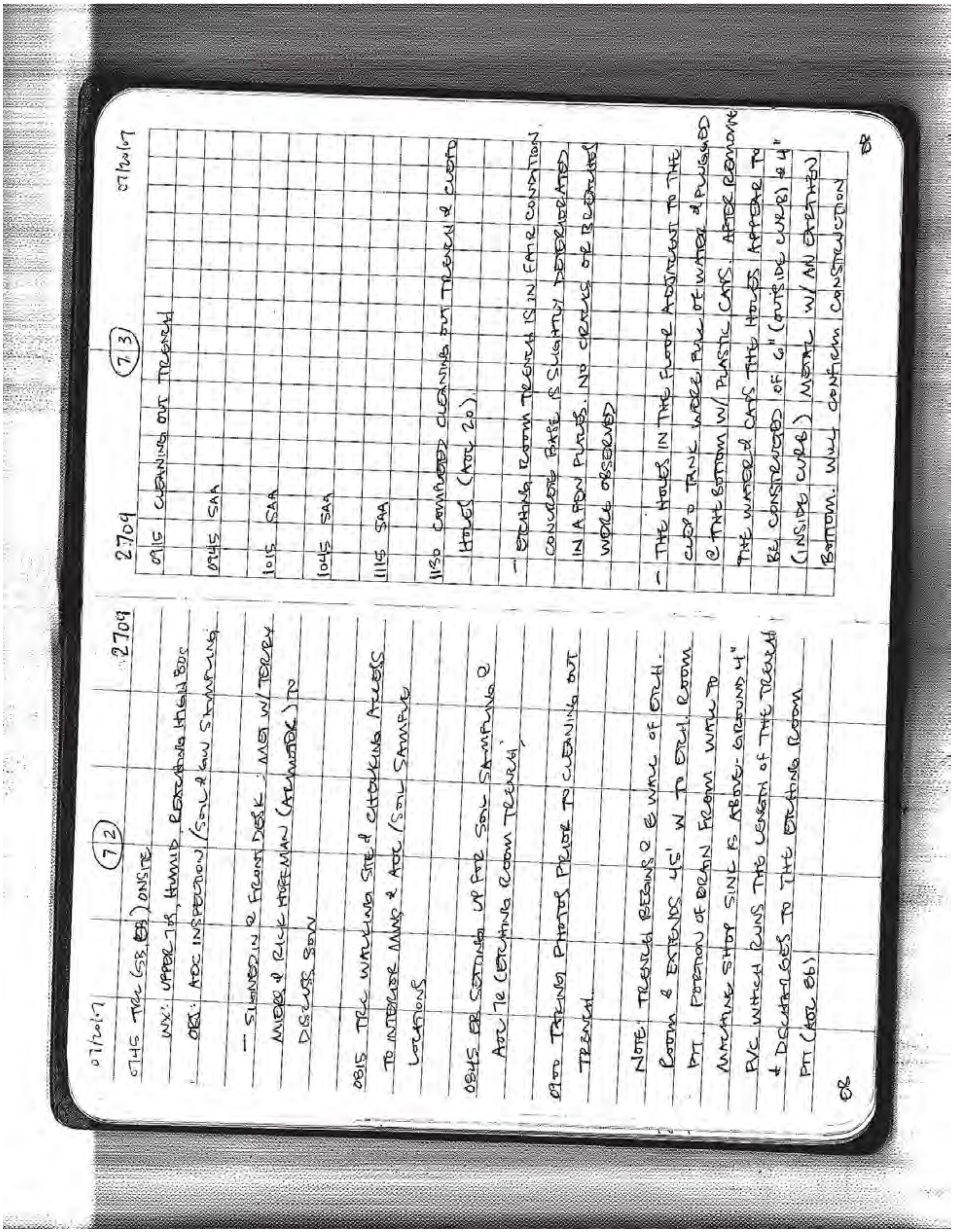
Completed standardized forms will be maintained by the Project Manager or Field Team Leader during the duration of the program and will be archived in the project files following completion of the field effort.

It is good practice to scan field notes and logs at the conclusion of field activities and store the resulting pdf files in the project directory.

6.0 SOP REVISION HISTORY

REVISION NUMBER	REVISION DATE	REASON FOR REVISION
0	JANUARY 2013	NOT APPLICABLE

Attachment A: Example Page from Field Book



07/20/07 (72) 2709

0745 TRC (SB, EB) ONSITE
WX: UPPER 70s, HUMID, REACHING HIGH 80s
OBJ: AOC INSPECTION / SOIL & GW SAMPLING

– SIGNED IN @ FRONT DESK; MET W/ TERRY MIERS & RICK HOFFMAN (ARMOTEK) TO DISCUSS SOW

0815 TRC WALKING SITE & CHECKING ACCESS TO INTERIOR MWS & AOC / SOIL SAMPLE LOCATIONS

0845 EB SETTING UP FOR SOIL SAMPLING @ AOC 72 (ETCHING ROOM TRENCH)

0900 TAKING PHOTOS PRIOR TO CLEANING OUT TRENCH.

NOTE: TRENCH BEGINS @ E WALL OF ETCH. ROOM & EXTENDS 45' W TO ETCH. ROOM PIT. PORTION OF DRAIN FROM WALL TO MACHINE SHOP SINK IS ABOVE-GROUND 4" PVC WHICH RUNS THE LENGTH OF THE TRENCH & DISCHARGES TO THE ETCHING ROOM PIT (AOC 86)

EB

2709 (73) 07/20/07

0915 CLEANING OUT TRENCH

0945 SAA

1015 SAA

1045 SAA

1115 SAA

1130 COMPLETED CLEANING OUT TRENCH & CLOSED HOLES (AOC 20).

– ETCHING ROOM TRENCH IS IN FAIR CONDITION. CONCRETE BASE IS SLIGHTLY DETERIORATED IN A FEW PLACES. NO CRACKS OR BREACHES WERE OBSERVED

– THE HOLES IN THE FLOOR ADJACENT TO THE CLOSED TANK WERE FULL OF WATER & PLUGGED @ THE BOTTOM W/ PLASTIC CAPS. AFTER REMOVING THE WATER & CAPS THE HOLES APPEAR TO BE CONSTRUCTED OF 6" (OUTSIDE CURB) & 4" (INSIDE CURB) METAL W/ AN EARTHEN BOTTOM. WILL CONFIRM CONSTRUCTION

EB

Attachment B: Example Daily Field Report Log

DAILY FIELD REPORT LOG

CLIENT: PROJECT:	DATE:
ADDRESS:	PROJECT #:
WEATHER:	PAGE: _____ OF _____
FIELD ACTIVITY:	

TIME	DESCRIPTION OF DAILY ACTIVITIES

THIS FIELD REPORT PROVIDES ONLY THE RESULTS OF OBSERVATIONS AND TESTS BY TRC PERSONNEL. THIS REPORT SHOULD NOT BE CONSTRUED AS SUPERVISION, DIRECTION, OR A RECOMMENDATION.

Prepared By: Date/Time:	TRC 123 Technology Drive Irvine, California 92618

Attachment C: SOP Fact Sheet

FIELD ACTIVITY DOCUMENTATION

PURPOSE AND OBJECTIVE

The objective of documenting field activities is to ensure that a collection of facts is recorded, the activities can be reconstructed from the documentation, and the field activities are adequately logged in a manner that will be acceptable if the record is required as evidence in legal proceedings. An additional objective of adequately documenting field activities is to provide complete information that is useful and understandable to someone other than the note taker. Facts and observations must be accurately recorded because the field books and field data forms provide the basis for future reports and analysis.

WHAT TO BRING

- Field book(s) – bound book with water-resistant pages
- Indelible marking pens
- Field data forms – generic or project-specific
- Digital camera
- Pocket ruler
- GPS device

OFFICE

- Ensure that there is adequate space for notes on the upcoming field event in the existing field book.
- If a new field book must be issued, note the field book number on the spine.
- A new field book should contain the following information on the inside cover: Project name; site address; site contact, if available; project number(s); TRC's name, address and phone number; and start and end dates of field book entries.
- Each field book may have a designated number (i.e., Book #1, Book #2, etc.) listed on the outside front cover.

ON-SITE

- Data collection activities will be recorded in field books. Entries will be of adequate detail so that individuals who were not onsite can reconstruct the day.
- The terminology used in recording all field data should be objective, factual, and free of personal interpretation.
- At the beginning of each daily entry, the date, start time, weather, and names of all field team members present will be entered.
- The start and end of each day's entries in the field book or Daily Field Report Log will be signed or initialed and dated by the person(s) making the entry.
- It is expected that field notes will generally be collected every 15 minutes. Information included in the field book may include, but need not be limited to, the following:
  - Names of all people involved in field activities;
  - Weather conditions;
  - Day's objectives/scope of work;
  - Vehicle used, travel time to site and mileage;
  - Equipment calibration information;
  - Summary of equipment brought by subcontractor;
  - Any changes made to site-specific protocol/plan;
  - Sample location and identification;
  - Communications while on site;
  - Field screening results;
  - Sample collection methods and equipment;
  - Sample collection date (month/day/year) and time (24-hour);
  - Sample depths;
  - Sample description (color, odor, texture, etc.);
  - Tests or analyses to be performed;
  - Sample preservation and storage conditions;
  - Unusual events or observations;
  - Volume and type of waste generated;
  - Sketches or diagrams.
- Upon receipt of the field book or Daily Field Report Log for a particular activity, the designated person recording the notes will begin recording notes on a new page.
- The person(s) recording the notes will sign/initial the new page and indicate the date, time, and weather conditions, prior to recording information about the field activity.
- The field book or Daily Field Report Log should indicate whether any Field Data Forms are being used.
- Additional logs such as photo logs, health and safety logs or equipment logs may be required depending on the site requirements.

FIELD ACTIVITY DOCUMENTATION

DOS AND DO NOTS OF FIELD ACTIVITY DOCUMENTATION

DOs:

- DO have the following items when going into the field: Field Book and an indelible marking pen (i.e. ball-point pen) ONLY; field forms; contact phone numbers; business cards.
- DO review all available figures and workplans.
- DO take note of any atypical conditions at the site.
- DO call the Project Manager or Field Team Leader if unexpected conditions are encountered or at least twice during the work day to update them. It is also recommended to call when activities are winding down for the day to make sure that the workplan has been fully implemented and there are no additional tasks to complete.
- DO have the numbers for contractors, vehicle and equipment rental providers and utility companies readily available while in the field.

DO NOTs:

- DO NOT sign anything in the field. This includes disposal documentation, statements, etc.; call the Project Manager if there are any concerns.
- DO NOT use markers to label samples or record field notes.

Title: **Chain-of-Custody Procedures**	Procedure Number: **RMD 002**
	Revision Number: **0**
	Effective Date: **March 2013**

Authorization Signatures	
03/01/2013	03/01/2013
Technical Review James Peronto Date	Remediation Practice Quality Coordinator Elizabeth Denly Date

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Page No.

FIGURES

ATTACHMENTS

1.0 INTRODUCTION

1.1 Scope & Applicability

This Standard Operating Procedure (SOP) guides TRC personnel in proper Chain-of-Custody practices.

This SOP was prepared to direct TRC personnel in the sample custody procedure requirements associated with field sample collection. Other state or federal requirements may be above and beyond the scope of this SOP and will be followed, if applicable. Sample custody procedures are an important part of the field investigation program in order to maintain data quality and to be able to document proof of proper handling. Sample custody begins at the collection of the samples and continues until the samples have been analyzed. Sample custody is addressed in three parts: field sample collection, laboratory analysis, and final evidence files.

Custody is one of several factors that are necessary for the admissibility of environmental data as evidence in a court of law or other evidentiary venue. Custody procedures help to satisfy the two major requirements for admissibility: relevance and authenticity. An overriding consideration essential for the validation of environmental measurement data is the necessity to demonstrate that samples have been obtained from the locations stated and that they have reached the laboratory without alteration (i.e., representative of the identified sample media).

1.2 Summary of Method

Evidence of the sample tracking from collection to shipment, laboratory receipt, and laboratory custody (until proper sample disposal and the introduction of field investigation results as evidence in legal proceedings when pertinent) must be properly documented.

A sample or evidence file is considered to be in a person's custody if the item is:

- In a person's possession
- In the view of the person after being in a person's possession
- Secured and preserved so that no one can tamper with it after having been in a person's possession
- In a secured area, restricted to authorized personnel

The Field Team Leader or designee is responsible for overseeing and supervising the implementation of proper sample custody procedures in the field. The Field Team Leader or designee is also responsible for ensuring sample custody until the samples have been transferred to a courier or directly to the laboratory. Once received by the laboratory, the samples proceed through an orderly processing sequence specifically designed to ensure continuous integrity of both the sample and its documentation.

1.3 Equipment

The following list is an example of items that may be utilized when implementing sample custody procedures in the field. Project-specific conditions or requirements may warrant the use of

additional items or deletion of items from this list. Many of these items may be provided by the selected analytical laboratory for a given project.

- Chain-of-Custody forms
- Sample labels
- Sample tags
- Custody seals
- Computer
- Indelible/waterproof ink
- Printer

2.0 PROCEDURES

Sample custody and transfer procedures are summarized below. These procedures are intended to ensure that the samples will arrive at the laboratory with the Chain-of-Custody intact. The Chain-of-Custody procedures are initiated in the field immediately following sample collection. The procedures consist of four main components: (1) preparing and attaching a unique sample label to each sample collected, (2) completing the Chain-of-Custody (COC) form, (3) reviewing the COC form for accuracy and (4) preparing the samples for shipment and transfer of custody.

2.1 Specific Chain-of-Custody Procedures

2.1.1 Sample Labels

Field personnel are responsible for uniquely identifying and labeling all samples collected during a field investigation program. All labeling must be completed in indelible/waterproof ink and securely affixed to the sample container. Individual sample containers may be pre-labeled or labeled in the field at the time of collection. Sufficient sample information should be cross-referenced in the field documentation for tracking purposes.

Sample labels typically contain the following information:

- Unique sample identification
- Sample location and/or depth/description number, if different from above
- Sample matrix
- Type of analysis to be performed
- Type of chemical preservation used
- Grab or composite designation
- Filtered or unfiltered
- Sampling date and time
- Sampler's affiliation and initials
- Site and/or client name

An example of a sample label is provided in Figure 1.

2.1.2 Custody Seals

Custody seals may be secured across the shipping container to ensure content integrity. The seals contain both the date and the signature of the person affixing them and must be completed in indelible/waterproof ink. Custody seals are attached to the cover seal of the cooler and can be covered with clear plastic tape after being signed and dated by field personnel. An example of a custody seal is shown in Figure 1. The use of custody seals will be determined on a project-specific basis by the Project Manager.

2.1.3 Chain-of-Custody Form

For all analyses, COC forms must be completed for each sample set submitted. COC forms are initiated by the samplers in the field and maintained until samples are analyzed by the laboratory. If multiple laboratories are being used, a separate set of COC forms must be completed for each laboratory receiving samples to ensure proper transfer of custody from the time of sample collection to analysis. These forms serve as a record of sample collection, transfer, shipment, and receipt by the laboratory. These forms typically contain the following pertinent information:

- Project/site name and/or project number
- Carrier name, if applicable
- Air bill numbers(s), if known and applicable
- Laboratory name and address
- Sample identifications
- Sample matrix (e.g., soil, water)
- Type of sample (i.e., grab or composite)
- Date/time sample collected
- Size, type, and number of containers
- Preservative used
- Required analysis or method
- Turnaround time
- Names of individuals responsible for custody of samples
- Date shipped or otherwise transferred

Figure 2 provides an example COC form. It should be noted that this is an example format only. Laboratories typically provide their own laboratory-specific COC form. Other COC formats may be used as long as all of the applicable information is included. COC forms will be initiated in the field.

All entries on the COC form must be legible and must be made in blue or black permanent ink. No erasures or obliterations can be made. If an incorrect entry is made, the information must be crossed out with a single strike mark which is signed or initialed and dated by the person recording the information. The correction must be written adjacent to the error. The original entry should still be legible even though crossed out.

2.1.4 Transfer of Custody

Samples will be accompanied by a properly completed COC form during each step of custody transfer and shipment. When physical possession of samples is transferred, both the individual relinquishing the samples and the individual receiving them will sign, date, and record the time of transfer on the COC form.

All samples will be shipped directly to the laboratories by a TRC employee, an overnight commercial carrier, or a laboratory-supplied courier service.

In the case of sample shipment by an overnight commercial carrier, a properly prepared air bill, including the project number (Figure 3), will serve as an extension of the COC form while the samples are in transit. The COC forms will be sealed inside the sample cooler within a clear plastic bag and the custody seals, if used, will be completed on the outside of the cooler prior to shipment. Commercial carriers are not required to sign off on the custody forms since the forms are sealed inside the cooler prior to shipment so any custody seal remains intact. The original COC form will accompany the samples at all times. A copy of all COC forms submitted to the laboratory will be retained by the sampler along with field records/logbooks documenting sample collection and will be placed in the project files.

If at the completion of sampling the samples are not shipped directly from the field or point of collection to the analytical laboratory, the samples will be temporarily stored in an iced cooler at a secure location (e.g., locked vehicle, residence, office) or in a locked refrigerator at the TRC office. Access to the secure location and transfer of the sample containers for laboratory delivery shall only be provided by a TRC employee and such sample transfer shall be recorded on the COC form.

3.0 QUALITY ASSURANCE/QUALITY CONTROL

Following sample collection, all samples will be brought to a location for batching and paperwork checks. At this location, labels and logbook information are cross-checked to ensure there is no error in sample identification or sample collection time and that all samples are accounted for. The sample information is transferred to the COC form. The samples are packaged to prevent breakage and/or leakage, and the shipping containers are labeled for transport.

The Field Team Leader has the responsibility of maintaining the COC and air bill documentation. Individual responsibilities may be delegated to other field staff, as appropriate. Quality control procedures will place emphasis on ensuring that appropriate samples were collected and submitted to the laboratory for the correct analyses. The COC forms will also be reviewed by the Field Team Leader or designee to ensure that all required information is clearly presented.

Many laboratories will provide a sample receipt confirmation via electronic mail upon request. COC forms should be cross-checked with laboratory sample receipt confirmations, if applicable, to ensure that all samples were received and logged-in correctly by the laboratory.

4.0 INVESTIGATION-DERIVED WASTE DISPOSAL

Not applicable.

5.0 DATA MANAGEMENT AND RECORDS MANAGEMENT

The Project Manager or Field Team Leader will maintain an inventory of all COC forms completed during the program and will be responsible for ensuring that they are archived in the project files following the completion of the field work.

It is good practice to scan all completed COC forms at the conclusion of field activities and store the resulting electronic PDF files in the project directory.

6.0 REFERENCES

A Compendium of Superfund Field Operations Methods EPA/540/P-87/001. December 1987.

U.S. Environmental Protection Agency (EPA) Office of Enforcement and Compliance Monitoring – National Enforcement Investigations Center (NEIC) requirements (NEIC, 1986)

7.0 SOP REVISION HISTORY

REVISION NUMBER	REVISION DATE	REASON FOR REVISION
0	MARCH 2013	NOT APPLICABLE

Figure 1 Example Sample Label and Custody Seal

Example Custody Seal

Sample Label

CLIENT/SOURCE	☐ GRAB ☐ COMPOSITE OTHER
SITE NAME	DATE
SAMPLE #	TIME
ANALYSIS	PRESERVATIVE
	COLL. BY

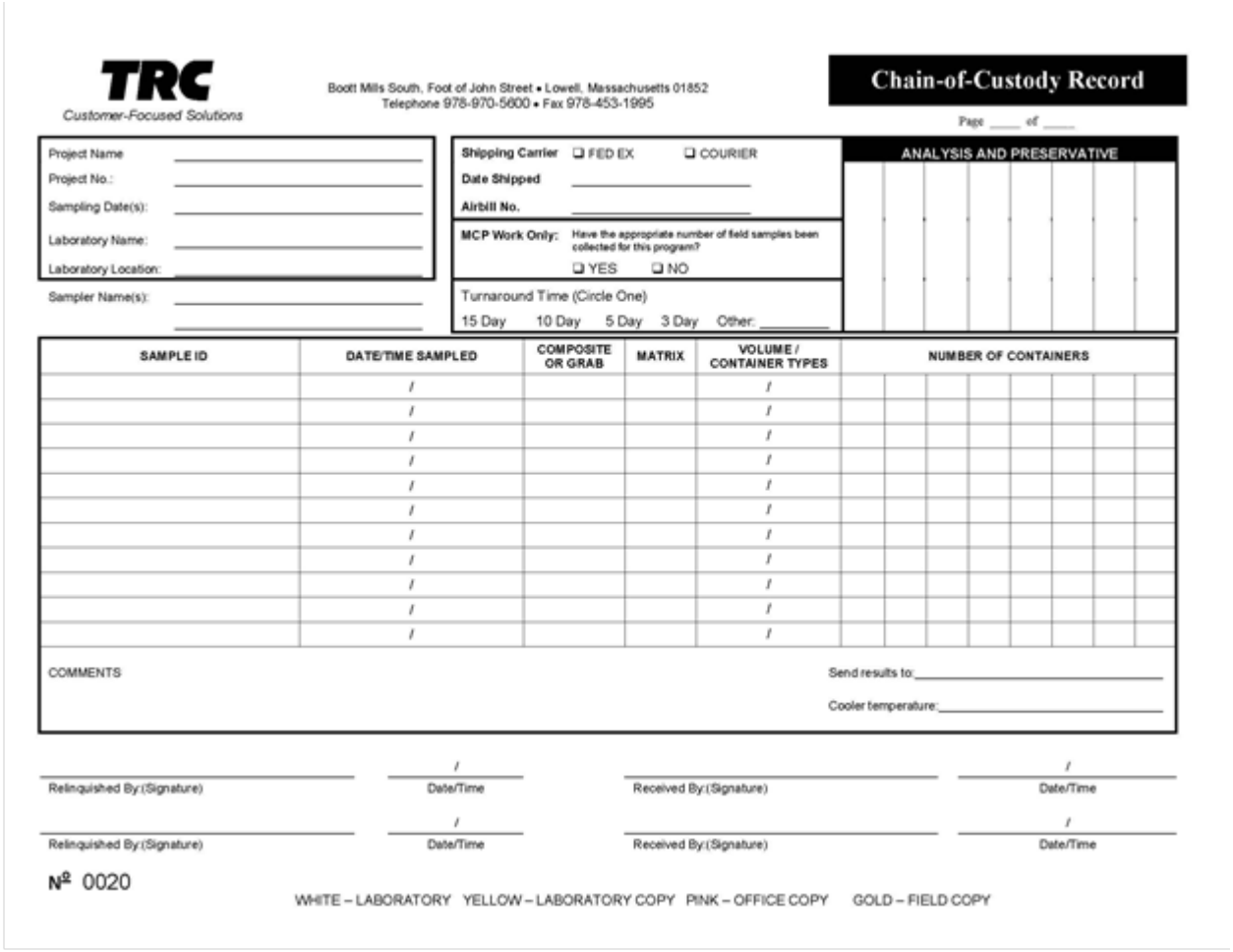
Custody Seal

CUSTODY SEAL

Date

Signature

Figure 2 Example Chain-of-Custody Form



TRC
Customer-Focused Solutions

Boott Mills South, Foot of John Street • Lowell, Massachusetts 01852
Telephone 978-970-5600 • Fax 978-453-1995

Chain-of-Custody Record

Page ____ of ____

Project Name _____
Project No.: _____
Sampling Date(s): _____
Laboratory Name: _____
Laboratory Location: _____
Sampler Name(s): _____

Shipping Carrier ❑ FED EX ❑ COURIER
Date Shipped _____
Airbill No. _____

MCP Work Only: Have the appropriate number of field samples been collected for this program?
❑ YES ❑ NO

Turnaround Time (Circle One)
15 Day 10 Day 5 Day 3 Day Other: _____

ANALYSIS AND PRESERVATIVE

SAMPLE ID	DATE/TIME SAMPLED	COMPOSITE OR GRAB	MATRIX	VOLUME / CONTAINER TYPES	NUMBER OF CONTAINERS
	/			/	
	/			/	
	/			/	
	/			/	
	/			/	
	/			/	
	/			/	
	/			/	
	/			/	
	/			/	
	/			/	

COMMENTS

Send results to: _____

Cooler temperature: _____

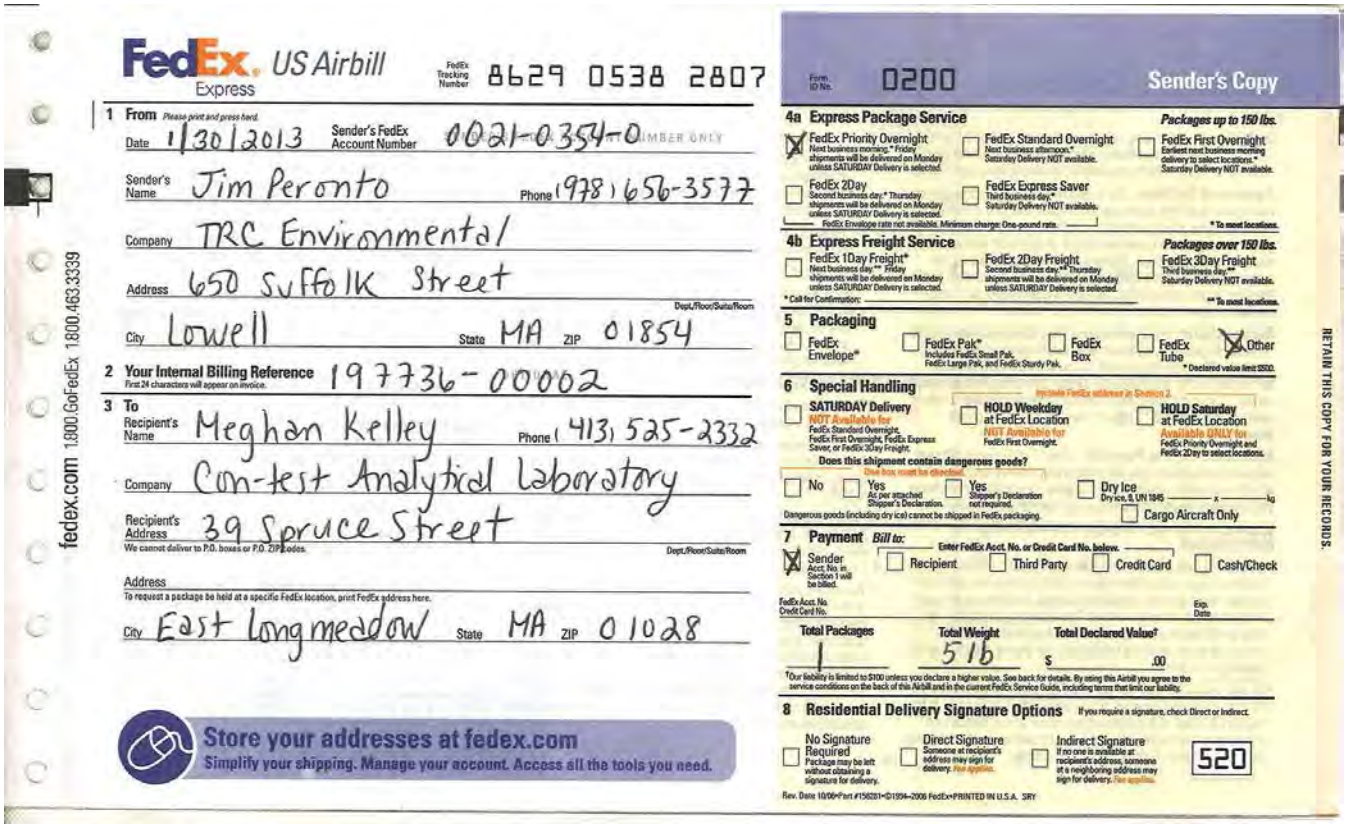
_____ / _____ _____ / _____
Relinquished By:(Signature) Date/Time Received By:(Signature) Date/Time

_____ / _____ _____ / _____
Relinquished By:(Signature) Date/Time Received By:(Signature) Date/Time

№ 0020

WHITE – LABORATORY YELLOW – LABORATORY COPY PINK – OFFICE COPY GOLD – FIELD COPY

Figure 3 Example Federal Express Air Bill



FedEx. US Airbill Express — FedEx Tracking Number 8629 0538 2807

1 From — Date 1/30/2013 — Sender's FedEx Account Number 0021-0354-0 — Sender's Name Jim Peronto — Phone (978) 656-3577 — Company TRC Environmental — Address 650 Suffolk Street — City Lowell — State MA — ZIP 01854

2 Your Internal Billing Reference 197736-00002

3 To — Recipient's Name Meghan Kelley — Phone (413) 525-2332 — Company Con-test Analytical Laboratory — Recipient's Address 39 Spruce Street — Address — City East Longmeadow — State MA — ZIP 01028

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fedex.com 1.800.GoFedEx 1.800.463.3339

Form ID No. 0200 — Sender's Copy

4a Express Package Service — Packages up to 150 lbs.
- [X] FedEx Priority Overnight — Next business morning.* Friday shipments will be delivered on Monday unless SATURDAY Delivery is selected.
- [ ] FedEx Standard Overnight — Next business afternoon.* Saturday Delivery NOT available.
- [ ] FedEx First Overnight — Earliest next business morning delivery to select locations.* Saturday Delivery NOT available.
- [ ] FedEx 2Day — Second business day.* Thursday shipments will be delivered on Monday unless SATURDAY Delivery is selected.
- [ ] FedEx Express Saver — Third business day.* Saturday Delivery NOT available.

FedEx Envelope rate not available. Minimum charge: One-pound rate. * To most locations.

4b Express Freight Service — Packages over 150 lbs.
- [ ] FedEx 1Day Freight* — Next business day.** Friday shipments will be delivered on Monday unless SATURDAY Delivery is selected.
- [ ] FedEx 2Day Freight — Second business day.** Thursday shipments will be delivered on Monday unless SATURDAY Delivery is selected.
- [ ] FedEx 3Day Freight — Third business day.** Saturday Delivery NOT available.

* Call for Confirmation: ** To most locations.

5 Packaging
- [ ] FedEx Envelope*
- [ ] FedEx Pak* — Includes FedEx Small Pak, FedEx Large Pak, and FedEx Sturdy Pak.
- [ ] FedEx Box
- [ ] FedEx Tube
- [X] Other — * Declared value limit $500.

