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November 21, 2018

Mr. John Mefford
Washington State Department of Ecology
CRO Toxics Cleanup Program
1250 West Alder Street
Union Gap, WA 98903-0009

Re: Submittal of First Semi-Annual 2018 Groundwater Monitoring and Cap Inspection Report
BNSF – Glacier Park East Site
NE Corner of U. S. Highway 2 and Chumstick Highway
Leavenworth, Washington
Facility/Site No.: 349
Cleanup Site ID No.: 4234
Agreed Order No.: DE 01 TCPCR-3168

Dear Mr. Mefford:

On behalf of the BNSF Railway Company, TRC is pleased to submit the attached *First Semi-Annual 2018 Groundwater Monitoring and Cap Inspection Report* for the Glacier Park East Site located in Leavenworth, Washington. This report has been prepared to summarize the groundwater monitoring and sampling activities and results, and cap inspection results performed at the Site during the second quarter of 2018.

If you have any questions regarding the attached work plan, please contact me at (425) 489-1938, extension 18177.

Sincerely,

Keith Woodburne, L.G.
Senior Project Manager

cc: Scott MacDonald, BNSF
Attachment: *First Semi-Annual 2018 Groundwater Monitoring and Cap Inspection Report,* dated November 21, 2018

Results you can rely on

FIRST SEMI-ANNUAL 2018 GROUNDWATER MONITORING AND CAP INSPECTION REPORT

BNSF Glacier Park East
Leavenworth, Washington

Prepared for:

BNSF Railway Company
605 Puyallup Avenue South
Tacoma, Washington 98421

Prepared by:

TRC

November 2018

FIRST SEMI-ANNUAL 2018 GROUNDWATER MONITORING AND CAP INSPECTION REPORT

November 21, 2018

BNSF Glacier Park East
Leavenworth, Washington

TRC Project No. 296562

Prepared For:

BNSF Railway Company
605 Puyallup Avenue South
Tacoma, Washington 98421

By:

Alexander Lesher

Alexander Lesher
Senior Engineer

Keith Wood

Keith Woodburne L.G.
Senior Project Manager

State of Washington
2955
Licensed Geologist
Keith L. Woodburne

TRC
19874 141st Place NE
Woodinville, Washington
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1.0 INTRODUCTION

This first semi-annual 2018 groundwater monitoring report has been prepared on behalf of BNSF Railway Company (BNSF) to document site assessment activities, including groundwater monitoring and cap inspection activities conducted by TRC at the Glacier Park East site (Site; Figure 1) in Leavenworth, Washington. The Site is located northeast of the intersection of U. S. Highway 2 and Chumstick Highway. The groundwater monitoring event and cap inspection activities were completed on June 13, 2018.

The purpose of the groundwater monitoring event was to evaluate the nature and extent of Site contaminants detected above Washington State Department of Ecology's (Ecology) Model Toxics Control Act (MTCA) Method A cleanup level (Ecology, 2013). Contaminants detected in groundwater at the Site during previous investigations include:

- Total Petroleum Hydrocarbons (TPH) as gasoline-range organics (GRO), diesel-range organics (DRO), and oil-range organics (ORO); and
- Benzene, toluene, ethylbenzene, and total xylenes (BTEX).

In addition, this report includes a summary of the inspection of the cap and associated drainage system. Cleanup activities at the Site were conducted under Agreed Order No. DE 01TCPCR-3168. In September 2001, BNSF and Chevron entered into the Agreed Order with Ecology and since then approved cleanup actions have consisted of isolating soil contamination and monitoring groundwater.

2.0 GROUNDWATER MONITORING AND SAMPLING ACTIVITIES

During the first semi-annual 2018 reporting period, TRC also conducted the second quarterly 2018 gauging event for the shallow piezometers.

2.1 Monitoring Well Gauging and Sampling

On June 13, 2018, depth to groundwater was gauged in six (6) Site monitoring wells (MW-1 through MW-6) and three (3) piezometers (PZ-1 through PZ-3). Groundwater samples were collected from five (5) wells (MW-1, MW-2, MW-3, MW-4, and MW-6).

Due to concentrations reported below laboratory detection limits from groundwater samples collected in all three shallow piezometers in April 2017, collection from these piezometers has since been discontinued. The locations of the monitoring wells and piezometers are shown in Figure 2.

Groundwater samples were collected via bladder pump, disposable polyethylene bladders, and dedicated skip bonded polyethylene tubing using low-flow purging and sampling procedures in accordance with TRC's Groundwater Sampling Standard Operating Procedure (SOP), revised August 2017. During sample collection, TRC recorded field parameters such as dissolved oxygen (DO), pH, temperature, conductivity, turbidity, and oxidation reduction potential (ORP) using a YSI multi-meter, flow-through cell, and LaMotte turbidity meter.

Following parameter stabilization, the discharge tubing was disconnected from the flow-through cell and the samples were collected in laboratory provided bottles then immediately placed on ice. The bladder pump was disassembled and decontaminated and the disposable bladder was replaced between each sampling location.

TRC general field procedures for groundwater gauging and low flow sample collection are provided in the SOP included as Appendix A.

The groundwater samples for MW-1, MW-2, MW-3, MW-4, and MW-6 were analyzed for:

- DRO and ORO by Ecology Northwest Method NWTPH-Dx;
- GRO by NWTPH-Gx; and
- BTEX by United States Environmental Protection Agency (US EPA) Method 8260C.

At the request of Ecology, analysis of DRO and ORO was conducted with and without Silica Gel Cleanup (SGC). SGC is a laboratory procedure used in the measurement of dissolved-phase constituents in groundwater to minimize the potential for interferences of naturally occurring non-petroleum organic matter during the extraction process. The concern at the Site is the lateral extent and stability of the dissolved-phase groundwater plume.

Copies of the laboratory analytical reports and chain-of-custody documentation are provided in Appendix B.

3.0 GROUNDWATER MONITORING RESULTS

An initial groundwater monitoring event was scheduled for May 2018, but due to sampling equipment failure, only groundwater elevation gauging data was recorded (Table 1).

3.1 Groundwater Flow Direction

During the June 2018 monitoring event, groundwater elevations ranged from 1,093.71 feet above mean sea level (amsl) at monitoring well MW-5 to 1,102.75 feet amsl at MW-6.

Monitoring well MW-5 appears to have been installed in a less permeable silt as compared to lithologies observed at depth during installation of other site wells (GeoEngineers, 2001). As a result, monitoring well MW-5 has been excluded from the groundwater flow direction and gradient calculations due to a significantly lower groundwater elevation compared to other Site monitoring wells.

The groundwater flow direction determined from the June 2018 monitoring data is generally to the north to northwest (Figure 3). While the general groundwater flow direction has fluctuated during previous monitoring events, the predominant historical trend has been towards the east-southeast (Figure 4). However, since offsite well MW-6 was installed in May 2017, the groundwater flow direction when including the groundwater elevation in MW-6 in the determination has been towards the north to northwest.

The groundwater gradient was relatively consistent throughout the Site, with an approximate gradient of 0.0035 ft/ft.

Due to insufficient water in the shallow piezometers (i.e., water levels measured below the bottom of the well screen), a groundwater flow direction in the perched water-bearing zone could not be determined. During a previous sampling event on May 30, 2017, a groundwater flow direction in the perched zone was generally to the south-southwest.

3.2 Groundwater Sample Results

During the first semi-annual 2018 monitoring event, the following concentrations were reported and trends observed in Site monitoring wells:

- There were no exceedances of any MTCA Method A cleanup levels in the groundwater samples collected from off-site monitoring well MW-6.
- GRO was not detected in any of the groundwater samples. Historically, GRO concentrations in wells MW-2 and MW-3 have fluctuated over the period of record (October 2001 through June 2018).

  GRO concentrations in well MW-2 have exhibited a clear decreasing trend since March 2012 and have remained below the laboratory reporting limit of 100 µg/L since December 2012, with the exception of the June 2016, May 2017, and November 2017 events.

  GRO concentrations in well MW-3 have generally declined since December 2012 and have remained consistently below the MTCA Method A cleanup level since the March 2014 sampling event.

  GRO concentrations in well MW-4 exhibited generally decreasing trends between 2003 and 2010, and concentrations have remained below laboratory reporting limits and well below the MTCA Method A cleanup level since the March 2012 sampling event.
- DRO concentrations ranged from 204 µg/L (MW-6) to 1,150 µg/L (MW-4) when SGC was not used during laboratory analysis. Concentrations from groundwater samples collected from monitoring wells MW-3 and MW-4 (both without SGC) exceeded the MTCA Method A cleanup level of 500 µg/L.

  DRO concentrations have decreased significantly after the cap was installed in 2003, however, they began to fluctuate starting in approximately 2009 (wells MW-2 and MW-3) and 2010 (well MW-4).

  When SGC was applied to the analysis, DRO was not detected in any of the groundwater samples.
- ORO concentrations ranged from 335 µg/L (MW-6) to 1,060 µg/L (MW-4) without SGC. Concentrations in the groundwater samples collected from MW-1, MW-3, and MW-4 (without SGC) exceeded the MTCA Method A cleanup level of 500 µg/L.

ORO concentrations were generally consistent in each well during the period of record but began to fluctuate in approximately 2009 (well MW-3), 2010 (well MW-2), and 2012 (well MW-4). ORO concentrations have exhibited a similar trend to DRO concentrations in wells MW-3 and MW-4.

When SGC was applied to the analysis, ORO was not detected in any of the groundwater samples.

- BTEX was not detected in any of the groundwater samples at or above the laboratory reporting limit. Benzene concentrations in groundwater samples from MW-3 have fluctuated since approximately 2001 but have remained consistently below the MTCA Method A cleanup level since March 2014.

A summary of current and historical groundwater analytical results is provided in Table 2 and current results are presented on Figure 5. Graphs depicting groundwater elevation versus TPH concentrations for wells MW-2, MW-3, and MW-4 are included as Figures 6, 7, and 8 respectively.

3.3 Natural Attenuation and Water 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, and nutrients are combined 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 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, hydrocarbon-degrading microbes will respire anaerobically utilizing nitrate, iron (III), manganese, and sulfate to assist in petroleum hydrocarbon degradation.

During this sampling event field DO values ranged from 1.29 mg/L (MW-4) to 6.61 mg/L (MW-2). Historically, a positive correlation between low sulfate concentrations and low DO values (less than 1 mg/L) have been observed at MW-3, which suggests potentially increasingly anaerobic conditions. Furthermore, ferrous iron and low DO concentrations have been detected in samples collected from MW-3 and MW-4 during historic events.

Groundwater pH and temperature measurements continue to be within a range deemed adequate for hydrocarbon-degrading microbial populations.

Current and historical water quality and geochemical parameters are summarized in Table 3.

4.0 INVESTIGATION DERIVED WASTE

Purge water collected during the June 2018 sampling event was transported to the TRC office in Woodinville, WA for storage in a properly labeled drum DOT-rated drum contained in overpack and will be disposed of with a BNSF-approved waste disposal facility at the end of calendar year 2018.

5.0 CAP INSPECTION ACTIVITIES

In 2003, an asphaltic concrete cap was constructed at the Site in order to contain the residual contamination in soil, which has exhibited concentrations of Site contaminants greater than the MTCA Method A cleanup levels, from leaching to groundwater. The cap consists of approximately 10 feet of imported clean soil to raise the Site to the elevation of surrounding roadways with a layer of asphaltic concrete placed over the soil. The edges of the raised cap are surrounded by a large rock barrier to prevent erosion and limit access to the surface of the cap. As part of the cap remedy, routine inspection is required to monitor and document the integrity of the cap and associated drainage system.

Inspection of the cap and associated drainage system was conducted on June 13, 2018 as part of the first semi-annual 2018 monitoring event. Inspection of the cap and associated drainage system included:

- identifying areas of wear, cracks, or defects in the asphaltic concrete
- measuring and removing (if warranted) accumulated sediment deposited in catch basins and containment vessels, if warranted; and
- documentation of vegetation growth along the cap edges

The overall condition of the asphaltic concrete cap and associated drainage system is good to fair. During the June 2018 inspection, several cracks were identified along the edges, corners, and one in the middle of the cap. Most of the cracks along the edges appear to be caused by vegetation roots growing near cap edges. The crack located in the middle of the cap extends from north to south between MW-2 and the NE corner of the cap approximately 85 feet long and up to 0.75 inches wide. This trending crack appears to have formed from vegetation near the corner of the cap and enlarged from infiltration of surface water and subsequent freeze/ thaw cycles.

Sediment was not observed and no water was flowing in the pipe within the catch basin towards the grit chamber. Within the grit chamber, sediment was not observed and no water was visible in the large corrugated pipe. Within the vault, neither sediment nor water was visible.

In August 2016, vegetation surrounding the cap was removed. However, during the June 2018 cap inspection, a considerable amount of shrubbery and tree growth was again observed on the southern edge of the cap (Appendix C). Therefore TRC recommends having a professional landscaping contractor remove the new growth during or prior to the second semi-annual 2018 groundwater monitoring event to prevent crack formation and maintain the cap's effectiveness of preventing surface water infiltration.

On June 13, 2018 all identified cracks in the asphalt cap were sealed by a professional asphalt and concrete contractor to prevent infiltration of surface water below the asphalt cap. TRC was present to oversee the activities.

The Cap Inspection and Drainage log including photographic documentation are presented in Appendix C.

6.0 CONCLUSIONS AND RECOMMENDATIONS

TRC collected groundwater samples from four (4) Site monitoring wells (MW-1, MW-2, MW-3, and MW-4), and one (1) off-site monitoring well (MW-6) during the first semi-annual 2018 monitoring event. DRO and ORO were detected in the groundwater samples prepared without SGC from MW-3 and MW-4 at concentrations greater than the MTCA Method A cleanup level. ORO was detected in the groundwater sample prepared without SGC from MW-1 at a concentration greater than the MTCA Method A cleanup level.

SGC of groundwater samples for analysis by NWTPH-Dx has been in use at the Site since 2001 and long-term trends have been established and monitored using that approach. To accurately evaluate the use of SGC on groundwater samples and to demonstrate degradation of the dissolved-phase plume over time, TRC recommends continuing analysis of DRO and ORO both with and without SGC preparation.

In 2017, TRC conducted a water supply / irrigation well survey to better understand the variability in Site groundwater flow and potential sources of that variability. Due to the distance from the Site, TRC determined that the supply wells likely have no effect on groundwater elevation and flow direction fluctuations at the Site.

Off-site monitoring well MW-6 was installed in May 2017 in the presumed downgradient direction from the current monitoring well network to evaluate the potential for impacted groundwater to be migrating offsite towards the Wenatchee River. Groundwater elevation data from MW-6 has not been consistent with the groundwater elevations of the on-site wells and indicate that the groundwater flow direction at the location of MW-6 is towards the Site. Additionally, all of the groundwater samples collected from MW-6 have been below MTCA Method A cleanup levels.

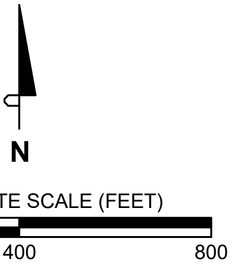
7.0 REFERENCES

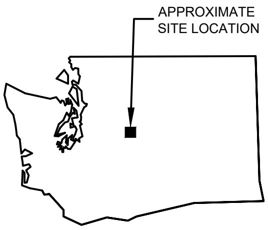
GeoEngineers, 2001. Monitoring Well Installation and Ground Water Analysis, Glacier Park East Site, Leavenworth, Washington.

Ecology, 2013. Model Toxics Control Act Regulation and Statute, MTCA Cleanup Regulation Chapter 173-340 WAC, Model Toxics Control Act Chapter 70.105D RCW, Uniform Environmental Covenants Act Chapter 64.70 RCW. Publication No. 94-06. Revised 2013.

FIGURES

SOURCE AERIAL PHOTO: Google Earth Professional, June 2015.





PROJECT:

BNSF Glacier Park East Site
Chumstick Highway and State Highway 2
Leavenworth, Washington

TITLE:

VICINITY MAP

DRAWN BY:	R. Collins	PROJ NO.:	296562
CHECKED BY:	K. Newman	**FIGURE 1**	
APPROVED BY:	A. Meugniot		
DATE:	July 2018		

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FILE NO.: Fig1_Vicinity Map_Aerial.dwg

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Version: 2017-03-03

SOURCE AERIAL PHOTO: Google Earth Professional, June 2015.

SOURCES: Groundwater Potentiometric Map by Kennedy/Jenks Consultants, December 2013, and site plans by Geo Engineers, March 2002.