6 Special Handling — Include FedEx address in Section 2.
- [ ] SATURDAY Delivery — NOT Available for FedEx Standard Overnight, FedEx First Overnight, FedEx Express Saver, or FedEx 3Day Freight.
- [ ] HOLD Weekday at FedEx Location — NOT Available for FedEx First Overnight.
- [ ] HOLD Saturday at FedEx Location — Available ONLY for FedEx Priority Overnight and FedEx 2Day to select locations.

Does this shipment contain dangerous goods? One box must be checked.
- [ ] No
- [ ] Yes — As per attached Shipper's Declaration.
- [ ] Yes — Shipper's Declaration not required.
- [ ] Dry Ice — Dry Ice, 9, UN 1845 ____ x ____ kg

Dangerous goods (including dry ice) cannot be shipped in FedEx packaging.
- [ ] Cargo Aircraft Only

7 Payment — Bill to: — Enter FedEx Acct. No. or Credit Card No. below.
- [X] Sender — Acct. No. in Section 1 will be billed.
- [ ] Recipient
- [ ] Third Party
- [ ] Credit Card
- [ ] Cash/Check

FedEx Acct. No. or Credit Card No. — Exp. Date

Total Packages: 1 — Total Weight: 5 lb — Total Declared Value†: $ .00

†Our liability is limited to $100 unless you declare a higher value. See back for details. By using this Airbill you agree to the service conditions on the back of this Airbill and in the current FedEx Service Guide, including terms that limit our liability.

8 Residential Delivery Signature Options — If you require a signature, check Direct or Indirect.
- [ ] No Signature Required — Package may be left without obtaining a signature for delivery.
- [ ] Direct Signature — Someone at recipient's address may sign for delivery. Fee applies.
- [ ] Indirect Signature — If no one is available at recipient's address, someone at a neighboring address may sign for delivery. Fee applies.

520

Rev. Date 10/09 • Part #156231 • ©1994–2009 FedEx • PRINTED IN U.S.A. SRY

RETAIN THIS COPY FOR YOUR RECORDS.

Attachment A: SOP Fact Sheet

CHAIN-OF-CUSTODY PROCEDURES

PURPOSE AND OBJECTIVE

Chain-of-Custody procedures have been developed to direct TRC personnel in the sample custody procedure requirements associated with field sample collection. Other state or federal requirements may be above and beyond the scope of this SOP and should be followed, if applicable. Sample custody procedures are an important part of the field investigation program to maintain data quality and to be able to document proof of proper handling. Sample custody begins at the collection of the samples and continues until the samples have been analyzed. Sample custody is addressed in three parts: field sample collection, laboratory analysis, and final evidence files.

WHAT TO BRING

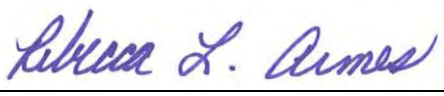
- Chain-of-Custody (COC) forms
- Sample Labels
- Custody Seals (if required)
- Indelible/waterproof ink

ON-SITE

- Complete all sample labels with indelible/waterproof ink.
- At a minimum, sample labels should include: site name; unique sample identification; sample date and time.
- COC forms must be completed for each sample set and must be initiated in the field by the sampler.
- COC forms must be completed in blue or black permanent ink.
- At a minimum, the COC forms should include: site name; sample identification; sample matrix; type of preservative; type of analysis; sampling date; and sampler's name.
- Once sampling activity is completed and the COC form is filled out, place samples in sample coolers.
- Package samples to prevent breakage and/or leakage.
- The COC forms will be reviewed by the Field Team Leader or designee prior to relinquishing the samples.
- The original COC form must accompany samples to the laboratory.
- When samples are transferred from one person to another, both the relinquisher and the person receiving the samples should sign, date and record the date of transfer on the COC form.
- If samples are not sent directly to laboratory, samples need to remain on ice and be stored in a secure location.

Title: **Water Level and Product Measurements**	Procedure Number: **ECR 004**
	Revision Number: **1**
	Effective Date: **December 2016**

Authorization Signatures

			
Technical Reviewer	Date	ECR Practice Quality Coordinator	Date
Rebecca Armes	12/15/16	Elizabeth Denly	12/15/16

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ATTACHMENTS

1.0 INTRODUCTION

1.1 Scope and Applicability

This Standard Operating Procedure (SOP) was prepared to direct TRC personnel in the methods for conducting water level, separate-phase product, and/or total well depth measurements in monitoring wells, piezometers, and boreholes during field investigations.

1.2 Summary of Method

Depth-to-water (DTW) measurements are used to evaluate pressure and/or elevation changes within the aquifer. The procedure involves using a water level indicator capable of an accuracy of ±0.01 feet, or a similar piece of equipment, to measure the DTW in a monitoring well, piezometer, or borehole from a set reference point. When used in conjunction with an accurate site elevation survey, DTW data can be converted to potentiometric surface elevations to support groundwater flow direction analysis, as well as other aquifer characteristics. In addition, pressure changes recorded in a well during a slug, pumping, or packer test can be used to determine aquifer characteristics, such as hydraulic conductivity and storage parameters.

It is also a good practice to gauge the total depth of a monitoring well while taking water levels. This practice can help confirm: 1) the correct well in a cluster of wells screened at different depths; 2) that the well is clear of obstructions; 3) whether the well may be silting up and need further development; and 4) the correct purge volume for a well when sampling. Total depth measurements in a well may be necessary when TRC is taking over project work at a site with existing monitoring wells or the site wells have not been accessed for a significant amount of time.

The objective of separate-phase product measurements is to obtain measurements of the thickness of separate-phase product in the water column. The thickness of both dense non-aqueous phase liquid (DNAPL) and light non-aqueous phase liquid (LNAPL) can be determined using an oil/water interface probe. It should be noted that the thickness of LNAPL or DNAPL in a well ("apparent thickness") most likely differs from the thickness in the formation ("actual thickness").

- For LNAPL, the procedure involves measuring the depth to the separate-phase product and the depth to the underlying groundwater from a set reference point. The difference between these two measurements is the thickness of the LNAPL in the well.

- For DNAPL, the procedure involves measuring the depth to the separate-phase product and the depth to the bottom of the well, borehole, etc. The difference between these two measurements is the thickness of the DNAPL in the well.

1.3 Equipment

The following list of equipment may be utilized when conducting water level and separate-phase product measurements. Site-specific conditions may warrant the use of additional items or deletion of items from this list. For specialized sampling programs involving per- and polyfluorinated alkyl substances (PFAS), refer to Attachment D for further details.

- Appropriate level of personal protection
- Electronic water level indicator
- Oil/water interface probe
- Extra batteries for water level/interface probe
- Field book and monitoring form
- Well keys
- Socket-wrench
- Containers to hold water and isopropanol for calibration
- Tap water
- Isopropanol
- Previous measurement data (if available)
- Precision ruler or measuring tape
- Permanent marker (e.g., Sharpie®)
- Decontamination supplies

1.4 Definitions

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.
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 polyvinyl chloride (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.
Non-aqueous Phase Liquid (NAPL)	Petroleum or other fluid that is immiscible in water and tends to remain as a separate liquid in the subsurface.
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.

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.
Low-permeability Formation	A geologic formation that has very slow recharge and discharge rates due to small pore spaces in the formation material. A clay formation is considered to have low permeability and has a very slow recharge rate compared to a more permeable formation, such as sand or gravel.
Total Depth of Well	Distance from the measuring point to the bottom of the well.

1.5 Health & Safety Considerations

TRC personnel will be on site when implementing this SOP. Therefore, TRC personnel shall follow the site-specific health and safety plan (HASP). TRC personnel will use the appropriate level of personal protective equipment (PPE) as defined in the HASP.

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.

1.6 Cautions and Potential Problems

Special care should be taken when using equipment if PFAS are known or suspected to be present. Please refer to Attachment D for details.

- DTW measurements of all wells in a water level survey should be collected within the shortest amount of time possible but, at a minimum, within a 24-hour period to ensure near contemporaneous data collection during a groundwater elevation recording event. However, note that certain conditions may produce relatively rapid changes in groundwater elevations, which might necessitate collecting readings over a shorter time period. Such conditions should be noted in the field book. Rapid groundwater elevation changes may occur due to:
  - Rapid changes in atmospheric pressure
  - Variable pumping of nearby wells
  - Precipitation events
  - Tidal influences
  - Rapid changes in nearby surface water levels (e.g., dam release, upstream thunderstorm)
- Allow water levels in newly installed wells to stabilize for approximately 24 hours before taking measurements for the purpose of a water level survey. Recovery might take longer in wells installed in low permeability formations.
- Because the tops of monitoring wells and piezometers are often cut unevenly, be sure to take DTW measurements from a pre-marked or notched spot on the well to ensure consistent data collection over time. Since land survey vertical elevation measurements are generally taken

from the highest point on the well casing (i.e., where survey rod rests), this point should also be marked and used for water level measurements. If the tops of the monitoring wells and piezometers are not marked, the DTW measurement should be taken from the north side of the riser and the location marked on the casing top edge.

- To limit the possibility of cross contamination, DTW measurements should be collected in order from the least to the most contaminated wells and piezometers when contamination is known or suspected. Be sure to decontaminate the entire length of the submerged tape between well measurements to reduce the potential for cross contamination. Refer to Attachment D and ECR SOP 010 for decontamination of PFAS. Some wells with NAPL or excessive condensation may have residues on the side of the riser that may also contaminate the tape.
- If the presence of NAPL is suspected at a site, an oil/water interface probe should be used to conduct water level measurements. When DNAPL is a suspected contaminant characteristic at a site, the interface probe should be lowered to the bottom of the well until DNAPL is encountered, if present.
- NAPL may foul the probe and could cause a delayed response when going from NAPL to water. Resolution may require taking repeated measurements by raising and/or lowering the probe through the interface.
- Most water level meters have a "sensitivity" setting, which is often located on the on/off dial. The sensitivity setting may need adjustment depending on the site water chemistry.
- Excessive condensation on the inside well materials may cause the tape to stick on the well casing and/or cause a false reading above the water level. This is especially true of deeper wells. Previous elevation data should be consulted to determine if a reading is consistent and plausible for that well. The above mentioned sensitivity adjustment can be used to compensate. In some cases, the line may have to be weighted to remedy the line sticking to the casing.
- Tight well caps and low permeability formations may not have allowed the potentiometric surface to equilibrate in the well after seasonal, tidal or other area groundwater level fluctuations. If this is the case, allow the wells to equilibrate before collecting measurements by taking readings several minutes after removing the well plug; in addition, re-measure the first well after the last well to verify that the water level is not fluctuating. Another round of water levels may need to be collected if a significant discrepancy from the first set of measurements is observed; this should be discussed with the Project Manager. If this is a concern, vented well caps or plugs may need to be used.
- In some instances, artesian well conditions may exist, where the potentiometric surface is higher in elevation than the top of the well casing (TOC). In these situations, it is pertinent to note the water level elevation as above the TOC or add a known length of riser pipe in order to measure an actual elevation. Once the water level has equilibrated in the riser pipe, the same procedures can be followed for measuring water level when separate-phase product is not suspected. Note that when converting the DTW measurement to an elevation, the riser pipe length needs to be added to the surveyed TOC.

- Groundwater gradients at some sites can be very shallow and if gradient and groundwater flow pattern (gradient direction) determination are part of the project objectives, it is critical that groundwater level measurements obtained from wells are as accurate as possible. Special care should be taken to allow the water level to equilibrate after removing sealing caps, and the same water level indicator should be used for all measurements if possible. All wells should be measured within the minimum possible time. This is particularly important in areas with potential tidal influences.

- If more than one measuring device must be used for multiple wells across an area with a shallow groundwater gradient, the "zero calibration check" (see Section 2.1.1) becomes especially important.

- If the monitoring well or piezometer is secured with an air- and water-tight lockable cap, caution should be taken when removing the cap due to the possible buildup of pressure in the well casing. Try to ease the cap off and relieve the pressure slowly in order to prevent injury. Do not stand or lean over top of well when releasing cap.

- Flush-mounted wells may be subject to water collection in the well can around the top of the riser pipe. In such instances, sufficient water should be evacuated from the well can prior to removing the well cap to ensure that ambient water does not enter the riser. The condition should be documented and the potential need for repair discussed with the Project Manager.

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 work plan. These requirements may include:

- OSHA 40-hour Health and Safety Training for Hazardous Waste Workers (HAZWOPER)
- 8-hour annual refresher training

2.0 PROCEDURES

To be useful for establishing groundwater gradient, the reference point should be tied with a known vertical datum, such as the National Geodetic Vertical Datum (NGVD), or a local datum (e.g., site-specific arbitrary datum).

Water levels should be allowed to equilibrate prior to measurement after removing sealing well caps. There are no set guidelines, and appropriate equilibration times can range from minutes to hours depending on well recharge, local geology, and project objectives.

If available, prior site water and product level measurement data should be reviewed and available to field personnel during the collection of new data for direct comparison to aid in identifying and resolving potential measurement errors while in the field.

When measuring well depths with an electronic water level indicator, measure and add the length of the probe beneath the circuit closing electrodes to the depth measured to obtain the true depth.

The following procedures must be followed during the collection of water level and product measurements. Procedures may vary depending on the equipment used and contaminants present at the site. Special care should be taken when using measurement equipment if PFAS are known or suspected to be present. Please refer to Attachment D for details.

2.1 Calibration and Operational Checks

Refer to the project's Quality Assurance Project Plan (QAPP) for calibration frequency and any site-specific calibration procedures for water and separate-phase product level meters. Calibration of the meters is optional; the need for calibration and the frequency of calibration will be dependent upon the meter used and project-specific data quality objectives. Operational checks of meters will be performed prior to use in the field at the start of each day and several times throughout the day, as appropriate.

2.1.1 Operational Check of Water Level Meters

1. Push the Start or Test button (typically provided) on the meter to test the battery and circuitry on the water level indicator. The meter audible indicator should sound and test light illuminate (if equipped).

2. Release the start/test button and lower the water level probe into a container filled with tap water until the meter audible indicator sounds or visual indicator light turns on. During this check, set sensitivity adjustment (if provided) to highest setting, then decrease if necessary (e.g., saline water).

Inspect the measuring tape and water level probe connection for any signs of visible damage (e.g., cuts, kinks, separating splices). If the tape appears damaged at the connection to the probe, while the meter is sounding, perform the procedure in Section 2.1.2.

2.1.2 Calibration of Water Level Meters

1. While the meter is sounding from the procedure used in Section 2.1.1, use a ruler or measuring tape to measure the distance between the water surface and the 1-foot increment mark on the water level tape.

2. Check that the 1-foot increment is actually 1 foot from the water surface. Note any discrepancy in the field book and discuss with the Project Manager. If necessary, repair and/or replace the water level meter.

2.1.3 Calibration and Operational Check of Oil/Water Interface Meters

1. Oil/water interface meters will have one distinguishing sound and/or colored light to represent detection of water and a separate distinguishing sound to represent detection of separate-phase product. Read the instrument manufacturer's operations manual to determine the instrument's audible sound or light differentiation for water and separate-phase product (e.g., continuous beep for product and intermittent beep for water).

2. Push the Start or Test button (typically provided) on the meter to test the battery and circuitry on the water level indicator. The meter audible indicator should sound and test light illuminate (if equipped).

3. Water Level Sensor Operational and Calibration Checks

   a. Lower the water level probe into a container filled with tap water until the appropriate sound for water is heard as determined in Step 1.

   b. While the meter is sounding, use a ruler or measuring tape to measure the distance between the water surface and the 1-foot increment mark on the water level tape.

   c. Check that the 1-foot increment is actually 1 foot from the water surface. Note any discrepancy in the field book and discuss with the Project Manager.

4. Oil Level Sensor Operational and Calibration Checks

   a. If the operation or calibration of the oil level probe is suspected to be faulty, consult with the meter manufacturer for additional troubleshooting.

2.2 Procedures for Measuring Depth to Water When Separate-phase Product is Not Suspected

If possible, and when applicable, start at wells that are least contaminated and proceed to those wells that are most contaminated. Additionally, allow sufficient time for each monitoring well or piezometer to equilibrate after removing the protective cap prior to taking readings.

1. Record the condition of the well (e.g., protective casing, concrete collar, lock in place, etc.), equipment being used, and the current weather conditions in the field book or on the water level monitoring form or well inspection report.

2. Use HASP-specified gloves. Stand upwind of the well and remove the well lid. Unlock and remove the well cap slowly to relieve pressure build up that may have occurred in the well casing. Follow HASP requirements for well head and breathing zone air monitoring.

3. Identify the previous measuring point marking or notch on the riser or casing (if present). If no previous measuring point exists, use a permanent marker to mark a location on the rim of the riser or casing (typically the highest point). Record this location in the field book or on the water level monitoring form (e.g., top of riser or top of casing).

4. Using a previously decontaminated water level meter, turn on the meter, check the audible/visual indicator (push the "Test" button), reel the electronic probe into the well riser (with the increments visible) slowly until the meter sounds.

5. Grasp the tape with hand, withdraw the tape, and lower it again slowly until the sound is again audible. Check the DTW on the tape and make a mental note of the depth to within 0.01 feet.

6. Lower the probe again slowly and repeat the measurement for precision. In the field book or on the water level monitoring form, record the DTW from the measuring point noted in

Step #3 to the nearest 0.01 feet. If measuring the total depth of the well, proceed to Section 2.4).

7. Decontaminate the probe and the entire length of the submerged tape in accordance with the manufacturer specifications. Refer to Attachment D and ECR SOP 010, Equipment Decontamination, for decontamination procedures for sites with known or suspected PFAS contamination.

2.3 Procedure for Measuring Depth to Water and Product Levels When Separate-phase Product is Suspected

If possible, and when applicable, start at wells that are least contaminated and proceed to those wells that are most contaminated. Additionally, allow sufficient time for each monitoring well or piezometer to equilibrate after removing the protective cap prior to taking readings.

1. Record the condition of the well (e.g., protective casing, concrete collar, lock in place, etc.), equipment being used, and the current weather conditions in the field book, water level monitoring form, or well inspection report.

2. Use HASP-specified gloves. Stand upwind of the well and remove the well lid. Unlock and remove the well cap slowly to relieve pressure build up that may have occurred in the well casing. Follow HASP requirements for well head and breathing zone air monitoring.

3. Identify the previous measuring point marking or notch on the riser or casing (if present). If no previous measuring point exists, use a permanent marker to mark a location on the rim of the riser or casing (typically the highest point). Record this location in the field book or on the water level monitoring form (e.g., top of riser or top of casing).

4. Using a previously decontaminated oil/water interface probe, turn on the meter, check the audible indicator, and slowly reel the electronic probe into the well riser (with the increments visible) until the appropriate sound for water or separate-phase product is heard as determined in Section 2.1.3.

5. If water is encountered first (as determined by the audible sound on the meter, which represents water), follow steps 5 and 6 from Section 2.2. In the field book or on the water level monitoring form, record the DTW from the measuring point noted in Step 3 to the nearest 0.01 feet.

6. If water is encountered first and DNAPL is suspected, continue lowering the probe until product is encountered (as determined by the audible sound on the meter, which represents product). In the field book or on the water level monitoring form, record the depth to product from the measuring point noted in Step #3.

7. Calculate the thickness of the DNAPL in the well using the following equation:

   (Total depth of well) - (Depth to product) = DNAPL thickness

8. If LNAPL is encountered before water, record the depth to product from the measuring point noted in Step #3 in the field book and continue lowering the probe until water is encountered.

   NOTE: For LNAPL, it is necessary to take both the air/product interface measurement on the way down into the product and the water/product interface measurement on the way back up. This is required when passing through product into water, since some product may adhere to the probe sensors due to surface tension and, as a result, a greater product thickness measurement may be erroneously obtained. Therefore, when LNAPL is detected, the probe should be lightly shaken or raised and lowered rapidly in a short vertical motion while the probe is within the water column to remove any product that may have been carried down with the probe. After passing through the product, the water/product interface should then be measured as the probe is raised very slowly back up from the underlying water into the product. Once the interface is detected, the probe can be raised and lowered in small increments to precisely determine the interface and obtain accurate measurements. Repeat these measurements as needed to confirm water/product interfaces and product thickness on multiple measurements.

9. In the field book or on the water level monitoring form, record the DTW from the measuring point noted in Step #3. If measuring the total depth of the well, proceed to Section 2.4.

10. Calculate the thickness of the LNAPL in the well using the following equation:

    (DTW) - (Depth to product) = LNAPL thickness

11. Decontaminate the probe and the entire length of the submerged tape in accordance with the manufacturer specifications. Refer to Attachment D for measurement equipment used at sites with known or suspected PFAS contamination and ECR SOP 010, Equipment Decontamination, for PFAS decontamination procedures.

2.4 Procedure for Measuring Total Well Depth

When measuring the total depth of a well, the water level and separate-phase product level, if present, should be determined first (see Section 2.2 or 2.3). It is recommended that the tone function of the instrument remain engaged during the total depth measurement.

1. After the water level and product level, if present, have been determined, continue reeling the electronic probe into the well riser (with the increments visible) until the probe encounters resistance. Resistance may be inferred when the probe appears to stop descending and the tape slackens against the side of the riser.

2. Determine whether the observed resistance likely represents the total depth of the well by raising and then lowering the probe to the level of the previously encountered resistance several times at different positions in the well. Then compare the observed level of resistance to available information about the total depth of the well, such as well log data or previous total depth measurements.

3. Measure the total depth of the well by: 1) noting the depth (to the nearest 0.01 feet) at which the probe first touches bottom before the tape begins to slacken; 2) adding the measured length from the bottom of the probe to the fluid level sensor in the probe; and 3) recording the combined lengths as the total depth.

4. In the field book or on the water level monitoring form, record the total depth of the well from the measuring point.

5. Also, note any observations about the conditions encountered in the well during the total depth measurement. A clear and distinct bottom reading would indicate little or no sediment in the bottom of the well. A soft and indistinct probe landing would indicate the presence of silt or sediment in the bottom of the well. A total depth measurement inconsistent with the well log or previous total depth measurements may indicate an obstruction in the well or significant sedimentation at the bottom of the well.

6. Decontaminate the probe and the portion of the tape inserted in the riser in accordance with the manufacturer specifications. Refer to Attachment D for measurement equipment used at sites with known or suspected PFAS contamination and ECR SOP 010, Equipment Decontamination, for PFAS decontamination procedures.

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 following Quality Assurance/Quality Control procedures apply:

- Operate field instruments according to the manufacturers' manuals.

- Calibrate field instruments at the proper frequency.

- Check the DTW at least two times in order to compare results. If results do not agree to within 0.02 feet, take a third measurement. If results still do not agree, check for possible equipment failure or review the cautions and potential problems listed in Section 1.6. Repeat the measurement when the cause of the precision nonconformance has been discovered and corrected.

5.0 DATA MANAGEMENT AND RECORDS MANAGEMENT

- Record water and separate-phase product level measurements on field forms or in a field book. See Attachment A for an example of a Water and Product Level Monitoring Form and Attachment B for an example of field book documentation.
- The following additional information may be recorded in the field book:
  - Well/piezometer or monitoring point identification number
  - Well/piezometer or monitoring point location (sketch of the sample point or reference to a location figure)
  - Visual or sensory description (e.g., odors, product, etc.)
  - Time and date measurements were taken
  - Personnel performing the task
  - Weather conditions during task
  - Other pertinent observations
  - Measurement equipment used
  - Calibration procedures used
  - Decontamination procedures used
  - Fixed measuring point used for DTW measurements

6.0 REFERENCES

Compendium of Superfund Field Operations Methods. EPA/540/P-87/001. December 1987.

U.S. EPA Environmental Response Team, Standard Operating Procedures, *Manual Water Level Measurements*, SOP 2043. February 11, 2000.

U.S. EPA Region 4. Science and Ecosystem Support Division (SESD) Operating Procedure, *Groundwater Level and Well Depth Measurement*, SESDPROC-105-R2. January 29, 2013.

7.0 SOP REVISION HISTORY

REVISION NUMBER	REVISION DATE	REASON FOR REVISION
1	DECEMBER 2016	ADDED ATTACHMENT D TO ACCOMMODATE SOP MODIFICATIONS REQUIRED WHEN SAMPLING FOR PFAS; CHANGED NAMING CONVENTION FOR SOP FROM RMD TO ECR.

ATTACHMENT A

EXAMPLE WATER AND PRODUCT LEVEL MONITORING FORM

WATER AND PRODUCT LEVEL MONITORING FORM

Technician: _____ Job #/Task #: _____ Date: _____

Site # _____ Project Manager _____ Page _____ of _____

Well #	TOC	Time Gauged	Total Depth (feet)	Depth to Water (feet)	Depth to Product (feet)	Product Thickness (feet)	Time Sampled	Misc. Well Notes

FIELD DATA COMPLETE QA/QC COC WELL BOX CONDITION SHEETS

MANIFEST DRUM INVENTORY TRAFFIC CONTROL

TRC

Field Meh Data Sheet GW 4/8/2013

ATTACHMENT B

EXAMPLE FIELD BOOK DOCUMENTATION FOR WATER LEVELS

Location _____ Date 3/4/1999 109

Project / Client _____

sunny, 80°F, slight westerly breeze

WELL I.D.	Depth To Water (ft)	Depth To Product (ft)	Measuring Point	Comments
MW-1A	2.10	–	TOC	no lock present
MW-1B	2.15	–	TOR	–
MW-2A	3.42	–	TOR	–
MW-2B	3.41	–	TOR	expansion plug missing
MW-3A	3.64	3.60	TOR	petro odor
MW-3B	3.70	–	TOC	–
MW-4A	1.55	–	TOR	–
MW-4B	1.57	–	TOR	–
MW-5A	6.30	–	TOR	–
MW-5B	6.64	–	TOR	concrete collar gone
PZ-10	4.33	–	TOR	–
PZ-11	4.22	–	TOR	–
PZ-12	4.47	–	TOR	–
PZ-13	8.03	–	TOR	–
PZ-14	8.88	–	TOR	well cap broken
PZ-15	5.09	–	TOR	–

Note: TOC = Top of casing
TOR = Top of riser

Thomas S. Weymouth 3/4/99

ATTACHMENT C

SOP FACT SHEET

WATER LEVEL AND PRODUCT MEASUREMENT PROCEDURES

PURPOSE AND OBJECTIVE

The following water level and product measurement procedures have been developed to direct TRC personnel in the methods of collecting water levels and product measurements in the field. Other state or federal requirements may be above and beyond the scope of this SOP and should be followed, if applicable. Depth-to-water (DTW) measurements are used to evaluate pressure and/or elevation changes within the aquifer. The objective of separate-phase product measurements is to obtain measurements of the thickness of separate-phase product in the water column. Both of these measurements are very important as they drive remediation decisions.

WHAT TO USE

- Water level meter
- Oil/Water interface probe
- Extra batteries
- Well keys
- Socket set
- Decontamination supplies
- Field book
- Indelible/waterproof ink

ON-SITE WELL GAUGING

- Prior to well gauging, site water level measurement data should be reviewed for direct comparison to aid in identifying and resolving potential measurement errors while in the field.
- Conduct an operational check of the water level meter by pushing the Start or Test button on the meter to test the battery and circuitry on the water level indicator. The meter audible indicator should sound and test light illuminate.
- If possible and when applicable, start at wells that are least contaminated and proceed to those wells that are most contaminated.
- Prior to collecting a water level, record the condition of the well (e.g., protective casing, concrete collar, lock in place, etc.).
- Stand upwind of the well and remove the well lid. Unlock and remove the well cap slowly to relieve pressure buildup that may have occurred in the well casing. Allow the well time to equilibrate.
- Identify the previous measuring point marking or notch on the riser or casing (if present). If no previous measuring point exists, use a permanent marker to mark a location on the rim of the riser or casing (typically the highest point). Record this location in the field book.
- Grasp the tape with hand, withdraw the tape, and lower it slowly until the sound is audible. Check the DTW on the tape and make a mental note of the depth to within 0.01 feet. Lower the probe again slowly and repeat the measurement for precision.
- If total depth measurements were not recorded recently, advance the tape to the bottom of the well to record a total depth.
- Decontaminate the probe and tape between each well.

ON-SITE PRODUCT MONITORING

- Prior to product gauging, product measurement data should be reviewed for direct comparison to aid in identifying and resolving potential measurement errors while in the field.
- Using a previously decontaminated oil/water interface probe, turn on the meter, check the audible indicator, and slowly reel the electronic probe into the well riser (with the increments visible) until the appropriate sound for water or separate-phase product is heard (intermittent tone for water; steady tone for product).
- If water is encountered first (as determined by the audible sound on the meter, which represents water), record the DTW from the measuring point to the nearest 0.01 feet.
- If water is encountered first and dense non-aqueous phase liquid (DNAPL) is suspected, continue lowering the probe until product is encountered (as determined by the audible sound on the meter, which represents product). In the field book or on the water level monitoring form, record the depth to product from the measuring point. If light non-aqueous phase liquid (LNAPL) is encountered before water, record the depth to product from the measuring point and continue lowering the probe until water is encountered and record the depth to water.
- Decontaminate the probe and tape between each well.

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.

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.

Water Level and Product Measurement Protocols for PFAS	
SOP Section Number	**Modifications to SOP**
1.3	• 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. • Use new plastic buckets for wash and rinse water. • Do not use "tap" water for operational check of the water level sensor of the oil/water interface meter. • Ensure that PFAS-free water is used during the decontamination procedure. • Do not use a plastic ruler to check measurements. • Refer to SOP 010, Equipment Decontamination, for decontamination supplies.
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 procedures: • Tyvek® suits should not be worn. 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. • Food and drink should not be allowed within the data measurement collection area. Bottled water and hydration drinks (e.g., Gatorade®) may be consumed in the staging area only. • Personnel involved with measurement data collection should wear a new pair of nitrile gloves between each well measurement. Avoid handling unnecessary items with nitrile gloves. • Avoid wearing clothing laundered with fabric softeners. • Avoid wearing new clothing (recommended six washings since purchase). Clothing made of cotton is preferred. • Avoid using cosmetics, moisturizers, hand creams, or other related products as part of cleaning/showering the morning of sampling and decontamination field work.
2.1.1	• Do not use potable "tap" water for operational check of the water level meter. Use deionized, distilled, or organic-free water.
2.1.2 and 2.1.3	• Do not use potable "tap" water for operational check of the water level sensor of the oil/water interface meter. Use deionized, distilled, or organic-free water. • Do not use a plastic ruler to check measurements.
2.2 (7) ; 2.3 (11); and 2.4 (6)	• Use only Alconox® or Liquinox® soap; do not use Decon 90. • Ensure that PFAS-free water is used during the decontamination

Water Level and Product Measurement Protocols for PFAS	
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	procedure.
5.0	• 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.

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

Authorization Signatures

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

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ATTACHMENTS

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 <u>all</u> 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) = πr^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

Interstate Technology Regulatory Council (ITRC). March 2006. *Technology Overview of Passive Sampler Technologies.*

USEPA. November 1992. *RCRA Ground-Water Monitoring: Draft Technical Guidance*. EPA/530-R-93-001. USEPA Office of Solid Waste.

USEPA. April 1996. *Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures*. EPA Ground Water Issue. EPA/540-S-95-504. USEPA Office of Solid Waste and Emergency Response.

USEPA. May 2002. *Ground-Water Sampling Guidelines for Superfund and RCRA Project Managers*. EPA/542-S-02-001. USEPA Office of Solid Waste and Emergency Response.

USEPA. September 2004. Field Sampling Guidance Document #1220: Groundwater Well Sampling. USEPA Region 9 Laboratory Richmond, California.

USEPA, January 19, 2010. *Low Stress (low flow) Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells*. USEPA Region 1, Rev. 3.

USEPA. March 6, 2013. *Groundwater Sampling*. SESDPROC-301-R3. USEPA Region 4, Science and Ecosystem Support Division. Athens, Georgia.

USEPA. April 22, 2014. Passive (No Purge) Samples. http://www.clu-in.org/characterization/technologies/default.focus/sec/Passive_%28no%20purge%29_Samplers/cat/Overview/

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

TRC

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 _____ ft. (from ground)

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. LNAPL/DNAPL Depth = _____

Well Volume _____ 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: _____

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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:		SAMPLE	TIME:		DATE:	
PURGE METHOD:	☐ PUMP				PH:	SU	CONDUCTIVITY:		umhos/cm
	☐ BAILER				ORP:	mV	DO:		mg/L
DEPTH TO WATER:		T/ PVC	FLOW-THRU CELL VOLUME		TURBIDITY:		NTU		
DEPTH TO BOTTOM:		T/ PVC			☐ NONE	☐ SLIGHT	☐ MODERATE	☐ VERY	
PUMP INTAKE DEPTH:		T/ PVC		LITERS	TEMPERATURE:	°C	OTHER:		
WELL VOLUME:		☐ LITERS	☐ GALLONS		COLOR:		ODOR:		
VOLUME REMOVED:		☐ LITERS	☐ GALLONS		FILTRATE (0.45 um)	☐ YES	☐ NO		
COLOR:		ODOR:			FILTRATE COLOR:		FILTRATE ODOR:		
TURBIDITY					QC SAMPLE:	☐ MS/MSD	☐ DUP-		
☐ NONE	☐ SLIGHT	☐ MODERATE	☐ VERY		COMMENTS:				
DISPOSAL METHOD:	☐ GROUND	☐ DRUM	☐ OTHER						

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:	

TRC

Groundwater Sampling Record for Organics (For Wells with Passive Diffusion Bags)

Project Name/No:	Well ID:

Installation of PDBs:

TRC Personnel: _____

Date: _____

Time: _____

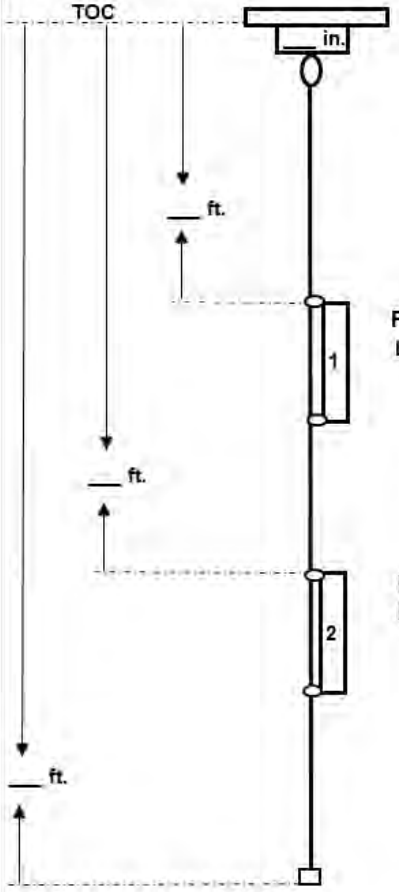
DTW (ft): _____

Sampling of PDBs:

TRC Personnel: _____

Date: _____

DTW (ft): _____



PDB #1
Length: ___ in.

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

PDB #2
Length: ___ in.

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) = $\pi r^2 h$

- 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 4°C 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.

Title: **Equipment Decontamination**	Procedure Number: **RMD 010**
	Revision Number: **0**
	Effective Date: **April 2014**

Authorization Signatures

Technical Reviewer	Date	Remediation Practice Quality Coordinator	Date
James Peronto	4/9/14	Elizabeth Denly	4/9/14

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ATTACHMENTS

1.0 INTRODUCTION

1.1 Scope & Applicability

This Standard Operating Procedure (SOP) was prepared to direct TRC personnel in the procedures needed for decontamination of equipment used in the field during environmental investigations (e.g., sediment, soil, groundwater investigations). Other state or federal requirements may be above and beyond the scope of this SOP and will be followed, if applicable. In all instances, the actual procedures used should be documented and described in the field notes. Preventing or minimizing potential cross-contamination of samples is important for the collection of representative samples, avoiding the possible introduction of sampling error into sample results, and for protecting the health and safety of site personnel.

Removing or neutralizing potential contaminants that may have accumulated on equipment and vehicles ensures protection of personnel, reduces or eliminates potential transfer of contaminants to clean areas, and minimizes the likelihood of sample cross-contamination.

The use of dedicated, disposable, new sampling equipment (e.g., disposable liners, plastic spoons, plastic or aluminum bowls) should be considered as an alternative to equipment decontamination and the subsequent generation of decontamination fluids.

1.2 Summary of Method

Equipment decontamination is used to remove potential contaminants from a sampling device or piece of field equipment prior to and between the collection of samples and is also used to limit personnel exposure to residual contamination that may be present on used field equipment.

Contaminants can be physically removed from equipment or deactivated by sterilization or disinfection. Gross contamination of equipment requires physical decontamination, including abrasive and nonabrasive methods. These include the use of brushes, air and wet blasting, and high-pressure water, followed by a wash/rinse process using appropriate cleaning solutions. A solvent rinse may be required when organic contamination is present, and an acid rinse may be required when metals are parameters of interest. Equipment decontamination procedures can vary depending on the media being sampled and the type of sampling equipment being used. Disposal of decontamination fluids will be handled on a project-specific basis and will be in accordance with all applicable regulations.

1.3 Equipment

The following equipment may be utilized when decontaminating equipment. Project-specific conditions or requirements 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)
- Alconox®, Liquinox® or other nonphosphate concentrated laboratory-grade soap

- Simple Green® or other nontoxic biodegradable cleaner
- Deionized, distilled, or organic-free water, as appropriate (may be supplied by the laboratory or purchased from commercial vendors depending on project requirements)
- Pump sprayer
- Pressure sprayer
- Squeeze bottle filled with pesticide-grade hexane (option for organic analyses)
- Squeeze bottle filled with pesticide-grade methanol (option for organic analyses)
- Squeeze bottle filled with pesticide-grade isopropanol (option for organic analyses)
- Squeeze bottle filled with 10 percent nitric acid (option for metals analyses and stainless-steel equipment)
- Squeeze bottle filled with 1 percent nitric acid (option for metals analyses)
- Container (squeeze bottle to 5-gallon bucket) filled with potable water and a nonphosphate, laboratory-grade soap (approximately 1 tablespoon of soap to 5 gallons of water)
- Extra quantities of above listed liquids
- Potable water
- Containers, such as buckets or wash basins (the type and number of containers is dependent on the procedure)
- Scrub brushes
- Small wire brush
- Aluminum foil
- Polyethylene sheeting
- A container for decontamination of pumps and associated tubing.

1.4 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.

Samples containing chemical contaminants may be handled during implementation of this SOP. Certain decontamination fluids, including solvents and/or acids, are considered hazardous materials, and TRC employees will appropriately handle and store them at all times. Appropriately manage chemicals that pose specific toxicity or safety concerns, and follow any other relevant requirements as appropriate. Hazardous substances may be incompatible or may react to produce heat, chemical reactions, or toxic products. Some hazardous substances may be incompatible with clothing or equipment and can permeate or degrade protective clothing or equipment. Also, hazardous substances may pose a direct health hazard to workers through inhalation or skin contact or if exposed to heat/flame and they combust. Safety data sheets for chemicals handled by TRC personnel should be maintained in a designated location at the project site.

1.5 Cautions and Potential Problems

- The use of deionized, distilled or organic-free water commonly available from commercial vendors may be acceptable for decontamination of sampling equipment provided that it has been certified by the vendor as analyte-free and/or meets the project-specific requirements.

- Alconox®, Liquinox®, or other nonphosphate, concentrated, laboratory-grade soap may contain trace quantities of perchlorate.

- Avoid using an excessive amount of soap during decontamination procedures, as this could result in difficulty rinsing the soap residue off of the equipment. Typically the soap solution is prepared using 1 tablespoon of soap to 5 gallons of water.

- Use sufficient amount of decontamination fluid (e.g., acid or solvent rinses) so that the fluid flows over the equipment and runs off. Spraying the equipment with a minimal amount of decontamination fluid that does not run off is ineffective.

- Spent decontamination solutions are considered investigation-derived waste (IDW) and must be managed as directed by the site-specific field program. Project and regulatory requirements, chemical compatibility, ambient conditions and professional judgment should be used to determine the appropriate decontamination process with respect to combining and/or segregating decontamination fluids. Section 3 of this SOP provides more guidance on the disposal procedures.

- Several procedures can be established to minimize the potential for cross-contamination or analytical interference by decontamination fluids. For example:

  - The use of methanol in the decontamination procedure may not be appropriate if methanol is a contaminant of concern.

  - Isopropanol may be used as a substitute for methanol but may not be appropriate when collecting samples for volatile organic compound (VOC) analyses. Residual isopropanol on the equipment may cause substantial interferences in subsequent VOC analyses and may result in unnecessary dilutions and/or false positive results if isopropanol is not removed in subsequent decontamination steps. It should also be noted that the application of isopropanol to hot metal surfaces (e.g., a steam-cleaned split spoon) may cause oxidation of the isopropanol to acetone.

  - If hexane is used in the decontamination procedure, caution should be used to ensure that the hexane is completely volatilized and the equipment is subsequently rinsed when samples are to be analyzed for VOCs and volatile petroleum hydrocarbons (VPH). Residual hexane on equipment could interfere with the VOC and VPH analyses and may result in unnecessary dilutions and/or false positive results.

  - Cover monitoring and sampling equipment with protective material (i.e., aluminum foil, polyethylene sheeting, or Ziploc® bags) to minimize potential re-contamination after decontamination.

- Use disposable sampling equipment when appropriate to minimize the need for decontamination. Although disposable sampling tools are encouraged in order to minimize the generation of decontamination fluids, it should be noted that plastic tools may not be appropriate for collection of samples to be analyzed for semivolatile organic compounds (SVOCs), pesticides, and polychlorinated biphenyls (PCBs). Potential phthalate contamination may cause significant interferences in the subsequent analyses and may result in unnecessary dilutions and/or false positive results.

- After decontamination, equipment should be handled only by personnel wearing clean disposable powder-free nitrile gloves to prevent recontamination.
- If equipment decontamination is performed in the field, the equipment should be moved away (preferably upwind) from the decontamination area to prevent recontamination.
- Equipment that is not decontaminated properly may result in potentially high biased results in field samples. **Note:** Equipment blank collection may be appropriate after decontamination of equipment used to collect highly contaminated samples.

1.6 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 work plan. These requirements may include:

- Occupational Safety and Health Administration (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

Refer to the site-specific sampling plan and/or Quality Assurance Project Plan (QAPP), if applicable, for site-specific procedures. Other state or federal requirements may be above and beyond the scope of this SOP and will be followed if applicable. In all instances, the actual procedures used should be documented and described in the field notes.

2.1 General

All personnel, sample containers, and equipment leaving the contaminated area of a site must be decontaminated. Various decontamination methods will either physically remove contaminants by abrasive and/or washing actions, inactivate contaminants by disinfection or sterilization, or both. Decontamination procedures should be documented in the field book.

2.2 Physical Decontamination Procedures

In many cases, gross contamination can be removed by physical means. The physical decontamination techniques appropriate for equipment decontamination can be grouped into two categories: abrasive methods and nonabrasive methods. In general, heavy equipment decontamination is conducted by drilling and construction subcontractors and not by TRC personnel. However, TRC personnel will typically need to document such decontamination efforts as part of project work.

ABRASIVE CLEANING METHODS APPROPRIATE FOR DRILLING EQUIPMENT (DRILLING RIGS, ETC.)

Abrasive cleaning methods involve rubbing and wearing away the top layer of the surface containing the contaminant. The following abrasive methods are available but are not commonly used:

- *Mechanical:* Mechanical cleaning methods use brushes of metal or nylon. The amount and type of contaminants removed will vary with the hardness of bristles, length of brushing time, and degree of brush contact.

- *Air Blasting:* Air blasting is used for cleaning large equipment, such as bulldozers, drilling rigs, or auger bits. The equipment used in air blasting employs compressed air to force abrasive material through a nozzle at high velocities. The distance between the nozzle and the surface cleaned, as well as the pressure of air, the time of application, and the angle at which the abrasive material strikes the surface, determines cleaning efficiency. Air blasting has several disadvantages, including it is unable to control the amount of materials removed, it can aerate contaminants, and it generates large amounts of waste.

- *Wet Blasting:* Wet blasting, also used to clean large equipment, involves use of a suspended fine abrasive delivered by compressed air to the contaminated area. The amount of materials removed can be carefully controlled by using very fine abrasives. One disadvantage of this method is the generation of a large amount of waste.

NONABRASIVE CLEANING METHODS APPROPRIATE FOR FIELD EQUIPMENT (DRILLING AUGERS AND RIGS, ETC.)

Nonabrasive cleaning methods involve forcing the contaminant off of a surface with pressure. In general, less of the equipment surface is removed using nonabrasive methods. The following non-abrasive methods are available:

- *High-pressure Potable Water:* This method consists of a high-pressure pump, an operator-controlled directional nozzle, and a high-pressure hose. Flow rates typically range from 20 to 140 liters per minute.

  This procedure is used the majority of the time and is more appropriate for equipment with painted surfaces.

- *Ultrahigh-Pressure Potable Water:* This system produces a pressurized water jet. The ultrahigh-pressure spray removes tightly adhered surface film. The water velocity ranges from 500 meters per second (m/sec) to 900 m/sec. Additives can enhance the method. This method is not applicable for hand-held sampling equipment.

  This procedure is not commonly used but would be appropriate for carbon steel drilling rods and augers.

2.3 Procedure for Sampling Equipment

Sampling equipment, such as split-spoon samplers, shovels, hand augers, trowels, spoons, spatulas, bailers, tethers, dippers, and pumps, will be cleaned using the following procedure**.** **Note:** The overall number of containers needed for collection of decontamination fluids may vary depending on chemical compatibilities, project and regulatory requirements, and ultimate disposal methods for these fluids.

1. Lay out sufficient polyethylene sheeting on the ground or floor to allow placement of the necessary number of containers (e.g., plastic wash basins or buckets) and an air drying area. The number of decontamination steps and designated containers should be determined prior to field sampling based on the site-specific sampling plan. At a minimum, one container should be designated for the detergent wash. A second container should be designated for water rinsing. A third container may be designated for nonwater rinsing. If more than one, the nonwater rinsate fluids may need to be separated. Nonwater rinsate fluids should not be combined with the detergent wash during decontamination. Place the containers on the polyethylene sheeting. The decontamination line should progress from "dirty" to "clean".

   Note: In instances where acid or solvent rinses are required, additional containers may be needed to manage collection and subsequent disposal of the spent decontamination fluids.

2. Fill the first container with potable water. Add sufficient nonphosphate concentrated laboratory-grade soap to cause suds to form in the container. Do not use an excessive amount of the soap (approximately 1 tablespoon of soap to 5 gallons of water), or rinsing the soap residue off of the equipment will be difficult.

3. Brush any visible dirt off of the sampling equipment into a designated area before getting equipment wet.

4. Using a clean, coarse scrub brush, submerge and wash the sampling equipment in the soap solution in the first container, removing all dirt or visible hydrocarbons. Allow excess soap to drain off the equipment into the container when finished. If cleaning a pump that is not completely disassembled, run the submerged pump in the container long enough to allow sufficient contact time with the internal components of the pump.

5. Rinse the equipment with potable water over an appropriate container, using a coarse scrub brush or pressure sprayer to aid in the rinse if necessary. If an additional acid or solvent rinse is not required, proceed to Step 8.

6. **If sampling for metals and if required by the project, rinse the equipment with nitric acid over an appropriate container. Consider using a container dedicated to acidic solutions to

minimize the volume of liquid that needs to be neutralized later. A 10 percent nitric acid solution is used on stainless steel equipment. A 1 percent nitric acid solution is used on all other equipment. If not required, this step may be omitted.

Rinse the equipment over an appropriate container using deionized, distilled or organic-free water. If cleaning a pump that is not completely disassembled, run the submerged pump in the container long enough to allow sufficient contact time with the internal components of the pump.

7. **If sampling for organic parameters and if required by the project, rinse the equipment over an appropriate container using pesticide-grade methanol or isopropanol (see Cautions and Potential Problems). If oily, a pesticide-grade hexane rinse should follow the methanol/isopropanol rinse, or as an alternative, Simple Green® can be used if approved by the Project Manager. Consider using an appropriate container dedicated to volatile solvents to minimize the volume of liquid that subsequently needs to be managed as IDW. If not required, this step may be omitted.

   Allow the equipment to completely air dry prior to proceeding to the next step.

   **** Steps 6 and 7 are optional and may be used on a site-specific basis. The site-specific sampling plan or QAPP, if available, should be consulted. In the absence of a sampling plan or QAPP, the Project Manager will decide upon the necessity of these steps.**

8. Rinse the equipment over an appropriate container using deionized, distilled or organic-free water. If cleaning a pump that is not completely disassembled, run the submerged pump in the container long enough to allow sufficient contact time with the internal components of the pump.

9. Allow the equipment to completely air dry on a clean surface (e.g., polyethylene sheeting or a clean container) (See*NOTE).

   ***NOTE** that if temperature or humidity conditions preclude air drying equipment, sufficient spares, if possible, should be available so that no item of sampling equipment need be used more than once. If an ample amount of spare equipment is not available and the equipment will not completely air dry, additional rinses with deionized, distilled or organic-free water should be used. The inability of equipment to air dry and the usage of additional rinses should be recorded in the field book or on the appropriate form.

10. Reassemble equipment, if necessary, and wrap completely in clean, unused, protective material. Reuse of equipment on the same day without wrapping in protective material is acceptable.

11. Spent decontamination fluids are considered IDW and must be managed as directed by the site-specific field program.

12. Record the decontamination procedure in the field book or on the appropriate form.

2.4 Procedure for Measuring Equipment

Measuring equipment, such as pressure transducers, water level indicators, oil/water interface probes, and soil moisture/pH meters will be cleaned using the following procedure, unless it conflicts with the manufacturer's recommendations.

1. Fill two clean containers (e.g., plastic wash basins or buckets) with potable water.

2. Add sufficient nonphosphate concentrated laboratory-grade soap to one container to form a thin layer of soap suds. If oily residues are apparent, the use of Simple Green® may be required.

3. Brush any visible dirt off of the measuring equipment before getting the equipment wet.

4. Either spray rinse the device with the soap solution over the first container, or for heavily soiled equipment, immerse the device in the container containing soap and gently agitate. Scrub device if it is soiled. Do not submerse any electrical controls or take-up reels. Submerse only that portion of the device that came in contact with potential contaminants.

5. Immerse the device in the container containing the potable water and gently agitate. Do not submerse any electrical connectors or take-up reels. Submerse only that portion of the device that came in contact with potential contaminants.

6. Spray rinse equipment with deionized, distilled, or organic-free water over the last container used.

7. Allow the equipment to air dry if time allows.

8. Record the decontamination procedure in the field book or on the appropriate form.

3.0 INVESTIGATION-DERIVED WASTE DISPOSAL

Field personnel should discuss specific documentation and containerization requirements for IDW disposal with the Project Manager.

Each project must consider IDW disposal methods and have a plan in place prior to performing the field work. Provisions must be in place regarding what will be done with IDW. If IDW 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

One type of quality control sample specific to the field decontamination process is the equipment blank. The equipment blank provides information about the effectiveness of the decontamination process employed in the field. An equipment blank can detect contamination that may arise from potentially contaminated equipment or equipment that has not been decontaminated effectively.

Equipment blanks consist of a sample of analyte-free (i.e., deionized, distilled, organic-free) water that is poured over and through a decontaminated sampling device and placed in a clean sample container. Ideally, the reagent water should come from the laboratory and be certified as clean. If the blank water is not certified as clean and/or not supplied by the laboratory performing the analyses, a separate water blank that has not run through the sampling equipment should also be sent to the laboratory for analysis.

Equipment blanks are typically collected for all parameters of interest at a minimum rate of 1 per 20 samples for each parameter. The frequency of equipment blank collection will vary from project to project, depending upon the data quality objectives, and will be specified in either the site-specific sampling plan or QAPP. Equipment blanks are typically not required if dedicated sampling equipment is used.

5.0 DATA MANAGEMENT AND RECORDS MANAGEMENT

All reagents used must be documented in the field book or on the appropriate form. Any deviations from the decontamination procedures specified in the sampling plan or QAPP must be approved by the Quality Assurance (QA) Officer and Project Manager and documented in the field book. The lot number and vendor of each reagent used should be documented in the field book. Refer to RMD SOP 001 for field documentation procedures.

6.0 REFERENCES

USEPA. December 1987. *A Compendium of Superfund Field Operations Methods*. EPA/540/P-87/001.

USEPA. January 1991. *Compendium of ERT Groundwater Sampling Procedures*. OSWER Directive 9360.4-06. PB91-9211275.

USEPA. November 1992. *RCRA Ground-Water Monitoring: Draft Technical Guidance*. EPA/530-R-93-001. USEPA Office of Solid Waste.

USEPA. January 1999. *Compendium of ERT Groundwater Sampling Procedures*. EPA/540/P-91/007. OSWER Directive 9360.4-06. PB91-921275.

USEPA. December 20, 2011. *Field Equipment Cleaning and Decontamination*. SESDPROC-205-R2. Region 4. Science and Ecosystems Support Division. Athens, Georgia.

7.0 SOP REVISION HISTORY

REVISION NUMBER	REVISION DATE	REASON FOR REVISION
0	APRIL 2014	NOT APPLICABLE

Attachment A: SOP Fact Sheet

EQUIPMENT DECONTAMINATION

PURPOSE AND OBJECTIVE

Removing or neutralizing potential contaminants that may have accumulated on equipment and vehicles ensures protection of personnel, reduces or eliminates potential transfer of contaminants to clean areas, and minimizes the likelihood of sample cross-contamination. Preventing or minimizing potential cross-contamination of samples is important for the collection of representative samples, avoiding the possible introduction of sampling error into sample results, and for protecting the health and safety of site personnel.

WHAT TO BRING

- Field book
- Appropriate PPE
- Site-specific HASP
- Alconox®, Liquinox® or other nonphosphate concentrated laboratory-grade soap
- Simple Green® or other nontoxic biodegradable cleaner
- Deionized, distilled, or organic-free water, as appropriate
- Potable water (or water containers if potable water source on site or nearby)
- Pump or pressure sprayer
- Squeeze bottles filled with appropriate decontamination chemicals (e.g., organic solvents, nitric acid)
- Containers, such as buckets or wash basins (type and number is dependent on the procedure)
- Scrub brushes
- Aluminum foil
- Polyethylene sheeting

OFFICE

- Prepare/update the site-specific HASP; make sure the field team is familiar with the latest version.
- Review site-specific sampling plan/QAPP for decontamination procedures and procedures for management of investigation-derived waste (IDW) (e.g., used decontamination solutions).
- Confirm all required decontamination supplies are in stock or order as needed.

ON-SITE

- Verify project HASP including safety data sheets for decontamination chemicals used on site.
- Conduct daily Health & Safety tailgate meetings, as appropriate.
- Establish a designated equipment and personnel decontamination area.
- Provide for the proper collection and management of all IDW.
- Verify that appropriate PPE is worn by all site personnel (including subcontractors) and the work area is safe.

SAMPLING EQUIPMENT DECONTAMINATION - PROCEDURES

Sampling equipment, such as split-spoon samplers, shovels, hand augers, trowels, spoons, spatulas, bailers, tethers, dippers, and pumps, will be cleaned using the following procedure. **A more simplified procedure for decontamination of measuring equipment is presented in the SOP.** Note: The overall number of containers needed for collection of decontamination fluids may vary depending on chemical compatibilities, project and regulatory requirements, and ultimate disposal methods for these fluids.

1. Lay out sufficient polyethylene sheeting on the ground or floor and the necessary number of containers (e.g., plastic wash basins or buckets) and an air drying area. At a minimum, one container should be designated for the detergent wash. A second container should be designated for water rinsing. A third container may be designated for nonwater rinsing. Nonwater rinsate fluids should not be combined with the detergent wash during decontamination. The decontamination line should progress from "dirty" to "clean".
   Note: In instances where acid or solvent rinses are required, additional containers may be needed to manage collection and subsequent disposal of the spent decontamination fluids.
2. Fill the first container with potable water. Add sufficient nonphosphate concentrated laboratory-grade soap to cause suds to form in the container.
3. Brush any visible dirt off of the sampling equipment before getting equipment wet.
4. Using a clean, coarse scrub brush, submerge and wash the sampling equipment in the soap solution in the first container.

EQUIPMENT DECONTAMINATION

5. Rinse the equipment with potable water over an appropriate container. If an additional acid or solvent rinse is not required, proceed to Step 8.
6. **If sampling for metals and if required by the project, rinse the equipment with nitric acid over an appropriate container. Consider using a container dedicated to acidic solutions to minimize the volume of liquid that needs to be neutralized later. A 10 percent nitric acid solution is used on stainless steel equipment. A 1 percent nitric acid solution is used on all other equipment. If not required, this step may be omitted.
7. **If sampling for organic parameters and if required by the project, rinse the equipment over an appropriate container using pesticide-grade methanol or isopropanol (see Caution and Potential Problems). If oily, a pesticide-grade hexane rinse should follow the methanol/isopropanol rinse, or as an alternative, Simple Green® can be used if approved by the Project Manager. Consider using an appropriate container dedicated to volatile solvents to minimize the volume of liquid that subsequently needs to be managed as IDW. If not required, this step may be omitted.
   Allow the equipment to completely air dry prior to proceeding to the next step.
   ** Steps 6 and 7 are optional and may be used on a site-specific basis. The site-specific sampling plan or QAPP, if available, should be consulted. In the absence of a sampling plan or QAPP, the Project Manager will decide upon the necessity of these steps.
8. Rinse the equipment over an appropriate container using deionized, distilled or organic-free water.
9. Allow the equipment to completely air dry on a clean surface (e.g., polyethylene sheeting or a clean container).
   *NOTE that if temperature or humidity conditions preclude air drying equipment, sufficient spares, if possible, should be available so that no item of sampling equipment need be used more than once. If an ample amount of spare equipment is not available and the equipment will not completely air dry, additional rinses with deionized, distilled or organic-free water should be used. The inability of equipment to air dry and the usage of additional rinses should be recorded in the field logbook or on the appropriate form.
10. Reassemble equipment, if necessary, and wrap completely in clean, unused, protective material. Reuse of equipment on the same day without wrapping in protective material is acceptable.
11. Spent decontamination fluids are considered IDW and must be managed as directed by the site-specific field program.

INVESTIGATION DERIVED WASTE (IDW) DISPOSAL

Field personnel should review the project work plan and ensure project-specific IDW management documentation and containerization requirements are specified or discussed with the Project Manager before going to the project site.

DATA MANAGEMENT AND RECORDS MANAGEMENT

All reagents used must be documented in the field book or an appropriate field form. Any deviations from the decontamination procedures specified in the work plan, sampling plan or QAPP must be approved by the Quality Assurance (QA) Officer and Project Manager and documented in the field book. The lot number and vendor of each reagent used should be documented in the field logbook. Refer to RMD SOP 001 for field documentation procedures.

DOS AND DO NOTS OF EQUIPMENT DECONTAMINATION

DOs:

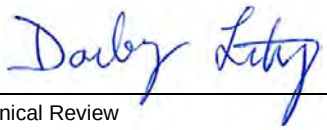
- DO call the Project Manager or field team leader if unexpected conditions are encountered or at least daily to update them on site work.
- DO manage and collect IDW in accordance with project requirements.
- DO use deionized, distilled or analyte free water that is provided by the laboratory, is certified analyte-free, and/or meets project requirements.
- DO use sufficient amount of decontamination fluids so that the fluid flows over the equipment and runs off.
- DO use new wrapped disposable dedicated sampling equipment when appropriate to minimize the need for decontamination.

DO NOTs:

- DO NOT use an excessive amount of soap during decontamination.
- DO NOT sign anything in the field unless authorized in writing by client. This includes waste disposal documentation, statements, etc.; call PM if this issue arises.

Title: **Calibration of Field Instruments for Water Quality Parameters**	Procedure Number: **RMD 011**
	Revision Number: **0**
	Effective Date: **November 2014**

Authorization Signatures

	
Technical Review — Date Darby Litz — 11/21/2014	Remediation Practice Quality Coordinator — Date Elizabeth Denly — 11/21/14

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LIST OF ATTACHMENTS

1.0 INTRODUCTION

1.1 Scope and Applicability

The purpose of this standard operating procedure (SOP) is to provide a framework for calibrating field instruments used to measure water quality parameters for ground water and surface water. Water quality instruments addressed in this SOP include those that measure temperature, pH, dissolved oxygen (DO), conductivity/specific conductance, oxidation-reduction potential (ORP), and turbidity.

1.2 Summary of Method

All monitoring instruments must be calibrated before they are used to measure environmental samples. This SOP outlines the general methods for field instrument calibration, calibration documentation requirements, and corrective action procedures that will be implemented during field activities. Calibration procedures are different for each field instrument used and these procedures should be provided by the instrument manufacturer. The manufacturer's instruction manual (including the instrument specifications) should accompany the instrument into the field.

At a minimum, calibration and/or a calibration check must be performed at the beginning of each day prior to use. Site-specific work plans should be consulted for required calibration frequency. Note: The initial calibration may be performed in the office prior to the field event or by the equipment supplier; however, calibration checks should be performed on site prior to use on the day of the fieldwork.