PROJECT:

BNSF Glacier Park East Site
Chumstick Highway and State Highway 2
Leavenworth, Washington

TITLE:

SITE PLAN

DRAWN BY:	R. Collins	PROJ NO.:	296562
CHECKED BY:	K. Newman	FIGURE 2	
APPROVED BY:	A. Meugniot		
DATE:	July 2018		

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FILE NO.: Fig2_Site Plan.dwg

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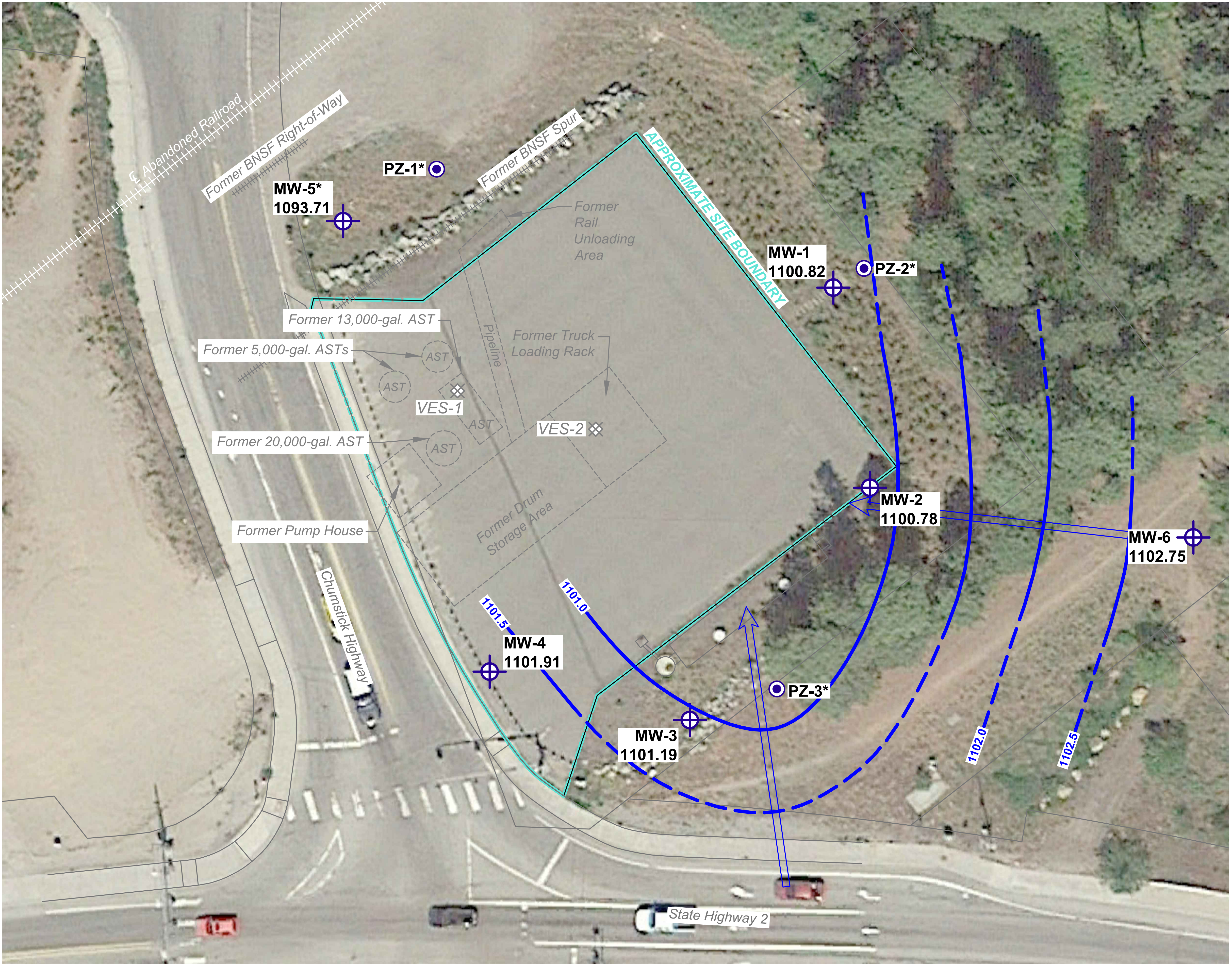

LEGEND

⌖	Monitoring well (approximate)
◉	Piezometer location
⊠	Former vapor extraction well (approximate)
1096.76	Groundwater elevation (ft-msl), June 2018
1102.5 ━	Groundwater elevation contour line (ft-msl), June 2018, dashed where inferred
⇩	General direction of groundwater gradient

*NOTE: * = Location not used in contouring.*

N

SCALE (FEET)

0 30 60

SOURCES: Groundwater Potentiometric Map by Kennedy/Jenks Consultants, December 2013, and site plans by Geo Engineers, March 2002.

PROJECT:

BNSF Glacier Park East Site
Chumstick Highway and State Highway 2
Leavenworth, Washington

TITLE:

GROUNDWATER ELEVATION CONTOUR MAP
June 2018

DRAWN BY:	R. Collins	PROJ NO.:	296562
CHECKED BY:	K. Newman	**FIGURE 3**	
APPROVED BY:	A. Meugniot		
DATE:	July 2018		

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FILE NO.: Fig3_GW_June18.dwg

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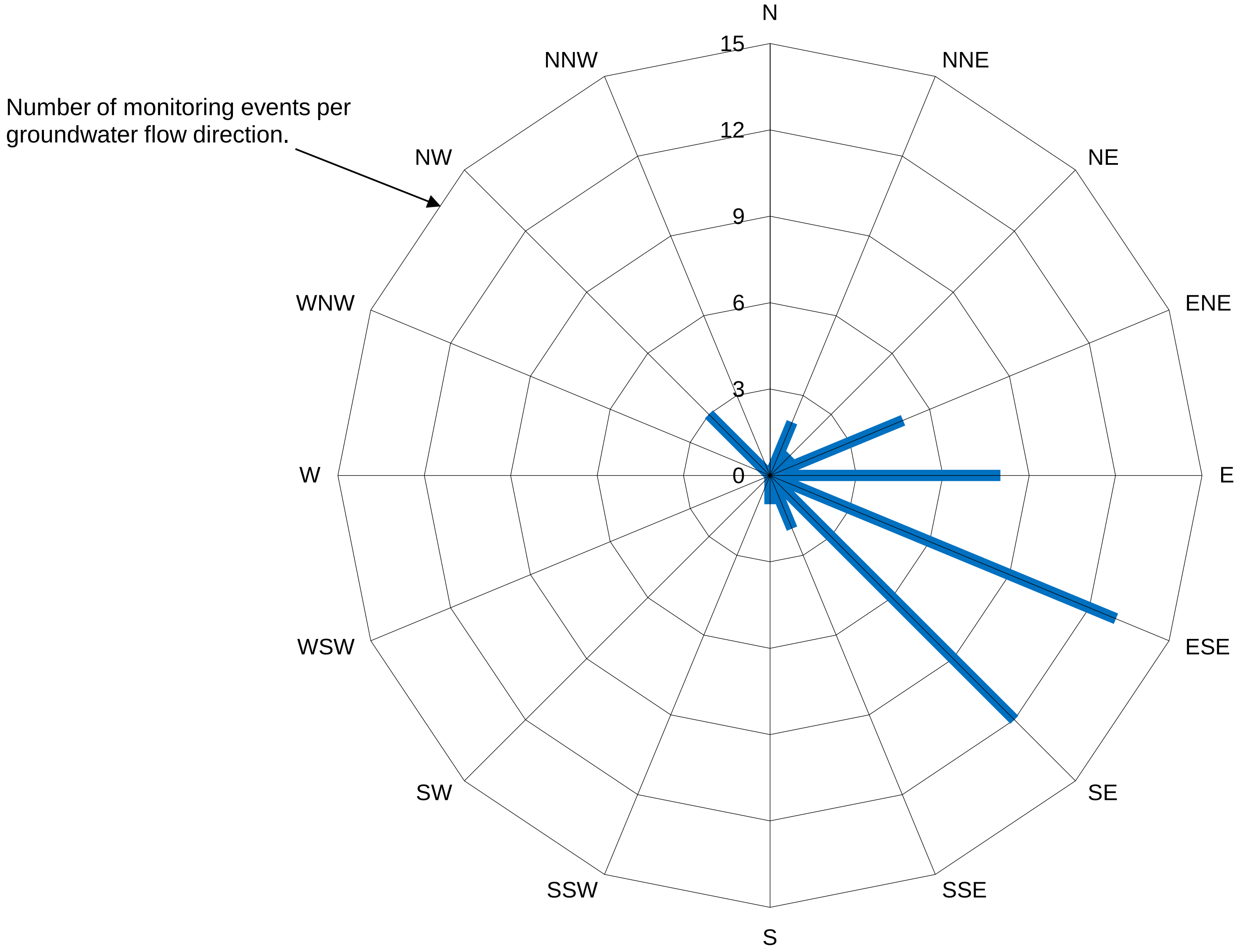
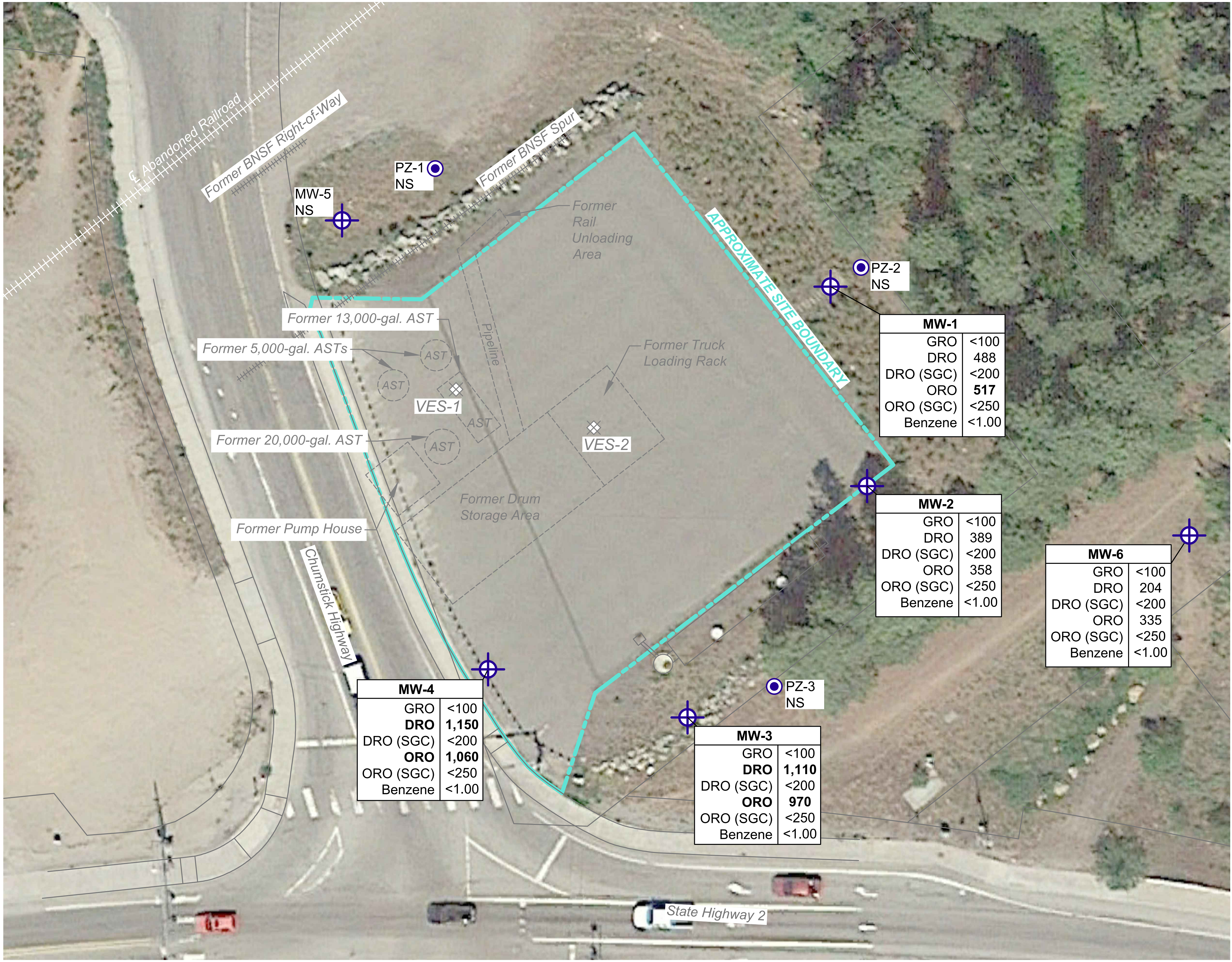
Figure 4
Historical Groundwater Flow Directions
October 2001 through June 2018

BNSF Railway Company
Glacier Park East Site, Leavenworth, Washington



Notes:
Groundwater flow directions do not include MW-5 groundwater elevations.
Groundwater flow directions from 2001 to April 2010 are calculated using historic data provided by Kennedy-Jenks.
Groundwater flow directions from August 2010 to November 2010 are from previous reports provided by Kennedy-Jenks.



MW-1

GRO	<100
DRO	488
DRO (SGC)	<200
ORO	**517**
ORO (SGC)	<250
Benzene	<1.00

MW-2

GRO	<100
DRO	389
DRO (SGC)	<200
ORO	358
ORO (SGC)	<250
Benzene	<1.00

MW-6

GRO	<100
DRO	204
DRO (SGC)	<200
ORO	335
ORO (SGC)	<250
Benzene	<1.00

MW-4

GRO	<100
DRO	**1,150**
DRO (SGC)	<200
ORO	**1,060**
ORO (SGC)	<250
Benzene	<1.00

MW-3

GRO	<100
DRO	**1,110**
DRO (SGC)	<200
ORO	**970**
ORO (SGC)	<250
Benzene	<1.00

LEGEND

⊕ Monitoring well (approximate)

◉ Piezometer location

⊠ Former vapor extraction well (approximate)

MW-2

GRO	<100
DRO	389
DRO (SGC)	<200
ORO	358
ORO (SGC)	<250
Benzene	<1.00

Groundwater analytical results (µg/L), June 2018

NOTES:

NS	Not sampled
GRO	Gasoline range organics
DRO	Diesel range organics
DRO (SGC)	Diesel range organics with SGC
ORO	Heavy oil range organics
DRO (SGC)	Heavy oil range organics with SGC
SGC	Silica gel cleanup
BOLD	Analytical result is greater than or equal to Model Toxics Control Act (MTCA) Method A cleanup levels for GRO (800 µg/L), DRO (500 µg/L), ORO (500 µg/L) and benzene (5 µg/L).

N

SCALE (FEET)

0 30 60

SOURCES: Groundwater Potentiometric Map by Kennedy/Jenks Consultants, December 2013, and site plans by Geo Engineers, March 2002.

PROJECT:

BNSF Glacier Park East Site
Chumstick Highway and State Highway 2
Leavenworth, Washington

TITLE:

GROUNDWATER ANALYTICAL RESULTS
June 2018

WORKING COPY

DRAWN BY:	R. Collins	PROJ NO.:	296562
CHECKED BY:	K. Newman	**FIGURE 5**	
APPROVED BY:	A. Meugniot		
DATE:	July 2018		

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FILE NO.: Fig5_GW Analytical Results_June18.dwg

11x17 --- ATTACHED XREF'S: --- ATTACHED IMAGES: Aerial_Leavenworth_Site_June15; TRC_Reversed Out Blue Logo;
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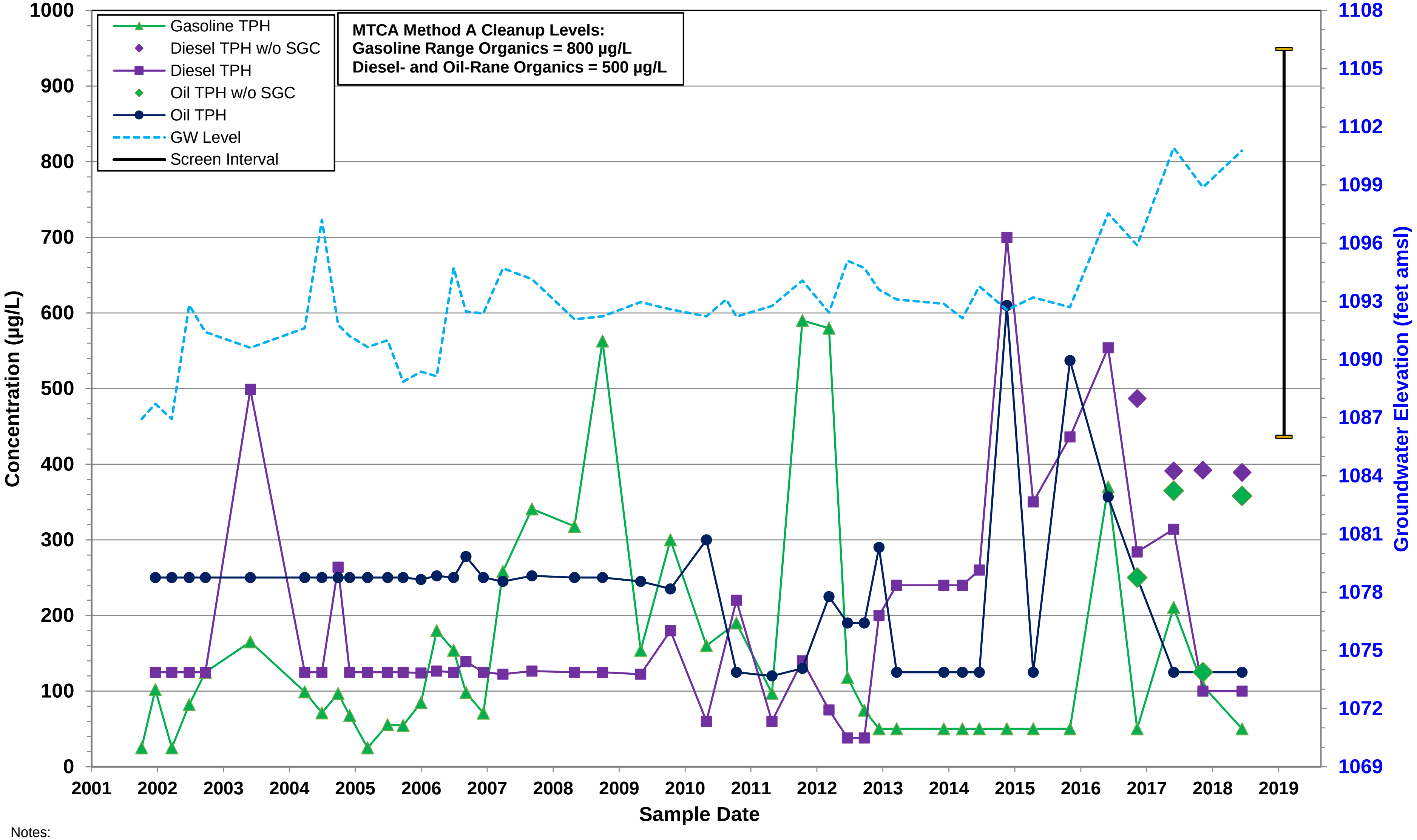
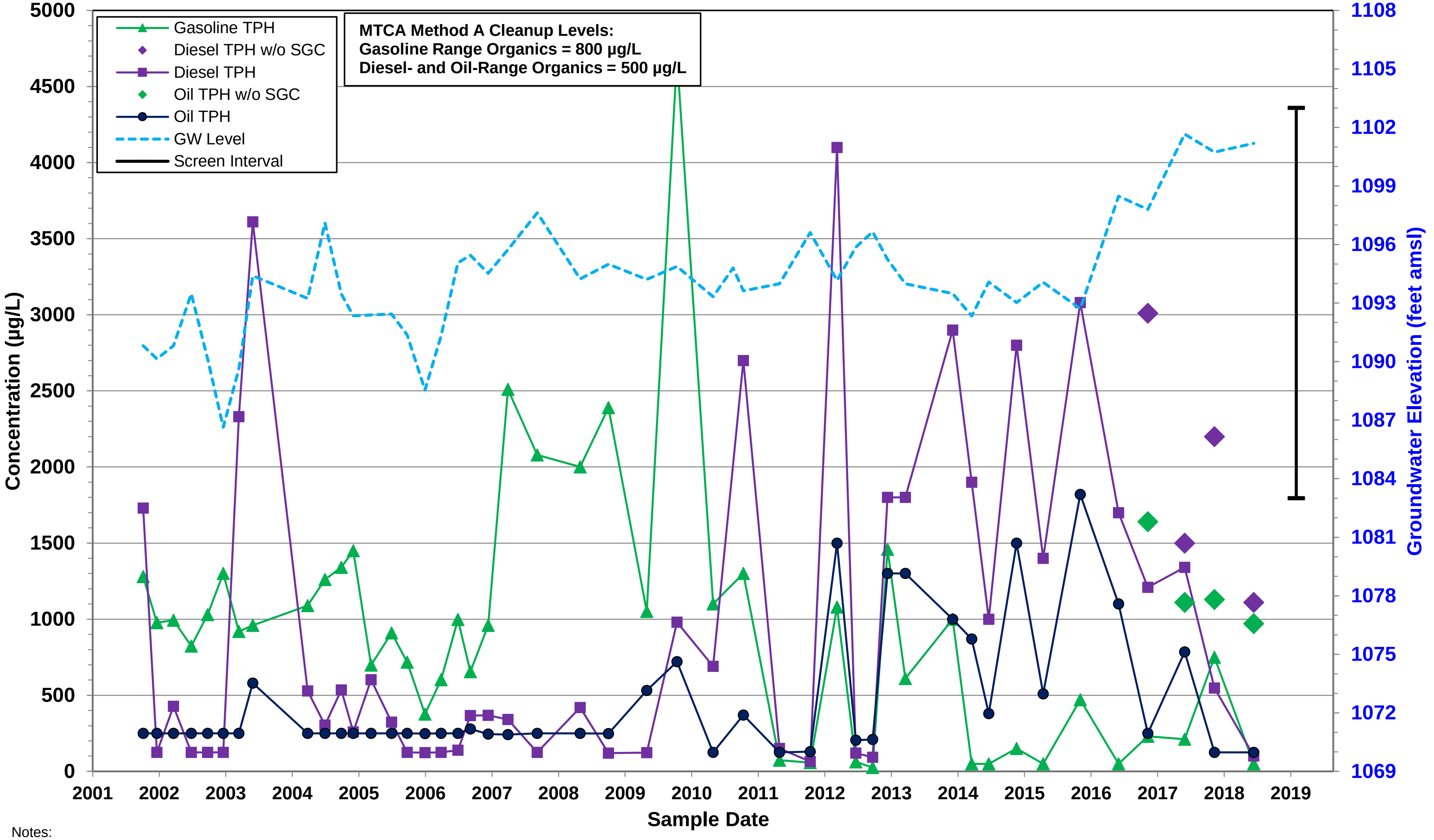
Figure 6
Groundwater Elevation versus Total Petroleum Hydrocarbons - MW-2
BNSF Railway Company
Glacier Park East, Leavenworth, Washington



Notes:
1. Non-detect (ND) results shown as half the laboratory reporting limit.

Figure 7
Groundwater Elevation versus Total Petroleum Hydrocarbons - MW-3

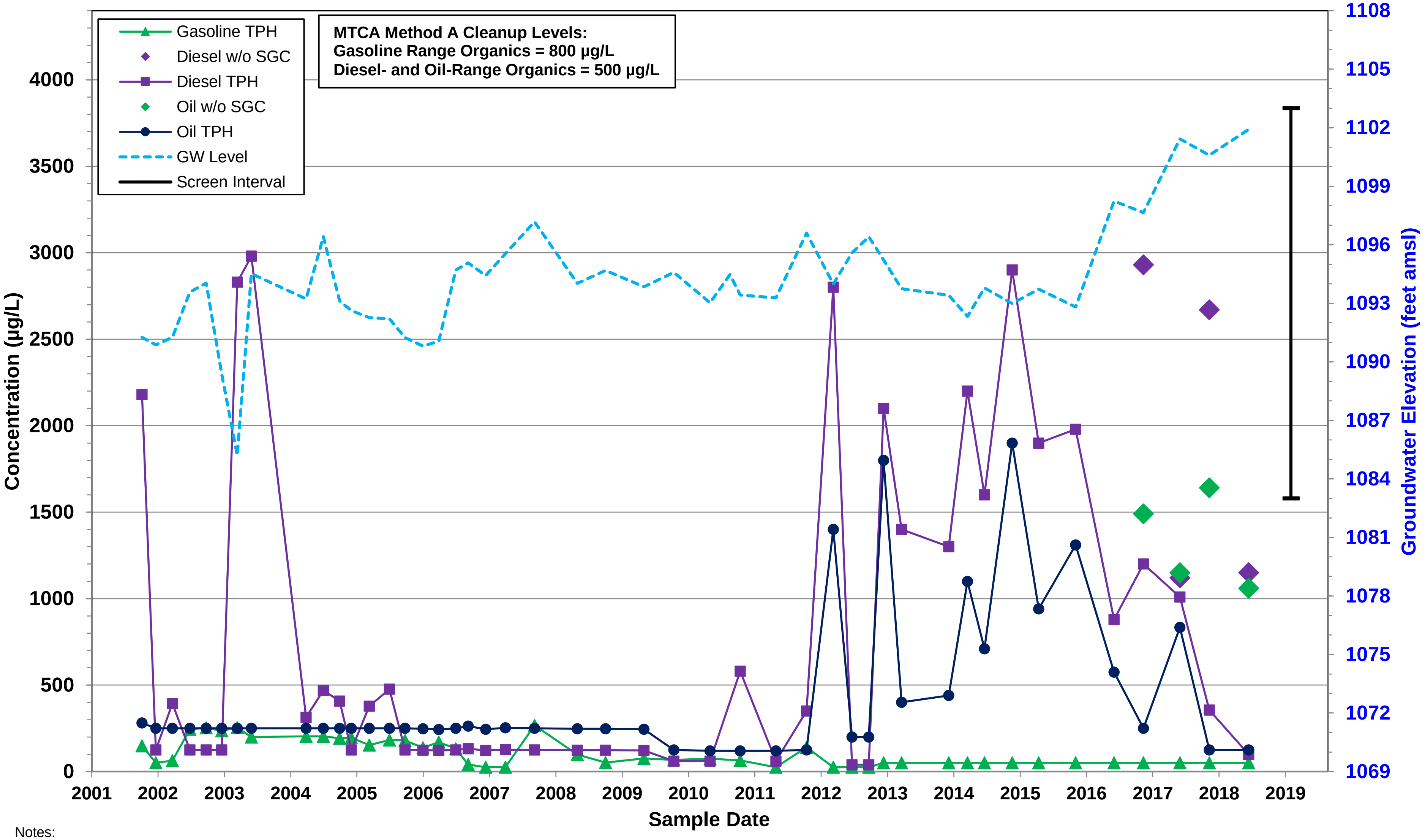
BNSF Railway Company
Glacier Park East, Leavenworth, Washington



Notes:
1. Non-detect (ND) results shown as half the laboratory reporting limit.

Figure 8
Groundwater Elevation versus Total Petroleum Hydrocarbons - MW-4

BNSF Railway Company
Glacier Park East, Leavenworth, Washington



Notes:
1. Non-detect (ND) results shown as half the laboratory reporting limit.

TABLES

Table 1
Summary of Groundwater Elevation Data

BNSF Railway Company
Glacier Park East
Leavenworth, Washington

Monitoring Well	Well Elevation (feet amsl)	Date	Depth to Water (feet bgs)	Water Elevation (feet msl)	Change in Water Elevation (feet)
MW-1	1,149.84	10/5/2001	59.12	1,090.72	--
		12/20/2001	59.41	1,090.43	-0.29
		3/21/2002	59.12	1,090.72	0.29
		6/26/2002	57.29	1,092.55	1.83
		9/24/2002	57.70	1,092.14	-0.41
		12/18/2002	62.26	1,087.58	-4.56
	1,153.50	3/14/2003	65.22	1,088.28	0.70
		5/30/2003	60.30	1,093.20	4.92
	1,153.24	3/26/2004	60.44	1,092.80	-0.40
		6/29/2004	56.45	1,096.79	3.99
		9/27/2004	60.50	1,092.74	-4.05
		12/1/2004	60.69	1,092.55	-0.19
		3/9/2005	61.10	1,092.14	-0.41
		6/29/2005	61.11	1,092.13	-0.01
		9/23/2005	61.82	1,091.42	-0.71
		12/30/2005	61.69	1,091.55	0.13
		3/28/2006	61.76	1,091.48	-0.07
		6/29/2006	58.89	1,094.35	2.87
		9/5/2006	59.23	1,094.01	-0.34
		12/11/2006	59.14	1,094.10	0.09
		3/30/2007	57.85	1,095.39	1.29
		9/6/2007	--	--	--
		4/29/2008	59.30	1,093.94	-1.45
		10/1/2008	59.22	1,094.02	0.08
		4/30/2009	59.36	1,093.88	-0.14
		10/12/2009	58.94	1,094.30	0.42
		4/29/2010	59.85	1,093.39	-0.91
	1,153.21	8/17/2010	59.10	1,094.11	0.72
		10/12/2010	59.90	1,093.31	-0.80
		4/28/2011	60.02	1,093.38	0.07
		10/13/2011	58.29	1,095.11	1.73
		3/9/2012	59.34	1,093.87	-1.24
		6/20/2012	57.74	1,095.47	1.60
		9/20/2012	56.95	1,096.26	0.79
		12/11/2012	58.39	1,095.01	-1.25
		3/18/2013	59.31	1,093.90	-1.11
		12/4/2013	59.35	1,093.86	-0.04
		03/18/2014	60.08	1,093.13	-0.73
		06/19/2014	59.11	1,094.10	0.97
		11/19/2014	59.78	1,093.43	-0.67
		4/14/2015	59.80	1,093.41	-0.02
		11/3/2015	59.80	1,093.41	0.00
		6/1/2016	56.09	1,097.12	3.71
		11/9/2016	56.82	1,096.39	-0.73
		4/11/2017	57.97	1,095.24	-1.15
	1,157.11	5/30/2017	56.01	1,101.10	5.86
		11/8/2017	60.35	1,096.76	-4.34
		5/15/2018	56.38	1,100.73	3.97
		6/13/2018	56.29	1,100.82	0.09

Table 1
Summary of Groundwater Elevation Data
BNSF Railway Company
Glacier Park East
Leavenworth, Washington

Monitoring Well	Well Elevation (feet amsl)	Date	Depth to Water (feet bgs)	Water Elevation (feet msl)	Change in Water Elevation (feet)
MW-2	1,150.95	10/5/2001	64.02	1,086.93	-6.93
		12/20/2001	63.24	1,087.71	0.78
		3/21/2002	64.02	1,086.93	-0.78
		6/26/2002	58.14	1,092.81	5.88
		9/24/2002	59.53	1,091.42	-1.39
		12/18/2002	--	--	--
		3/14/2003	--	--	--
		5/30/2003	60.35	1,090.60	0.00
	1,161.19	3/26/2004	69.57	1,091.62	1.02
		6/29/2004	63.98	1,097.21	5.59
		9/27/2004	69.40	1,091.79	-5.42
		12/1/2004	69.98	1,091.21	-0.58
		3/9/2005	70.55	1,090.64	-0.57
		6/29/2005	70.20	1,090.99	0.35
		9/23/2005	72.34	1,088.85	-2.14
		12/30/2005	71.82	1,089.37	0.52
		3/28/2006	72.06	1,089.13	-0.24
		6/29/2006	66.46	1,094.73	5.60
		9/5/2006	68.72	1,092.47	-2.26
		12/11/2006	68.81	1,092.38	-0.09
		3/30/2007	66.48	1,094.71	2.33
		9/6/2007	67.05	1,094.14	-0.57
		4/29/2008	69.11	1,092.08	-2.06
		10/1/2008	68.96	1,092.23	0.15
		4/30/2009	68.23	1,092.96	0.73
		10/12/2009	68.60	1,092.59	-0.37
		4/29/2010	68.96	1,092.23	-0.36
	1,161.12	8/17/2010	68.02	1,093.10	0.87
		10/12/2010	68.91	1,092.21	-0.89
		4/28/2011	68.65	1,092.76	0.55
		10/13/2011	67.05	1,094.07	1.31
		3/9/2012	68.69	1,092.43	-1.64
		6/20/2012	66.03	1,095.09	2.66
		9/20/2012	66.40	1,094.72	-0.37
		12/11/2012	67.81	1,093.60	-1.12
		3/18/2013	68.02	1,093.10	-0.50
		12/4/2013	68.25	1,092.87	-0.23
		03/18/2014	68.99	1,092.13	-0.74
		06/19/2014	67.35	1,093.77	1.64
		11/19/2014	68.56	1,092.56	-1.21
		4/14/2015	67.92	1,093.20	0.64
		11/3/2015	68.42	1,092.70	-0.50
		6/1/2016	63.59	1,097.53	4.83
		11/9/2016	65.23	1,095.89	-1.64
		4/11/2017	66.58	1,094.54	-1.35
	1,165.01	5/30/2017	64.09	1,100.92	6.38
		11/8/2017	66.13	1,098.88	-2.04
		5/15/2018	64.59	1,100.42	1.54
		6/13/2018	64.23	1,100.78	0.36

Table 1
Summary of Groundwater Elevation Data
BNSF Railway Company
Glacier Park East
Leavenworth, Washington

Monitoring Well	Well Elevation (feet amsl)	Date	Depth to Water (feet bgs)	Water Elevation (feet msl)	Change in Water Elevation (feet)
MW-3	1,151.20	10/5/2001	60.38	1,090.82	--
		12/20/2001	61.06	1,090.14	-0.68
		3/21/2002	60.38	1,090.82	0.68
		6/26/2002	57.72	1,093.48	2.66
		9/24/2002	58.01	1,090.14	-3.34
		12/18/2002	64.56	1,086.64	-3.50
	1,156.35	3/14/2003	66.72	1,089.63	2.99
		5/30/2003	61.95	1,094.40	4.77
	1,156.34	3/26/2004	63.10	1,093.24	-1.16
		6/29/2004	59.22	1,097.12	3.88
		9/27/2004	62.88	1,093.46	-3.66
		12/1/2004	63.99	1,092.35	-1.11
		3/9/2005	63.95	1,092.39	0.04
		6/29/2005	63.90	1,092.44	0.05
		9/23/2005	64.98	1,091.36	-1.08
		12/30/2005	67.80	1,088.54	-2.82
		3/28/2006	65.01	1,091.33	2.79
		6/29/2006	61.27	1,095.07	3.74
		9/5/2006	60.89	1,095.45	0.38
		12/11/2006	61.81	1,094.53	-0.92
		3/30/2007	60.60	1,095.74	1.21
		9/6/2007	58.71	1,097.63	1.89
		4/29/2008	62.10	1,094.24	-3.39
		10/1/2008	61.35	1,094.99	0.75
		4/30/2009	62.12	1,094.22	-0.77
		10/12/2009	61.46	1,094.88	0.66
		4/29/2010	63.01	1,093.33	-1.55
	1,156.29	8/17/2010	61.49	1,094.80	1.47
		10/12/2010	62.66	1,093.63	-1.17
		4/28/2011	62.58	1,093.99	0.36
		10/13/2011	59.96	1,096.61	2.62
		3/9/2012	62.12	1,094.17	-2.44
		6/20/2012	60.43	1,095.86	1.69
		9/20/2012	59.64	1,096.65	0.79
		12/11/2012	61.33	1,095.24	-1.41
		3/18/2013	62.30	1,093.99	-1.25
		12/4/2013	62.80	1,093.49	-0.50
		03/18/2014	63.95	1,092.34	-1.15
		06/19/2014	62.21	1,094.08	1.74
		11/19/2014	63.26	1,093.03	-1.05
		4/14/2015	62.22	1,094.07	1.04
		11/3/2015	63.58	1,092.71	-1.36
		6/1/2016	57.81	1,098.48	5.77
		11/9/2016	58.49	1,097.80	-0.68
		4/11/2017	60.35	1,095.94	-1.86
	1,160.19	5/30/2017	58.53	1,101.66	5.72
		11/8/2017	59.45	1,100.74	-0.92
		5/15/2018	59.00	1,101.19	0.45
		6/13/2018	59.00	1,101.19	0.00

Table 1
Summary of Groundwater Elevation Data
BNSF Railway Company
Glacier Park East
Leavenworth, Washington