1.3 Equipment

The following equipment may be utilized when calibrating water quality parameter measuring equipment. Project-specific conditions or laboratory requirements may warrant the addition 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).
- Water quality meter capable of measuring one or more of the following based on project scope: pH, temperature, DO, specific conductivity, and ORP (e.g., YSI 600XL, Horiba U-50, Hydrolab Quanta/QED MP-20, or equivalent)
- Turbidity meter (e.g., LaMotte Model 2020e, Hach 2100P, or equivalent)
- Deionized water
- Flow-through cell
- Ring stand with clamp
- Paper towels
- Soft tissue (e.g., Kimwipes®)
- Cuvettes

- Buffer solutions at pH 4, 7 and 10 standard units (SU)*. Commercially available solutions that have been validated by comparison to National Institute of Standards and Technology (NIST) standards are recommended for routine use.
- Conductivity solution (potassium chloride, typically 1,413 micromhos/centimeter [µmhos/cm])*
- ORP calibration solution (e.g., Zobell)*
- Turbidity standards (0, 1, 10 nephelometric turbidity units [NTUs] or StablCal Kit)*
- Zero DO solution (0.0 milligrams per liter [mg/L])*
- DO membrane kit (electrolyte solution, membranes)
- NIST thermometer (0.2ºC accuracy)*
- Small glass or polyethylene jars to hold the calibration standards (4-8 oz.)
- Field book
- Field instrument calibration logs
- Cup or spray bottle for the deionized water

*Dependent on the project-specific requirements and the instrument manufacturer

1.4 Definitions

Not applicable

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.

Implementing this SOP will require the use of calibration solutions. The following health and safety precautions must be taken with the pH, conductivity, turbidity, zero DO and ORP solutions: Avoid inhalation, skin and eye contact, and ingestion.

Maintenance of the instruments will require the use of liquid cleaners. Although these substances are not hazardous materials, TRC will appropriately handle and store them at all times in accordance with manufacturer's instructions.

1.6 Cautions and Potential Problems

General cautions and potential problems are discussed below. Specific issues for individual parameters are discussed in Section 2.

- Prior to calibration, all instrument probes must be cleaned according to the manufacturer's instructions. Failure to perform this step (proper maintenance) can lead to erroneous measurements. Rental instruments are routinely maintained by the vendor but should be checked for residues upon receipt.

- Prior to using calibration standards, check and record all expiration dates and lot numbers for the solutions on the field instrument calibration log. Discard any calibration standards that are past their expiration date.
- Avoid storing calibration solutions in extremely hot or cold temperatures to maintain solution integrity and prevent calibration errors.
- The volume of the calibration solutions must be sufficient to cover both the probe being calibrated and the temperature sensor (see manufacturer's instructions for additional information).
- Pre-rinse the sensor and calibration cup with a small amount of calibration solution to minimize dilution or cross-contamination.
- If desired, use a ring stand and clamp to secure the sonde in an upright position. This will prevent the sonde from falling over and damaging the probes.
- While calibrating or performing sample measurements, make sure there are no air bubbles lodged between the probe and the probe guard.
- Do not immerse the sensors in sea water or other highly saline water, alcohol or organic solvents.
- Problems during calibration may indicate the need to clean or replace sensors, electrodes or membranes or replace the calibration solutions.
- Have several clean absorbent paper towels or cotton cloths available to dry the probe between rinses and calibration solutions. Shake excess water off of the probes and dry off the outside of the probe sensors.
- All meters may have different relative accuracy, which will be specified in the instrument manual. Confirm that the meter being used meets the project's accuracy requirements.

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 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

Prior to use, instruments that will be used during field activities will be inspected to ensure they are clean, checked for possible malfunctions, and calibrated in accordance with manufacturer's

procedures. Often, equipment provided by a rental company is calibrated prior to shipment, and a calibration certificate is provided with the equipment. Review the calibration certificate provided by the equipment supplier.

Calibration checks (or verifying that instrument readings fall within an acceptable range of a standard without running through the full instrument calibration steps) will be performed on field instruments prior to their initial use, at least once daily, or whenever indications of faulty readings or instrument malfunction occurs. Some instruments or certain project scopes may require more frequent calibration checks depending on project quality objectives. In general, instrument selection and calibration will include the following steps:

- Determine which instruments are needed for the specific field tasks. Record the make, model number, and serial number of the instrument on the field instrument calibration log or in the field book.
- Obtain the necessary instruments and standard solutions for calibration. Check expiration dates on standard solutions and replace if out of date. Record the manufacturer, true value, lot number and expiration date of the standard solutions on the field instrument calibration log or in the field book.
- Assemble the instrument and turn it on allowing the instrument to warm up.
- Check battery charge, and charge or replace if necessary.
- Clean instrument (if necessary).
- If applicable, program the multi-probe instrument so that the applicable parameters to be measured will be displayed.
- Calibrate the instrument prior to field use in accordance with manufacturer's procedures. (Note: If applicable, calibrate DO and conductivity first, because these parameters may affect the other calibrations).
- Document all calibration activities and results on the field instrument calibration log or in the field book.
- If the instrument malfunctions and cannot be corrected, obtain a replacement.
- Clean and decontaminate the instrument after use and before storage.
- Conduct calibration checks at least once per day or as needed.

The subsections that follow provide additional details and guidance regarding calibration for specific parameters; however, since every field instrument is different, refer to the specific instrument's manual for appropriate operating and calibration procedures.

2.1 Temperature

Most instrument manuals state that calibration of the temperature sensor is not required, but this SOP recommends that the temperature sensor be checked to verify its accuracy. This accuracy check should be performed at least once per year and the accuracy check date/information should be kept with the instrument. If the accuracy check date/information is not included with the instrument or the last check was performed over a year prior to the date of use, it is recommended that the temperature sensor accuracy be checked at the beginning of the sampling event. If the instrument contains multiple temperature sensors, each sensor should be checked. Accuracy checks may be performed by the manufacturer/equipment supplier or in the field. Review the calibration certificate provided by the equipment supplier.

In the event of suspect temperature readings, the following verification procedure can be performed.

FIELD VERIFICATION PROCEDURE

1. Record the manufacturer, model number, and the certification number of the NIST thermometer being used to check the instrument's temperature sensor on the field instrument calibration log or in the field book. Allow a container filled with water to equilibrate to ambient temperature.

2. Place an NIST thermometer and the instrument's temperature sensor into the water, and wait approximately 2 to 3 minutes for both temperature readings to stabilize.

3. Record the temperature displayed by the thermometer and the temperature sensor on the field instrument calibration log or in the field book.

4. Compare the two measurements. The instrument's temperature sensor must agree with the NIST thermometer measurement within the accuracy of the sensor (typically $\pm$0.15ºC). If the measurements do not agree, determine the correction factor to be applied to any subsequent temperature measurements made with this instrument. This correction factor must be applied to all readings made with the temperature sensor of this instrument.

   Correction Factor = NIST thermometer value – temperature sensor value

5. Record the date the temperature sensor check was performed and the correction factor that was determined, if applicable, on the field instrument calibration log or in the field book.

2.2 Dissolved Oxygen

DO is the volume of oxygen that is dissolved in water and is typically measured using an electrochemical membrane sensor.

CAUTIONS AND POTENTIAL PROBLEMS WITH DO MEASUREMENTS

- The DO probe's membrane and electrolyte solution should be checked prior to the sampling period and replaced if needed. If wrinkles or air bubbles are present under the membrane, if the membrane is torn or dirty, or if the electrolyte solution looks contaminated, replace both the membrane and electrolyte solution prior to calibration. Failure to perform this step may lead to erratic or erroneous measurements.
- Rental instruments are routinely maintained by the vendor, but the membrane should be checked for signs of wear upon receipt.
- If the probe reading shows the error message, "value out of range", the instrument probe must be recalibrated at a minimum. If the error persists, replace the sensor membrane and recalibrate.
- Most meters will allow you to calibrate the meter in air or against a wet sponge, which gives a "saturated air" calibration. Like pH, conductivity, and ORP, DO is heavily dependent on temperature. DO is also dependent upon barometric pressure. Typically DO is calibrated by entering the barometric pressure (usually in mm of mercury).

Barometric pressure is dependent upon elevation, so be aware of substantial differences in elevation between your sampling location and the location from which you are obtaining the barometric pressure reading. Use the Oxygen Solubility at Indicated Pressure chart in Attachment A for comparison to your calibrated reading.

- Barometric pressure should be corrected to local altitude for DO calibration:

  True BP (mm Hg) = [Corrected BP (mm Hg)] – [2.5 * Local Altitude (ft. above sea level)/100]

- If the calibration cup is used for DO, ensure the cup is loose to allow for pressure equilibration.
- Wait 3 to 5 minutes for the air in the cup to saturate with water during DO calibration.
- If calibrating in air, remove water droplets from the membrane by shaking the probe prior to inserting it into the calibration environment.
- Allow the temperature to stabilize completely in the calibration environment.
- Always keep the sensor clean of biofouling, such as bacteria or algae growth which may generate or consume oxygen resulting in erroneous readings.
- Keep the sensor free of oil, which could clog the membrane and prevent oxygen from diffusing to the sensor.
- Store the probe in a moist environment to keep the membrane from drying out, but do not store it in water which could encourage algae growth on the probe.

CALIBRATION PROCEDURE

1. Gently dry the temperature sensor according to manufacturer's instructions.

2. Place a wet sponge, a wet paper towel, or 1/8 inch of water on the bottom of the DO calibration container that comes with the instrument. (The protective cover of the probe assembly also serves as the container used for the DO calibration.)

3. Place the DO probe in the container without the probe coming in contact with the wet sponge or paper towel. The probe must fit loosely in the container to ensure it is vented to the atmosphere.

4. Allow the confined air to become saturated with water vapor (saturation occurs in approximately 3 to 5 minutes as temperature becomes stable). During this time, turn on the instrument to allow the DO probe to warm up (may require at least 10-20 minutes warm-up time).

5. Record the barometric pressure (usually in mm of mercury) from the instrument's onboard sensor, if available. If the instrument does not have an onboard barometer, this measurement can also be determined from an on-site barometer if a weather station is on site and manually entered into the meter. It is recommended that the barometric pressure not be obtained from the local weather service unless the pressure is corrected for the elevation of the sampling location and this is the only source of barometric data. [**Note:** inches of mercury times 25.4 mm/inch mercury equals mm of mercury].

6. Record the DO reading in mg/L and percent and compare this reading to the Oxygen Solubility at Indicated Pressure chart in Attachment A. For example, if the barometric pressure is 750 mm Hg and the temperature inside the calibration cup is 25ºC, the DO in mg/L reading should be 8.13 mg/L. Record this value on the field instrument calibration log.

7. If the values recorded on the field instrument calibration log for DO in mg/L do not agree with the published values from Attachment A and are not within the accuracy of the instrument (such as ± 0.2 mg/L and ± 2%, depending on the reading), repeat calibration. If this does not work, change the membrane and electrolyte solution and repeat calibration.

8. Remove the probe from the container, rinse it with deionized water, pat it dry with a towel, and place it into a zero (0.0 mg/L) DO standard if being used as part of the calibration. Fill the protective cup with the fresh zero DO standard. Pour the zero DO standard into the protective cup; the standard should be close enough to the top, so that the DO probe fits tightly into the container (no headspace). Check and record the unit's temperature reading.

9. Wait until the "mg/L DO" readings have stabilized. The instrument should read between -0.5 and +0.5 mg/L or to the accuracy of the instrument (usually ± 0.2 mg/L) within 3 minutes. Record this value on the field instrument calibration log. If the instrument does not reach this value, it may be necessary to clean the probe and change the membrane and electrolyte solution. Repeat the zero DO step if the value obtained is not acceptable. If this does not work, prepare a new 0.0 mg/L standard. If these procedures do not work, consult the equipment vendor for troubleshooting or equipment replacement.

   NOTE: For Zero DO checks: The solution used for this check contains sodium meta-bisulfite or sodium sulfite, which are harmful to the sensor and membrane. It is common practice to recalibrate the meter to 100% saturation after conducting a zero DO check to confirm that the sensor is still operating correctly. A zero DO check is not performed every day the instrument is in use for this reason, but a check should be performed at a minimum of once per sampling event. If conducting this check, be sure to record the manufacturer, true value, lot number, and expiration date of the solution on the field instrument calibration log.

2.3 pH

The pH is the measure of the degree of the acidity or alkalinity of a solution as measured on a scale of 0 to 14 SU. The pH of a sample is determined electrometrically using a glass electrode. All pH measurements are in SU.

CAUTIONS AND POTENTIAL PROBLEMS WITH PH MEASUREMENTS

- Choose the appropriate buffered standards that will bracket the expected values at the sampling locations. For ground water, the pH will usually be close to 7 SU. A minimum of two standards are typically needed for the calibration: one close to 7 SU, one at least two pH units below 7 SU or at least two pH units above 7 SU. The instrument will need to be re-calibrated if the water sample's pH is outside the range defined by the two standards used in the initial calibration, either by adding a third calibration point (if the meter will allow) or by selecting two new pH standards that bracket the water sample's pH.

- Regardless if performing a two- or three-point calibration, always calibrate with pH 7 buffer first.

CALIBRATION PROCEDURE

1. Allow the buffered standards to equilibrate to the ambient temperature.

2. Fill calibration containers with the buffered standards to ensure the pH probe and temperature sensor are completely submerged.

3. Remove the cover of the probe, rinse the probe in a cup filled with deionized water or use a spray bottle, and blot the probe dry with a soft tissue.

4. Enter the value of the first pH buffer solution (e.g., pH 7), immerse the probe in the standard, and allow at least 1 minute for temperature equilibration before proceeding. Record the temperature on the field instrument calibration log.

5. Enter the buffered solution value (7) into the pH calibration menu of the instrument. Allow the pH reading to stabilize for approximately 30 seconds, and if the reading does not change, finish the calibration and record the calibrated value on the field instrument calibration log. The calibration values after adjustment shall be within the accuracy of the instrument, or as required by the project. For example, if the accuracy of the meter is $\pm$0.1 SU, then the calibration values after adjustment shall be between 6.9 and 7.1 SU. If the calibration values after adjustment are outside of this range, recalibrate. If readings continue to fluctuate or readings do not stabilize after recalibration, consult the equipment vendor for troubleshooting or equipment replacement (e.g., may need a new pH electrode).

6. Remove probe from the initial buffer solution, rinse in a cup filled with deionized water or use a spray bottle, and blot dry with soft tissue. Dispose of the used buffer solution.

7. Immerse probe into the second buffer solution (e.g., pH 4). Repeat step #5, substituting "4" into the pH calibration menu instead of "7".

8. Remove probe from the second buffer solution, rinse in a cup filled with deionized water or use a spray bottle, and blot dry with soft tissue. Dispose of the used buffer solution.

9. Immerse probe in third buffer solution (e.g., pH 10) or continue to step #11 if only a two-point calibration is being performed. Repeat step #5, substituting "10" into the pH calibration menu instead of "7".

10. Remove probe from the third buffer solution, rinse in a cup filled with deionized water or use a spray bottle, and blot dry with soft tissue. Dispose of the used buffer solution.

11. To perform the instrument pH check, select monitoring/run mode, (ensure that the initial buffer solution temperature [pH 7] has not changed), and immerse the probe into the buffer solution. Wait for the reading to stabilize. The instrument should read the initial standard value (7 SU) within the accuracy of the instrument, or as required by the project. Record the pH 7 check reading on the field instrument calibration log. If the reading is not within the acceptance criteria, then re-calibrate the instrument. If re-calibration does not correct the

instrument reading, then the calibration range may be too wide. Reducing the calibration range by using standards that are closer together may improve the instrument's accuracy.

2.4 Specific Conductance

Conductivity is used to measure the ability of an aqueous solution to conduct an electrical current. Specific conductance is the conductivity value corrected to 25ºC. Calibrating an instrument for specific conductance automatically calibrates the instrument for conductivity and vice-versa.

CAUTIONS AND POTENTIAL PROBLEMS WITH SPECIFIC CONDUCTANCE MEASUREMENTS

- Most instruments are calibrated against a single standard that is near the specific conductance of the environmental samples. A second standard that is above the environmental sample specific conductance can be used to check the linearity of the instrument in the range of measurements. However, a single-point calibration standard is adequate to assess the accuracy and operation of the sensor.
- Calibrate the conductivity with a standard near the anticipated conductivity of the water. For fresh water, a 1 mS/cm standard is appropriate.
- For some meters, it is important that the top vent hole of the conductivity sensor be immersed during the calibration. Review the instrument manual to determine if this is required.
- Specific conductance/conductivity can have different units (e.g., mmho/cm, mS/cm, µmho/cm, µS/cm), especially on auto-ranging instruments. Note: mhos/cm = Siemens/cm. Check with the Project Manager or database manager to determine if field measurements should be restricted to a consistent unit (e.g., µmhos/cm or µS/cm, not mmhos/cm or mS/cm) so that conversion is not necessary when importing data into a database.
- Be aware of meters which autocorrect for temperature and how to enter the calibration value per the procedures in the instrument's manual. To calibrate instruments that autocorrect for temperature, enter the calibration value of the solution (µmhos/cm at 25°C). For instruments without automatic temperature compensation, the solution's conductivity value must be corrected for the temperature that the sensor is reading before entering the value into the meter. In some cases, you may be able to adjust the temperature of the calibration solution to near 25°C, such that the standard calibration value is applicable; otherwise an adjustment for temperature needs to be accounted for. Additionally, if calibrating for conductivity instead of specific conductance, the solution's conductivity value must be corrected for the temperature that the sensor is reading.

CALIBRATION PROCEDURE

1. Allow the calibration standard to equilibrate to the ambient temperature.

2. Remove probe from its storage container, rinse the probe with a small amount of deionized water, and pat dry the sensor with a soft tissue.

3. Lower the sensor into the conductivity standard. Gently move the probe up and down in the solution to remove any air bubbles from the sensor if present. Allow the probe to sit in the solution for at least 30 seconds to allow values to equilibrate before proceeding.

4. Enter the calibration value of the solution (e.g., 1,413 µmhos/cm at 25°C). Record the temperature of the solution on the field instrument calibration log, and allow the specific conductance reading to stabilize for approximately 30 seconds. Record the calibrated value after stabilization on the field instrument calibration log. The reading should be within ±5% of the true value. If the reading is not within this range, recalibrate. If readings continue to fluctuate significantly after a recalibration, consult the equipment vendor for troubleshooting or equipment replacement.

5. Remove probe from the standard, rinse the probe with deionized water, and replace the protective cover over the sensors.

2.5 Oxidation-Reduction Potential (ORP)

The oxidation-reduction potential is the electrometric difference measured in a solution between an inert indicator electrode and a suitable reference electrode. The electrometric difference is measured in millivolts and is temperature dependent.

CAUTIONS AND POTENTIAL PROBLEMS WITH ORP MEASUREMENTS

- Note that ORP is not usually the same as Eh. Eh is ORP measured relative to a standard hydrogen electrode (SHE). Typical ORP reference electrodes used in the field are Ag/AgCl electrodes, not SHEs. The difference is that Eh would be approximately 200mV higher than ORP measured against a Ag/AgCl reference electrode. See Standard Methods 2580B and YSI Tech Note (2005) for more details.
- Some meters allow you to calibrate ORP, but many do not allow calibration. Testing solutions are available to verify your ORP reading but they are not accurate enough to be used as calibration standards.
- ORP is temperature dependent. Look up the millivolt (mV) calibration value at the measured temperature from the millivolt versus temperature correction table usually found on the standard bottle or on the standard instruction sheet. It may be necessary to interpolate millivolt values between temperatures.

CALIBRATION OR VERIFICATION PROCEDURE

1. Allow the calibration standard (e.g., a Zobell solution) to equilibrate to ambient temperature.

2. Remove the cover of the probe, and place it into the standard.

3. While stirring the standard, wait for the probe temperature to stabilize, and then read the temperature.

4. Look up the millivolt (mV) value at this temperature from the millivolt versus temperature correction table usually found on the standard bottle or on the standard instruction sheet. It may be necessary to interpolate millivolt values between temperatures. Enter the

temperature-corrected ORP value, and calibrate the instrument. Record the values on the field instrument calibration log.

5. The reading should remain unchanged within manufacturer's specifications. If it changes, re-calibrate. If readings continue to change after calibration, consult the manufacturer.

6. If the instrument instruction manual states the instrument is factory calibrated, then verify the factory calibration against the standard. If the reading does not agree with the standard within the accuracy of the instrument, the instrument will need to be re-calibrated by the manufacturer.

2.6 Turbidity

Turbidity refers to how clear the water is and is a measure of relative sample clarity. The greater the amount of total suspended solids in the water, the higher the measured turbidity. The turbidity method is based upon a comparison of intensity of light scattered by a sample under defined conditions with the intensity of light scattered by a standard reference suspension. A turbidity meter is a nephelometer with a visible light source for illuminating the sample and one or more photo-electric detectors placed 90 degrees to the path of the light source. Turbidity values are recorded in NTUs.

CAUTIONS AND POTENTIAL PROBLEMS WITH TURBIDITY MEASUREMENTS

- Some instruments will only accept one standard. For these instruments, the standards will serve as check points.
- Some regulatory agencies will not allow turbidity measurements through a flow-through cell, and require a stand alone turbidity meter. Verify that the selected meter will meet project objectives prior to use.
- For the greatest accuracy during the calibration procedure, ensure that after the meter is blanked and the blank is scanned as a sample, the reading is 0.00 NTU. If not, re-zero the meter and scan the blank again until it reads 0.00 NTU. When scanning the calibration standards as the sample, scan the calibration standard three times removing the tube from the chamber after each scan. The readings should be consistent. Use the last consistent reading to calibrate the meter. If the readings are not consistent, avoid using an aberrant reading to calibrate the meter.
- The meter should be placed on a surface that is free from vibrations. Vibrations can cause high readings.
- Gently mix the sample by inverting before taking a reading, but avoid introducing air bubbles.
- Scratches, fingerprints, and water droplets on the outside of the cuvettes can cause additional light scatter, leading to inaccurate readings. If necessary, wipe the outside of the cuvette with a soft tissue. If the cuvette is scratched or dirty, discard.
- Ensure that the cuvette is always placed in the chamber in the same orientation, as differences in orientation can cause differences in results. Proper cuvette orientation may be indicated by a mark or arrow on both the cuvette and the instrument.

CALIBRATION PROCEDURES – STAND ALONE TURBIDITY METER

NOTE: Sometimes standards are provided in the cuvette with the meter.

1. Rinse a cuvette with deionized water. Shake the cuvette to remove as much water as possible. Do not wipe the inside of the cuvette, because lint from the wipe may remain in the cuvette. Add the standard to the cuvette.

2. Place the 0.0 NTU standard into the instrument and scan the sample (measure the standard). Record the reading on the field instrument calibration log. The 10.0 NTU standard can be measured after the 0.0 NTU standard is scanned.

3. Select the 10.0 NTU standard and scan the sample (measure the standard). The reading should be within ±10% of the true value. Record the reading on the field instrument calibration log. If the reading is within the acceptance criteria, then move on to step # 5. If not, calibrate the instrument to 10.0 NTU. Record the reading and any significant changes on the field instrument calibration log.

4. After adjusting the calibration, re-read the 10.0 NTU standard to ensure it is now meeting accuracy requirements. If not, repeat step #3. Otherwise, continue to step #5.

5. Repeat step #3, if needed, for the 1.0 NTU standard.

6. After adjusting the calibration, re-read the 1.0 NTU standard to ensure it is now meeting accuracy requirements (±10% of the true value). If not, repeat step #3. Otherwise, continue to step #7.

7. As a final check of the instrument, scan the blank (0.0 NTU standard). The unit display should read very close to zero. Record the reading on the field instrument calibration log.

   NOTE: If during the calibration procedure, you find the value of the standard is >50% from the expected value (e.g., 0.49 NTU for the 1.0 NTU standard), scrolling to the true value (e.g., 1.0 NTU) and attempting to calibrate will result in an error code, because the value to which you have changed it is >50% of the expected value of the standard. In this case, it is necessary to re-calibrate the unit from the beginning starting with a blank. If this fails to produce adjustable and reproducible values for the 1.0 and 10.0 NTU standards, re-calibrate using new standards and discard the current standards. If the meter still fails to calibrate following repeated attempts at calibration, consult the equipment vendor for troubleshooting or equipment replacement.

   NOTE: If only performing a two-point calibration (depending on project requirements), the 0.0 NTU and 10 NTU (or comparable NTU level) standards should be used.

CALIBRATION PROCEDURES – MULTI-PARAMETER METER WITH FLOW-THROUGH CELL

This is a two point calibration with a standard and turbidity free water. The standard can be formazin, polymer beads, or a meter-specific quick calibration solution. Turbidity free water

can be obtained by filtering distilled or deionized water through a 0.1, 0.3, or 0.45 micron filter.

1. Rinse the calibration cup and sensors with the turbidity free water. Fill the cup with enough water so that the turbidity sensor is covered (sensors pointed down).

2. Scan the sample (measure the standard). After the reading has stabilized, enter the zero turbidity value into the meter in accordance with manufacturer directions and record the reading on the field instrument calibration log.

3. Rinse the calibration cup and sensors with the standard solution. Fill the cup with enough standard solution so that the turbidity sensor is covered (sensors pointed down).

4. Scan the sample (measure the standard). After the reading has stabilized, enter the standard solution turbidity value into the meter in accordance with manufacturer directions and record the reading on the field instrument calibration log. If the reading is within the acceptance criteria, calibration is complete. If not, recalibrate the instrument. Record the reading and any significant changes on the field instrument calibration log.

   NOTE: If during the calibration procedure, you find the value of the standard is outside of the range acceptable by the meter and attempting to calibrate results in an error code, it is necessary to re-calibrate the unit from the beginning starting with a blank/turbidity free water. If this fails to produce acceptable and reproducible values for the standards, re-calibrate using new standards and discard the current standards. If the meter still fails to calibrate following repeated attempts at calibration, consult the equipment vendor for troubleshooting or equipment replacement.

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 or roll-off bin, 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

In addition to checking the calibration of instruments prior to measurements, calibration checks may also be required at other times of the day. If there are significant temperature fluctuations or erroneous readings, a calibration check may be required. Some programs require a post-calibration check at the conclusion of the day to ensure that instrument drift has not occurred. Refer to the site-specific work plan for calibration frequency.

Comparing current values with historical values at the same measuring location can be helpful in assessing instrument and calibration reliability.

5.0 DATA MANAGEMENT AND RECORDS MANAGEMENT

All work must be dated and signed by the analyst. Any changes should be crossed out with a single line, initialed, and dated.

Prior to calibrating, the field equipment and calibration standard information should be recorded on a field instrument calibration log and/or in the field book. For field equipment, the information recorded should include the make, model number, and the serial number of the instrument. Each instrument can be assigned an identification number that can be referenced in future field notes or when filling out the field instrument calibration log.

For calibration standards, the information recorded should include the manufacturer, expiration date, true value, and any other description, such as lot number. Each calibration standard can also be assigned an identification number that can be referenced in future field notes or when filling out the field instrument calibration log. If standards are not supplied with an expiration date, the standards should be initialed and dated when received and when opened (not applicable for standards supplied with the rental equipment).

The calibration records provided by the equipment vendor and the certificates of analysis for each standard will be maintained in the project files.

All calibration measurements must be documented in the field book or on a separate field instrument calibration log. Example field instrument calibration logs are presented in Attachment B. At a minimum, the field instrument calibration log must include the instrument information described above, calibration standard information described above, calibration date, and the instrument calibration results.

6.0 REFERENCES

USEPA. January 19, 2010. *Standard Operating Procedure, Calibration of Field Instruments,* Revision No. 2. USEPA Region I.

American Public Health Association, American Water Works Association, and Water Environment Federation. January 2012. *Standard Methods for the Examination of Water and Wastewater,* 22nd Edition.

YSI Environmental. 2005. *Measuring ORP on YSI 6-Series Sondes: Tips, Cautions and Limitations*. YSI Environmental Tech Note. http://www.ysi.com/media/pdfs/T608-Measuring-ORP-on-YSI-6-Series-Sondes-Tips-Cautions-and-Limitations.pdf.

7.0 SOP REVISION HISTORY

REVISION NUMBER	REVISION DATE	REASON FOR REVISION
0	NOVEMBER 2014	NOT APPLICABLE

Attachment A

Oxygen Solubility at Indicated Pressure

Attachment A (page 1 of 2)

Oxygen Solubility at Indicated Pressure

Temp.	Pressure (Hg)							
	760	755	750	745	740	735	730	mm
°C	29.92	29.72	29.53	29.33	29.13	28.94	28.74	in
0	14.57	14.47	14.38	14.28	14.18	14.09	13.99	mg/l
1	14.17	14.08	13.98	13.89	13.79	13.70	13.61	
2	13.79	13.70	13.61	13.52	13.42	13.33	13.24	
3	13.43	13.34	13.25	13.16	13.07	12-98	12.90	
4	13.08	12.99	12.91	12.82	12.73	12.65	12.56	
5	12.74	12.66	12.57	12.49	12.40	12.32	12.23	
6	12.42	12.34	12.26	12.17	12.09	12.01	11.93	
7	12.11	12.03	11.95	11.87	11.79	11.71	11.63	
8	11.81	11.73	11.65	11.57	11.50	11.42	11.34	
9	11.53	11.45	11.38	11.30	11.22	11.15	11.07	
10	11.28	11.19	11.11	11.04	10.96	10.89	10.81	
11	10.99	10.92	10.84	10.77	10.70	10.62	10.55	
12	10.74	10.67	10.60	10.53	10.45	10.38	10.31	
13	10.50	10.43	10.36	10.29	10.22	10.15	10.08	
14	10.27	10.20	10.13	10.06	10.00	9.93	9.86	
15	10.05	9.98	9.92	9.85	9.78	9.71	9.65	
16	9.83	9.76	9.70	9.63	9.57	9.50	9.43	
17	9.63	9.57	9.50	9.44	9.37	9.31	9.24	
18	9.43	9.37	9.30	9.24	9.18	9.11	9.05	
19	9.24	9.18	9.12	9.05	8.99	8.93	8.87	
20	9.06	9.00	8.94	8.88	8.82	8.75	8.69	
21	8.88	8.82	8.76	8.70	8.64	8.58	8.52	
22	8.71	8.65	8.59	8.53	8.47	8.42	8.36	
23	8.55	8.49	8.43	8.38	8.32	8.26	8.20	
24	8.39	8.33	8.28	8.22	8.16	8.11	8.05	
25	8.24	8.18	8.13	8.07	8.02	7.96	7.90	
26	8.09	8.03	7.98	7.92	7.87	7.81	7.76	
27	7.95	7.90	7.84	7.79	7.73	7.68	7.62	
28	7.81	7.76	7.70	7.65	7.60	7.54	7.49	
29	7.68	7.63	7.57	7.52	7.47	7.42	7.36	
30	7.55	7.50	7.45	7.39	7.34	7.29	7.24	
31	7.42	7.37	7.32	7.27	7.22	7.16	7.11	
32	7.30	7.25	7.20	7.15	7.10	7.05	7.00	
33	7.08	7.13	7.08	7.03	6.98	6.93	6.88	
34	7.07	7.02	6.97	6.92	6.87	6.82	6.78	
35	6.95	6.90	6.85	6.80	6.76	6.71	6.66	
36	6.84	6.79	6.76	6.70	6.65	6.60	6.55	
37	6.73	6.68	6.64	6.59	6.54	6.49	6.45	
38	6.63	6.58	6.54	6.49	6.44	6.40	6.35	
39	6.52	6.47	6.43	6.38	6.35	6.29	6.24	
40	6.42	6.37	6.33	6.28	6.24	6.19	6.15	
41	6.32	6.27	6.23	6.18	6.14	6.09	6.05	
42	6.22	6.18	6.13	6.09	6.04	6.00	5.95	
43	6.13	6.09	6.04	6.00	5.95	5.91	5.87	
44	6.03	5.99	5.94	5.90	5.86	5.81	5.77	
45	5.94	5.90	5.85	5.81	5.77	5.72	5.68	

(Continued)

Table taken from EPA Region I SOP, Calibration of Field Instruments, January 10, 2010.