Monitoring Well	Well Elevation (feet amsl)	Date	Depth to Water (feet bgs)	Water Elevation (feet msl)	Change in Water Elevation (feet)
MW-4	1,155.29	10/5/2001	64.03	1,091.26	--
		12/20/2001	64.42	1,090.87	-0.39
		3/21/2002	64.03	1,091.26	0.39
		6/26/2002	61.72	1,093.57	2.31
		9/24/2002	61.26	1,094.03	0.46
		12/18/2002	65.92	1,089.37	-4.66
	1,158.42	3/14/2003	73.22	1,085.20	-4.17
		5/30/2003	63.90	1,094.52	9.32
	1,156.92	3/26/2004	63.70	1,093.22	-1.30
		6/29/2004	60.50	1,096.42	3.20
		9/27/2004	63.79	1,093.13	-3.29
		12/1/2004	64.29	1,092.63	-0.50
		3/9/2005	64.66	1,092.26	-0.37
		6/29/2005	64.72	1,092.20	-0.06
		9/23/2005	65.67	1,091.25	-0.95
		12/30/2005	66.11	1,090.81	-0.44
		3/28/2006	65.86	1,091.06	0.25
		6/29/2006	62.21	1,094.71	3.65
		9/5/2006	61.85	1,095.07	0.36
		12/11/2006	62.50	1,094.42	-0.65
		3/30/2007	61.38	1,095.54	1.12
		9/6/2007	59.75	1,097.17	1.63
		4/29/2008	62.90	1,094.02	-3.15
		10/1/2008	62.24	1,094.68	0.66
		4/30/2009	63.07	1,093.85	-0.83
		10/12/2009	62.33	1,094.59	0.74
		4/29/2010	63.89	1,093.03	-1.56
	1,156.90	8/17/2010	62.43	1,094.47	1.44
		10/12/2010	63.48	1,093.42	-1.05
		4/28/2011	63.63	1,093.27	-0.15
		10/13/2011	60.73	1,096.17	2.90
		3/9/2012	62.92	1,093.98	-2.19
		6/20/2012	61.32	1,095.58	1.60
		9/20/2012	60.48	1,096.42	0.84
		12/11/2012	62.11	1,094.79	-1.63
		3/19/2013	63.15	1,093.75	-1.04
		12/4/2013	63.49	1,093.41	-0.34
		03/18/2014	64.57	1,092.33	-1.08
		06/19/2014	63.11	1,093.79	1.46
		11/19/2014	63.91	1,092.99	-0.80
		4/14/2015	63.18	1,093.72	0.73
		11/3/2015	64.09	1,092.81	-0.91
		6/1/2016	58.66	1,098.24	5.43
		11/9/2016	59.25	1,097.65	-0.59
		4/11/2017	61.26	1,095.64	-2.01
	1,160.80	5/30/2017	59.38	1,101.42	5.78
		11/8/2017	60.21	1,100.59	-0.83
		5/15/2018	59.82	1,100.98	0.39
		6/13/2018	58.89	1,101.91	0.93

Table 1
Summary of Groundwater Elevation Data
BNSF Railway Company
Glacier Park East
Leavenworth, Washington

Monitoring Well	Well Elevation (feet amsl)	Date	Depth to Water (feet bgs)	Water Elevation (feet msl)	Change in Water Elevation (feet)
MW-5	1,158.11	10/5/2001	75.57	1,082.54	--
		12/20/2001	74.23	1,083.88	1.34
		3/21/2002	75.57	1,082.54	-1.34
		6/26/2002	67.96	1,090.15	7.61
		9/24/2002	73.87	1,084.24	-5.91
		12/18/2002	74.60	1,083.51	-0.73
	1,158.11	3/14/2003	73.09	1,085.02	1.51
		5/30/2003	68.95	1,089.16	4.14
		3/26/2004	72.15	1,085.96	-3.20
		6/29/2004	65.78	1,092.33	6.37
		9/27/2004	73.40	1,084.71	-7.62
		12/1/2004	72.99	1,085.12	0.41
		3/9/2005	73.25	1,084.86	-0.26
		6/29/2005	73.06	1,085.05	0.19
		9/23/2005	75.51	1,082.60	-2.45
		12/30/2005	73.86	1,084.25	1.65
		3/28/2006	73.65	1,084.46	0.21
		6/29/2006	68.18	1,089.93	5.47
		9/5/2006	73.52	1,084.59	-5.34
		12/11/2006	72.48	1,085.63	1.04
		3/30/2007	69.10	1,089.01	3.38
		9/6/2007	--	--	--
		4/29/2008	72.40	1,085.71	0.00
		10/1/2008	73.66	1,084.45	-1.26
		4/30/2009	71.29	1,086.82	2.37
		10/12/2009	73.97	1,084.14	-2.68
		4/29/2010	71.60	1,086.51	2.37
	1,158.09	8/17/2010	72.17	1,085.92	-0.59
		10/12/2010	73.07	1,085.02	-0.90
		4/28/2011	71.56	1,087.05	2.03
		10/13/2011	72.23	1,085.86	-1.19
		3/9/2012	73.08	1,085.01	-0.85
		6/20/2012	67.64	1,090.45	5.44
		9/20/2012	71.23	1,086.86	-3.59
		12/11/2012	73.23	1,085.38	-1.48
		3/18/2013	72.09	1,086.00	0.62
		12/4/2013	72.81	1,085.28	-0.72
		03/18/2014	72.28	1,085.81	0.53
		06/19/2014	69.41	1,088.68	2.87
		11/19/2014	72.44	1,085.65	-3.03
		4/14/2015	71.30	1,086.79	1.14
		11/3/2015	72.62	1,085.47	-1.32
		6/1/2016	68.90	1,089.19	3.72
		11/9/2016	70.73	1,087.36	-1.83
		4/11/2017	70.34	1,087.75	0.39
	1,161.99	5/30/2017	65.86	1,096.13	8.38
		11/8/2017	72.15	1,089.84	-6.29
		5/15/2018	66.69	1,095.30	5.46
		6/13/2018	68.28	1,093.71	-1.59

Table 1
Summary of Groundwater Elevation Data

BNSF Railway Company
Glacier Park East
Leavenworth, Washington

Monitoring Well	Well Elevation (feet amsl)	Date	Depth to Water (feet bgs)	Water Elevation (feet msl)	Change in Water Elevation (feet)
MW-6	1,159.11	5/30/2017	56.58	1,102.53	--
		11/8/2017	57.26	1,101.85	-0.68
		5/15/2018	56.94	1,102.17	0.32
		6/13/2018	56.36	1,102.75	0.58
PZ-1	1,159.50	11/9/2016	Dry	Dry	--
		2/17/2017	--	--	--
		4/11/2017	13.59	1,145.91	--
		4/21/2017	13.69	1,145.81	-0.10
	1,163.04	5/30/2017	16.90	1,146.14	0.33
		11/8/2017	Dry	Dry	--
		5/15/2018	Dry	Dry	--
		6/13/2018	Dry	Dry	--
PZ-2	1,146.87	11/9/2016	14.07	1,132.80	--
		2/17/2017	9.23	1,137.64	--
		4/11/2017	0.13	1,146.74	9.10
		4/21/2017	0.43	1,146.44	-0.30
	1,150.45	5/30/2017	4.33	1,146.12	-0.32
		11/8/2017	14.46	1,135.99	-10.13
		5/15/2018	4.79	1,145.66	9.67
		6/13/2018	6.33	1,144.12	-1.54
PZ-3	1,154.66	11/9/2016	Dry	Dry	--
		2/17/2017	Dry	Dry	--
		4/11/2017	21.1	1,133.56	--
		4/21/2017	20.83	1,133.83	0.27
	1,158.24	5/30/2017	22.67	1,135.57	1.74
		11/8/2017	Dry	Dry	--
		5/15/2018	Dry	Dry	--
		6/13/2018	Dry	Dry	--

Notes:
-- = not measured
bgs = below ground surface
amsl = above mean sea level
Elevation datum: NGVD29
Vertical datum of 6/5/17 survey: NAVD88

Table 2
Summary of Groundwater Analytical Results

BNSF Railway Company
Glacier Park East
Leavenworth, Washington

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

Monitoring Well	Date Sampled	Total Petroleum Hydrocarbons					Volatile Organic Compounds			
		Gasoline Range	Diesel Range (w/ SGC)	Diesel Range (w/o SGC)[2]	Heavy Oil Range (w/ SGC)	Heavy Oil Range (w/o SGC)[2]	Benzene	Toluene	Ethyl - benzene	Total Xylenes
MTCA Method A Cleanup Levels [1]		**800**	**500**	**500**	**500**	**500**	**5**	**1,000**	**700**	**1,000**
MW-1	10/4/2001	<50	<281 I	--	<562	--	<0.5	**1.79**	<0.5	<1.0
	12/20/2001	<50	<250 J	--	<500	--	<0.5	<0.5	<0.5	<1.0
	3/21/2002	<50	<250	--	<500	--	<0.5	<0.5	<0.5	<1.0
	6/26/2002	<50	<250	--	<500	--	<0.5	<0.5	<0.5	<1.0
	9/24/2002	<50	<250	--	<500	--	<0.5	<0.5	<0.5	<1.0
	12/18/2002	<50	<250	--	<500	--	<0.5	<0.5	<0.5	<1.0
	3/14/2003	<50	**543**	--	<500	--	<0.5	<0.5	<0.5	**1.24**
	5/30/2003	<50	**710**	--	<500	--	<0.5	<0.5	<0.5	<1.0
	3/26/2004	<50	<250	--	<500	--	<0.5	<0.5	<0.5	<1.0
	6/29/2004	<50	<250	--	<500	--	<0.5	<0.5	<0.5	<1.0
	9/27/2004	<50	<250	--	<500	--	<0.5	<0.5	<0.5	<1.0
	12/1/2004	<50	<250	--	<500	--	<0.5	<0.5	<0.5	<1.0
	3/9/2005	<50	<250	--	<500	--	<0.5	<0.5	<0.5	<1.0
	6/29/2005	<50	**1,710**	--	**1,130**	--	<0.5	<0.5	<0.5	<1.0
	6/29/2005 - Dup	<50	**1,040**	--	**722**	--	<0.5	<0.5	<0.5	<1.0
	9/23/2005	<50	<250	--	<500	--	<0.5	<0.5	<0.5	<1.0
	12/30/2005	<50	<282	--	<562	--	<0.5	<0.5	<0.5	<1.0
	3/28/2006	<50	<253	--	<505	--	<0.5	<0.5	<0.5	<1.0
	6/29/2006	<50	<253	--	<505	--	<0.5	<0.5	<0.5	<1.0
	9/5/2006	<80	<248	--	<495	--	<0.5	<0.5	<0.5	<1.0
	12/11/2006	<50	<250	--	<500	--	<0.5	<0.5	<0.5	<1.0
	3/30/2007	<50	<248	--	<495	--	<0.5	<0.5	<0.5	<1.0
	6/13/2018	<100	<200	**488**	<250	**517**	<1.00	<1.00	<1.00	<3.00
MW-2	10/4/2001	<50	--	--	--	--	<0.5	<0.5	<0.5	<1.0
	12/20/2001	**102**	<250 J	--	<500	--	**0.52**	<0.5	<0.5	<1.0
	3/21/2002	<50	<250	--	<500	--	<0.5	<0.5	<0.5	<1.0
	6/26/2002	**82**	<250	--	<500	--	<0.5	<0.5	<0.5	**1.73**
	9/24/2002	**125**	<250	--	<500	--	<0.5	<0.5	**0.815**	**1.06**
	12/18/2002	--	--	--	--	--	--	--	--	--
	3/14/2003	--	--	--	--	--	--	--	--	--
	5/30/2003	**165**	**499**	--	<500	--	**1.18**	<0.5	<0.5	<1.0
	3/26/2004	**99.1**	<250	--	<500	--	<0.5	<0.6	<0.5	**1.30**
	6/29/2004	**71.2**	<250	--	<500	--	<0.5	<0.5	<0.5	<1.0
	9/27/2004	**96.9**	**264**	--	<500	--	<0.5	<0.5	<0.5	<1.0
	12/1/2004	**67.8**	<250	--	<500	--	<0.5	<0.5	<0.5	<1.0
	3/9/2005	<50	<250	--	<500	--	<0.5	<0.5	<0.5	<1.0
	6/29/2005	**55.6**	<250	--	<500	--	<0.5	<0.5	<0.5	<1.0
	9/23/2005	**54.6**	<250	--	<500	--	<0.5	<0.5	<0.5	<1.0
	12/30/2005	**84.6**	<248	--	<495	--	<0.5	<0.5	**0.763**	**2.74**
	3/28/2006	**180**	<253	--	<505	--	**0.558**	<0.5	**0.993**	**1.38**
	6/29/2006	**154**	<250	--	<500	--	**0.801**	<0.5	<0.5	<1.0
	9/5/2006	**98.2**	<278	--	<556	--	**0.932**	<0.5	**0.79**	<1.0
	12/11/2006	**71**	<250	--	<500	--	<0.5	<0.5	<0.5	<1.0
	3/30/2007	**258**	<245	--	<490	--	**2.66**	<0.5	**1.11**	**2.12**
	9/6/2007	**341**	<253	--	<505	--	**5.28**	<0.5	**3.67**	**3.23**
	4/29/2008	**318**	<250	--	<500	--	**3.22**	<0.5	**0.968**	**1.28**
	10/1/2008	**563**	<250	--	<500	--	**2.97**	**0.608**	**3.93**	**2.88**
	4/30/2009	**154**	<245	--	<490	--	**0.604**	<0.5	<0.5	**1.10**
	10/12/2009	**300**	**180**	--	<470	--	**1.0 H**	<1.0	<1.0	<1.0
	4/29/2010	**160**	<120	--	**300**	--	<0.5	<0.5	<0.5	**1.8**
	10/12/2010	**190**	**220**	--	<250	--	**0.76**	<0.5	<0.5	<1.0
	4/28/2011	**97**	<120	--	<240	--	<1.0	<1.0	<1.0	<1.0
	10/13/2011	**590**	**140**	--	<260	--	**4.6**	<1.0	**6.4**	**2.7**
	3/9/2012	**580**	**75.2**	--	<450	--	<1.0	<1.0	<1.0	<3.0

Table 2
Summary of Groundwater Analytical Results
BNSF Railway Company
Glacier Park East
Leavenworth, Washington

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

Monitoring Well	Date Sampled	Total Petroleum Hydrocarbons					Volatile Organic Compounds			
		Gasoline Range	**Diesel Range** (w/ SGC)	**Diesel Range** (w/o SGC)[2]	**Heavy Oil Range** (w/ SGC)	**Heavy Oil Range** (w/o SGC)[2]	**Benzene**	**Toluene**	**Ethyl - benzene**	**Total Xylenes**
MTCA Method A Cleanup Levels [1]		**800**	**500**	**500**	**500**	**500**	**5**	**1,000**	**700**	**1,000**
MW-2 Continued	6/20/2012	**118**	<76	--	<380	--	**1.1**	<1.0	<1.0	<3.0
	9/20/2012	**74.7**	<76	--	<380	--	<1.0	<1.0	<1.0	<3.0
	12/11/2012	<100	**200**	--	**290**	--	<1.0	<1.0	<1.0	<3.0
	3/18/2013	<100	**240**	--	<250	--	<0.5	<5.0	<0.5	<1.5
	12/4/2013	<100	**240**	--	<250	--	<0.5	<5.0	<0.5	<1.5
	3/18/2014	<100	**240**	--	<250	--	<0.5	<5.0	<0.5	<1.5
	6/19/2014	<100	**260**	--	<250	--	<0.5	<5.0	<0.5	<1.5
	11/20/2014	<100	**700**	--	**610**	--	<0.5	<5.0	<0.5	<1.5
	4/15/2015	<100	**350**	--	<250	--	<0.5	<5.0	<0.5	<1.5
	11/3/2015	<100	**436**	--	**537**	--	<0.5	<5.0	<0.5	<1.5
	6/1/2016	**370**	**554**	--	**357**	--	**5.54**	<5.0	**2.39**	<1.50 B
	11/9/2016	<100	**284**	**487**	<500	<500	<1.0	<5.0	<1.0	<3.0
	5/30/2017	**211**	**314**	**391**	<250	**365**	<1.00	<1.00	<1.00	<3.00
	11/8/2017	**107**	<200	**392**	<250	<250	<1.00	<1.00	<1.00	<3.00
	6/13/2018	<100	<200	**389**	<250	**358**	<1.00	<1.00	<1.00	<3.00
MW-3	10/5/2001	**1,280 I**	**1,730**	--	<500	--	**28.1 I**	**11.2 I**	**51.6 I**	**4.52 I**
	12/20/2001	**977 I**	<250 J	--	<500 J	--	**19.2 I**	**2.40 I**	**7.62 I**	**3.55 I**
	12/20/2001 - Dup	**950 I**	<250 J	--	<500 J	--	**19.3 I**	**2.42 I**	**7.60 I**	**3.55 I**
	3/21/2002	**993 I**	**255**	--	<500	--	**14.9 I**	**2.95 I**	**4.58 I**	**7.35 I**
	3/21/2002 - Dup	**963 I**	**428**	--	<500	--	**16.7 I**	**1.23 I**	**2.66 I**	**1.84 I**
	6/26/2002	**823**	<250	--	<500	--	**16.6**	**1.02 I**	**2.46 I**	**3.6**
	6/26/2002 - Dup	**762**	<250	--	<500	--	**15.4**	**1.03 I**	**2.48 I**	**3.56 I**
	9/24/2002	**1,020 I**	<250 J	--	<500 J	--	**16.2 I**	**4.77 I**	**29.4 I**	**8.74 I**
	9/24/2002 - Dup	**1,030 I**	<250 J	--	<500 J	--	**16.3 I**	**4.73 I**	**29.6 I**	**8.69 I**
	12/18/2002	**1,300**	<250	--	<500	--	**20.7**	**7.42**	**78.9**	**10.4**
	12/18/2002 - Dup	**1,250**	<250	--	<500	--	**21.1**	**7.43**	**79.4**	**10.2**
	3/14/2003	**919 I**	**2,330**	--	<500	--	**12 I**	**2.58 I**	**27.7 I**	**2.5 I**
	3/14/2003 - Dup	**849 I**	**2,200**	--	<500	--	**11.4 I**	**2.21 I**	**25.5 I**	**2.32 I**
	5/30/2003	**959**	**2,820**	--	<500	--	**22.7**	**6.01**	**42.8**	**7.12**
	5/30/2003 - Dup	**845**	**3,610**	--	**580**	--	**14.4**	**3.88**	**27**	**3.46**
	3/26/2004	**1,060**	**443**	--	<500	--	**19.7**	**7.44**	**24**	**4.32**
	3/26/2004 - Dup	**1,090**	**528**	--	<500	--	**19.1**	**7.14**	**23**	**3.62**
	6/29/2004	**1,260**	**305**	--	<500	--	**25.6**	**8.11**	**20.7**	**2.99**
	6/29/2004 - Dup	**1,050**	<250	--	<500	--	**21.7**	**6.82**	**17.4**	**2.61**
	9/27/2004	**1,340**	**535**	--	<500	--	**19.4**	**9.41**	**31.8**	**7.29**
	12/1/2004	**1,450**	**259**	--	<500	--	**20.9**	**8.06**	**27**	**4.82**
	3/9/2005	**698**	**602**	--	<500	--	**11.7**	**2.52**	**4.84**	**1.28**
	3/9/2005 - Dup	**639**	**334**	--	<500	--	**9.33**	**1.98**	**3.84**	<1.0
	6/29/2005	**909**	**324**	--	<500	--	**11**	**1.67**	**4.72**	**2.27**
	6/29/2005 - Dup	--	--	--	<501	--	--	--	--	--
	9/23/2005	**718**	<250	--	<500	--	**7.38**	**0.994**	**1.96**	**2.25**
	12/30/2005	**377**	<248	--	<495	--	**5.01**	**0.799**	**0.89**	**1.04**
	3/28/2006	**603**	<250	--	<500	--	**4.28**	<0.5	**0.918**	**1.99**
	6/29/2006	**998**	<278	--	<500	--	**12.7**	**1.61**	**10.5**	**3.03**
	9/5/2006	**655**	**366**	--	<556	--	**20.1**	**8.83**	**74.5**	**33.5**
	12/11/2006	**959**	**369**	--	<490	--	**4.66**	<0.5	<0.5	**2.06**
	3/30/2007	**2,510**	**341**	--	<485	--	**32.3**	**17.7**	**89.9**	**56.8**
	9/6/2007	**2,080**	<250	--	<500	--	**30.7**	**38.8**	**137**	**106**
	4/29/2008	**1,550 J**	**419 I**	--	<476	--	**12.8**	**16.2**	**48.4**	**29.9**
	4/29/2008 - Dup	**2,000 J**	<250	--	<500	--	**16.7**	**19.9**	**54.6**	**31.7**
	10/1/2008	**2,250 J**	<248	--	<495	--	**17.4**	**24.2**	**117**	**84.2**
	10/1/2008 - Dup	**2,390 J**	<240	--	<481	--	**18.3**	**25.4**	**118**	**88.9**
	4/30/2009	**1,050**	<248	--	**532**	--	**9.39**	**7.33**	**26.5**	**25**
	4/30/2009 - Dup	**1,040**	<238	--	<476	--	**9.36**	**7.3**	**26.2**	**24.6**
	10/12/2009	**4,600**	**980**	--	**720**	--	**27**	**41**	**180**	**40**
	10/12/2009 - Dup	**4,700**	**910**	--	**570**	--	**27**	**43**	**190**	**42**
	4/29/2010	**1,100**	**690**	--	<250	--	**9.9**	**7.5**	**16**	**13**

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

Monitoring Well	Date Sampled	Total Petroleum Hydrocarbons					Volatile Organic Compounds			
		Gasoline Range	Diesel Range (w/ SGC)	Diesel Range (w/o SGC)^2	Heavy Oil Range (w/ SGC)	Heavy Oil Range (w/o SGC)^2	Benzene	Toluene	Ethyl - benzene	Total Xylenes
MTCA Method A Cleanup Levels [1]		**800**	**500**	**500**	**500**	**500**	**5**	**1,000**	**700**	**1,000**
MW-3 Continued	4/29/2010 - Dup	**890**	**480**	--	<250	--	**9**	**6.4**	**14**	**12**
	10/12/2010	**1,300**	**1,600**	--	<240	--	**11**	**18**	**69**	**68**
	10/12/2010 - Dup	**1,300**	**2,700**	--	**370**	--	**10**	**18**	**70**	**69**
	4/28/2011	**65**	**120**	--	<250	--	**1**	<1.0	<1.0	<1.0
	4/28/2011 - Dup	**74**	**150**	--	<250	--	**1**	<1.0	<1.0	<1.0
	10/13/2011	<50	<130	--	<260	--	<1.0	<1.0	<1.0	<1.0
	10/13/2011 - Dup	**57**	<120	--	<250	--	<1.0	<1.0	<1.0	<1.0
	3/9/2012	**1,080**	**3,800**	--	**1,400**	--	**10**	**9.6**	**9.7**	**18.6**
	3/9/2012 - Dup	**985**	**4,100**	--	**1,500**	--	**9.1**	**8.7**	**8.9**	**17**
	6/20/2012	**50.6**	**120**	--	<380	--	**1.4**	<1.0	<1.0	<3.0
	6/20/2012 - Dup	**62.1**	<82	--	<410	--	**1.6**	<1.0	<1.0	<3.0
	9/20/2012	<50	**93**	--	<420	--	<1.0	<1.0	<1.0	<3.0
	9/20/2012 - Dup	<50	<79	--	<400	--	<1.0	<1.0	<1.0	<3.0
	12/11/2012	**1,460**	**1,800**	--	**1,300**	--	**7.3**	**39.9**	**14.9**	**71.5**
	12/11/2012 - Dup	**708**	**1,600**	--	**1,300**	--	**3.7**	**22.9**	**7.2**	**35.1**
	3/18/2013	**600**	**1,800**	--	**1,300**	--	**5.2**	**7.8**	**2.7**	**24**
	3/18/2013 - Dup	**610**	**1,100**	--	**250**	--	**5.4**	**8.1**	**2.8**	**25**
	12/4/2013	**1,000**	**2,300**	--	**630**	--	**14**	**21**	**19**	**110**
	12/4/2013 - Dup	**1,000**	**2,900**	--	**1,000**	--	**14**	**20**	**19**	**110**
	3/18/2014	<100	**1,900**	--	**860**	--	**1.7**	<5.0	<0.5	**1.6**
	3/18/2014 - Dup	<100	**1,900**	--	**870**	--	**1.6**	<5.0	<0.5	**1.6**
	6/19/2014	<100	**800**	--	**250**	--	**0.95**	<5.0	<0.5	<1.5
	6/19/2014 - Dup	<100	**1,000**	--	**380**	--	<0.5	<5.0	<0.5	<1.5
	11/20/2014	**150**	**2,700**	--	**1,400**	--	**1.7**	<5.0	**0.74**	<1.5
	11/20/2014 - Dup	**120**	**2,800**	--	**1,500**	--	**1.8**	<5.0	**0.64**	<1.5
	4/15/2015	<100	**1,400**	--	**510**	--	**0.77**	<5.0	<0.5	<1.5
	11/3/2015	**471**	**3,080**	--	**1,820**	--	**4.65**	<5.0	**1.95**	**5.68**
	6/1/2016	<100	**1,700**	--	**1,100**	--	**1.21**	<5.0	<0.5	<1.5 B
	11/10/2016	**230**	**1,210**	**3,010**	<500	**1,640**	**2.87**	<5.0	<1.0	<3.0
	5/30/2017	**212**	**1,340**	**1,500**	**785**	**1,110**	**1.83**	<1.00	<1.00	<3.00
	11/9/2017	**749**	**547**	**2,200**	<250	**1,130**	**4.16**	**14.7**	**26.7**	**79.3**
	6/13/2018	<100	<200	**1,110**	<250	**970**	<1.00	<1.00	<1.00	<3.00
MW-4	10/5/2001	**149**	**1,940**	--	<561	--	<0.5	**2.17**	<0.5	<1.0
	10/5/2001 - Dup	**140**	**2,180**	--	<561	--	<0.5	**2.08**	<0.5	<1.0
	12/20/2001	**50.7**	<250 J	--	<500 J	--	<0.5	<0.5	<0.5	<1.0
	3/21/2002	**63.4**	**393**	--	<500	--	<0.5	<0.5	<0.5	<1.0
	6/26/2002	**244**	<250	--	<500	--	**2.73**	<0.5	<0.5	**1.06**
	9/24/2002	**253**	<250	--	<500	--	**3.31**	<0.5	<0.5	**1.01**
	12/18/2002	**236**	<250	--	<500	--	**1.73**	<0.5	<0.5	<1.0
	3/14/2003	**254**	**2,830**	--	<500	--	**0.847**	<0.5	<0.5	<1.0
	5/30/2003	**199**	**2,980**	--	<500	--	**0.602**	<0.5	<0.5	<1.0
	3/26/2004	**204**	**314**	--	<500	--	<0.5	<0.5	<0.5	<1.0
	6/29/2004	**204**	**469**	--	<500	--	<0.5	<0.5	<0.5	<1.0
	9/27/2004	**192**	**408**	--	<500	--	<0.5	<0.5	<0.5	<1.0
	12/1/2004	**196**	<250	--	<500	--	<0.5	<0.5	<0.5	<1.0
	3/9/2005	**153**	**378**	--	<500	--	<0.5	<0.5	<0.5	<1.0
	6/29/2005	**183**	**477**	--	<500	--	<0.5	<0.5	<0.5	<1.0
	9/23/2005	**180**	<250	--	<500	--	<0.5	<0.5	<0.5	<1.0
	12/30/2005	**137**	<248	--	<495	--	<0.5	<0.5	<0.5	<1.0
	3/28/2006	**170**	<243	--	<485	--	<0.5	<0.5	<0.5	<1.0
	6/29/2006	**132**	<250	--	<500	--	<0.5	<0.5	<0.5	<1.0
	9/5/2006	<80	<263	--	<526	--	<0.5	<0.5	<0.5	<1.0
	12/11/2006	<50	<245	--	<490	--	<0.5	<0.5	<0.5	<1.0
	3/30/2007	<50	<253	--	<505	--	<0.5	<0.5	<0.5	<1.0
	9/6/2007	**267**	<250	--	<500	--	0.65	<0.5	<0.5	<3.0
	4/29/2008	**98.7**	<248	--	<495	--	<0.5	<0.5	<0.5	<1.0

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		Total Petroleum Hydrocarbons					Volatile Organic Compounds			
Monitoring Well	**Date Sampled**	**Gasoline Range**	**Diesel Range** (w/ SGC)	**Diesel Range** (w/o SGC)^2	**Heavy Oil Range** (w/ SGC)	**Heavy Oil Range** (w/o SGC)^2	**Benzene**	**Toluene**	**Ethyl - benzene**	**Total Xylenes**
MTCA Method A Cleanup Levels [1]		**800**	**500**	**500**	**500**	**500**	**5**	**1,000**	**700**	**1,000**
MW-4 Continued	10/1/2008	**52.2**	<248	--	<495	--	<0.5	<0.5	<0.5	<1.0
	4/30/2009	**76.4**	<245	--	<490	--	--	<0.5	<0.5	<1.0
	10/12/2009	**68**	<120	--	<250	--	<1.0	<1.0	<1.0	<1.0
	4/29/2010	**75**	<120	--	<240	--	<0.5	<0.5	<0.5	<1.0
	10/12/2010	**65**	**580**	--	<240	--	<0.5	<0.5	<0.5	<1.0
	4/28/2011	<50	<120	--	<240	--	<1.0	<1.0	<1.0	<1.0
	10/13/2011	**140**	**350**	--	<250	--	<1.0	<1.0	<1.0	<1.0
	3/9/2012	<50	**2,800**	--	**1,400**	--	<1.0	<1.0	<1.0	<3.0
	6/20/2012	<50	<79	--	<400	--	<1.0	<1.0	<1.0	<3.0
	9/20/2012	<50	<79	--	<400	--	<1.0	<1.0	<1.0	<3.0
	12/11/2012	<100	**2,100**	--	**1,800**	--	<1.0	<1.0	<1.0	<3.0
	3/18/2013	<100	**1,400**	--	**400**	--	<0.5	<5.0	<0.5	<1.5
	12/4/2013	<100	**1,300**	--	**440**	--	<0.5	<5.0	<0.5	<1.5
	3/18/2014	<100	**2,200**	--	**1,100**	--	<0.5	<5.0	<0.5	<1.5
	6/19/2014	<100	**1,600**	--	**710**	--	<0.5	<5.0	<0.5	<1.5
	11/20/2014	<100	**2,900**	--	**1,900**	--	<0.5	<5.0	<0.5	<1.5
	4/15/2015	<100	**1,900**	--	**940**	--	**0.56**	<5.0	<0.5	<1.5
	4/15/2015 - Dup	<100	**1,800**	--	**790**	--	<0.5	<5.0	<0.5	<1.5
	11/3/2015	<100	**1,980**	--	**1,310**	--	<0.5	<5.0	<0.5	<1.5
	6/1/2016	<100	**878**	--	**575**	--	<0.5	<5.0	<0.5	<1.5 B
	6/1/16 - Dup	<100	**1,160**	--	**937**	--	<0.5	<5.0	<0.5	<1.5 B
	11/10/2016	<100	**1,200**	**2,930**	<500	**1,490**	<1.0	<5.0	<1.0	<3.0
	11/10/2016- Dup	<100	**1,070**	**2,930**	<500	**1,500**	<1.0	<5.0	<1.0	<3.0
	5/30/2017	<100	**1,040**	**1,090**	**880**	**1,120**	<1.00	<1.00	<1.00	<3.00
	5/30/2017- Dup	<100	**1,010**	**1,120**	**833**	**1,150**	<1.00	<1.00	<1.00	<3.00
	11/8/2017	<100	**324**	**2,680**	<250	**1,710**	<1.00	<1.00	<1.00	<3.00
	11/8/2017- Dup	<100	**356**	**2,670**	<250	**1,640**	<1.00	<1.00	<1.00	<3.00
	6/13/2018	<100	<200	**1,150**	<250	**1,060**	<1.00	<1.00	<1.00	<3.00
	6/13/2018 - Dup	<100	<200	**1,160**	<250	**1,170**	<1.00	<1.00	<1.00	<3.00
MW-5	10/5/2001	<50	--	--	--	--	<0.5	<0.5	<0.5	<1.0
	12/20/2001	<50	<250 J	--	<500	--	<0.5	<0.5	<0.5	<1.0
	3/21/2002	<50	<250	--	<500	--	<0.5	<0.5	<0.5	<1.0
	6/26/2002	<50	<250	--	<500	--	<0.5	<0.5	<0.5	<1.0
	9/24/2002	<50	<250	--	<500	--	<0.5	<0.5	<0.5	<1.0
	12/18/2002	<50	<250	--	<500	--	<0.5	<0.5	<0.5	<1.0
	3/14/2003	<50	<250	--	<500	--	<0.5	<0.5	<0.5	**1.24**
	5/30/2003	<50	<250	--	<500	--	<0.5	<0.5	<0.5	<1.0
	3/26/2004	<50	<250	--	<500	--	<0.5	<0.5	<0.5	<1.0
	6/29/2004	<50	<250	--	<500	--	<0.5	<0.5	<0.5	<1.0
	9/27/2004	<50	<250	--	<500	--	<0.5	<0.5	<0.5	<1.0
	9/27/2004 - Dup	<50	<250	--	<500	--	<0.5	<0.5	<0.5	<1.0
	12/1/2004	<50	<250	--	<500	--	<0.5	<0.5	<0.5	<1.0
	12/1/2004 - Dup	<50	<250	--	<500	--	<0.5	<0.5	<0.5	<1.0
	3/9/2005	<50	<250	--	<500	--	<0.5	<0.5	<0.5	<1.0
	6/29/2005	<50	<250	--	<500	--	<0.5	<0.5	<0.5	<1.0
	9/23/2005	<50	<250	--	<500	--	<0.5	<0.5	<0.5	<1.0
	9/23/2005 - Dup	<50	<250	--	<500	--	<0.5	<0.5	<0.5	<1.0
	12/30/2005	<50	<250	--	<500	--	<0.5	<0.5	<0.5	<1.0
	12/30/2005 - Dup	<50	<248	--	<495	--	<0.5	<0.5	<0.5	<1.0
	3/28/2006	<50	<243	--	<485	--	<0.5	<0.5	<0.5	<1.0
	3/28/2006 - Dup	<50	<250	--	<500	--	<0.5	<0.5	<0.5	<1.0
	6/29/2006	<50	<250	--	<500	--	<0.5	<0.5	<0.5	<1.0
	6/29/2006 - Dup	<50	<263	--	<526	--	<0.5	<0.5	<0.5	<1.0
	9/5/2006	<80	<278	--	<556	--	<0.5	<0.5	<0.5	<1.0
	9/5/2006 - Dup	<80	<253	--	<505	--	<0.5	<0.5	<0.5	<1.0
	12/11/2006	<50	<250	--	<500	--	<0.5	<0.5	<0.5	<1.0
	12/11/2006 - Dup	<50	<248	--	<495	--	<0.5	<0.5	<0.5	<1.0
	3/30/2007	<50	<245	--	<490	--	<0.5	<0.5	<0.5	<1.0
	3/30/2007 - Dup	<50	<245	--	<490	--	<0.5	<0.5	<0.5	<1.0

Table 2
Summary of Groundwater Analytical Results
BNSF Railway Company
Glacier Park East
Leavenworth, Washington

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

Monitoring Well	**Date Sampled**	**Total Petroleum Hydrocarbons**					**Volatile Organic Compounds**			
		Gasoline Range	**Diesel Range** (w/ SGC)	**Diesel Range** (w/o SGC)[2]	**Heavy Oil Range** (w/ SGC)	**Heavy Oil Range** (w/o SGC)[2]	**Benzene**	**Toluene**	**Ethyl - benzene**	**Total Xylenes**
MTCA Method A Cleanup Levels [1]		**800**	**500**	**500**	**500**	**500**	**5**	**1,000**	**700**	**1,000**
MW-6	5/31/2017	<100	<200	<400	<250	<500	<1.00	<1.00	<1.00	<3.00
	11/9/2017	<100	<200	<200	<250	<250	<1.00	<1.00	<1.00	<3.00
	6/13/2018	<100	<200	**204**	<250	**335**	<1.00	<1.00	<1.00	<3.00
PZ-1	4/21/2017	<100	<200	<200	<250	<250	<1.00	<1.00	<1.00	<3.00
PZ-2	4/21/2017	<100	<200	<200	<250	<250	<1.00	<1.00	<1.00	<3.00
PZ-3	4/21/2017	<100	<200	<200	<250	<250	<1.00	<1.00	<1.00	<3.00

Notes:
Bold indicates reported detections and shading indicates concentrations greater than or equal to MTCA Method A Cleanup Levels.