Attachment A (Page 2 of 2)

Oxygen Solubility at Indicated Pressure (continued)

Temp.	Pressure (Hg)								
	725	720	715	710	705	700	695	690	mm
°C	28.54	28.35	28.15	27.95	27.76	27.56	27.36	27.17	in
0	13.89	13.80	13.70	13.61	13.51	13.41	13.32	13.22	mg/l
1	13.51	13.42	13.33	13.23	13.14	13.04	12.95	12.86	
2	13.15	13.06	12.07	12.88	12.79	12.69	12.60	12.51	
3	12.81	12.72	12.63	12.54	12.45	12.36	12.27	12.18	
4	12.47	12.39	12.30	12.21	12.13	12.04	11.95	11.87	
5	12.15	12.06	11.98	11.89	11.81	11.73	11.64	11.56	
6	11.84	11.73	11.68	11.60	11.51	11.43	11.35	11.27	
7	11.55	11.47	11.39	11.31	11.22	11.14	11.06	10.98	
8	11.26	11.18	11.10	11.02	10.95	10.87	10.79	10.71	
9	10.99	10.92	10.84	10.76	10.69	10.61	10.53	10.46	
10	10.74	10.66	10.59	10.51	10.44	10.36	10.29	10.21	
11	10.48	10.40	10.33	10.28	10.18	10.11	10.04	9.96	
12	10.24	10.17	10.10	10.02	9.95	9.88	9.81	9.46	
13	10.01	9.94	9.87	9.80	9.73	9.66	9.59	9.52	
14	9.79	9.72	9.65	9.68	9.51	9.45	9.38	9.31	
15	9.58	9.51	9.44	9.58	9.31	9.24	9.18	9.11	
16	9.37	9.30	9.24	9.17	9.11	9.04	8.97	8.91	
17	9.18	9.11	9.05	8.98	8.92	8.85	8.79	8.73	
18	8.99	8.92	8.86	8.80	8.73	8.67	8.61	8.54	
19	8.81	8.74	8.68	8.62	8.56	8.49	8.43	8.37	
20	8.63	8.57	8.51	8.45	8.39	8.33	8.27	8.21	
21	8.46	8.40	8.34	8.28	8.22	8.16	8.10	8.04	
22	8.30	8.24	8.18	8.12	8.06	8.00	7.95	7.89	
23	8.15	8.09	8.03	7.97	7.91	7.86	7.80	7.74	
24	7.99	7.94	7.88	7.82	7.76	7.71	7.65	7.59	
25	7.85	7.79	7.74	7.68	7.60	7.57	7.51	7.46	
26	7.70	7.65	7.59	7.54	7.48	7.43	7.37	7.32	
27	7.57	7.52	7.46	7.41	7.35	7.30	7.25	7.19	
28	7.44	7.38	7.33	7.28	7.22	7.17	7.12	7.06	
29	7.31	7.26	7.21	7.15	7.10	7.05	7.00	6.94	
30	7.19	7.14	7.08	7.03	6.98	6.93	6.88	6.82	
31	7.06	7.01	6.96	6.91	6.86	6.81	6.76	6.70	
32	6.95	6.90	6.85	6.80	6.70	6.70	6.64	6.59	
33	6.83	6.78	6.73	6.68	6.83	6.58	6.53	6.48	
34	6.73	6.68	6.63	6.58	6.53	6.48	6.43	6.38	
35	6.61	6.56	6.51	6.47	6.42	6.37	6.36	6.27	
36	6.51	6.46	6.41	6.36	6.31	6.27	6.22	6.17	
37	6.40	6.35	6.31	6.26	6.21	6.16	6.12	6.07	
38	6.30	6.26	6.21	6.16	6.12	6.07	6.02	5.98	
39	6.26	6.15	6.11	6.06	6.01	5.97	5.92	5.87	
40	6.10	6.06	6.01	5.96	5.92	5.86	5.83	5.78	
41	6.00	5.96	5.91	5.87	5.82	5.78	5.73	5.69	
42	5.91	5.86	5.82	5.77	5.73	5.69	5.64	5.60	
43	5.82	5.78	5.73	5.69	5.65	5.60	5.56	5.51	
44	5.72	5.68	5.64	5.59	5.55	5.51	5.46	5.42	
45	5.64	5.59	5.55	5.51	5.47	5.42	5.38	5.34	

Table taken from EPA Region I SOP, Calibration of Field Instruments, January 10, 2010.

Attachment B

Example Field Instrument Calibration Logs

TRC Field Instrument Calibration Log

Date:_____ Site Name:_____

Water Quality Instrument Type / ID:_____

Turbidity Instrument Type / ID:_____

Date of Last Temperature Probe Check:_____

Dissolved Oxygen (DO)

Time	Barometric Pressure (mm Hg)	Temperature (°Celsius)	Oxygen Solubility at Indicated Pressure (mg/L) (On Instrument)	Actual Oxygen Solubility at Indicated Pressure (mg/L) (Refer to Attachment A)	Zero DO Check (mg/L)	Comments	Initials

pH

Time	Solution Temperature (°Celsius)	pH 7	pH 4	pH 10	pH 7 Check	Comments	Initials

Specific Conductance

Time	Specific Conductance Reading (umhos/cm3)	Comments	Initials

Oxidation Reduction Potential (ORP)

Time	Solution Temperature (°Celsius)	ORP Reading (mV) (Refer to std instruction sheet)	Actual ORP Reading (mV) (On Instrument)	Comments	Initials

Turbidity

Time	Zero Standard	Standard #1 (___NTUs)	Standard #2 (___NTUs)	Comments	Initials

Calibration Fluid ID / Expiration Date:

Zero DO:_____ Specific Conductance_____

pH 4_____ pH 7:_____ pH 10_____

ORP_____

Zero Turbidity:_____ Turbidity Std. # 1_____ Turbidity Std. # 2_____

Signed_____

PAGE _____ OF _____

WATER QUALITY METER CALIBRATION LOG

PROJECT NAME:	0	MODEL:	SAMPLER: SN
PROJECT NO.:	0.00	SERIAL #:	DATE:

PH CALIBRATION CHECK

pH 7 (LOT #): (EXP. DATE): POST-CAL. READING / STANDARD	pH 4 / 10 (LOT #): (EXP. DATE): POST-CAL. READING / STANDARD	CAL. RANGE	TIME
/	/	☐ WITHIN RANGE	
/	/	☐ WITHIN RANGE	
/	/	☐ WITHIN RANGE	
/	/	☐ WITHIN RANGE	

SPECIFIC CONDUCTIVITY CALIBRATION CHECK

CAL. READING (LOT #): (EXP. DATE): POST-CAL. READING / STANDARD	TEMPERATURE (°CELSIUS)	CAL. RANGE	TIME
/		☐ WITHIN RANGE	
/		☐ WITHIN RANGE	
/		☐ WITHIN RANGE	
/		☐ WITHIN RANGE	

ORP CALIBRATION CHECK

CAL. READING (LOT #): (EXP. DATE): POST-CAL. READING / STANDARD	TEMPERATURE (°CELSIUS)	CAL. RANGE	TIME
/		☐ WITHIN RANGE	
/		☐ WITHIN RANGE	
/		☐ WITHIN RANGE	
/		☐ WITHIN RANGE	

D.O. CALIBRATION CHECK

CAL. READING POST-CAL. READING /SATURATED AIR	TEMPERATURE (°CELSIUS)	CAL. RANGE	TIME
/		☐ WITHIN RANGE	
/		☐ WITHIN RANGE	
/		☐ WITHIN RANGE	
/		☐ WITHIN RANGE	

TURBIDITY CALIBRATION CHECK

CALIBRATION READING (NTU) (LOT #): (EXP. DATE): POST-CAL. READING / STANDARD	(LOT #): (EXP. DATE): POST-CAL. READING / STANDARD	CAL. RANGE	TIME
/	/	☐ WITHIN RANGE	
/	/	☐ WITHIN RANGE	
/	/	☐ WITHIN RANGE	
/	/	☐ WITHIN RANGE	

COMMENTS

☐ AUTOCAL SOLUTION
(LOT #):
(EXP. DATE):

☐ STANDARD SOLUTION (S)
LIST LOT NUMBERS AND EXPIRATION DATES UNDER CALIBRATION CHECK

CALIBRATED PARAMETERS	CALIBRATION RANGES [1]
☐ pH	pH: +/- 0.2 S.U.
☐ COND	COND: +/- 1% OF CAL. STANDARD
☐ ORP	ORP: +/- 25 mV
☐ D.O.	D.O.: VARIES
☐ TURB	TURB: +/- 5% OF CAL. STANDARD
☐ _____	[1] CALIBRATION RANGES ARE SPECIFIC TO THE MODEL OF THE WATER QUALITY METER
☐ _____	

NOTES

PROBLEMS ENCOUNTERED	CORRECTIVE ACTIONS

SIGNED _____ DATE _____

CHECKED BY _____ DATE _____

REVISED 06/2011

Attachment C

SOP Fact Sheet

WATER QUALITY PARAMETER INSTRUMENT CALIBRATION

PURPOSE AND OBJECTIVE

Before a meter is utilized in the field, it will be calibrated and checked in accordance with this SOP to ensure proper operation. Water quality instruments addressed in this SOP include those that measure temperature, pH, dissolved oxygen (DO), conductivity/specific conductance, oxidation-reduction potential (ORP), and turbidity for the purposes of field screening and field measurements.

WHAT TO BRING

- Appropriate Level of PPE
- Field book
- Field instrument calibration logs
- Water quality meter capable of measuring one or more of the following based on project scope: pH, temperature, DO, specific conductivity, and ORP (e.g., YSI 600XL, Horiba U-50, Hydrolab Quanta/QED MP-20, or equivalent)
- Deionized water
- Flow-through cell
- Ring stand with clamp
- Paper towels
- Soft tissue (e.g., Kimwipes®)
- Cuvettes
- Buffer solutions at pH 4, 7 and 10 standard units (SU)*
- Conductivity solution (potassium chloride, typically 1,413 µhos/cm)*
- ORP calibration solution (e.g., Zobell)*
- Turbidity standards (0, 1, 10 nephelometric turbidity units [NTUs] or StablCal Kit)*
- Zero DO solution (0.0 mg/L)*
- DO membrane kit (electrolyte solution, membranes)
- NIST thermometer (0.2°C accuracy)*
- Small glass or polyethylene jars to hold the calibration standards (4-8 oz.)
- Cup or spray bottle for the deionized water

*Dependent on the project-specific requirements and the instrument manufacturer

OFFICE

- Review project work plan and confirm what field measurements are required based on the scope of work.
- Confirm that all necessary equipment (including necessary calibration solutions) are available in-house or order if necessary.
- All meters may have different relative accuracy, which will be specified in the instrument manual. Confirm that the meter being used meets the project's accuracy requirements.
- Confirm that a copy of the manufacturer's instruction manual is available to accompany the instrument into the field.
- Properly clean/decontaminate the instrument before storage or returning equipment to rental vendor.

CALIBRATION PROCEDURES

- Prior to use, inspect instruments to ensure instruments are clean, check for possible malfunctions, and calibrate in accordance with manufacturer's procedures. Note: The initial calibration may be performed in the office prior to the field event or by the equipment supplier; however, calibration checks should be performed on site prior to use on the day of the fieldwork.
- Calibration checks (or verifying that instrument readings fall within an acceptable range of a standard without running through the full instrument calibration steps) will be performed on field instruments prior to their initial use, at least once daily, or whenever indications of faulty readings or instrument malfunction occurs. Some instruments or certain project scopes may require more frequent calibration checks depending on project quality objectives.
- In general, instrument selection and calibration will include the following steps:
  1. Determine which instruments are needed for the specific field tasks. Record the make, model number, and serial number of the instrument on the field instrument calibration log or in the field book.
  2. Obtain the necessary instruments and standard solutions for calibration. Check expiration dates on standard solutions and replace if out of date. Record the manufacturer, true value, lot number and expiration date of the standard solutions on the field instrument calibration log or in the field book.
  3. Assemble the instrument and turn it on allowing the instrument to warm up.
  4. Check battery charge, and charge or replace if necessary.
  5. Clean instrument (if necessary).
  6. If applicable, program the multi-probe instrument so that the applicable parameters to be measured will be displayed.
  7. Calibrate the instrument prior to field use in accordance with manufacturer's procedures. (Note: If applicable, calibrate DO and conductivity first, because these parameters may affect the other calibrations).
  8. Document all calibration activities and results in the field instrument calibration log or field book.
  9. If the instrument malfunctions and cannot be corrected, document the issues, qualify any erroneous data, and obtain a replacement.
  10. Clean and decontaminate the instrument after use and before storage.

11. Conduct calibration checks at least once per day or additionally as needed.

INVESTIGATION-DERIVED WASTE (IDW) DISPOSAL

Field personnel should review the project work plan and ensure project-specific IDW management documentation and containerization requirements are specified or discussed with the Project Manager before going to the project site.

DATA MANAGEMENT AND RECORDS MANAGEMENT

- Prior to calibrating, the field equipment and calibration standard information should be recorded on a field instrument calibration log and/or in a field book. For field equipment, the information recorded should include the make, model number, and the serial number of the instrument. Each instrument can be assigned an identification number that can be referenced in future field notes or when filling out the field instrument calibration log.
- For calibration standards, the information recorded should include the manufacturer, expiration date, true value, and any other description, such as lot number.
- The calibration records provided by the equipment vendor and the certificates of analysis for each standard will be maintained in the project files.
- All calibration measurements must be documented in a field logbook or on a separate field instrument calibration log. At a minimum, the field instrument calibration log must include the instrument information described above, calibration standard information described above, calibration date, and the instrument calibration results.

DOs AND DO NOTs OF WATER QUALITY PARAMETER INSTRUMENT CALIBRATION

DOs

- DO wear appropriate PPE (i.e., chemical resistant gloves and safety glasses) when cleaning and calibrating water quality instruments.
- DO confirm what field measurements are required, and what accuracy is required based on the scope of work.
- DO ensure you have the instrument instruction manual available if needed, as well as contact information for the manufacturer or rental company for troubleshooting questions.
- DO properly document calibration procedures and calibration checks performed.
- DO note when erroneous readings/equipment malfunctions are observed and any troubleshooting and/or corrective measures taken.
- DO conduct calibration checks at least once per day or additionally as needed.
- DO properly store the calibration standard solutions. Avoid extreme hot/cold temperatures. Frozen solution is useless and extreme temperatures can make calibration difficult and/or calibration may not work at all.

DO NOTs

- DO NOT use expired calibration solutions.
- DO NOT immerse the sensors in sea water or other highly saline water, alcohol, or organic solvents.
- DO NOT forget to clean and decontaminate the instrument after use and before storage.
- DO NOT store the sensors improperly (e.g., avoid storing in extreme hot or cold temperatures, make sure appropriate storage solutions are being used per manufacturer's recommendations).

APPENDIX B

GROUNDWATER MONITORING FIELD DATA SHEETS

FIELD REPORT FORM

Project No.: 278114 Date: 1/17/18

Project Name: BNSF Winlock Personnel: KRN

Weather: Overcast, 50's Page: 1 of 1

First Semi-Annual 2018 GW Sampling

1255 Arrived on site, put on PPE, went over health and safety.

1305 Opened wells MW-1 through MW-7 to allow a minimum of 15 minutes for equilibration to atmospheric pressure. Well cap for MW-1 is broken and needs to be replaced. Ponded water above and in the well box for MW-3. Well box full of sediment and gravel. Recommend replacing well box.

1350 Measure depth to water in MW-1 through MW-7 (see DTW field form dated 1/17/18).

1500 Begin purging groundwater from MW-1 (see GW sampling field form dated 1/17/18)

1556 Collect sample from MW-1.

1700 Begin bailing ponded water from MW-3 well box to prepare for purging.

1740 Begin purging from MW-3.

1810 Collect sample from MW-3.

1900 Clean up site, depart site.

KN

FIELD REPORT FORM

Project No.: 278114
Project Name: BNSF Winlock
Weather:

Date: 1/18/18
Personnel: KRN
Page: 1 of 1

0730 Arrive onsite, put on PPE, go over health and safety.
0740 Begin purging MW-2 (see GW sampling field form dated 1/18/18).
0820 Collect sample from MW-2 along with duplicate sample MW-20.
0930 Begin purging from MW-6.
1000 Collect sample from MW-6.
1150 Begin purging from MW-7.
1214 Collect sample from MW-7.

1044 Begin purging from MW-4.
1111 Collect sample from MW-4.

1248 Begin purging from MW-5.
1318 Collect sample from MW-5.
1330 Clean up site, depart site. Approximately 10 gallons of purge water stored in buckets to be disposed of in drum in the TRC warehouse.
1530 Drop off cooler full of GW samples to FedEx drop location in Olympia.

KN

DEPTH TO WATER FIELD FORM

Project No.: 278114
Site Name: BASE Winlock

TRC Personnel: KRN
Date: 1/17/18

Well Number	Screen Interval	Depth to Water	Depth to Product	Free Product Thickness (ft)	Free Product Recovery	Total Depth	Comments
MW-1		2.02				11.30	missing well cap
MW-2		2.04				10.92	
MW-3		1.80				9.60	ponded well box, needs risers and new well box
MW-4		1.45				10.99	
MW-5		4.67				10.32	
MW-6		3.01				10.16	
MW-7		5.23				9.06	

WELL ID MW-1

GROUNDWATER SAMPLING RECORD

TRC

Sheet 1 of 2

Project Number: 278114

Project Name: BNSF Winlock

Date: 1/17/18

Personnel: KRN

Weather: raining, 50's

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

Well Integrity	
Concrete Collar:	good
Well Cap:	broken (metal lid)
Security Lock:	
Standing Water:	yes

Well Volume	
Initial DTW (ft btoc)	2.02
Measured Total Depth (ft btoc)	11.30
Height of water Column	
Casing Volume (gal)	

Sampling Method:	peri pump
Pump Intake Depth:	7 ft btoc

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)
1505	2.03									125	
1508	3.17	9.74	5.71	0.144	14.72	-175.9	46.7	clear	none		
1511	3.32	9.35	5.63	0.134	9.88	-197.4	38.6				
1514	3.49	9.28	5.60	0.134	7.92	-204.3	34.2				
1517	3.56	9.17	5.56	0.130	6.34	-201.5	29.5				
1520	3.65	9.23	5.53	0.130	5.06	-157.2	29.2				
1523	3.73	9.24	5.51	0.130	4.46	-137.8	29.8				
1526	3.85	9.23	5.48	0.128	3.67	-137.2	29.3				
1529	3.95	9.23	5.44	0.127	3.10	-162.8	24.9				
1532	3.99	9.27	5.42	0.125	2.82	-163.4	22.3				
1535	4.05	9.28	5.40	0.125	2.66	-146.9	22.4				
1538	4.11	9.26	5.37	0.124	2.36	-167.1	20.5				
1541	4.20	9.26	5.36	0.125	2.25	-169.8	20.1				
1544	4.23	9.30	5.34	0.124	2.04	-161.3	20.6				
1547	4.29	9.32	5.32	0.125	1.88	-156.8	18.3				

Sample Name	
Sample Time	

Comments:

Need to replace monitoring well lid on MW-1.

WELL ID MW-1

GROUNDWATER SAMPLING RECORD

TRC

Sheet 2 of 2

Project Number: 278114

Project Name:

Date: 1/17/18

Personnel: KRN

Weather: raining, 50's

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

Well Integrity	
Concrete Collar:	good
Well Cap:	broken metal lid
Security Lock:	
Standing Water:	yes

Well Volume	
Initial DTW (ft btoc)	2.02
Measured Total Depth (ft btoc)	11.30
Height of water Column	
Casing Volume (gal)	

Sampling Method:	peri pump
Pump Intake Depth:	7 ft btoc

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)
1550	4.33	9.29	5.31	0.124	1.76	-163.4	17.3	clear	none	125	
1553	4.35	9.32	5.31	0.124	1.67	-169.8	16.3	↓	↓	↓	
1556	4.39	9.26	5.30	0.125	1.57	-166.4	15.2	↓	↓	↓	
								↓	↓	↓	
								↓	↓	↓	
								↓	↓	↓	
								↓	↓	↓	
								↓	↓		

Sample Name	MW1-0118
Sample Time	1556

Comments:

WELL ID MW-2

GROUNDWATER SAMPLING RECORD

TRC

Sheet 1 of 1

Project Number: 278114

Project Name: BNSF Winlock

Date: 1/18/18

Personnel: KRN

Weather: overcast/drizzling, 40's

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

Well Integrity	
Concrete Collar:	good
Well Cap:	good
Security Lock:	
Standing Water:	yes

Well Volume	
Initial DTW (ft btoc)	2.04
Measured Total Depth (ft btoc)	10.92
Height of water Column	
Casing Volume (gal)	

Sampling Method:	peri pump
Pump Intake Depth:	~7 ft btoc

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)
0749	2.82									125	
0752	2.99	7.78	5.88	0.152	3.94	-215.0	67.4	none	clear		
0755	3.18	7.55	5.87	0.153	2.91	-226.1	68.3				
0758	3.29	7.39	5.87	0.153	2.90	-235.9	68.9				
0801	3.39	7.36	5.87	0.153	2.83	-239.7	68.7				
0804	3.48	7.48	5.87	0.153	2.25	-197.2	70.7				
0807	3.56	7.50	5.87	0.155	1.87	-200.3	45.6				
0810	3.61	7.49	5.86	0.155	1.68	-212.3	44.4				
0813	3.70	7.49	5.87	0.155	1.50	-190.2	35.0				
0816	3.75	7.55	5.87	0.156	1.41	-153.4	32.4				
0819	3.82	7.57	5.87	0.156	1.31	-146.4	29.3				

Sample Name	MW2-0118	MW20-0118 (duplicate)
Sample Time	0819	0749

Comments:

Ferrous Iron in-field: ~2.5-3 mg/L

WELL ID MW-3

GROUNDWATER SAMPLING RECORD

TRC

Sheet 1 of 1

Project Number: 278114

Project Name: BNSF Winlock

Date: 1/17/18

Personnel: KRN

Weather: raining, 40's

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

Well Integrity	
Concrete Collar:	good
Well Cap:	good
Security Lock:	yes
Standing Water:	yes

Well Volume	
Initial DTW (ft btoc)	1.80
Measured Total Depth (ft btoc)	9.60
Height of water Column	
Casing Volume (gal)	

Sampling Method:	peri pump
Pump Intake Depth:	7 ft btoc

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)
1749	2.10									125	
1752	2.15	8.87	5.51	0.208	2.63	-61.9	>1000	slightly cloudy	brown		
1755	2.26	8.75	5.51	0.207	2.89	-71.0					
1758	2.41	8.52	5.57	0.199	3.20	-71.3					
1801	2.70	8.47	5.55	0.199	3.11	-72.4					
1804	2.80	8.52	5.59	0.200	2.96	-73.8					
1807	2.91	8.55	5.62	0.201	2.85	-77.6					
1810	3.03	8.56	5.60	0.201	2.73	-74.2					

Sample Name	MW3-0118
Sample Time	1810

Comments: Ponded water above well box and in well box. Concrete collar is several inches below grade.

Ferrous Iron in-field: ~3.5mg/L

WELL ID MW-4

GROUNDWATER SAMPLING RECORD

TRC

Sheet 1 of 1

Project Number: 278114

Project Name: BNSF Winlock

Date: 1/18/18

Personnel: KRN

Weather: drizzling, 40's

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

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

Well Volume	
Initial DTW (ft btoc)	1.45
Measured Total Depth (ft btoc)	10.99
Height of water Column	
Casing Volume (gal)	

Sampling Method:	peri pump
Pump Intake Depth:	7 ft btoc

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)
1044	1.88							few floating flakes		125	
1047	2.09	8.67	5.90	0.122	2.44	-201.3	292	clear	yellow		
1050	2.21	8.69	5.85	0.123	2.27	-168.8	240				
1053	2.30	8.70	5.83	0.123	2.35	-206.7	206				
1056	2.35	8.77	5.83	0.121	1.63	-226.0	191				
1059	2.38	8.81	5.83	0.121	1.40	-182.6	154				
1102	2.41	8.85	5.84	0.120	1.21	-172.2	110				
1105	2.43	8.95	5.85	0.120	1.14	-180.5	87.6	none	clear		
1108	2.44	9.00	5.87	0.120	1.09	-176.1	77.0	↓	↓	↓	
1111	2.45	9.09	5.89	0.120	1.00	-176.3	70.1				

Sample Name	MW4-0118
Sample Time	1111

Comments:

Ferrous Iron in-field: ~1.5 mg/L

WELL ID MW-5

GROUNDWATER SAMPLING RECORD

TRC

Sheet 1 of 1

Project Number: 278114

Project Name: BNSF Winlock

Date: 1/18/18

Personnel: KRN

Weather: drizzling, 40's

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

Well Integrity	
Concrete Collar:	good
Well Cap:	good
Security Lock:	
Standing Water:	YES

Well Volume	
Initial DTW (ft btoc)	4.67
Measured Total Depth (ft btoc)	10.32
Height of water Column	
Casing Volume (gal)	

Sampling Method:	peri pump
Pump Intake Depth:	7 ft btoc

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)
1248	4.45									150	
1251	4.52	9.56	6.21	0.266	2.82	-213.1	17.3	clear	none		
1254	4.59	9.57	6.22	0.266	2.21	-212.2	14.8				
1257	4.63	9.56	6.22	0.265	1.83	-216.7	12.3				
1300	4.71	9.57	6.21	0.260	1.78	-220.1	9.57				
1303	4.74	9.54	6.22	0.255	2.16	-209.8	7.44				
1306	4.80	9.54	6.21	0.243	2.29	-199.9	5.66				
1309	4.83	9.51	6.20	0.236	2.99	-201.7	5.46				
1312	4.87	9.43	6.19	0.228	2.52	-196.2	6.13				
1315	4.92	9.35	6.15	0.216	2.88	-194.6	3.88				
1318	4.95	9.34	6.14	0.209	2.99	-191.8	3.33				

Sample Name	MW5-0118
Sample Time	1318

Comments:

WELL ID MW-6

GROUNDWATER SAMPLING RECORD

TRC

Sheet 1 of 1

Project Number: 278114

Project Name: BNSF Winlock

Date: 1/18/18

Personnel: KRN

Weather: overcast, 40's

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

Well Integrity	
Concrete Collar:	good
Well Cap:	good
Security Lock:	
Standing Water:	yes

Well Volume	
Initial DTW (ft btoc)	3.01
Measured Total Depth (ft btoc)	10.16
Height of water Column	
Casing Volume (gal)	

Sampling Method:	peri pump
Pump Intake Depth:	7 ft btoc

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)
0936	3.75									150	
0939	4.05	8.12	5.83	0.201	2.95	-207.1	35.4	clear	none		
0942	4.17	8.30	5.85	0.200	2.60	-156.8	30.9				
0945	4.32	8.37	5.87	0.201	2.24	-147.6	32.5				
0948	4.39	8.43	5.87	0.200	1.90	-141.0	31.2				
0951	4.49	8.52	5.88	0.200	1.64	-134.9	25.1				
0954	4.55	8.60	5.88	0.200	1.55	-132.2	23.4				
0957	4.63	8.72	5.89	0.200	1.44	-129.6	18.3				
1000	4.68	8.78	5.90	0.201	1.28	-132.2	15.8				

Sample Name	MW6-0118
Sample Time	1000

Comments:

Ferrous Iron in-field: ~3.5 mg/L

WELL ID MW-7

GROUNDWATER SAMPLING RECORD

TRC

Sheet 1 of 1

Project Number: 278114

Project Name: BNSF Winlock

Date: 1/18/18

Personnel: KRN

Weather: drizzling, 40's

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

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

Well Volume	
Initial DTW (ft btoc)	5.23
Measured Total Depth (ft btoc)	9.06
Height of water Column	
Casing Volume (gal)	

Sampling Method:	peri pump
Pump Intake Depth:	7 ft btoc

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)
1150	5.40									125	
1153	5.49	9.44	6.19	0.184	5.02	-205.2	70.1	clear	none		
1156	5.53	9.33	6.18	0.184	3.86	-202.5	57.3				
1159	5.60	9.26	6.16	0.184	3.30	-190.3	52.9				
1202	5.64	9.24	6.16	0.184	3.11	-181.2	41.3				
1205	5.70	9.19	6.16	0.181	2.96	-173.0	28.0				
1208	5.72	9.17	6.16	0.180	2.87	-175.3	23.6				
1211	5.78	9.15	6.14	0.179	2.72	-177.6	17.9				
1214	5.81	9.14	6.12	0.179	2.78	-177.4	15.1				

Sample Name	MW7-0118
Sample Time	1214

Comments:

TRC - BNSF Region 1

10874 141st Place NE
Woodinville, WA 98072

Billing Information:
Keith Woodburne
19874 141st Place NE
Woodinville, WA 98072

Report to: Keith Woodburne

Email To: kwoodburne@trcsolutions.com, ameugniot@trcsolutions.com,

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

City/State Collected:

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

Client Project # 178114

Lab Project # **BNSF1TRC-CUMMINGS**

Collected by (print): K. Newman

Site/Facility ID #

P.O. #

Collected by (signature):

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

Quote #

Date Results Needed

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

L #
Table #
Acctnum: **BNSF1TRC**
Template: **T127006**
Prelogin: **P635381**
TSR: **134 - Mark W. Beasley**
PB:
Shipped Via:

Sample ID	Comp/Grab	Matrix *	Depth	Date	Time	No. of Cntrs	Pres Chk	ALK, Sulfate 250mlHDPE-NoPres	Dissolved Mn 250mlHDPE-NoPres	NO2NO3 250mlHDPE-H2SO4	NWTPHDXLVI 40mlAmb-HCl (with SGT)	RSK175 40mlAmb HCl	Sulfide 125mlAmb-S-NaOH+ZnAc	Total Fe, Mn 250mlHDPE-HNO3	V8260BTEXC 40mlAmb-HCl			Remarks	Sample # (lab only)
MW1-0118	Grab	GW	NA	1/17/18	1556	6					X				X				
MW2-0118		GW		1/18/18	0819	12		X	X	X	X	X	X	X	X				
MW20-0118		GW		1/18/18	0749	6					X				X				
MW3-0118				1/17/18	1810	18		X	X	X	X	X	X	X	X				
MW4-0118				1/18/18	1111	12		X	X	X		X	X	X					
MW5-0118				1/18/18	1218	6													
MW6-0118				1/18/18	1600	18		X	X	X	X	X	X	X	X				
MW7-0118				1/18/18	1214	6					X				X				
TRIP BLANK						N													

* 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 __ 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)	Date:	Time:	Received by: (Signature)	Trip Blank Received: Yes / No HCL / MeoH TBR	If preservation required by Login: Date/Time
Kurt Newman	1/18/18	1545			
Relinquished by : (Signature)	Date:	Time:	Received by: (Signature)	Temp: °C Bottles Received:	
Relinquished by : (Signature)	Date:	Time:	Received for lab by: (Signature)	Date: Time:	Hold: Condition: NCF / OK

APPENDIX C

LABORATORY ANALYTICAL REPORTS
AND
CHAIN-OF-CUSTODY DOCUMENTATION

ANALYTICAL REPORT

January 29, 2018

TRC - BNSF Region 1

Sample Delivery Group:	L964357
Samples Received:	01/19/2018
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

TABLE OF CONTENTS

MW2-0118 L964357-01 GW

Collected by: K. Newman
Collected date/time: 01/18/18 08:19
Received date/time: 01/19/18 08:45

Method	Batch	Dilution	Preparation date/time	Analysis date/time	Analyst
Wet Chemistry by Method 2320 B-2011	WG1064509	1	01/22/18 10:07	01/22/18 10:07	MCG
Wet Chemistry by Method 353.2	WG1065155	1	01/23/18 16:52	01/23/18 16:52	JER
Wet Chemistry by Method 4500S2 D-2011	WG1064539	1	01/22/18 16:22	01/22/18 16:22	TH
Wet Chemistry by Method 9056A	WG1064571	50	01/20/18 01:35	01/20/18 01:35	MAJ
Metals (ICPMS) by Method 6020A	WG1064222	1	01/20/18 13:03	01/20/18 18:14	JPD
Metals (ICPMS) by Method 6020A	WG1064592	1	01/21/18 16:12	01/21/18 19:21	WBD
Volatile Organic Compounds (GC) by Method RSK175	WG1065147	1	01/23/18 13:11	01/23/18 13:11	BG
Volatile Organic Compounds (GC/MS) by Method 8260C	WG1064751	1	01/20/18 22:08	01/20/18 22:08	LRL
Semi-Volatile Organic Compounds (GC) by Method NWTPHDX-SGT	WG1064644	1	01/20/18 00:50	01/22/18 20:23	TH
Semi-Volatile Organic Compounds (GC) by Method NWTPHDX-SGT	WG1064644	1	01/20/18 00:50	01/24/18 16:14	TH

MW2D-0118 L964357-02 GW

Collected by: K. Newman
Collected date/time: 01/18/18 07:49
Received date/time: 01/19/18 08:45

Method	Batch	Dilution	Preparation date/time	Analysis date/time	Analyst
Volatile Organic Compounds (GC/MS) by Method 8260C	WG1064751	1	01/20/18 22:28	01/20/18 22:28	LRL
Semi-Volatile Organic Compounds (GC) by Method NWTPHDX-SGT	WG1064644	1	01/20/18 00:50	01/22/18 20:39	TH
Semi-Volatile Organic Compounds (GC) by Method NWTPHDX-SGT	WG1064644	1	01/20/18 00:50	01/24/18 16:31	TH

MW3-0118 L964357-03 GW

Collected by: K. Newman
Collected date/time: 01/17/18 18:10
Received date/time: 01/19/18 08:45

Method	Batch	Dilution	Preparation date/time	Analysis date/time	Analyst
Wet Chemistry by Method 2320 B-2011	WG1064509	1	01/22/18 10:14	01/22/18 10:14	MCG
Wet Chemistry by Method 353.2	WG1065155	1	01/23/18 16:53	01/23/18 16:53	JER
Wet Chemistry by Method 4500S2 D-2011	WG1064539	1	01/22/18 16:23	01/22/18 16:23	TH
Wet Chemistry by Method 9056A	WG1064571	50	01/20/18 01:48	01/20/18 01:48	MAJ
Metals (ICPMS) by Method 6020A	WG1064222	1	01/20/18 13:03	01/20/18 18:18	JPD
Metals (ICPMS) by Method 6020A	WG1064592	1	01/21/18 16:12	01/21/18 19:25	WBD
Volatile Organic Compounds (GC) by Method RSK175	WG1065147	1	01/23/18 13:14	01/23/18 13:14	BG
Volatile Organic Compounds (GC/MS) by Method 8260C	WG1064751	1	01/20/18 22:48	01/20/18 22:48	LRL
Semi-Volatile Organic Compounds (GC) by Method NWTPHDX-SGT	WG1064644	1	01/20/18 00:50	01/22/18 20:56	TH
Semi-Volatile Organic Compounds (GC) by Method NWTPHDX-SGT	WG1064644	1	01/20/18 00:50	01/24/18 17:09	TH

MW4-0118 L964357-04 GW

Collected by: K. Newman
Collected date/time: 01/18/18 11:11
Received date/time: 01/19/18 08:45

Method	Batch	Dilution	Preparation date/time	Analysis date/time	Analyst
Wet Chemistry by Method 2320 B-2011	WG1064509	1	01/22/18 10:20	01/22/18 10:20	MCG
Wet Chemistry by Method 353.2	WG1065155	1	01/23/18 16:54	01/23/18 16:54	JER
Wet Chemistry by Method 4500S2 D-2011	WG1064539	1	01/22/18 16:23	01/22/18 16:23	TH
Wet Chemistry by Method 9056A	WG1064571	1	01/20/18 02:02	01/20/18 02:02	MAJ
Metals (ICPMS) by Method 6020A	WG1064222	1	01/20/18 13:03	01/20/18 18:21	JPD
Metals (ICPMS) by Method 6020A	WG1064592	1	01/21/18 16:12	01/21/18 19:06	WBD
Volatile Organic Compounds (GC) by Method RSK175	WG1065147	1	01/23/18 13:30	01/23/18 13:30	BG

MW6-0118 L964357-05 GW

Collected by: K. Newman | Collected date/time: 01/18/18 10:00 | Received date/time: 01/19/18 08:45

Method	Batch	Dilution	Preparation date/time	Analysis date/time	Analyst
Wet Chemistry by Method 2320 B-2011	WG1064509	1	01/22/18 10:35	01/22/18 10:35	MCG
Wet Chemistry by Method 353.2	WG1065155	1	01/23/18 16:56	01/23/18 16:56	JER
Wet Chemistry by Method 4500S2 D-2011	WG1064539	1	01/22/18 16:24	01/22/18 16:24	TH
Wet Chemistry by Method 9056A	WG1065148	1	01/22/18 19:29	01/22/18 19:29	MAJ
Metals (ICPMS) by Method 6020A	WG1064222	1	01/20/18 13:03	01/20/18 17:43	JPD
Metals (ICPMS) by Method 6020A	WG1064592	1	01/21/18 16:12	01/21/18 19:29	WBD
Volatile Organic Compounds (GC) by Method RSK175	WG1065147	1	01/23/18 13:33	01/23/18 13:33	BG
Volatile Organic Compounds (GC/MS) by Method 8260C	WG1064751	1	01/20/18 23:08	01/20/18 23:08	LRL
Semi-Volatile Organic Compounds (GC) by Method NWTPHDX-SGT	WG1064644	1	01/20/18 00:50	01/22/18 21:12	TH
Semi-Volatile Organic Compounds (GC) by Method NWTPHDX-SGT	WG1064644	1	01/20/18 00:50	01/24/18 17:25	TH

MW7-0118 L964357-06 GW

Collected by: K. Newman | Collected date/time: 01/18/18 12:14 | Received date/time: 01/19/18 08:45

Method	Batch	Dilution	Preparation date/time	Analysis date/time	Analyst
Volatile Organic Compounds (GC/MS) by Method 8260C	WG1064751	1	01/20/18 23:28	01/20/18 23:28	LRL
Semi-Volatile Organic Compounds (GC) by Method NWTPHDX-SGT	WG1064644	1	01/20/18 00:50	01/22/18 21:29	TH
Semi-Volatile Organic Compounds (GC) by Method NWTPHDX-SGT	WG1064644	1	01/20/18 00:50	01/24/18 17:42	TH

TRIP BLANK L964357-07 GW

Collected by: K. Newman | Collected date/time: 01/18/18 00:00 | Received date/time: 01/19/18 08:45

Method	Batch	Dilution	Preparation date/time	Analysis date/time	Analyst
Volatile Organic Compounds (GC/MS) by Method 8260C	WG1065634	1	01/23/18 16:47	01/23/18 16:47	LRL

All sample aliquots were received at the correct temperature, in the proper containers, with the appropriate preservatives, and within method specified holding times, unless qualified or notated within the report. Where applicable, 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

Wet Chemistry by Method 2320 B-2011

Analyte	Result	Qualifier	RDL	Dilution	Analysis	Batch
	ug/l		ug/l		date / time	
Alkalinity	97300		20000	1	01/22/2018 10:07	WG1064509

Sample Narrative:
L964357-01 WG1064509: Endpoint pH 4.5

Wet Chemistry by Method 353.2

Analyte	Result	Qualifier	RDL	Dilution	Analysis	Batch
	ug/l		ug/l		date / time	
Nitrate-Nitrite	ND		100	1	01/23/2018 16:52	WG1065155

Wet Chemistry by Method 4500S2 D-2011

Analyte	Result	Qualifier	RDL	Dilution	Analysis	Batch
	ug/l		ug/l		date / time	
Sulfide	ND		50.0	1	01/22/2018 16:22	WG1064539

Wet Chemistry by Method 9056A

Analyte	Result	Qualifier	RDL	Dilution	Analysis	Batch
	ug/l		ug/l		date / time	
Sulfate	ND		250000	50	01/20/2018 01:35	WG1064571

Metals (ICPMS) by Method 6020A

Analyte	Result	Qualifier	RDL	Dilution	Analysis	Batch
	ug/l		ug/l		date / time	
Iron	22600		100	1	01/20/2018 18:14	WG1064222
Manganese	428		5.00	1	01/20/2018 18:14	WG1064222
Manganese,Dissolved	372		5.00	1	01/21/2018 19:21	WG1064592

Volatile Organic Compounds (GC) by Method RSK175

Analyte	Result	Qualifier	RDL	Dilution	Analysis	Batch
	ug/l		ug/l		date / time	
Methane	2530		10.0	1	01/23/2018 13:11	WG1065147
Ethane	ND		13.0	1	01/23/2018 13:11	WG1065147
Ethene	ND		13.0	1	01/23/2018 13:11	WG1065147

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

Analyte	Result	Qualifier	RDL	Dilution	Analysis	Batch
	ug/l		ug/l		date / time	
Benzene	ND		1.00	1	01/20/2018 22:08	WG1064751
Toluene	ND		1.00	1	01/20/2018 22:08	WG1064751
Ethylbenzene	ND		1.00	1	01/20/2018 22:08	WG1064751
Total Xylenes	ND		3.00	1	01/20/2018 22:08	WG1064751
(S) Toluene-d8	*115*		*80.0-120*		*01/20/2018 22:08*	WG1064751
(S) Dibromofluoromethane	*87.2*		*76.0-123*		*01/20/2018 22:08*	WG1064751
(S) a,a,a-Trifluorotoluene	*109*		*80.0-120*		*01/20/2018 22:08*	WG1064751
(S) 4-Bromofluorobenzene	*106*		*80.0-120*		*01/20/2018 22:08*	WG1064751

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

Analyte	Result	Qualifier	RDL	Dilution	Analysis	Batch
	ug/l		ug/l		date / time	
Diesel Range Organics (DRO)	302		200	1	01/24/2018 16:14	WG1064644
Residual Range Organics (RRO)	ND	J3	250	1	01/22/2018 20:23	WG1064644
(S) o-Terphenyl	*89.3*		*52.0-156*		*01/24/2018 16:14*	WG1064644

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

Analyte	Result	Qualifier	RDL	Dilution	Analysis	Batch
	ug/l		ug/l		date / time	
(S) o-Terphenyl	*97.6*		*52.0-156*		*01/22/2018 20:23*	WG1064644

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

Analyte	Result ug/l	Qualifier	RDL ug/l	Dilution	Analysis date / time	Batch
Benzene	1.26		1.00	1	01/20/2018 22:28	WG1064751
Toluene	ND		1.00	1	01/20/2018 22:28	WG1064751
Ethylbenzene	ND		1.00	1	01/20/2018 22:28	WG1064751
Total Xylenes	ND		3.00	1	01/20/2018 22:28	WG1064751
(S) Toluene-d8	*115*		*80.0-120*		*01/20/2018 22:28*	WG1064751
(S) Dibromofluoromethane	*89.1*		*76.0-123*		*01/20/2018 22:28*	WG1064751
(S) a,a,a-Trifluorotoluene	*107*		*80.0-120*		*01/20/2018 22:28*	WG1064751
(S) 4-Bromofluorobenzene	*108*		*80.0-120*		*01/20/2018 22:28*	WG1064751

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)	228		200	1	01/24/2018 16:31	WG1064644
Residual Range Organics (RRO)	ND	J3	250	1	01/22/2018 20:39	WG1064644
(S) o-Terphenyl	*99.9*		*52.0-156*		*01/22/2018 20:39*	WG1064644
(S) o-Terphenyl	*86.5*		*52.0-156*		*01/24/2018 16:31*	WG1064644

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	Qualifier	RDL	Dilution	Analysis	Batch
	ug/l		ug/l		date / time	
Alkalinity	111000		20000	1	01/22/2018 10:14	WG1064509

Sample Narrative:
L964357-03 WG1064509: Endpoint pH 4.5

Wet Chemistry by Method 353.2

Analyte	Result	Qualifier	RDL	Dilution	Analysis	Batch
	ug/l		ug/l		date / time	
Nitrate-Nitrite	ND		100	1	01/23/2018 16:53	WG1065155

Wet Chemistry by Method 4500S2 D-2011

Analyte	Result	Qualifier	RDL	Dilution	Analysis	Batch
	ug/l		ug/l		date / time	
Sulfide	ND		50.0	1	01/22/2018 16:23	WG1064539

Wet Chemistry by Method 9056A

Analyte	Result	Qualifier	RDL	Dilution	Analysis	Batch
	ug/l		ug/l		date / time	
Sulfate	ND		250000	50	01/20/2018 01:48	WG1064571

Metals (ICPMS) by Method 6020A

Analyte	Result	Qualifier	RDL	Dilution	Analysis	Batch
	ug/l		ug/l		date / time	
Iron	40800		100	1	01/20/2018 18:18	WG1064222
Manganese	698		5.00	1	01/20/2018 18:18	WG1064222
Manganese,Dissolved	511		5.00	1	01/21/2018 19:25	WG1064592

Volatile Organic Compounds (GC) by Method RSK175

Analyte	Result	Qualifier	RDL	Dilution	Analysis	Batch
	ug/l		ug/l		date / time	
Methane	140		10.0	1	01/23/2018 13:14	WG1065147
Ethane	ND		13.0	1	01/23/2018 13:14	WG1065147
Ethene	ND		13.0	1	01/23/2018 13:14	WG1065147

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

Analyte	Result	Qualifier	RDL	Dilution	Analysis	Batch
	ug/l		ug/l		date / time	
Benzene	ND		1.00	1	01/20/2018 22:48	WG1064751
Toluene	ND		1.00	1	01/20/2018 22:48	WG1064751
Ethylbenzene	ND		1.00	1	01/20/2018 22:48	WG1064751
Total Xylenes	ND		3.00	1	01/20/2018 22:48	WG1064751
(S) Toluene-d8	*116*		*80.0-120*		*01/20/2018 22:48*	WG1064751
(S) Dibromofluoromethane	*87.2*		*76.0-123*		*01/20/2018 22:48*	WG1064751
(S) a,a,a-Trifluorotoluene	*108*		*80.0-120*		*01/20/2018 22:48*	WG1064751
(S) 4-Bromofluorobenzene	*107*		*80.0-120*		*01/20/2018 22:48*	WG1064751

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

Analyte	Result	Qualifier	RDL	Dilution	Analysis	Batch
	ug/l		ug/l		date / time	
Diesel Range Organics (DRO)	201		200	1	01/24/2018 17:09	WG1064644
Residual Range Organics (RRO)	ND	J3	250	1	01/22/2018 20:56	WG1064644
(S) o-Terphenyl	*95.1*		*52.0-156*		*01/24/2018 17:09*	WG1064644

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

Analyte	Result	Qualifier	RDL	Dilution	Analysis	Batch
	ug/l		ug/l		date / time	
(S) o-Terphenyl	*101*		*52.0-156*		*01/22/2018 20:56*	WG1064644

Wet Chemistry by Method 2320 B-2011

Analyte	Result	Qualifier	RDL	Dilution	Analysis	Batch
	ug/l		ug/l		date / time	
Alkalinity	76200		20000	1	01/22/2018 10:20	WG1064509

Sample Narrative:
L964357-04 WG1064509: Endpoint pH 4.5

Wet Chemistry by Method 353.2

Analyte	Result	Qualifier	RDL	Dilution	Analysis	Batch
	ug/l		ug/l		date / time	
Nitrate-Nitrite	ND	P1	100	1	01/23/2018 16:54	WG1065155

Wet Chemistry by Method 4500S2 D-2011

Analyte	Result	Qualifier	RDL	Dilution	Analysis	Batch
	ug/l		ug/l		date / time	
Sulfide	ND		50.0	1	01/22/2018 16:23	WG1064539

Wet Chemistry by Method 9056A

Analyte	Result	Qualifier	RDL	Dilution	Analysis	Batch
	ug/l		ug/l		date / time	
Sulfate	8280		5000	1	01/20/2018 02:02	WG1064571

Metals (ICPMS) by Method 6020A

Analyte	Result	Qualifier	RDL	Dilution	Analysis	Batch
	ug/l		ug/l		date / time	
Iron	7840		100	1	01/20/2018 18:21	WG1064222
Manganese	440		5.00	1	01/20/2018 18:21	WG1064222
Manganese,Dissolved	412		5.00	1	01/21/2018 19:06	WG1064592

Volatile Organic Compounds (GC) by Method RSK175

Analyte	Result	Qualifier	RDL	Dilution	Analysis	Batch
	ug/l		ug/l		date / time	
Methane	34.6		10.0	1	01/23/2018 13:30	WG1065147
Ethane	ND		13.0	1	01/23/2018 13:30	WG1065147
Ethene	ND		13.0	1	01/23/2018 13:30	WG1065147

Wet Chemistry by Method 2320 B-2011

Analyte	Result	Qualifier	RDL	Dilution	Analysis	Batch
	ug/l		ug/l		date / time	
Alkalinity	131000		20000	1	01/22/2018 10:35	WG1064509

Sample Narrative:
L964357-05 WG1064509: Endpoint pH 4.5

Wet Chemistry by Method 353.2

Analyte	Result	Qualifier	RDL	Dilution	Analysis	Batch
	ug/l		ug/l		date / time	
Nitrate-Nitrite	ND	J6	100	1	01/23/2018 16:56	WG1065155

Wet Chemistry by Method 4500S2 D-2011

Analyte	Result	Qualifier	RDL	Dilution	Analysis	Batch
	ug/l		ug/l		date / time	
Sulfide	ND		50.0	1	01/22/2018 16:24	WG1064539

Wet Chemistry by Method 9056A

Analyte	Result	Qualifier	RDL	Dilution	Analysis	Batch
	ug/l		ug/l		date / time	
Sulfate	ND		5000	1	01/22/2018 19:29	WG1065148

Metals (ICPMS) by Method 6020A

Analyte	Result	Qualifier	RDL	Dilution	Analysis	Batch
	ug/l		ug/l		date / time	
Iron	28400		100	1	01/20/2018 17:43	WG1064222
Manganese	574		5.00	1	01/20/2018 17:43	WG1064222
Manganese,Dissolved	486		5.00	1	01/21/2018 19:29	WG1064592

Volatile Organic Compounds (GC) by Method RSK175

Analyte	Result	Qualifier	RDL	Dilution	Analysis	Batch
	ug/l		ug/l		date / time	
Methane	3960		10.0	1	01/23/2018 13:33	WG1065147
Ethane	ND		13.0	1	01/23/2018 13:33	WG1065147
Ethene	ND		13.0	1	01/23/2018 13:33	WG1065147

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

Analyte	Result	Qualifier	RDL	Dilution	Analysis	Batch
	ug/l		ug/l		date / time	
Benzene	ND		1.00	1	01/20/2018 23:08	WG1064751
Toluene	ND		1.00	1	01/20/2018 23:08	WG1064751
Ethylbenzene	ND		1.00	1	01/20/2018 23:08	WG1064751
Total Xylenes	ND		3.00	1	01/20/2018 23:08	WG1064751
(S) Toluene-d8	*114*		*80.0-120*		*01/20/2018 23:08*	WG1064751
(S) Dibromofluoromethane	*86.4*		*76.0-123*		*01/20/2018 23:08*	WG1064751
(S) a,a,a-Trifluorotoluene	*109*		*80.0-120*		*01/20/2018 23:08*	WG1064751
(S) 4-Bromofluorobenzene	*108*		*80.0-120*		*01/20/2018 23:08*	WG1064751

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

Analyte	Result	Qualifier	RDL	Dilution	Analysis	Batch
	ug/l		ug/l		date / time	
Diesel Range Organics (DRO)	218		200	1	01/24/2018 17:25	WG1064644
Residual Range Organics (RRO)	ND	J3	250	1	01/22/2018 21:12	WG1064644
(S) o-Terphenyl	*96.6*		*52.0-156*		*01/22/2018 21:12*	WG1064644

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

Analyte	Result	Qualifier	RDL	Dilution	Analysis	Batch
	ug/l		ug/l		date / time	
(S) o-Terphenyl	*85.7*		*52.0-156*		*01/24/2018 17:25*	WG1064644

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	01/20/2018 23:28	WG1064751
Toluene	ND		1.00	1	01/20/2018 23:28	WG1064751
Ethylbenzene	ND		1.00	1	01/20/2018 23:28	WG1064751
Total Xylenes	ND		3.00	1	01/20/2018 23:28	WG1064751
(S) Toluene-d8	*114*		*80.0-120*		*01/20/2018 23:28*	WG1064751
(S) Dibromofluoromethane	*87.1*		*76.0-123*		*01/20/2018 23:28*	WG1064751
(S) a,a,a-Trifluorotoluene	*110*		*80.0-120*		*01/20/2018 23:28*	WG1064751
(S) 4-Bromofluorobenzene	*108*		*80.0-120*		*01/20/2018 23:28*	WG1064751

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	01/24/2018 17:42	WG1064644
Residual Range Organics (RRO)	ND	J3	250	1	01/22/2018 21:29	WG1064644
(S) o-Terphenyl	*88.3*		*52.0-156*		*01/24/2018 17:42*	WG1064644
(S) o-Terphenyl	*97.7*		*52.0-156*		*01/22/2018 21:29*	WG1064644

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

Analyte	Result	Qualifier	RDL	Dilution	Analysis	Batch
	ug/l		ug/l		date / time	
Benzene	ND		1.00	1	01/23/2018 16:47	WG1065634
Toluene	ND		1.00	1	01/23/2018 16:47	WG1065634
Ethylbenzene	ND		1.00	1	01/23/2018 16:47	WG1065634
Total Xylenes	ND		3.00	1	01/23/2018 16:47	WG1065634
(S) Toluene-d8	*104*		*80.0-120*		*01/23/2018 16:47*	WG1065634
(S) Dibromofluoromethane	*90.5*		*76.0-123*		*01/23/2018 16:47*	WG1065634
(S) a,a,a-Trifluorotoluene	*105*		*80.0-120*		*01/23/2018 16:47*	WG1065634
(S) 4-Bromofluorobenzene	*96.5*		*80.0-120*		*01/23/2018 16:47*	WG1065634

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

(LCS) R3281008-2 01/22/18 10:25 • (LCSD) R3281008-3 01/22/18 11:49

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 %
Alkalinity	100000	104000	102000	104	102	85.0-115			1.15	20

Sample Narrative:

LCS: Endpoint pH 4.5

LCSD: Endpoint pH 4.5

Method Blank (MB)

(MB) R3281272-1 01/23/18 16:22

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

L963611-01 Original Sample (OS) • Duplicate (DUP)

(OS) L963611-01 01/23/18 16:26 • (DUP) R3281272-4 01/23/18 16:27

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

L964357-04 Original Sample (OS) • Duplicate (DUP)

(OS) L964357-04 01/23/18 16:54 • (DUP) R3281272-6 01/23/18 16:55

Analyte	Original Result ug/l	DUP Result ug/l	Dilution	DUP RPD %	DUP Qualifier	DUP RPD Limits %
Nitrate-Nitrite	ND	84.0	1	200	J P1	20

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

(LCS) R3281272-2 01/23/18 16:23 • (LCSD) R3281272-3 01/23/18 16:24

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 %
Nitrate-Nitrite	5000	3930	4100	98.2	102	90-110			4.21	20

L964221-01 Original Sample (OS) • Matrix Spike (MS)

(OS) L964221-01 01/23/18 16:37 • (MS) R3281272-5 01/23/18 16:38

Analyte	Spike Amount ug/l	Original Result ug/l	MS Result ug/l	MS Rec. %	Dilution	Rec. Limits %	MS Qualifier
Nitrate-Nitrite	2500	156	2650	99.9	1	90-110	

L964357-05 Original Sample (OS) • Matrix Spike (MS) • Matrix Spike Duplicate (MSD)

(OS) L964357-05 01/23/18 16:56 • (MS) R3281272-7 01/23/18 16:57 • (MSD) R3281272-8 01/23/18 16:58

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 %
Nitrate-Nitrite	2500	ND	1890	1900	75.6	75.8	1	90-110	J6	J6	0.37	20

Method Blank (MB)

(MB) R3280943-1 01/22/18 16:12

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

L964121-01 Original Sample (OS) • Duplicate (DUP)

(OS) L964121-01 01/22/18 16:21 • (DUP) R3280943-4 01/22/18 16:21

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

L964570-01 Original Sample (OS) • Duplicate (DUP)

(OS) L964570-01 01/22/18 16:25 • (DUP) R3280943-7 01/22/18 16:25

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

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

(LCS) R3280943-2 01/22/18 16:13 • (LCSD) R3280943-3 01/22/18 16:13

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	464	464	92.8	92.8	85-115			0	20

L964141-01 Original Sample (OS) • Matrix Spike (MS) • Matrix Spike Duplicate (MSD)

(OS) L964141-01 01/22/18 16:21 • (MS) R3280943-5 01/22/18 16:22 • (MSD) R3280943-6 01/22/18 16:22

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	775	775	77.5	77.5	1	80-120	J6	J6	0	20

Method Blank (MB)

(MB) R3280590-1 01/19/18 09:40

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

L964026-01 Original Sample (OS) • Duplicate (DUP)

(OS) L964026-01 01/19/18 22:00 • (DUP) R3280590-4 01/19/18 22:14

Analyte	Original Result	DUP Result	Dilution	DUP RPD	DUP Qualifier	DUP RPD Limits
	ug/l	ug/l		%		%
Sulfate	23100	23100	1	0.112		15

L964146-01 Original Sample (OS) • Duplicate (DUP)

(OS) L964146-01 01/20/18 00:28 • (DUP) R3280590-7 01/20/18 00:41

Analyte	Original Result	DUP Result	Dilution	DUP RPD	DUP Qualifier	DUP RPD Limits
	ug/l	ug/l		%		%
Sulfate	12300	12400	1	0.599		15

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

(LCS) R3280590-2 01/19/18 09:54 • (LCSD) R3280590-3 01/19/18 10:07

Analyte	Spike Amount	LCS Result	LCSD Result	LCS Rec.	LCSD Rec.	Rec. Limits	LCS Qualifier	LCSD Qualifier	RPD	RPD Limits
	ug/l	ug/l	ug/l	%	%	%			%	%
Sulfate	40000	40100	40000	100	100	80-120			0.228	15

L964026-01 Original Sample (OS) • Matrix Spike (MS) • Matrix Spike Duplicate (MSD)

(OS) L964026-01 01/19/18 22:00 • (MS) R3280590-5 01/19/18 22:27 • (MSD) R3280590-6 01/19/18 22:41

Analyte	Spike Amount	Original Result	MS Result	MSD Result	MS Rec.	MSD Rec.	Dilution	Rec. Limits	MS Qualifier	MSD Qualifier	RPD	RPD Limits
	ug/l	ug/l	ug/l	ug/l	%	%		%			%	%
Sulfate	50000	23100	72500	72600	98.8	98.9	1	80-120			0.0464	15

L964146-01 Original Sample (OS) • Matrix Spike (MS)

(OS) L964146-01 01/20/18 00:28 • (MS) R3280590-8 01/20/18 00:55

Analyte	Spike Amount	Original Result	MS Result	MS Rec.	Dilution	Rec. Limits	MS Qualifier
	ug/l	ug/l	ug/l	%		%	
Sulfate	50000	12300	62400	100	1	80-120	

Method Blank (MB)

(MB) R3281090-1 01/22/18 15:15

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

L964172-01 Original Sample (OS) • Duplicate (DUP)

(OS) L964172-01 01/22/18 18:20 • (DUP) R3281090-4 01/22/18 18:30

Analyte	Original Result ug/l	DUP Result ug/l	Dilution	DUP RPD %	DUP Qualifier	DUP RPD Limits %
Sulfate	20900	19800	1	5		15

L962149-01 Original Sample (OS) • Duplicate (DUP)

(OS) L962149-01 01/22/18 17:30 • (DUP) R3281090-7 01/22/18 21:18

Analyte	Original Result ug/l	DUP Result ug/l	Dilution	DUP RPD %	DUP Qualifier	DUP RPD Limits %
Sulfate	ND	3220	1	0		15

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

(LCS) R3281090-2 01/22/18 15:25 • (LCSD) R3281090-3 01/22/18 15:35

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	39800	39600	99	99	80-120			1	15

L964172-01 Original Sample (OS) • Matrix Spike (MS) • Matrix Spike Duplicate (MSD)

(OS) L964172-01 01/22/18 18:20 • (MS) R3281090-5 01/22/18 18:59 • (MSD) R3281090-6 01/22/18 19:09

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	20900	64700	63400	88	85	1	80-120			2	15

L962149-01 Original Sample (OS) • Matrix Spike (MS)

(OS) L962149-01 01/22/18 17:30 • (MS) R3281090-8 01/22/18 21:28

Analyte	Spike Amount ug/l	Original Result ug/l	MS Result ug/l	MS Rec. %	Dilution	Rec. Limits %	MS Qualifier
Sulfate	50000	ND	53700	100	1	80-120	

Method Blank (MB)

(MB) R3280630-1 01/20/18 17:31

Analyte	MB Result	MB Qualifier	MB MDL	MB RDL
	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) R3280630-2 01/20/18 17:35 • (LCSD) R3280630-3 01/20/18 17:39

Analyte	Spike Amount	LCS Result	LCSD Result	LCS Rec.	LCSD Rec.	Rec. Limits	LCS Qualifier	LCSD Qualifier	RPD	RPD Limits
	ug/l	ug/l	ug/l	%	%	%			%	%
Iron	5000	5310	5300	106	106	80-120			0.319	20
Manganese	50.0	51.2	51.6	102	103	80-120			0.915	20

L964357-05 Original Sample (OS) • Matrix Spike (MS) • Matrix Spike Duplicate (MSD)

(OS) L964357-05 01/20/18 17:43 • (MS) R3280630-5 01/20/18 17:51 • (MSD) R3280630-6 01/20/18 17:54

Analyte	Spike Amount	Original Result	MS Result	MSD Result	MS Rec.	MSD Rec.	Dilution	Rec. Limits	MS Qualifier	MSD Qualifier	RPD	RPD Limits
	ug/l	ug/l	ug/l	ug/l	%	%		%			%	%
Iron	5000	28400	33400	33300	101	99.4	1	75-125			0.255	20
Manganese	50.0	574	624	625	99.8	102	1	75-125			0.164	20

Method Blank (MB)

(MB) R3280753-1 01/21/18 18:55

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

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

(LCS) R3280753-2 01/21/18 18:59 • (LCSD) R3280753-3 01/21/18 19:02

Analyte	Spike Amount	LCS Result	LCSD Result	LCS Rec.	LCSD Rec.	Rec. Limits	LCS Qualifier	LCSD Qualifier	RPD	RPD Limits
	ug/l	ug/l	ug/l	%	%	%			%	%
Manganese,Dissolved	50.0	46.1	46.5	92.3	93	80-120			0.734	20

L964357-04 Original Sample (OS) • Matrix Spike (MS) • Matrix Spike Duplicate (MSD)

(OS) L964357-04 01/21/18 19:06 • (MS) R3280753-5 01/21/18 19:14 • (MSD) R3280753-6 01/21/18 19:18

Analyte	Spike Amount	Original Result	MS Result	MSD Result	MS Rec.	MSD Rec.	Dilution	Rec. Limits	MS Qualifier	MSD Qualifier	RPD	RPD Limits
	ug/l	ug/l	ug/l	ug/l	%	%		%			%	%
Manganese,Dissolved	50.0	412	453	452	82.6	80.9	1	75-125			0.191	20

Method Blank (MB)

(MB) R3281125-1 01/23/18 09:10

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

L964075-01 Original Sample (OS) • Duplicate (DUP)

(OS) L964075-01 01/23/18 10:27 • (DUP) R3281125-2 01/23/18 11:18

Analyte	Original Result	DUP Result	Dilution	DUP RPD	DUP Qualifier	DUP RPD Limits
	ug/l	ug/l		%		%
Methane	1340	1310	1	2.11		20
Ethane	ND	0.000	1	0.000		20
Ethene	ND	0.000	1	0.000		20

L964144-01 Original Sample (OS) • Duplicate (DUP)

(OS) L964144-01 01/23/18 11:25 • (DUP) R3281125-3 01/23/18 13:43

Analyte	Original Result	DUP Result	Dilution	DUP RPD	DUP Qualifier	DUP RPD Limits
	ug/l	ug/l		%		%
Methane	ND	0.000	1	0.000		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) R3281125-4 01/23/18 13:46 • (LCSD) R3281125-5 01/23/18 13:49

Analyte	Spike Amount	LCS Result	LCSD Result	LCS Rec.	LCSD Rec.	Rec. Limits	LCS Qualifier	LCSD Qualifier	RPD	RPD Limits
	ug/l	ug/l	ug/l	%	%	%			%	%
Methane	67.8	74.4	69.3	110	102	85.0-115			7.03	20
Ethane	129	115	118	89.3	91.4	85.0-115			2.30	20
Ethene	127	118	122	93.3	95.7	85.0-115			2.62	20

Method Blank (MB)

(MB) R3281546-2 01/20/18 21:28

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	*113*			*80.0-120*
(S) Dibromofluoromethane	*87.5*			*76.0-123*
(S) a,a,a-Trifluorotoluene	*107*			*80.0-120*
(S) 4-Bromofluorobenzene	*103*			*80.0-120*

Laboratory Control Sample (LCS)

(LCS) R3281546-1 01/20/18 20:28

Analyte	Spike Amount ug/l	LCS Result ug/l	LCS Rec. %	Rec. Limits %	LCS Qualifier
Benzene	25.0	22.4	89.4	69.0-123	
Ethylbenzene	25.0	26.3	105	77.0-120	
Toluene	25.0	26.6	106	77.0-120	
Xylenes, Total	75.0	78.9	105	77.0-120	
(S) Toluene-d8			*109*	*80.0-120*	
(S) Dibromofluoromethane			*86.5*	*76.0-123*	
(S) a,a,a-Trifluorotoluene			*109*	*80.0-120*	
(S) 4-Bromofluorobenzene			*109*	*80.0-120*	

L964512-05 Original Sample (OS) • Matrix Spike (MS) • Matrix Spike Duplicate (MSD)

(OS) L964512-05 01/21/18 02:28 • (MS) R3281546-3 01/21/18 04:29 • (MSD) R3281546-4 01/21/18 04:49

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 %
Benzene	25.0	ND	19.3	19.6	77.4	78.4	1	34.0-147			1.33	20
Ethylbenzene	25.0	ND	24.2	26.4	96.9	105	1	42.0-147			8.46	20
Toluene	25.0	ND	24.3	26.0	97.1	104	1	42.0-141			6.70	20
Xylenes, Total	75.0	ND	72.9	79.9	97.2	107	1	41.0-148			9.16	20
(S) Toluene-d8					*107*	*116*		*80.0-120*				
(S) Dibromofluoromethane					*88.2*	*87.6*		*76.0-123*				
(S) a,a,a-Trifluorotoluene					*109*	*108*		*80.0-120*				
(S) 4-Bromofluorobenzene					*108*	*105*		*80.0-120*				

Method Blank (MB)

(MB) R3281372-2 01/23/18 16:28

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) a,a,a-Trifluorotoluene	*106*			*80.0-120*
(S) Toluene-d8	*105*			*80.0-120*
(S) Dibromofluoromethane	*88.9*			*76.0-123*
(S) 4-Bromofluorobenzene	*97.3*			*80.0-120*

Laboratory Control Sample (LCS)

(LCS) R3281372-1 01/23/18 15:30

Analyte	Spike Amount ug/l	LCS Result ug/l	LCS Rec. %	Rec. Limits %	LCS Qualifier
Benzene	25.0	22.8	91.3	69.0-123	
Ethylbenzene	25.0	26.0	104	77.0-120	
Toluene	25.0	25.6	103	77.0-120	
Xylenes, Total	75.0	79.1	105	77.0-120	
(S) a,a,a-Trifluorotoluene			*105*	*80.0-120*	
(S) Toluene-d8			*103*	*80.0-120*	
(S) Dibromofluoromethane			*88.8*	*76.0-123*	
(S) 4-Bromofluorobenzene			*96.6*	*80.0-120*	

Method Blank (MB)

(MB) R3281099-1 01/22/18 19:17

Analyte	MB Result	MB Qualifier	MB MDL	MB RDL
	ug/l		ug/l	ug/l
Diesel Range Organics (DRO)	U		66.7	200
Residual Range Organics (RRO)	U		83.3	250
(S) o-Terphenyl	*99.1*			*52.0-156*

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

(LCS) R3281099-2 01/22/18 19:34 • (LCSD) R3281099-3 01/22/18 19:50

Analyte	Spike Amount	LCS Result	LCSD Result	LCS Rec.	LCSD Rec.	Rec. Limits	LCS Qualifier	LCSD Qualifier	RPD	RPD Limits
	ug/l	ug/l	ug/l	%	%	%			%	%
Diesel Range Organics (DRO)	750	1030	1060	137	142	50.0-150			3.30	20
Residual Range Organics (RRO)	750	607	795	80.9	106	50.0-150		J3	26.8	20
(S) o-Terphenyl				*100*	*105*	*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
J	The identification of the analyte is acceptable; the reported value is an estimate.
J3	The associated batch QC was outside the established quality control range for precision.
J6	The sample matrix interfered with the ability to make any accurate determination; spike value is low.
P1	RPD value not applicable for sample concentrations less than 5 times the reporting limit.

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
Connecticut	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		

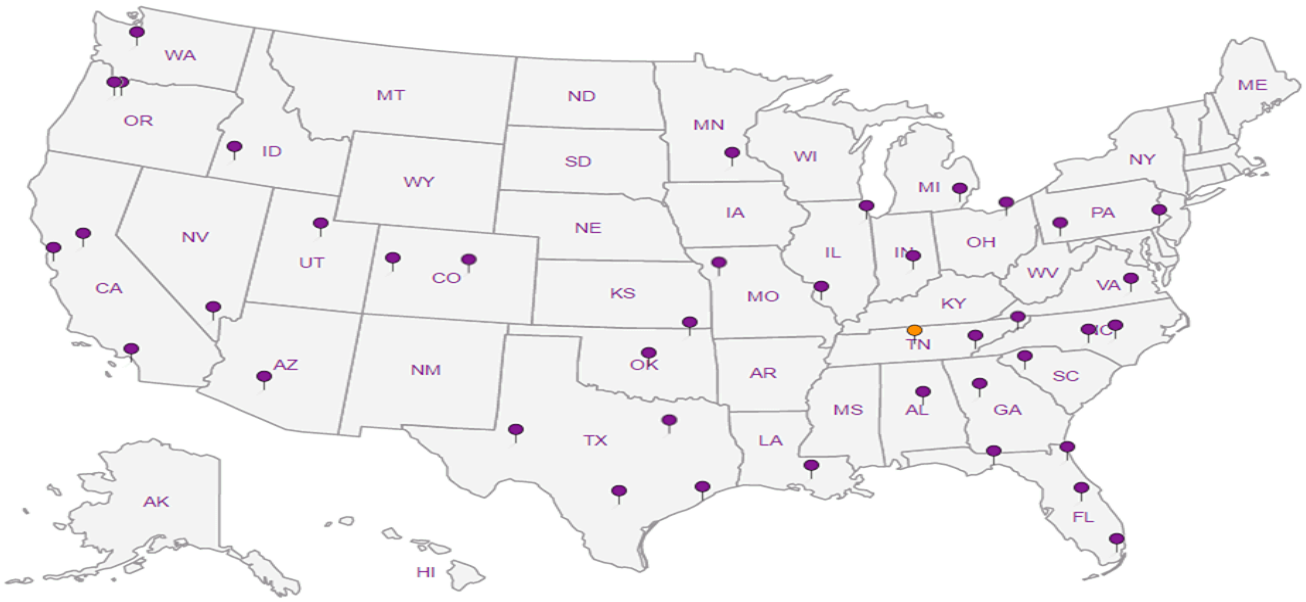
Third Party Federal Accreditations

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:
Keith Woodburne
19874 141st Place NE
Woodinville, WA 98072

Pres Chk

Report to: Keith Woodburne

Email To: kwoodburne@trcsolutions.com, ameugniot@trcsolutions.com,

Project Description: BNSF - Former Cummings Oil Lease Site

City/State Collected:

Phone: 425-489-1938
Fax:

Client Project # 278114

Lab Project # BNSF1TRC-CUMMINGS

Collected by (print): K. Newman

Site/Facility ID #

P.O. #

Collected by (signature):

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

Quote #

Date Results Needed

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 40mlAmb-HCl (with SGT)	RSK175 40mlAmb HCl	Sulfide 125mlAmb-S-NaOH+ZnAc	Total Fe, Mn 250mlHDPE-HNO3	V8260BTEXC 40mlAmb-HCl			Remarks	Sample # (lab only)
MW1-0118	Grab	GW	NA	1/17/18	1556	6				X				X				04
MW2-0118		GW		1/18/18	0819	13	X	X	X	X	X	X	X	X				01
MW20-0118		GW		1/18/18	0749	6				X				X				02
MW3-0118				1/17/18	1810	13	X	X	X	X	X	X	X	X				03
MW4-0118				1/18/18	1111	7	X	X	X		X	X	X					04
MW5-0118				1/18/18	1318	6												
MW6-0118				1/18/18	1000	13	X	X	X	X	X	X	X	X				05
MW7-0118				1/18/18	1214	6				X				X				06
TRIP BLANK						1												

Chain of Custody Page 1 of 1

ESC LAB SCIENCES
a subsidiary of Accutest

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

L# 964357

G139

Acctnum: BNSF1TRC
Template: T127006
Prelogin: P635381
TSR: 134 - Mark W. Beasley
PB:
Shipped Via: FedEx

* 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 __ FedEx __ Courier _____

Tracking # 746614666377

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)	Date:	Time:	Received by: (Signature)
Kari Newman	1/18/18	1515	
Relinquished by : (Signature)	Date:	Time:	Received by: (Signature)
Relinquished by : (Signature)	Date:	Time:	Received for lab by: (Signature) Marina Belugin

Trip Blank Received: Yes / No
1
HCL / MeoH
TBR

Temp: 21° °C Bottles Received: 70
TD11

If preservation required by Login: Date/Time

Date: 01-19-18 Time: 0845

Hold:

Condition: NCF / OK

Matthew Lockhart

ESC Lab Sciences
Non-Conformance Form

Login #:964357	Client:BNSF1TRC	Date:01/19/18	Evaluated by: Matthew Lockhart

Non-Conformance (check applicable items)

	Sample Integrity		Chain of Custody Clarification		
	Parameter(s) past holding time		Login Clarification Needed		**If Broken Container:**
	Improper temperature		Chain of custody is incomplete		Insufficient packing material around container
	Improper container type		Please specify Metals requested.		Insufficient packing material inside cooler
	Improper preservation		Please specify TCLP requested.		Improper handling by carrier (FedEx / UPS / Courie
	Insufficient sample volume.		Received additional samples not listed on coc.		Sample was frozen
	Sample is biphasic.		Sample ids on containers do not match ids on coc		Container lid not intact
	Vials received with headspace.		Trip Blank not received.		**If no Chain of Custody:**
	Broken container	X	Client did not "X" analysis.		Received by:
	Broken container:		Chain of Custody is missing		Date/Time:
	Sufficient sample remains				Temp./Cont. Rec./pH:
					Carrier:
					Tracking#

Login Comments:Client di not X analysis for Mw1-0118, MW5-0118, and trip blank.

Client informed by:		Call		Email		Voice Mail		Date: 1/22/18	Time: 1315
TSR Initials: MB		Client Contact: Amanda M.							

Login Instructions:

Place MW-1 and MW-5 on hold.
Log Trip Blank for V8260BTEXC

APPENDIX D

TERRESTRIAL ECOLOGICAL EVALUATION SUPPORTING DOCUMENTATION


BNSF Former Cummings Oil Lease Site
Approximate area of contiguous undeveloped land within 500 feet of the Site.
Legend
Contiguous land within 500 foot radius
Extent of soil contamination
NW Lilac St
NW Mill St
Kerron Ave
Laurel St
Soland Ct
Jebez St
603
NE 1st St
Front St
NE 2nd St
Griffith St
©2018 Google
Imagery Date: 6/21/2017 lat 46.497829° lon -122.940393° elev 337 ft eye alt 1560 ft
Google Earth

Washington State Department of Ecology
Toxics Cleanup Program

Terrestrial Ecological Evaluation Process - Primary Exclusions

Documentation Form

Exclusion #	Exclusion Detail	Yes or No?	Are Institutional Controls Required If The Exclusion Applies?
1	Will soil contamination be located at least 6 feet beneath the ground surface and less than 15 feet?	(Yes) / No	(Yes)
	Will soil contamination located at least 15 feet beneath the ground surface?	Yes / (No)	No
	Will soil contamination located below the conditional point of compliance?	(Yes) / No	(Yes)
2	Will soil contamination be covered by buildings, paved roads, pavement, or other physical barriers that will prevent plants or wildlife from being exposed?	Yes / (No)	(Yes)
3	Is there less than 1.5 acres of contiguous undeveloped land on the site, or within 500 feet of any area of the site affected by hazardous substances **other than** those listed in the table of Hazardous Substances of Concern? And Is there less than 0.25 acres of contiguous undeveloped land on or within 500 feet of any area of the site affected by hazardous substances **listed in** the table of Hazardous Substances of Concern?	(Yes) / No Yes / (No)	Other factors determine
4	Are concentrations of hazardous substances in the soil less than or equal to natural background concentrations of those substances at the point of compliance	Yes / (No)	No

[Exclusions Main] [TEE Definitions] [Simplified or Site-Specific?] [Simplified Ecological Evaluation] [Site-Specific Ecological Evaluation] [WAC 173-340-7493]

[TEE Home]

DEPARTMENT OF ECOLOGY
State of Washington

Technical Document:

Terrestrial Ecological Evaluations under the Model Toxics Control Act

February 2017

Publication no. XX-XX-XXX

Draft (Do not Cite or Quote)

Chapter 3: Do I conduct a Simplified or Site Specific Terrestrial Ecological Evaluation?

Ecology expects the majority of sites to qualify for one of the four primary exclusion criteria mentioned in the previous chapter. For more information regarding those exclusions, please refer to Chapter 2. However, as a brief review, those exclusions are:

- Contamination below the point of compliance.
- Incomplete exposure pathway.
- Type of contamination and proximity to ecological receptors, and;
- Concentrations below background levels.

Once it has been established that none of the above-mentioned exclusionary criteria apply, either a simplified or site-specific terrestrial ecological evaluation is required. MTCA specifically refers to the process of determining the type of evaluation that is required (simplified or site-specific) as "Applicability of a Simplified Terrestrial Ecological Evaluation." The specific regulation that refers to this process can be found in WAC 173-340-7492; Applicability of a Simplified Terrestrial Ecological Evaluation. WAC 173-340-7492 lists four criteria that are to be used in that determination. If any of the below criteria apply to your site, then a site-specific terrestrial ecological evaluation is necessary. Those criteria are:

- Natural areas.
- Vulnerable species.
- Extensive habitat, and;
- Risk to significant wildlife populations.

Natural Areas

If the site is located on, or directly adjacent to an area where management or land use plans will maintain or restore native or semi-native vegetation, then a site-specific terrestrial ecological evaluation is necessary. Examples of these areas include:

- Green-belts.
- Protected wetlands.
- Forestlands.
- Riparian areas.
- Locally designated environmentally sensitive areas.
- Open space areas managed for wildlife, and;
- Some parks and outdoor recreation areas.

The "Some parks and outdoor recreation areas" bulleted item does not include areas used for intensive sporting activities such as baseball, football, or dog parks. For the purposes of this section, the following definitions apply:

Native Vegetation: Means any plant community native to the state of Washington. The following sources shall be used in making this determination: *Natural Vegetation of Oregon and Washington*, J.F. Franklin and C.T. Dyrness, Oregon State University Press, 1988 (see Compendium – Section L); and *Vascular Plants of the Pacific Northwest* (5 Volumes), A. Cronquist, 1955-1969 (see Compendium – Section K).

Semi-native Vegetation: Means a plant community that includes at least some vascular plant species native to the state of Washington. The following shall not be considered semi-native vegetation:

- Areas planted for ornamental or landscaping purposes.
- Areas planted for cultivated crops, and;
- Areas significantly disturbed and predominantly covered by noxious, introduced plant species or weeds (e.g., Scotch broom, Himalayan blackberry or knap-weed).

Vulnerable Species

If the site is used by vulnerable species, a site-specific terrestrial ecological evaluation is necessary. Examples of listed vulnerable species are:

- A threatened or endangered species protected under the Federal Endangered Species Act (see Compendium – Section E).
- A wildlife species classified by the Washington State Department of Fish and Wildlife as a "priority species" or "species of concern" under Title 77 RCW (see Compendium – Section F), and;
- A plant species classified by the Washington State Department of Natural Resources Natural Heritage Program as "endangered," "threatened," or "sensitive" under Title 79 RCW (see Compendium – Section G).

Note: For plants, "used" means that a plant species grows at the site or has been found growing at the site. For animals, "used" means that individuals of a species have been observed to live, feed or breed at the site.

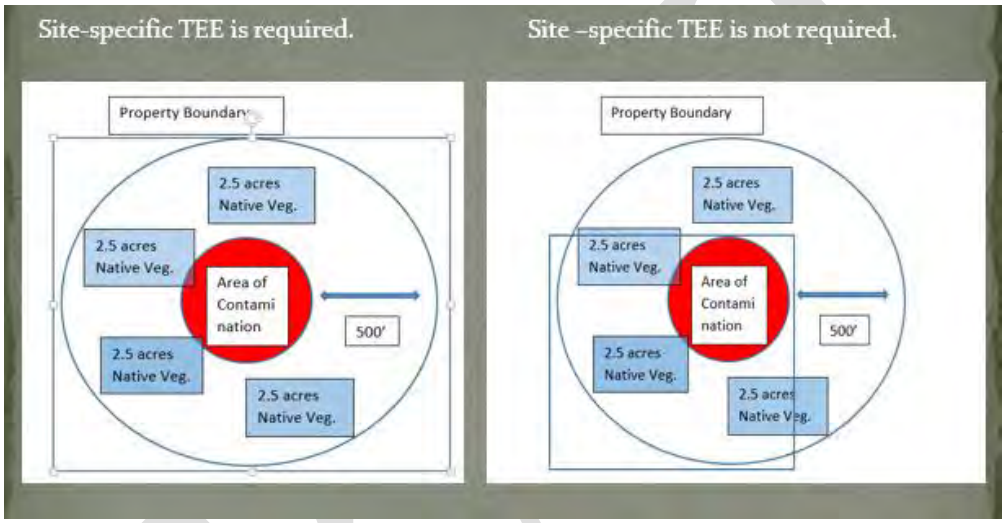
Please see the Compendium for lists of state or federally designated species that were listed at the time this document was completed:

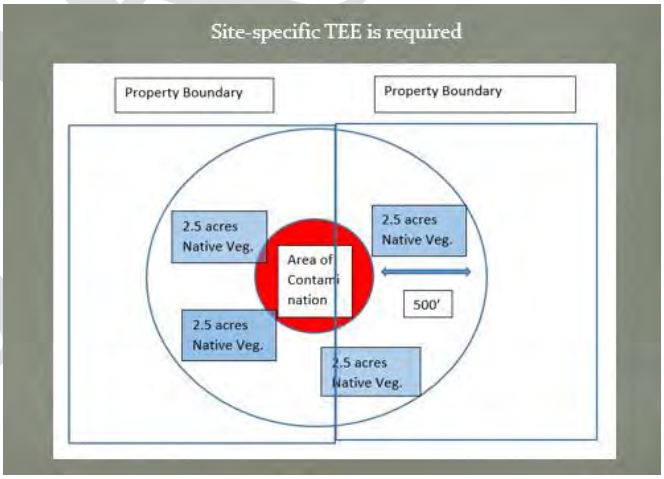
- Federal Endangered Species Act (Species) (see Compendium - Section E).
- Washington State Species of Concern (see Compendium – Section F), and;
- List of Rare Plant Species (see Compendium – Section G).

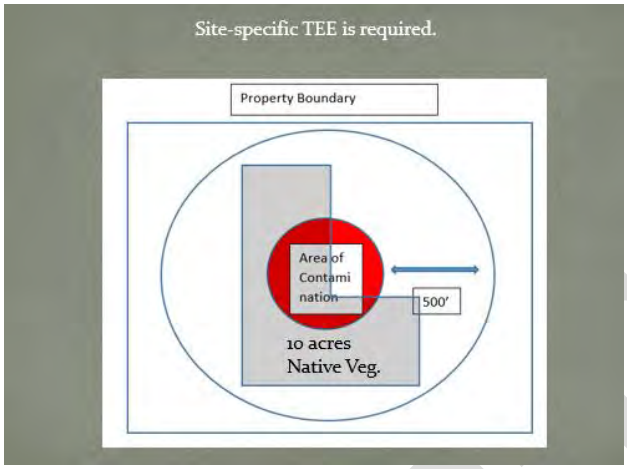
Extensive Habitat

If the site is located on a property that contains at least 10 acres of native vegetation within 500 feet of the site, not including vegetation beyond the property boundaries, a site-specific TEE is necessary. This total (ten acres) is applicable whether or not the native vegetation has been fragmented into smaller areas. See Figure 3.1 for a diagram explaining this section. Both scenarios depicted in figure 3 would require a site-specific terrestrial ecological evaluation.

Figure 3.1: Extensive Habitat Scenarios for Determination if a Site – Specific TEE is Necessary







Risk to Significant Wildlife Populations

If the department determines the contamination may present a risk to significant wildlife populations, a site – specific terrestrial ecological evaluation is necessary.

Chapter 4: The Simplified Terrestrial Ecological Evaluation

Once it has been established that none of the criteria requiring a site-specific TEE (as described in the "Applicability of a Simplified Terrestrial Ecological Evaluation") apply to the site, a Simplified Terrestrial Ecological Evaluation (TEE) should fulfill the requirements of the MCTA regulations.

Note: At any point in time, a site-specific TEE may be performed to fulfill the requirements of this chapter.

The simplified TEE process (Figure 4.1) is intended to identify sites which are not likely to pose a significant threat to ecological receptors. For sites that qualify to perform a simplified TEE, the process described in WAC 173-340-7492 must be followed. This chapter is intended to provide guidance for sites performing a simplified TEE.

The simplified TEE can be ended and a determination can be made that the site does not pose a significant risk to the environment if any of the three criteria listed below are met (as described in the subsections of this chapter). Those three criteria are:

- Exposure analysis.
- Pathways analysis, and;
- Toxicity analysis.

Those three criteria will be explained in their own separate sub-chapters. However, it is important to note that if any one of those three criteria has been met, the TEE process can be ended. If none of those three criteria have been met, ecological protective soil concentrations must be established using bioassay techniques or by using the option of conducting a site - specific TEE under WAC 173-340-7493 (see "Establishing Ecological Protective Soil Concentrations" section of this chapter). Alternatively, Table 4.1 (MTCA Table 749-2) indicator soil concentrations may be used as long as the cleanup levels of the contaminants specific to the site have been provided in the referenced table.

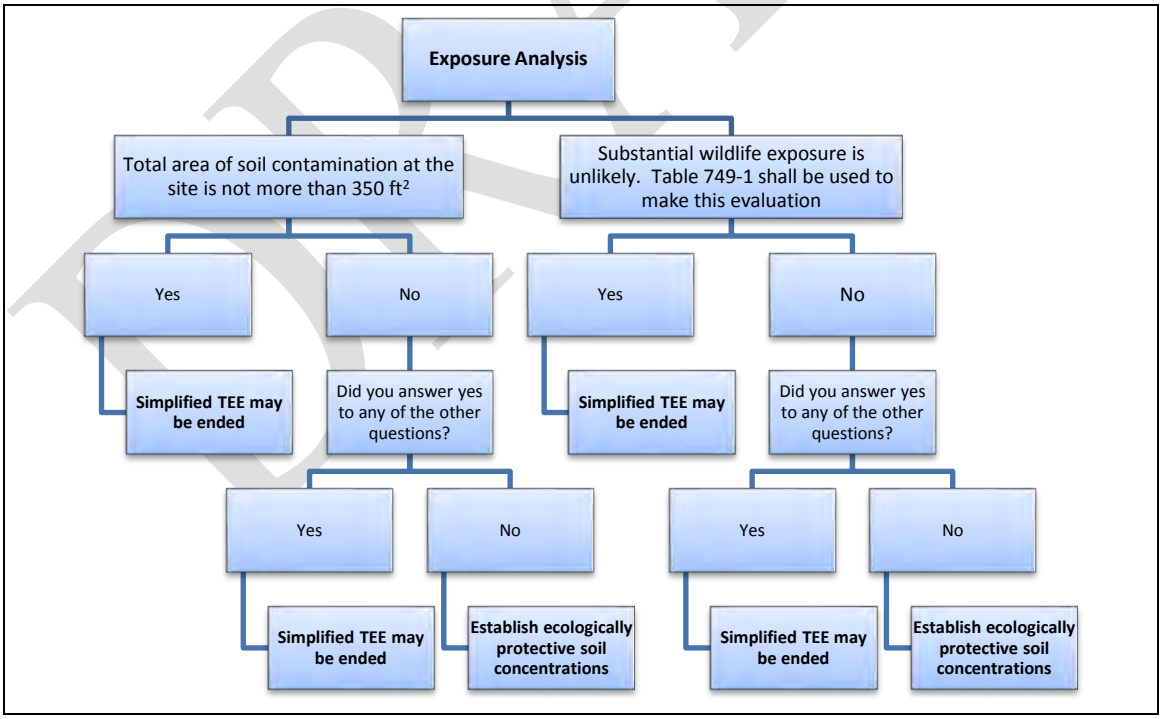
Exposure Analysis

The Exposure Analysis process (Figure 4.2) conducted while performing the simplified TEE is designed to determine the potential for significant exposure to ecological receptors that either use or inhabit sites. The TEE may be ended at a site where:

- The total area of soil contamination is not more than 350 square feet, or;
- Land use at the site and surrounding area make substantial wildlife exposure unlikely.