Abbrevations:
-- = not analyzed
< = not detected above laboratory reporting limit
Dup = duplicate sample
MTCA = Model Toxics Control Act
SGC = Silica Gel Cleanup

Footnotes:
B = analyte was detected in the associated blank.
I = analyte concentration may be artifically elevated because of co-eluting compounds or components.
J = surrogate recovery for this sample cannot be accurately quantified because of interference from co-eluting compounds and/or the surrogate recovery for the sample was outside established control limits because of a sample matrix effect.
H = samples were analyzed outside of the analytical holding time due to an analyst oversight.

[1] Washington State Department of Ecology, Model Toxics Control Act Regulation and Statute, MTCA Cleanup Regulation Chapter 173-340 WAC, Model Toxics Control Act Chapter 70.105D RCW, Uniform Environmental Covenants Act Chapter 64.70 RCW. Publication No. 94-06. Revised 2013.
[2] Samples were analyzed outside of the analytical holding time for samples collected on 11/9 and 11/10/2017 and should be considered minimum values.

Table 3
Summary of Water Quality and Geochemical Parameters
BNSF Railway Company
Glacier Park East
Leavenworth, Washington

Monitoring Well	Date Sampled	Water Quality Parameters						Geochemical Parameters							
		Temperature	pH	Conductivity	Turbidity	Dissolved Oxygen	ORP	Nitrate / Nitrite	Ammonia	Sulfate	Sulfide	Ferrous Iron	Methane	Alkalinity	Manganese
		°C	--	mS/cm	NTU	mg/L	mV	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
MW-1	6/20/2012	11.20	6.80	0.896	5.24	2.19	51.3	280	<100	7,200	<400	<200	<6.6	--	--
	9/20/2012	11.59	6.74	0.869	10.58	2.65	34.78	130	110	12,800	--	<200	<6.6	372,000	905
	12/11/2012	10.17	6.77	0.540	9.13	1.39	112.7	150	70	12,800	--	<30	<6.6	378,000	866
	3/18/2013	11.20	6.74	0.813	9.56	2.08	36.8	170	<100	11,000	--	<50	--	380,000	480
	12/4/2013	10.00	6.74	0.753	6.5	1.23	234	<100	<100	11,000	--	52	<10	450,000	930
	3/18/2014	11.24	6.61	0.807	9	1.02	174	120	<250	12,000	--	<50	<10	420,000	760
	6/19/2014	13.56	6.71	0.842	15.5	2.90	263	--	--	9,900	--	--	--	420,000	--
	6/13/2018	12.11	6.95	0.477	3.05	5.27	106	--	--	--	--	--	--	--	--
MW-2	3/09/2012	8.09	6.66	0.989	6.18	3.88	2.5	<50	<100	18,500	<400	<200	13	--	--
	6/20/2012	11.92	7.05	1.002	14.09	0.99	-128.3	--	--	--	--	--	--	--	--
	9/20/2012	12.25	7.01	0.928	12.43	0.94	-138.4	--	--	--	--	--	--	--	--
	3/18/2013	11.23	7.82	1.153	9.86	2.49	6.9	--	--	--	--	--	--	--	--
	12/04/2013	8.60	7.14	1.140	27.4	0.97	195	--	--	--	--	--	--	--	--
	3/18/2014	11.15	7.14	1.130	12	0.78	133	--	--	--	--	--	--	--	--
	6/19/2014	14.63	7.17	1.170	19.6	2.63	213	--	--	13,000	--	--	--	560,000	--
	11/20/2014	10.81	6.78	1.100	18.8	NA	58	--	--	--	--	--	--	--	--
	4/15/2015	14.03	7.84	0.584	1.97	NA	6	--	--	--	--	--	--	--	--
	11/03/2015	11.20	7.11	1.161	6.2	0.65	-39.1	--	--	--	--	--	--	--	--
	6/01/2016	17.40	6.79	1.155	49.7[a]	0.99	272.2	--	--	--	--	--	--	--	--
	11/09/2016	11.90	7.47	0.774	3.97	6.47	6.7	--	--	--	--	--	--	--	--
	5/30/2017	14.50	7.13	1.077	3.00	0.78	-32.3	--	--	--	--	--	--	--	--
	11/8/2017	10.82	6.86	0.814	3.16	0.61	91.0	--	--	--	--	--	--	--	--
	6/13/2018	11.94	7.78	0.731	52.6	6.61	113.5	--	--	--	--	--	--	--	--
MW-3	3/09/2012	11.60	6.01	1.167	23.37	0.48	7.3	<50	<100	4,300	<400	<200	10	--	--
	6/20/2012	17.02	6.26	0.958	9.43	1.29	25.7	<50	<100	4,900	2,600	<200	<6.6	--	--
	9/20/2012	15.85	6.31	0.971	9.52	2.09	26.8	54	140	5,100	--	700	<6.6	661,000	4,190
	12/11/2012	10.07	6.93	1.024	6.94	2.34	-7.3	<100	54	15,500	--	<30	<6.6	716,000	6,110
	3/18/2013	11.53	6.90	1.030	15.98	2.08	-79.3	<100	<100	<5,000	--	240	<10	620,000	5,800
	12/04/2013	10.80	7.03	1.250	10.70	0.20	-3.0	<100	<100	<5,000	--	1,200	<10	780,000	4,200
	3/18/2014	11.47	7.18	1.330	11	2.11	60	<100	<250	5,500	--	1,000	<10	720,000	3,600
	6/19/2014	13.68	7.19	1.290	27.6	2.45	153	--	--	7,500	--	--	--	680,000	--
	11/20/2014	11.52	6.79	1.240	6.8	NA	-56	--	--	--	--	--	--	--	--
	4/15/2015	15.60	7.75	0.603	1.02	NA	-81.0	--	--	--	--	--	--	--	--
	11/03/2015	12.10	6.91	1.426	2.30	0.7	-84.6	--	--	--	--	--	--	--	--
	6/01/2016	15.00	6.86	1.170	3.91	3.01	147.9	--	--	--	--	--	--	--	--
	11/10/2016	12.10	7.01	0.848	1.66	0.22	-18	--	--	--	--	--	--	--	--
	5/30/2017	15.90	6.94	1.117	-9.1[a]	0.81	-86.9	--	--	--	--	--	--	--	--
	11/9/2017	11.26	6.73	0.877	0.38	0.61	72.6	--	--	--	--	--	--	--	--
	6/13/2018	15.55	6.98	0.638	1.73	3.47	87.9	--	--	--	--	--	--	--	--

Table 3
Summary of Water Quality and Geochemical Parameters
BNSF Railway Company
Glacier Park East
Leavenworth, Washington

Monitoring Well	Date Sampled	Water Quality Parameters						Geochemical Parameters							
		Temperature	pH	Conductivity	Turbidity	Dissolved Oxygen	ORP	Nitrate / Nitrite	Ammonia	Sulfate	Sulfide	Ferrous Iron	Methane	Alkalinity	Manganese
		°C	--	mS/cm	NTU	mg/L	mV	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
MW-4	3/09/2012	8.41	6.56	1.149	8.54	1.76	13.4	<50	<100	18,500	<400	<200	<6.6	--	--
	6/20/2012	14.80	6.80	1.110	12.02	0.70	-49	53	<100	13,900	1,500	<200	<6.6	--	--
	9/20/2012	14.27	6.82	1.118	12.43	1.18	-75.43	<50	<100	9,700	--	<200	<6.6	620,000	7,250
	12/11/2012	11.24	6.81	1.024	8.84	3.19	-120.7	<100	57	4,330	--	<30	<6.6	640,000	8,680
	3/18/2013	11.50	6.91	1.073	20.54	2.49	-18.4	<100	<100	14,000	--	87	<10	460,000	5,600
	12/04/2013	11.50	6.98	1.320	25.6	0.30	125	<100	<100	17,000	--	250	<10	640,000	1,600
	3/18/2014	12.88	6.99	1.390	6	2.14	109	<100	<250	16,000	--	320	<10	650,000	710
	6/19/2014	15.56	6.99	1.360	33.6	2.95	143	--	--	8,100	--	--	--	620,000	--
	11/20/2014	12.35	6.79	1.250	14.5	NA	-17	--	--	--	--	--	--	--	--
	4/15/2015	19.29	7.71	0.559	1.57	NA	-24	--	--	--	--	--	--	--	--
	11/03/2015	12.30	6.92	1.351	5.1	1.50	-15.8	--	--	--	--	--	--	--	--
	6/01/2016	16.30	6.74	1.246	6.56	0.97	206.3	--	--	--	--	--	--	--	--
	11/10/2016	13.10	7.06	1.004	0.1	0.83	12.9	--	--	--	--	--	--	--	--
	5/31/2017	23.20	6.94	1.215	13.7	2.39	93.2	--	--	--	--	--	--	--	--
	11/8/2017	12.63	6.77	1.110	0.94	2.53	96.1	--	--	--	--	--	--	--	--
	6/13/2018	14.08	7.04	0.800	4.65	1.29	79.6	--	--	--	--	--	--	--	--
MW-5	6/19/2014	13.96	6.76	1.08	14.3	4.45	238	--	--	18,000	--	--	--	300,000	--
MW-6	5/30/2017	13.50	6.98	0.656	326[a]	0.89	-186.5	--	--	--	--	--	--	--	--
	11/09/2017	9.02	6.45	0.435	15	0.68	62.0	--	--	--	--	--	--	--	--
	6/13/2018	13.41	6.91	0.434	225	3.01	109.2	--	--	--	--	--	--	--	--

Notes:
-- = not analyzed/applicable
< = not detected above laboratory reporting limit
°C = degrees Celcius
µg/L = micrograms per liter
mg/L = milligrams per liter
mS/cm = millisiemens per centimeter
mV = millivolts
NA = not available. Dissolved oxygen sensor error during monitoring well purge.
NTU = nephalometric turbidity units
ORP = oxidation-reduction potential
[a] The reading is suspect as sample visually appeared to have lower turbidity than indicated by the meter.

APPENDIX A

STANDARD OPERATING PROCEDURES

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

Authorization Signatures

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

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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)

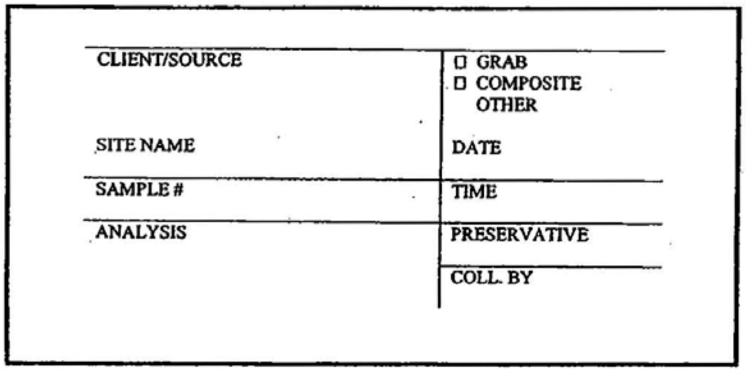
7.0 SOP REVISION HISTORY

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 #

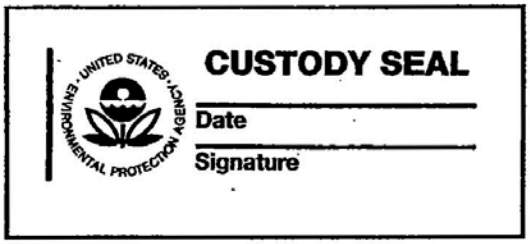
TIME

ANALYSIS

PRESERVATIVE

COLL. BY

Custody Seal



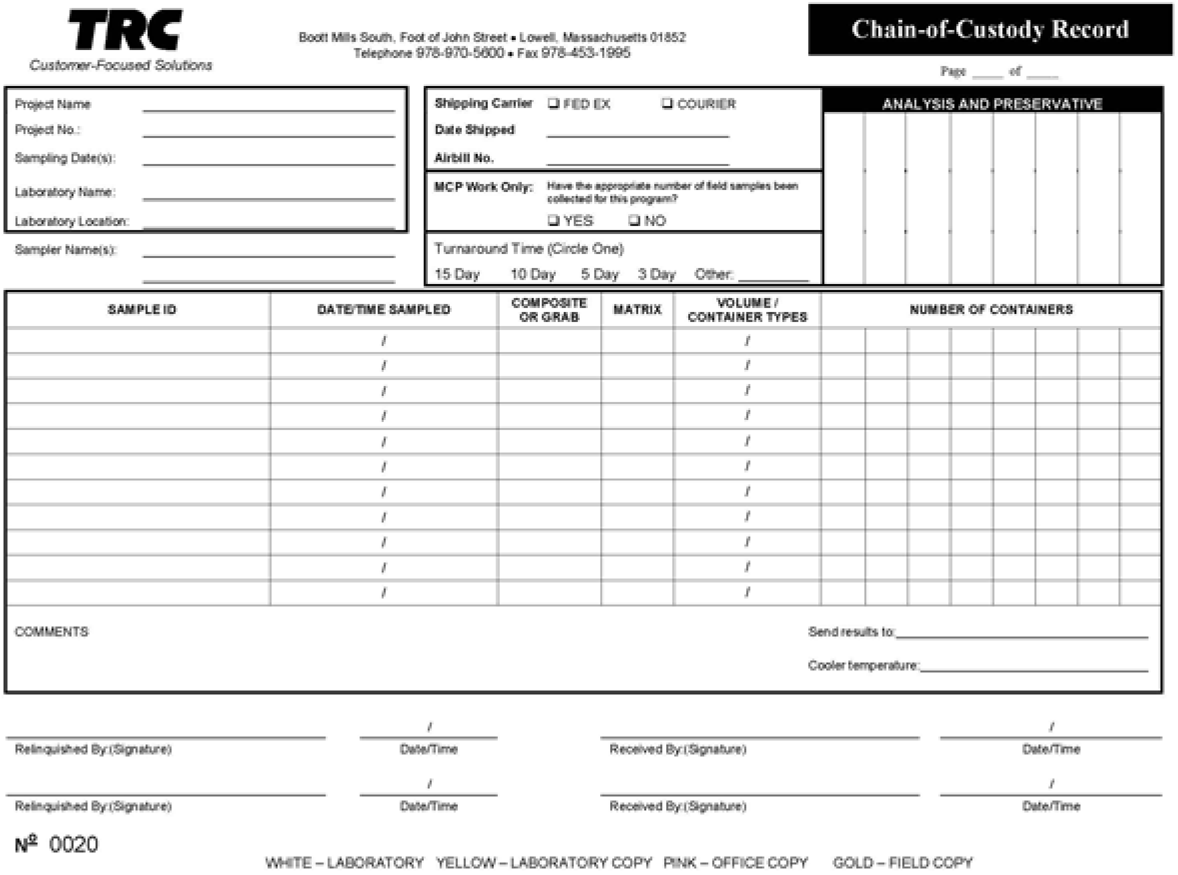
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

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

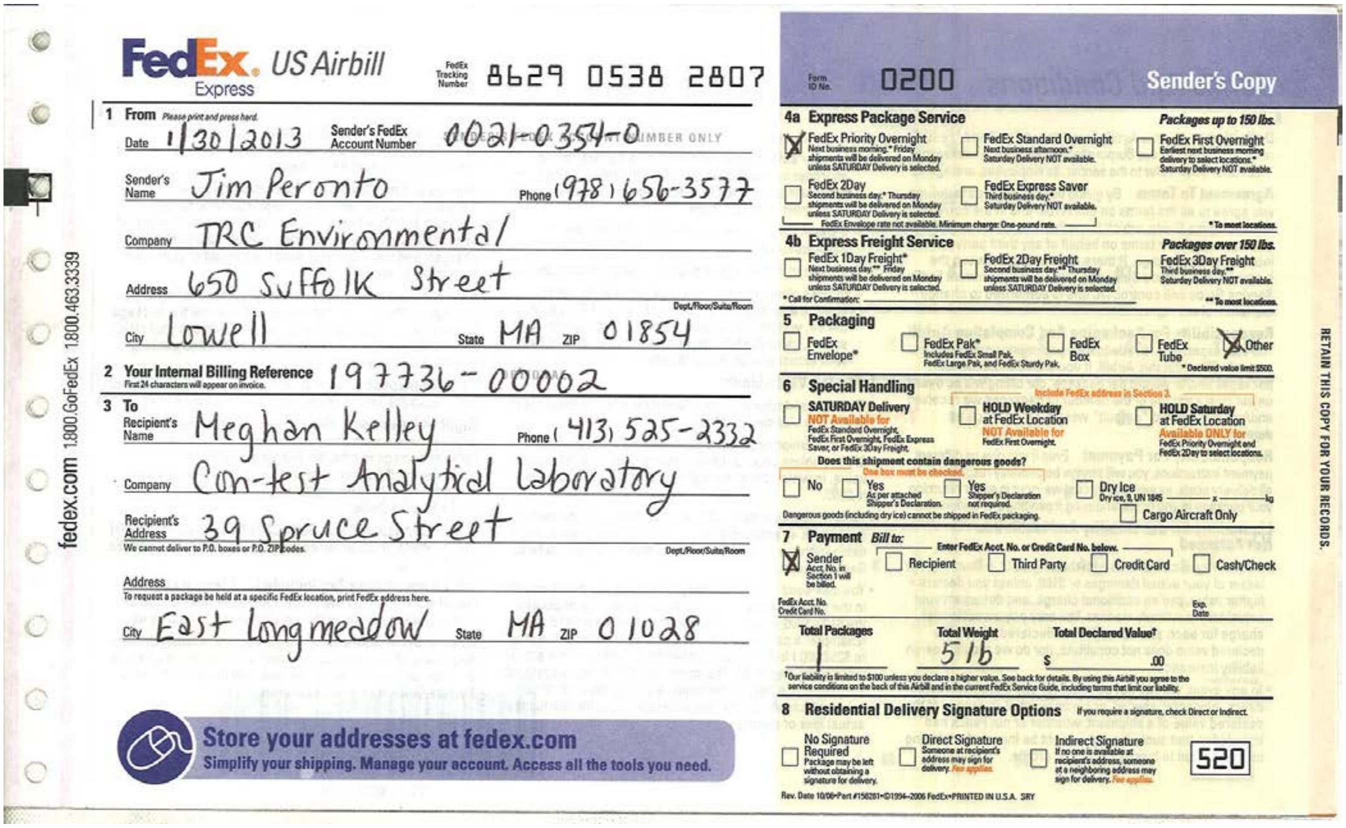
Send results to: ____________
Cooler temperature: ____________

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 Express US Airbill
FedEx Tracking Number 8629 0538 2807
Form ID No. 0200
Sender's Copy

fedex.com 1.800.GoFedEx 1.800.463.3339

1 From *Please print and press hard.*
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
Dept./Floor/Suite/Room
City Lowell State MA ZIP 01854

2 Your Internal Billing Reference 197736-00002
First 24 characters will appear on invoice.

3 To
Recipient's Name Meghan Kelley Phone (413) 525-2332
Company Con-test Analytical Laboratory
Recipient's Address 39 Spruce Street
We cannot deliver to P.O. boxes or P.O. ZIP codes.
Dept./Floor/Suite/Room
Address
To request a package be held at a specific FedEx location, print FedEx address here.
City East Longmeadow State MA ZIP 01028

Store your addresses at fedex.com
Simplify your shipping. Manage your account. Access all the tools you need.

4a Express Package Service *Packages up to 150 lbs.*
☒ 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
☒ Other
* Declared value limit $500.

6 Special Handling
Include FedEx address in Section 3.
☐ 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.
☒ Sender Acct. No. in Section 1 will be billed. ☐ Recipient ☐ Third Party ☐ Credit Card ☐ Cash/Check
FedEx Acct. No. 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

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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

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

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ATTACHMENTS

Attachment A	Example Water and Product Level Monitoring Form
Attachment B	Example Field Book Documentation for Water Levels
Attachment C	SOP Fact Sheet
Attachment D	SOP Modifications for PFAS

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

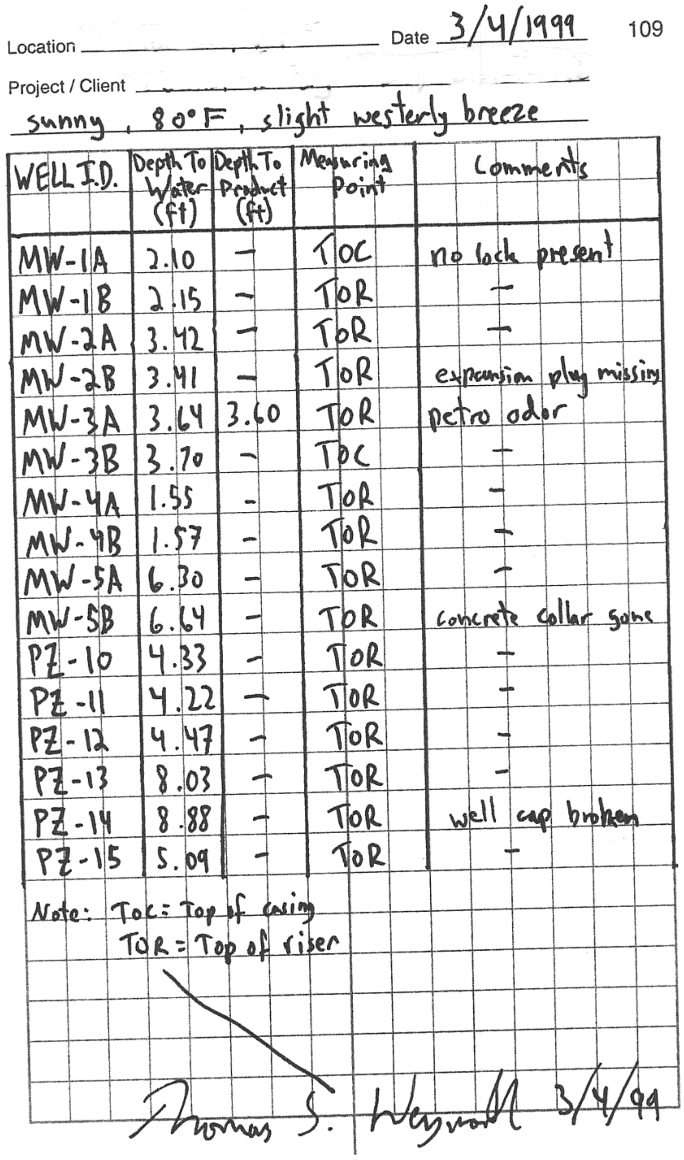
FIELD DATA COMPLETE QA/QC COC WELL BOX CONDITION SHEETS

MANIFEST DRUM INVENTORY TRAFFIC CONTROL

Field Mon 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	
SOP Section Number	**Modifications to SOP**
	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

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

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ATTACHMENTS

Attachment A	Groundwater Field Parameter Stabilization Criteria for Selected Jurisdictions
Attachment B	Example Groundwater Field Data Records
Attachment C	SOP Fact Sheet
Attachment D	SOP Modifications for PFAS

1.0 INTRODUCTION

1.1 Scope & Applicability

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

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

1.2 Summary of Method

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

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

1.3 Equipment

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

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

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

1.4 Definitions

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

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

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

1.5 Health & Safety Considerations

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

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

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

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

1.6 Cautions and Potential Problems

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

1.6.1 Pre-Sampling Issues

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

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

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

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

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

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

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

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

1.6.2 General Purging and Sampling Issues

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

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

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

(d) Some regulatory agencies may have concern about the use of peristaltic pumps when sampling for VOCs due to the potential for loss of VOCs during sampling and alteration of other water quality parameters such as pH and alkalinity. Samplers should review the requirements in the project-specific work plan and/or regulatory guidelines prior to performing the work. Explicit approval to use a peristaltic pump for the collection of VOCs may be required by the governing regulatory agency. An option may be to use the "soda straw" method to collect the VOC sample which does not allow the water to go through the pump head:

    (1) After purging the well with the peristaltic pump, collect all fractions except VOCs from the outlet side of the pump (i.e., VOCs will be collected last instead of first).
    (2) Turn the pump off.
    (3) Change into clean gloves.
    (4) Disconnect the tubing coming out of the well from the inlet side of the pump and immediately put a finger over the end of this tubing to prevent water from draining out of the tubing.
    (5) Retrieve tubing from the well, coiling it in one hand as it is being retrieved (maintain finger over end of tubing).
    (6) Open VOC vials. Briefly remove finger from end of tubing to allow water to flow into vial. Replace finger on end of tubing to stop flow. Do this for remaining VOC vials.

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

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

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

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

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

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

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

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

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

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

1.7 Personnel Qualifications

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

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

2.0 PROCEDURES

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

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

2.1 Pre-sampling Activities

(a) It should be determined if there is the requirement to determine static water level measurements on <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) = $\pi r^2 h\,(cf)$ **Equation 1**

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

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

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

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

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

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

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

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

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

2.2.2 Low-flow Purging Approach

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

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

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

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

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

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

2.2.3 Field Parameter Stabilization During Purging

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

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

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

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

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

2.2.4 Special Considerations During Purging

Wells Purged Dry/Purge Adequacy

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

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

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

Temporary Monitoring Wells

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

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

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

2.2.5 Equipment Considerations for Purging

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

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

2.2.5.1 Purging with a Suction Pump

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

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

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

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

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

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

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

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

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

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

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

2.2.5.2 Purging with a Submersible Pump

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

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

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

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

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

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

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

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

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

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

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

(g) Measure the water level and record the flow rate and the water level. This should be performed every 3 to 5 minutes during purging. For low-flow purging, the flow rate should be adjusted to result in a rate between 100 to 500 mL/min; however, if drawdown of the well is observed, a slower flow rate may be necessary. If using a bladder pump, it is recommended that the pump be set to deliver long pulses of water so that one pulse will fill a 40 mL volatile organic analysis (VOA) vial, if possible.
(h) Prior to recording the water quality indicator parameters, a minimum of one tubing volume should be purged. Note that this includes the volume of the flow-through cell.
(i) Proceed to steps (g) through (j) in Section 2.2.5.1.

2.2.5.3 Purging with a Bailer

(a) Determine the volume of water to be purged as described in Section 2.2.1.
(b) Take necessary precautions (e.g., laying plastic sheeting around the well) to prevent contamination of tubing or other purging/sampling equipment with foreign materials.
(c) Use a well-dedicated bailer (i.e., used exclusively for that well only), a decontaminated bailer or an unused, disposable bailer.
(d) Attach an appropriate length of (a) bailing line, (b) Teflon®-coated bailing wire or (c) rope with Teflon®-coated stainless steel leader to reach the bottom of the well. Secure a knot or series of knots to the top of the bailer. Be sure to have additional length of line to facilitate handling of the bailer at the surface (typically 10 ft).
(e) Lower the bailer gently into the well until it reaches the water column and fills with water from the bottom. Note: It is recommended that the bailer be lowered into the water to a depth that prevents the water from entering the top of the bailer. This is done to prevent excess turbulence caused by filling from the bottom and the top simultaneously. Controlling the line attached to the bailer as it is lowered into the well is also important to prevent degassing of the water as the bailer impacts the water. In shallow wells, controlling the line is not too difficult; however, for wells of greater depths it is common to utilize a hand-over-hand (windmill) approach using both hands to control longer lengths of line and prevent the loops in the line from tangling with one another. This procedure is simple to learn and saves a good deal of time by preventing tangles. Do not allow the bailing line or rope to become contaminated by surface soil.
(f) Once the bailer is full of water, gently withdraw the bailer from the well until it comes out of the top of the well. Be sure to control excess line in your hands to prevent the rope and bailer from touching the ground, and then grasp the bailer as it appears at the top of the well.
(g) Immediately pour the water into a vessel for water quality measurements, and record the measurements in the field book or on the Groundwater Field Data Record (at the project-required frequency). Otherwise, pour water into a 5-gallon bucket or other vessel to track the volume purged. As a general rule, standard 2-inch bailers are able to hold about 1 liter of water when full. This process will have to be repeated several times to complete adequate purging of the well (e.g., three to five well volumes).
(h) Record the volume of water purged on the Groundwater Field Data Record. Record the disposal method used for purge water in the field book.
(i) Once the required volume of water is removed (typically 3 to 5 well volumes) from the well and/or parameters are stabilized to the satisfaction of the project-specific work plan, proceed to Section 2.3, Post-purging Groundwater Sample Collection.

2.3 Post-purging Groundwater Sample Collection

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

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

(c) If using bottom-filling bailers,

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

2.3.1 Sample Collection Order

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

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

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

2.3.2 VOC Sample Collection

<u>Collection of VOCs/Volatile Petroleum Hydrocarbons (VPH):</u> 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:

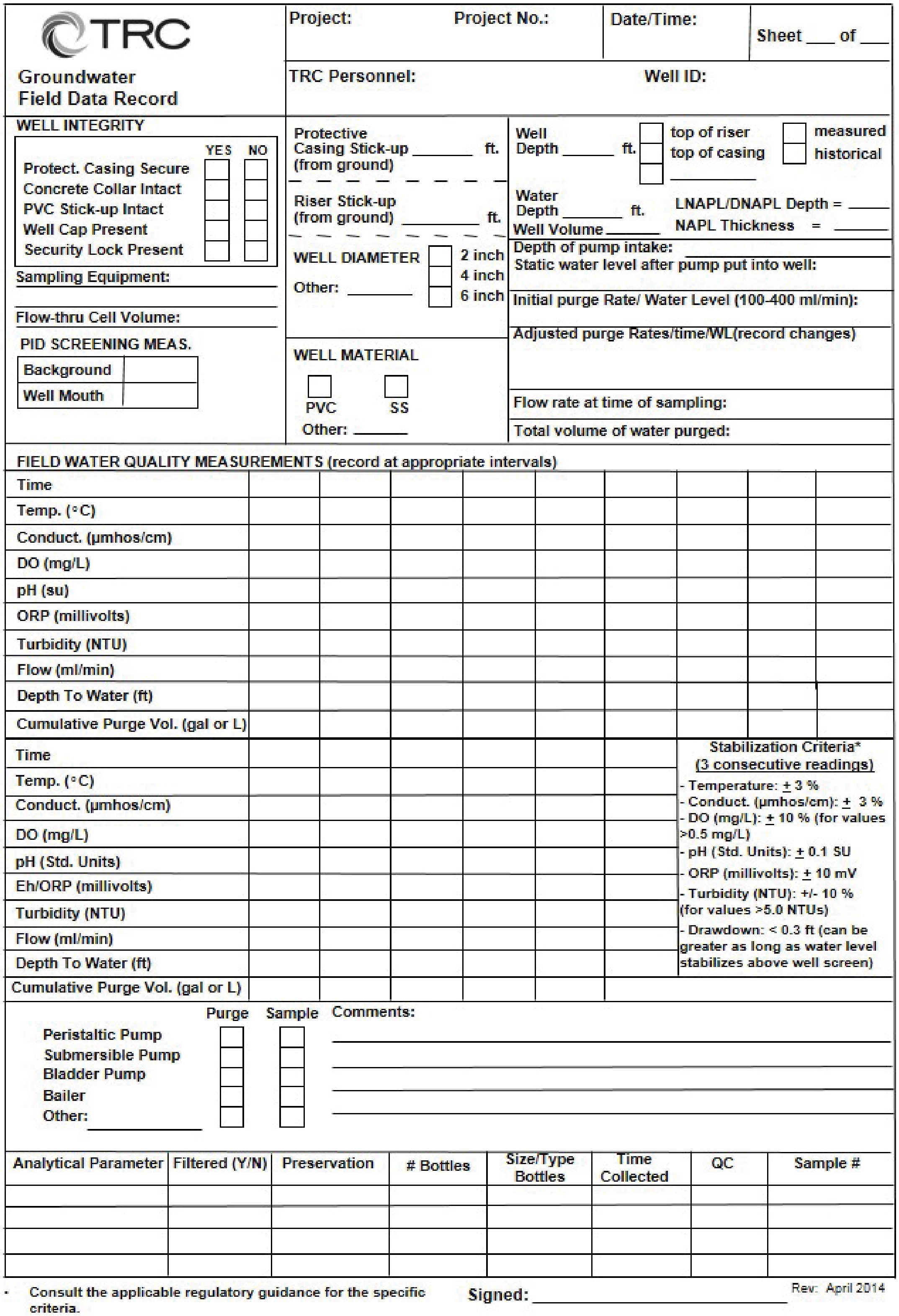
Groundwater Field Parameter Stabilization Criteria for Selected Jurisdictions

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



Groundwater Field Data Record

Project: **Project No.:** **Date/Time:** **Sheet ___ of ___**

TRC Personnel: **Well ID:**

WELL INTEGRITY

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

Sampling Equipment:

Flow-thru Cell Volume:

PID SCREENING MEAS.

Background	
Well Mouth	

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

Riser Stick-up (from ground) _________ ft.

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

WELL MATERIAL
☐ PVC ☐ SS
Other: ______

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

Water Depth _______ ft.

Well Volume _______

LNAPL/DNAPL Depth = _____

NAPL Thickness = ______

Depth of pump intake: ____________________

Static water level after pump put into well:

Initial purge Rate/ Water Level (100-400 ml/min):

Adjusted purge Rates/time/WL(record changes)

Flow rate at time of sampling:

Total volume of water purged:

FIELD WATER QUALITY MEASUREMENTS (record at appropriate intervals)

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

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

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

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

Comments:

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

- Consult the applicable regulatory guidance for the specific criteria.