The determination of land use and wildlife exposure is made with the use of Table 4.2 (MTCA Table 749-1), which is provided for in the MTCA Regulations (WAC 173-340-900). Generally, an experienced field biologist should complete the habitat evaluation. In cases where Table 4.2 (MTCA Table 749-1) is completed by less experienced personnel, conservative assumptions should be made while completing the exposure analysis (Table 4.2 Footnote [a]). The presence of wildlife corridors on or adjacent to the site such as greenbelts, riparian zones, or water bodies should also be considered while determining whether or not a site is likely to attract wildlife. If it has been determined that there is significant potential for ecological receptors to be exposed to contaminants at the site, then an analysis of exposure pathways and/or contaminants must be completed. These procedures have been outlined in the Pathways Analysis and Toxicity Analysis sections. The process for setting cleanup levels for sites evaluated using the TEE has provided in the Establish Ecologically Protective Soil Concentrations section.

Figure 4.2: Summary of Exposure Analysis



Note: Answering (yes) to any of the other questions includes both the pathways analysis and toxicity analysis [sections].

Table 4.2: Simplified Terrestrial Ecological Evaluation – Exposure Analysis Procedures[a]

Estimate the area of contiguous (connected) undeveloped land on or within 500 feet of any area of the contaminated soil to the nearest ½ acre (1/4 acre if the area is less than 0.5 acre). "Undeveloped land" means land that is not covered by existing buildings, roads, paved areas or other barriers that will prevent wildfire from feeding on plants, earthworms, insects or other food in or on the soil.	
1) From the table below, find the number of points corresponding to the area and enter this number in the box to the right.	
Area (acres) — Points 0.25 or less — 4 0.5 — 5 1.0 — 6 1.5 — 7 2.0 — 8 2.5 — 9 3.0 — 10 3.5 — 11 4.0 or more — 12	
2) Is this an industrial or commercial property? See the definition in WAC 173-340-200. If yes, enter a score of 3 in the box to the right. If no, enter a score of 1.	
3) Enter a score in the box to the right for the habitat quality of the contaminated soil and surrounding area, using the rating system shown below[b]. (High = 1, Intermediate = 2, Low = 3)	
4) Is the undeveloped land likely to attract wildlife? If yes, enter a score of 1 in the box to the right. If no, enter a score of 2[c].	
5) Are there any of the following soil hazardous substances present: Chlorinated dioxins/furans, PCB mixtures, DDT, DDE, DDD, aldrin, chlordane, dieldrin, endosulfan, endrin, heptachlor, benzene hexachloride, toxaphene, hexachlorobenzene, pentachlorophenol, or pentachlorobenzene? If yes, enter a score of 1 in the box to the right. If no, enter a score of 4.	
Add the numbers in the boxes on lines 2 through 5 and enter this number to the right. If this number is larger than the number in the box on line 1, the simplified TEE may be ended under WAC 173-340-7292(2) (a) (ii).	

Footnotes:

[a] It is expected that this habitat evaluation will be undertaken by an experienced field biologist. If this is not the case, enter a conservative score (1) for questions 3 and 4.

[b] **Habitat rating system.** Rate the quality of the habitat as high, intermediate, or low based on your professional judgment as a field biologist. The following are suggested factors to consider in making this evaluation:

- **Low:** Early successional vegetative stands; vegetation predominantly noxious, non-native, exotic plant species or weeds. Areas severely disturbed by human activity, including intensively cultivated croplands. Areas isolated from other habitat used by wildlife.
- **High:** Area is ecologically significant for one or more of the following reasons: Late successional native plant communities present; relatively high species diversity; used by an uncommon or rare species; priority habitat (as defined by the Washington Department of Fish and Wildlife); part of a larger area of habitat where size or fragmentation may be important for the retention of some species.
- **Intermediate:** Area does not rate as either high or low.

[c] Indicate "yes" if the area attracts wildlife or is likely to do so. Examples:

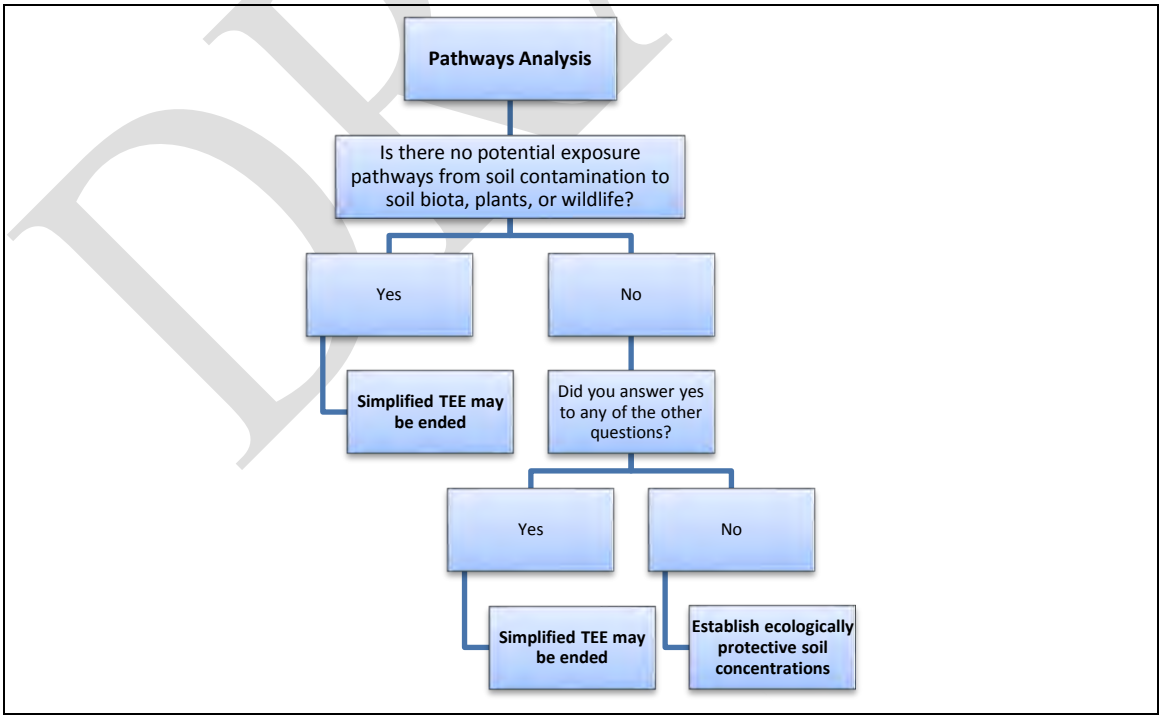
- Birds frequently visit the area to feed
- Evidence of high use by mammals (tracks, scat, etc…)
- Habitat "island" in an industrial area
- Unusual features of an area that make it important for feeding animals
- Heavy use during seasonal migrations
- Areas adjacent to wildlife corridors (i.e. greenbelts and waterways)

Pathways Analysis

The Pathways Analysis process (see Figure 4.3) conducted while performing the simplified TEE is designed to determine the exposure pathways from soil contamination to soil biota, plants or wildlife. For a commercial or industrial property, only potential exposure pathways to wildlife (e.g., small mammals, birds) need be considered. Only exposure pathways for priority chemicals of ecological concern listed in Table 4.1 (MTCA Table 749-2) at or above the concentrations provided must be considered. As a result, the toxicity analysis portion of the TEE should be performed concurrently with the pathways analysis. The results of the toxicity analysis are required to evaluate exposure pathways. Incomplete pathways may be due to the presence of man-made physical barriers, either currently existing or to be placed (future use) within a timeframe acceptable to the department, as part of a remedy or land use. These barriers may include, but are not limited to; parking lots, foundations, or geotextile membranes.

Conditional points of Compliance (See Chapter 1) may be changed to accommodate remedial alternatives provided that all of WAC 173-340-7490 (4) requirements have been satisfied. Barriers must break all significant exposure pathways and their design is dependent on site-specific environmental conditions and the chemical properties of contaminants. To ensure that such man-made barriers are maintained, a restrictive covenant shall be required by the department under WAC 173-340-440 under a consent decree, agreed order, or enforcement order, or as a condition to a written opinion regarding the adequacy of an independent remedial action.

Figure 4.3: Summary of Pathways Analysis



Note: Answering (yes) to any of the other questions includes both the exposure analysis and toxicity analysis [sections].

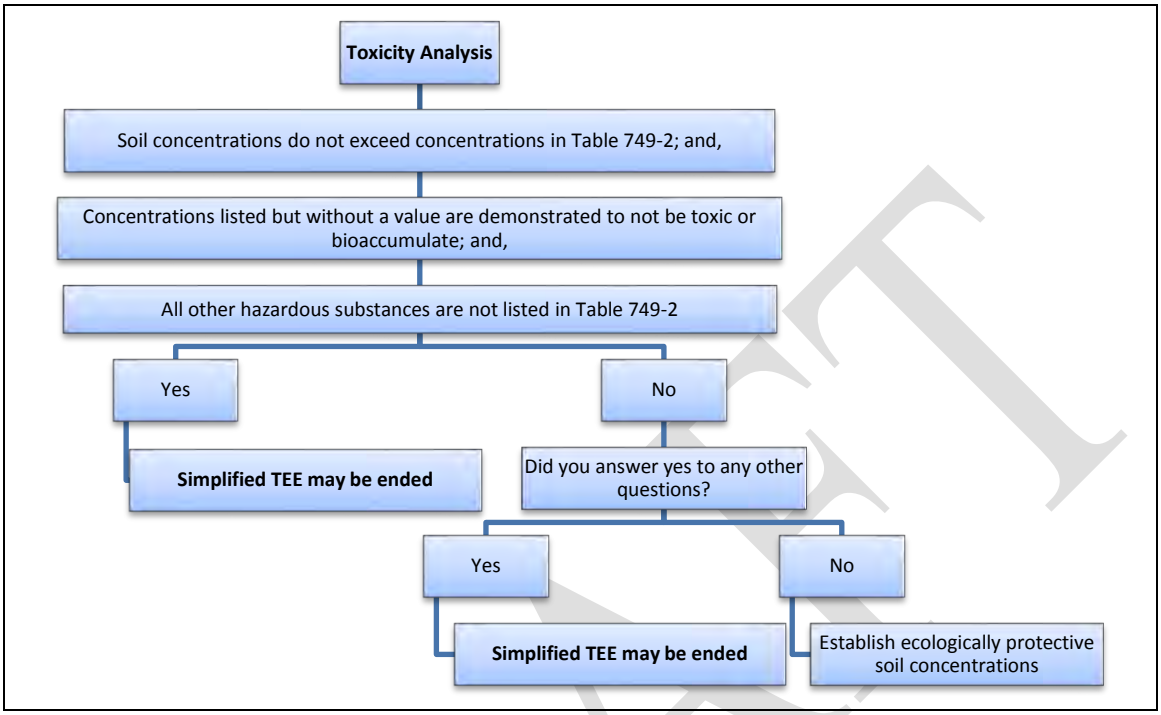
Toxicity Analysis

The Toxicity Analysis process (see Figure 4.4) conducted while performing the simplified TEE is designed to determine whether or not concentrations of toxicants are safe for ecological receptors using or inhabiting the site. The first step in the toxicity analysis process is to determine if site contaminants are listed and/or above Table 4.1 (MTCA Table 749-2) indicator soil concentrations. In cases where the table values are not provided and/or soil concentrations exceed the table values, a number of methods may be used to establish ecologically protective cleanup levels (see Establishing Ecologically Protective Soil Concentrations section). Otherwise, the Table 4.1 (MTCA Table 749-2) values may be used as cleanup levels. The TEE may be ended (without performing the exposure and pathway analyses) provided that cleanup plans are based on Table 4.1 (MTCA Table 749-2) values (provided that table values are available for all of the contaminants on site). Specifically, the evaluation may be ended if all of the following conditions are met at the site:

- For hazardous substances with a value listed in Table 4.1 (MTCA Table 749-2), soil concentrations at the point of compliance (see Chapter 1) do not exceed the applicable concentrations in this table;
- For hazardous substances listed in Table 4.1 (MTCA Table 749-2) but without a value, it is demonstrated that soil concentrations at the point of compliance are unlikely to be toxic or bioaccumulate based on bioassay procedures and wildlife exposure modeling and approved by the department; and,
- For other hazardous substances, the substances are not listed in Table 4.1 (MTCA Table 749-2).

Note: Whether a 6 foot conditional point of compliance is used or an alternative conditional point of compliance is deemed protective by Ecology, an institutional control is required if the contamination is within fifteen feet of the ground surface (see WAC 173-340-7490(4)(b)).

Figure 4.4: Summary of Toxicity Analysis



Note: Answering (yes) to any of the other questions includes both the pathways analysis and exposure analysis [sections]

Establishing Ecologically Protective Soil Concentrations

Establishing ecologically protective soil concentrations is required when the simplified TEE process cannot be ended under any of the simplified analysis criteria described in the previous subsections; exposure analysis, pathways analysis, or toxicity analysis. The ecologically protective soil concentrations can be established using the following methods:

- Use of the soil concentrations in Table 4.1 (MTCA Table 749-2).
- Derived soil concentrations using bioassay procedures described in WAC 173-340-7494(5) to determine concentrations toxic to soil biota and plants, and concentrations likely to bioaccumulate to toxic levels in animals as follows. Consult with the department before conducting bioassays;
    - For values in Table 4.1 (MTCA Table 749-2) based on toxicity to soil biota or plants, bioassays may be used to override the concentration in that table.
    - Bioassays may also be used to develop site-specific concentrations based on toxicity to soil biota and plants for substances listed in Table 4.1 (MTCA Table 749-2) but without a value.

- For values in Table 4.1 (MTCA Table 749-2) based on modeling of bioaccumulation in wildlife and for substances listed in Table 4.1 (MTCA Table 749-2) but without a value, bioassays can be used to develop a site-specific earthworm bioaccumulation and/or plant uptake factor for use in the model described in Table 5.2 (MTCA Table 749-4). When using this model to develop protective soil concentrations for simplified ecological evaluations under this provision, all the other default values must be used; or
- The person conducting the evaluation may also voluntarily elect to develop protective soil concentrations using a site-specific terrestrial ecological evaluation under WAC 173-340-7494, instead of under this section.

Setting Cleanup Levels Based on TEE Tables

The indicator soil concentrations provided in Table 4.1 (MTCA Table 749-2) and Table 5.1 (MTCA Table 749-3) may be used as cleanup levels at any site conducting a simplified TEE. A combination of the values from both tables and the results of bioassays may also be used in cases where safe chemical concentrations for one of more of the ecological receptor groups have not been determined. While the use of these table values as cleanup levels is considered acceptable, please note that the values are conservative and those selected cleanup levels may be more stringent than required to protect ecological receptors on a specific site. Ecology chose to use conservative values in the absence of site-specific information. In many cases, the use of bioassays and empirical studies results in ecologically protective cleanup levels that are less stringent than the human-health based cleanup values, in which case, human health is the driving aspect controlling acceptable chemical concentrations.

Assessing Soil Toxicity with Bioassays

An alternative method to setting cleanup levels based on table values would be to derive concentrations using the bioassay procedures. This is completed to determine concentrations considered toxic to soil biota and plants, and those concentrations likely to bioaccumulate to toxic levels in animals. Bioassays may be used to:

- Determine a safe, yet less conservative value than Table 4.1 (MTCA Table 749-2) based on toxicity to soil biota or plants.
- Develop site – specific concentrations based on toxicity to soil biota and plants for substances listed in Table 4.1 (MTCA Table 749-2), but without a value.
- Develop a site – specific earthworm bioaccumulation and/or plant uptake factor for use in the model described in Table 5.2 (MTCA Table 749-4).

For issues where existing or potential threats to plant life are a concern, use the test described in *Early Seedling Growth Protocol for Soil Toxicity Screening*, Ecology Publication No. 96-324 (see Compendium – Section M). For sites where risks to soil biota are a concern, use the test described in *Earthworm Bioassay Protocol for Soil Toxicity Screening*, Ecology Publication No. 96-327 (see Compendium – Section N). A supporting document describing toxicity tests for

receptors is *Protocols for Short Term Toxicity Screening of Hazardous Waste* Sites, Environmental Protection Agency Publication No. 600/3-88/029 (see Compendium – Section O). Soil concentrations protective of soil biota or plants may also be established with soil bioassays that use species ecologically relevant to the site rather than standard test species. Species that do or could occur at the site are considered ecologically relevant.

Table 4.2: Simplified Terrestrial Ecological Evaluation – Exposure Analysis Procedures[a]

Estimate the area of contiguous (connected) undeveloped land on or within 500 feet of any area of the contaminated soil to the nearest ½ acre (1/4 acre if the area is less than 0.5 acre). "Undeveloped land" means land that is not covered by existing buildings, roads, paved areas or other barriers that will prevent wildfire from feeding on plants, earthworms, insects or other food in or on the soil.	
1) From the table below, find the number of points corresponding to the area and enter this number in the box to the right.	
Area (acres) / Points 0.25 or less 4 0.5 5 1.0 6 1.5 7 2.0 8 2.5 9 3.0 10 3.5 11 4.0 or more 12	5
2) Is this an industrial or commercial property? See the definition in WAC 173-340-200. If yes, enter a score of 3 in the box to the right. If no, enter a score of 1.	3
3) Enter a score in the box to the right for the habitat quality of the contaminated soil and surrounding area, using the rating system shown below[b]. (High = 1, Intermediate = 2, Low = 3)	1
4) Is the undeveloped land likely to attract wildlife? If yes, enter a score of 1 in the box to the right. If no, enter a score of 2[c].	1
5) Are there any of the following soil hazardous substances present: Chlorinated dioxins/furans, PCB mixtures, DDT, DDE, DDD, aldrin, chlordane, dieldrin, endosulfan, endrin, heptachlor, benzene hexachloride, toxaphene, hexachlorobenzene, pentachlorophenol, or pentachlorobenzene? If yes, enter a score of 1 in the box to the right. If no, enter a score of 4.	4
Add the numbers in the boxes on lines 2 through 5 and enter this number to the right. If this number is larger than the number in the box on line 1, the simplified TEE may be ended under WAC 173-340-7292(2) (a) (ii).	9

Footnotes:

[a] It is expected that this habitat evaluation will be undertaken by an experienced field biologist. If this is not the case, enter a conservative score (1) for questions 3 and 4.

[b] **Habitat rating system.** Rate the quality of the habitat as high, intermediate, or low based on your professional judgment as a field biologist. The following are suggested factors to consider in making this evaluation:

- **Low:** Early successional vegetative stands; vegetation predominantly noxious, non-native, exotic plant species or weeds. Areas severely disturbed by human activity, including intensively cultivated croplands. Areas isolated from other habitat used by wildlife.
- **High:** Area is ecologically significant for one or more of the following reasons: Late successional native plant communities present; relatively high species diversity; used by an uncommon or rare species; priority habitat (as defined by the Washington Department of Fish and Wildlife); part of a larger area of habitat where size or fragmentation may be important for the retention of some species.
- **Intermediate:** Area does not rate as either high or low.

[c] Indicate "yes" if the area attracts wildlife or is likely to do so. Examples:

- Birds frequently visit the area to feed
- Evidence of high use by mammals (tracks, scat, etc…)
- Habitat "island" in an industrial area
- Unusual features of an area that make it important for feeding animals
- Heavy use during seasonal migrations
- Areas adjacent to wildlife corridors (i.e. greenbelts and waterways)

Voluntary Cleanup Program

Washington State Department of Ecology
Toxics Cleanup Program

TERRESTRIAL ECOLOGICAL EVALUATION FORM

Under the Model Toxics Control Act (MTCA), a terrestrial ecological evaluation is necessary if hazardous substances are released into the soils at a Site. In the event of such a release, you must take one of the following three actions as part of your investigation and cleanup of the Site:

1. Document an exclusion from further evaluation using the criteria in WAC 173-340-7491.
2. Conduct a simplified evaluation as set forth in WAC 173-340-7492.
3. Conduct a site-specific evaluation as set forth in WAC 173-340-7493.

When requesting a written opinion under the Voluntary Cleanup Program (VCP), you must complete this form and submit it to the Department of Ecology (Ecology). The form documents the type and results of your evaluation.

Completion of this form is not sufficient to document your evaluation. You still need to document your analysis and the basis for your conclusion in your cleanup plan or report.

If you have questions about how to conduct a terrestrial ecological evaluation, please contact the Ecology site manager assigned to your Site. For additional guidance, please refer to www.ecy.wa.gov/programs/tcp/policies/terrestrial/TEEHome.htm.

Step 1: IDENTIFY HAZARDOUS WASTE SITE	
Please identify below the hazardous waste site for which you are documenting an evaluation.	
Facility/Site Name: BNSF Former Cummings Oil Lease Site	
Facility/Site Address: 908 NW Kerron Ave	
Facility/Site No: 3151688	VCP Project No.: SW0775

Step 2: IDENTIFY EVALUATOR			
Please identify below the person who conducted the evaluation and their contact information.			
Name: Kaelin Newman		Title: Staff Geologist	
Organization: TRC Solutions			
Mailing address: 19874 141st Pl NE			
City: Woodinville	State: WA	Zip code: 98072	
Phone: 425-489-1938	Fax:	E-mail: knewman@trcsolutions.com	

Step 3: DOCUMENT EVALUATION TYPE AND RESULTS

A. Exclusion from further evaluation.

1. Does the Site qualify for an exclusion from further evaluation?

☐ Yes *If you answered **"YES,"** then answer **Question 2**.*

☒ No or Unknown *If you answered **"NO" or "UKNOWN,"** then skip to **Step 3B** of this form.*

2. What is the basis for the exclusion? *Check all that apply. Then skip to **Step 4** of this form.*

Point of Compliance: WAC 173-340-7491(1)(a)

☐ All soil contamination is, or will be,* at least 15 feet below the surface.

☐ All soil contamination is, or will be,* at least 6 feet below the surface (or alternative depth if approved by Ecology), and institutional controls are used to manage remaining contamination.

Barriers to Exposure: WAC 173-340-7491(1)(b)

☐ All contaminated soil, is or will be,* covered by physical barriers (such as buildings or paved roads) that prevent exposure to plants and wildlife, and institutional controls are used to manage remaining contamination.

Undeveloped Land: WAC 173-340-7491(1)(c)

☐ There is less than 0.25 acres of contiguous[#] undeveloped[±] land on or within 500 feet of any area of the Site and any of the following chemicals is present: chlorinated dioxins or furans, PCB mixtures, DDT, DDE, DDD, aldrin, chlordane, dieldrin, endosulfan, endrin, heptachlor, heptachlor epoxide, benzene hexachloride, toxaphene, hexachlorobenzene, pentachlorophenol, or pentachlorobenzene.

☐ For sites not containing any of the chemicals mentioned above, there is less than 1.5 acres of contiguous[#] undeveloped[±] land on or within 500 feet of any area of the Site.

Background Concentrations: WAC 173-340-7491(1)(d)

☐ Concentrations of hazardous substances in soil do not exceed natural background levels as described in WAC 173-340-200 and 173-340-709.

* An exclusion based on future land use must have a completion date for future development that is acceptable to Ecology.

[±] "Undeveloped land" is land that is not covered by building, roads, paved areas, or other barriers that would prevent wildlife from feeding on plants, earthworms, insects, or other food in or on the soil.

[#] "Contiguous" undeveloped land is an area of undeveloped land that is not divided into smaller areas of highways, extensive paving, or similar structures that are likely to reduce the potential use of the overall area by wildlife.

B. Simplified evaluation.

1. Does the Site qualify for a simplified evaluation?

- ■ Yes — *If you answered **"YES,"** then answer **Question 2** below.*
- ☐ No or Unknown — *If you answered **"NO"** or **"UNKNOWN,"** then skip to **Step 3C** of this form.*

2. Did you conduct a simplified evaluation?

- ■ Yes — *If you answered **"YES,"** then answer **Question 3** below.*
- ☐ No — *If you answered **"NO,"** then skip to **Step 3C** of this form.*

3. Was further evaluation necessary?

- ☐ Yes — *If you answered **"YES,"** then answer **Question 4** below.*
- ■ No — *If you answered **"NO,"** then answer **Question 5** below.*

4. If further evaluation was necessary, what did you do?

- ☐ Used the concentrations listed in Table 749-2 as cleanup levels. *If so, then skip to **Step 4** of this form.*
- ☐ Conducted a site-specific evaluation. *If so, then skip to **Step 3C** of this form.*

5. If no further evaluation was necessary, what was the reason? *Check all that apply. Then skip to **Step 4** of this form.*

Exposure Analysis: WAC 173-340-7492(2)(a)

- ☐ Area of soil contamination at the Site is not more than 350 square feet.
- ☒ Current or planned land use makes wildlife exposure unlikely. Used Table 749-1.

Pathway Analysis: WAC 173-340-7492(2)(b)

- ☐ No potential exposure pathways from soil contamination to ecological receptors.

Contaminant Analysis: WAC 173-340-7492(2)(c)

- ☐ No contaminant listed in Table 749-2 is, or will be, present in the upper 15 feet at concentrations that exceed the values listed in Table 749-2.
- ☐ No contaminant listed in Table 749-2 is, or will be, present in the upper 6 feet (or alternative depth if approved by Ecology) at concentrations that exceed the values listed in Table 749-2, and institutional controls are used to manage remaining contamination.
- ☐ No contaminant listed in Table 749-2 is, or will be, present in the upper 15 feet at concentrations likely to be toxic or have the potential to bioaccumulate as determined using Ecology-approved bioassays.
- ☐ No contaminant listed in Table 749-2 is, or will be, present in the upper 6 feet (or alternative depth if approved by Ecology) at concentrations likely to be toxic or have the potential to bioaccumulate as determined using Ecology-approved bioassays, and institutional controls are used to manage remaining contamination.

C. Site-specific evaluation. A site-specific evaluation process consists of two parts: (1) formulating the problem, and (2) selecting the methods for addressing the identified problem. Both steps require consultation with and approval by Ecology. *See* WAC 173-340-7493(1)(c).

1. Was there a problem? *See* WAC 173-340-7493(2).

☐ Yes *If you answered **"YES,"** then answer **Question 2** below.*

☐ No *If you answered **"NO,"** then identify the reason here and then skip to **Question 5** below:*

- ☐ No issues were identified during the problem formulation step.
- ☐ While issues were identified, those issues were addressed by the cleanup actions for protecting human health.

2. What did you do to resolve the problem? *See* WAC 173-340-7493(3).

☐ Used the concentrations listed in Table 749-3 as cleanup levels. *If so, then skip to **Question 5** below.*

☐ Used one or more of the methods listed in WAC 173-340-7493(3) to evaluate and address the identified problem. *If so, then answer **Questions 3 and 4** below.*

3. If you conducted further site-specific evaluations, what methods did you use?
Check all that apply. See WAC 173-340-7493(3).

- ☐ Literature surveys.
- ☐ Soil bioassays.
- ☐ Wildlife exposure model.
- ☐ Biomarkers.
- ☐ Site-specific field studies.
- ☐ Weight of evidence.
- ☐ Other methods approved by Ecology. If so, please specify:

4. What was the result of those evaluations?

- ☐ Confirmed there was no problem.
- ☐ Confirmed there was a problem and established site-specific cleanup levels.

5. Have you already obtained Ecology's approval of both your problem formulation and problem resolution steps?

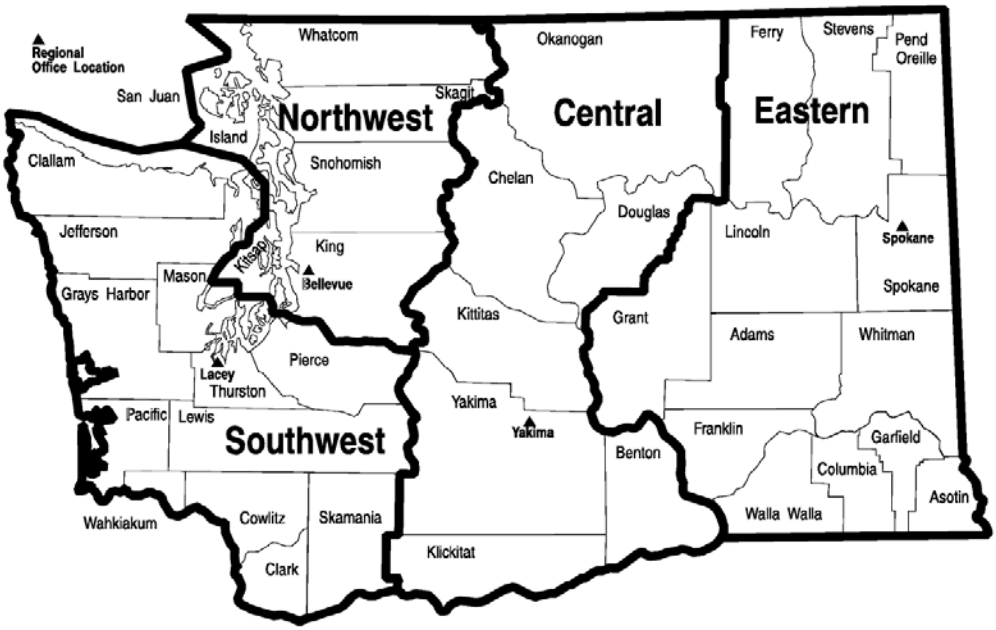
☐ Yes If so, please identify the Ecology staff who approved those steps:

☐ No

Step 4: SUBMITTAL

Please mail your completed form to the Ecology site manager assigned to your Site. If a site manager has not yet been assigned, please mail your completed form to the Ecology regional office for the County in which your Site is located.

Northwest Region: Attn: VCP Coordinator 3190 160th Ave. SE Bellevue, WA 98008-5452	**Central Region:** Attn: VCP Coordinator 1250 West Alder St. Union Gap, WA 98903-0009
Southwest Region: Attn: VCP Coordinator P.O. Box 47775 Olympia, WA 98504-7775	**Eastern Region:** Attn: VCP Coordinator N. 4601 Monroe Spokane WA 99205-1295



APPENDIX E

MANN-KENDALL STATISTICAL TREND ANALYSIS OF SELECT WELLS

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.)