Signed: __________________________

Rev: April 2014

WATER SAMPLE LOG

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

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

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

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

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

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

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

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

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

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

Installation of PDBs:

TRC Personnel: ____________________

Date: ____________________

Time: ____________________

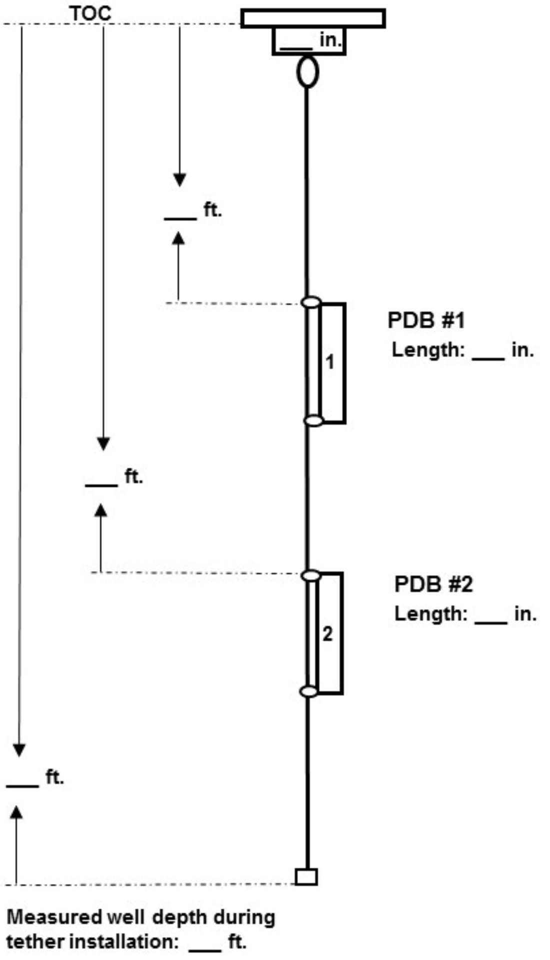
DTW (ft): ____________________

Sampling of PDBs:

TRC Personnel: ____________________

Date: ____________________

DTW (ft): ____________________



PDB #1

Sample ID: ____________________

Sample Time: ____________________

Evidence of algae, iron or other coatings?: ____________________

PDB #2

Sample ID: ____________________

Sample Time: ____________________

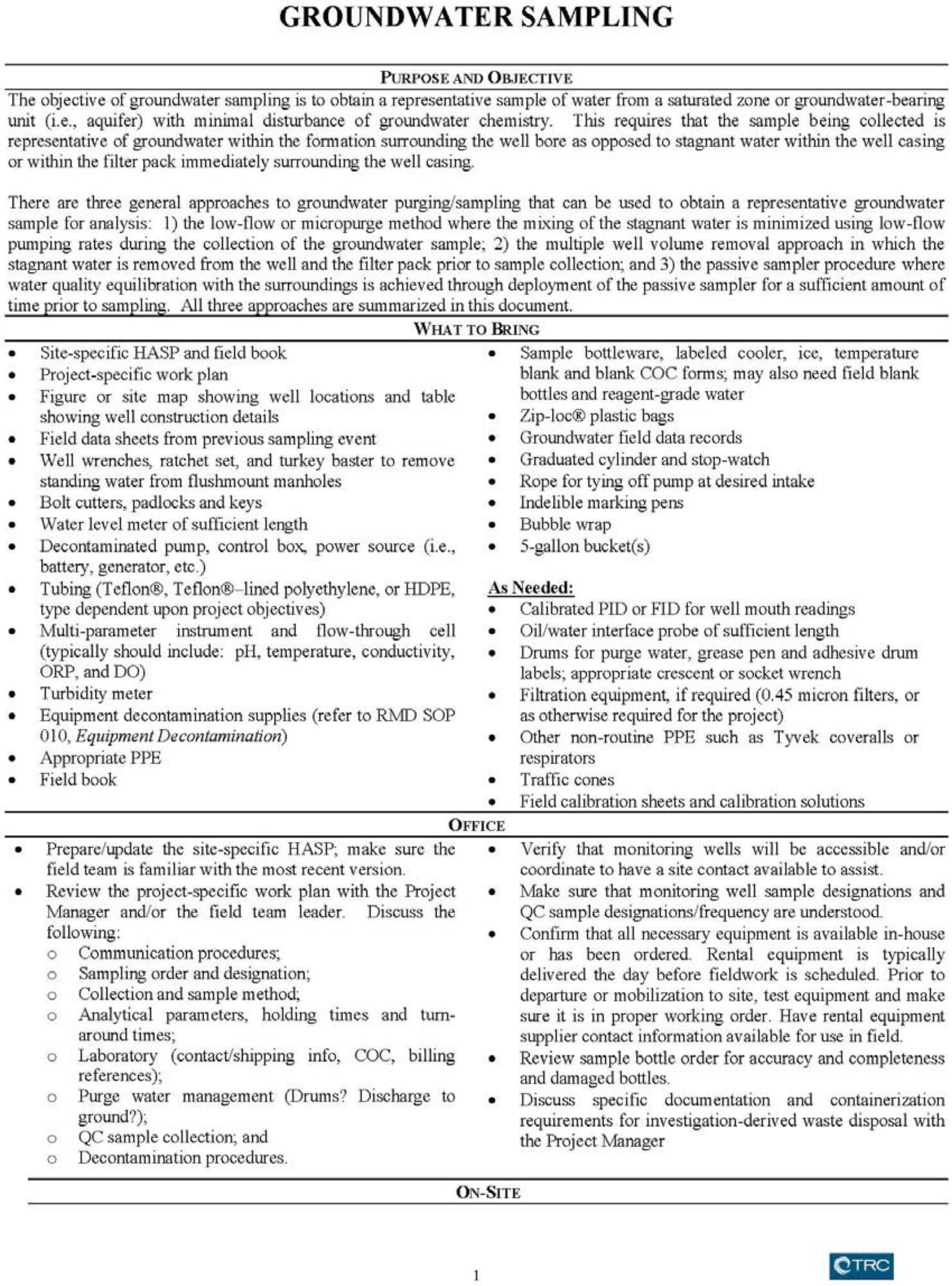
Evidence of algae, iron or other coatings?: ____________________

Measured well depth during tether installation: ___ ft.

Field Notes:

Rev: April 2014

Attachment C: SOP Fact Sheet



GROUNDWATER SAMPLING

PURPOSE AND OBJECTIVE

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

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

WHAT TO BRING

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

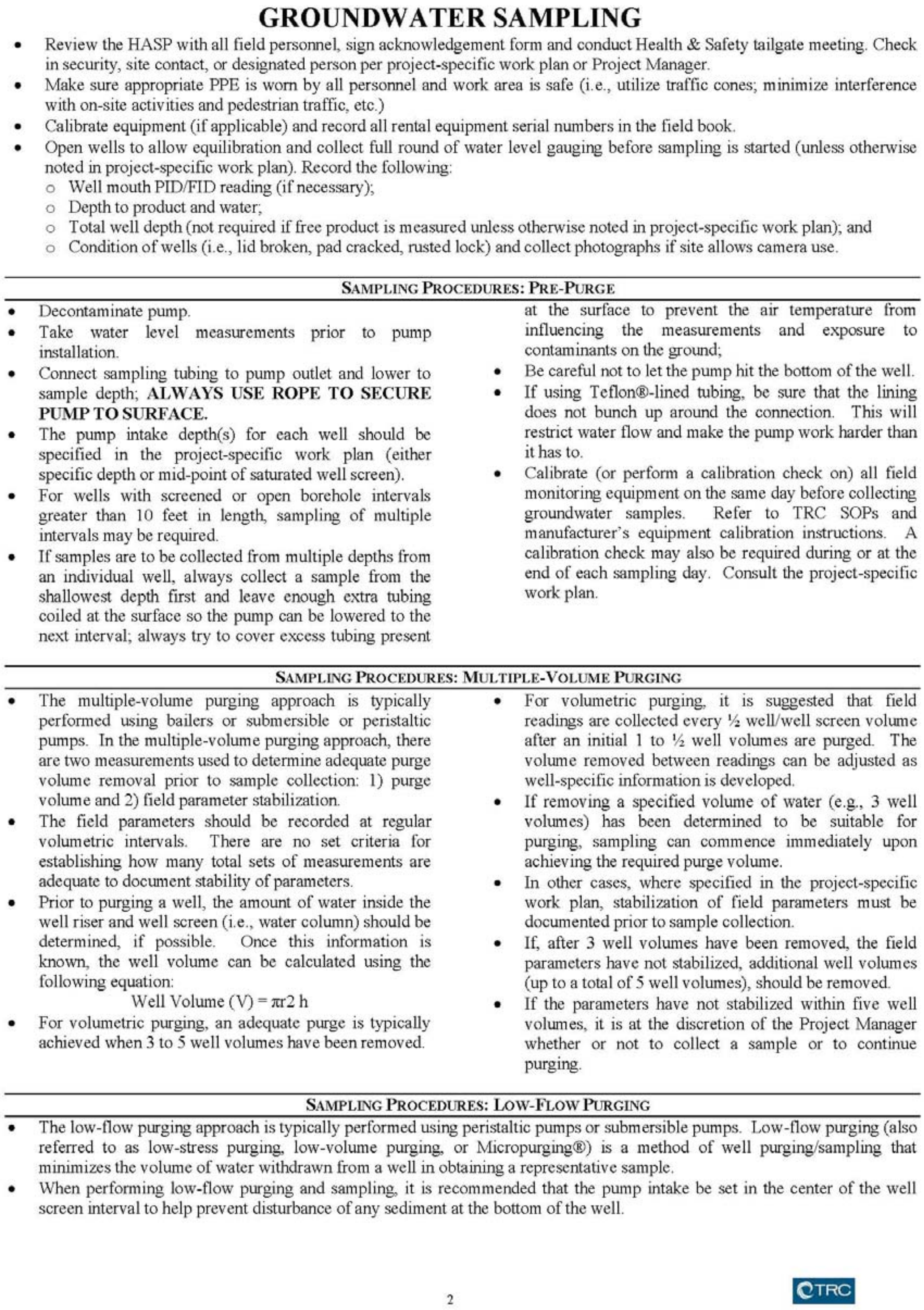
As Needed:

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

OFFICE

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

ON-SITE



GROUNDWATER SAMPLING

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

SAMPLING PROCEDURES: PRE-PURGE

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

SAMPLING PROCEDURES: MULTIPLE-VOLUME PURGING

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

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

SAMPLING PROCEDURES: LOW-FLOW PURGING

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

GROUNDWATER SAMPLING

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

Field Parameter Stabilization During Purging

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

POST-PURGE GROUNDWATER SAMPLE COLLECTION

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

PASSIVE SAMPLING

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

GROUNDWATER SAMPLING

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

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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.

APPENDIX B

CERTIFIED ANALYTICAL LABORATORY REPORTS AND CHAIN-OF-CUSTODY DOCUMENTATION

ANALYTICAL REPORT

June 26, 2018

TRC - BNSF Region 1

Sample Delivery Group:	L1002145
Samples Received:	06/15/2018
Project Number:	296562
Description:	BNSF - Leavenworth

Report To:

Amanda Meugniot
19874 141st Place NE
Woodinville, WA 98072

Entire Report Reviewed By:

Mark W. Beasley
Technical Service Representative

TABLE OF CONTENTS

SAMPLE SUMMARY

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

MW1-061318 L1002145-01 GW

Collected by	Collected date/time	Received date/time
Kaelin Newman	06/13/18 20:32	06/15/18 08:45

Method	Batch	Dilution	Preparation date/time	Analysis date/time	Analyst
Volatile Organic Compounds (GC) by Method NWTPHGX	WG1126367	1	06/19/18 10:25	06/19/18 10:25	LRL
Volatile Organic Compounds (GC/MS) by Method 8260C	WG1126623	1	06/19/18 18:47	06/19/18 18:47	BMB
Semi-Volatile Organic Compounds (GC) by Method NWTPHDX-NO SGT	WG1125904	1	06/20/18 08:06	06/20/18 19:46	DMG
Semi-Volatile Organic Compounds (GC) by Method NWTPHDX-SGT	WG1125905	1	06/19/18 09:38	06/19/18 19:23	MTJ

MW2-061318 L1002145-02 GW

Collected by	Collected date/time	Received date/time
Kaelin Newman	06/13/18 22:05	06/15/18 08:45

Method	Batch	Dilution	Preparation date/time	Analysis date/time	Analyst
Volatile Organic Compounds (GC) by Method NWTPHGX	WG1126367	1	06/19/18 10:47	06/19/18 10:47	LRL
Volatile Organic Compounds (GC/MS) by Method 8260C	WG1126623	1	06/19/18 19:07	06/19/18 19:07	BMB
Semi-Volatile Organic Compounds (GC) by Method NWTPHDX-NO SGT	WG1125904	1	06/20/18 08:06	06/20/18 20:06	DMG
Semi-Volatile Organic Compounds (GC) by Method NWTPHDX-SGT	WG1125905	1	06/19/18 09:38	06/19/18 19:42	MTJ

MW3-061318 L1002145-03 GW

Collected by	Collected date/time	Received date/time
Kaelin Newman	06/13/18 15:13	06/15/18 08:45

Method	Batch	Dilution	Preparation date/time	Analysis date/time	Analyst
Volatile Organic Compounds (GC) by Method NWTPHGX	WG1126367	1	06/19/18 11:10	06/19/18 11:10	LRL
Volatile Organic Compounds (GC/MS) by Method 8260C	WG1126623	1	06/19/18 19:26	06/19/18 19:26	BMB
Semi-Volatile Organic Compounds (GC) by Method NWTPHDX-NO SGT	WG1125904	1	06/20/18 08:06	06/20/18 20:26	DMG
Semi-Volatile Organic Compounds (GC) by Method NWTPHDX-SGT	WG1125905	1	06/19/18 09:38	06/19/18 20:01	MTJ

MW4-061318 L1002145-04 GW

Collected by	Collected date/time	Received date/time
Kaelin Newman	06/13/18 16:32	06/15/18 08:45

Method	Batch	Dilution	Preparation date/time	Analysis date/time	Analyst
Volatile Organic Compounds (GC) by Method NWTPHGX	WG1126367	1	06/19/18 11:32	06/19/18 11:32	LRL
Volatile Organic Compounds (GC/MS) by Method 8260C	WG1126623	1	06/19/18 19:46	06/19/18 19:46	BMB
Semi-Volatile Organic Compounds (GC) by Method NWTPHDX-NO SGT	WG1125904	1	06/20/18 08:06	06/20/18 20:46	DMG
Semi-Volatile Organic Compounds (GC) by Method NWTPHDX-SGT	WG1125905	1	06/19/18 09:38	06/19/18 20:21	MTJ

MW4D-061318 L1002145-05 GW

Collected by	Collected date/time	Received date/time
Kaelin Newman	06/13/18 14:00	06/15/18 08:45

Method	Batch	Dilution	Preparation date/time	Analysis date/time	Analyst
Volatile Organic Compounds (GC) by Method NWTPHGX	WG1126367	1	06/19/18 11:54	06/19/18 11:54	LRL
Volatile Organic Compounds (GC/MS) by Method 8260C	WG1126623	1	06/19/18 20:05	06/19/18 20:05	BMB
Semi-Volatile Organic Compounds (GC) by Method NWTPHDX-NO SGT	WG1125904	1	06/20/18 08:06	06/20/18 21:06	DMG
Semi-Volatile Organic Compounds (GC) by Method NWTPHDX-SGT	WG1125905	1	06/19/18 09:38	06/19/18 20:40	MTJ

MW6-061318 L1002145-06 GW

Collected by	Collected date/time	Received date/time
Kaelin Newman	06/13/18 13:49	06/15/18 08:45

Method	Batch	Dilution	Preparation date/time	Analysis date/time	Analyst
Volatile Organic Compounds (GC) by Method NWTPHGX	WG1126367	1	06/19/18 12:16	06/19/18 12:16	LRL
Volatile Organic Compounds (GC/MS) by Method 8260C	WG1126623	1	06/19/18 20:25	06/19/18 20:25	BMB
Semi-Volatile Organic Compounds (GC) by Method NWTPHDX-NO SGT	WG1125904	1	06/20/18 08:06	06/20/18 21:26	DMG
Semi-Volatile Organic Compounds (GC) by Method NWTPHDX-SGT	WG1125905	1	06/19/18 09:38	06/19/18 21:00	MTJ

	Collected by	Collected date/time	Received date/time
TRIP BLANK L1002145-07 GW	Kaelin Newman	06/13/18 00:00	06/15/18 08:45

Method	Batch	Dilution	Preparation date/time	Analysis date/time	Analyst
Volatile Organic Compounds (GC/MS) by Method 8260C	WG1126623	1	06/19/18 14:33	06/19/18 14:33	BMB

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

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

Volatile Organic Compounds (GC) by Method NWTPHGX

	Result	Qualifier	RDL	Dilution	Analysis	Batch
Analyte	ug/l		ug/l		date / time	
Gasoline Range Organics-NWTPH	ND		100	1	06/19/2018 10:25	WG1126367
(S) a,a,a-Trifluorotoluene(FID)	*97.6*		*77.0-122*		*06/19/2018 10:25*	WG1126367

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

	Result	Qualifier	RDL	Dilution	Analysis	Batch
Analyte	ug/l		ug/l		date / time	
Benzene	ND		1.00	1	06/19/2018 18:47	WG1126623
Toluene	ND		1.00	1	06/19/2018 18:47	WG1126623
Ethylbenzene	ND		1.00	1	06/19/2018 18:47	WG1126623
Total Xylenes	ND		3.00	1	06/19/2018 18:47	WG1126623
(S) Toluene-d8	*96.3*		*80.0-120*		*06/19/2018 18:47*	WG1126623
(S) Dibromofluoromethane	*102*		*76.0-123*		*06/19/2018 18:47*	WG1126623
(S) a,a,a-Trifluorotoluene	*99.6*		*80.0-120*		*06/19/2018 18:47*	WG1126623
(S) 4-Bromofluorobenzene	*105*		*80.0-120*		*06/19/2018 18:47*	WG1126623

Semi-Volatile Organic Compounds (GC) by Method NWTPHDX-NO SGT

	Result	Qualifier	RDL	Dilution	Analysis	Batch
Analyte	ug/l		ug/l		date / time	
Diesel Range Organics (DRO)	488		200	1	06/20/2018 19:46	WG1125904
Residual Range Organics (RRO)	517		250	1	06/20/2018 19:46	WG1125904
(S) o-Terphenyl	*101*		*52.0-156*		*06/20/2018 19:46*	WG1125904

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

	Result	Qualifier	RDL	Dilution	Analysis	Batch
Analyte	ug/l		ug/l		date / time	
Diesel Range Organics (DRO)	ND		200	1	06/19/2018 19:23	WG1125905
Residual Range Organics (RRO)	ND		250	1	06/19/2018 19:23	WG1125905
(S) o-Terphenyl	*85.8*		*52.0-156*		*06/19/2018 19:23*	WG1125905

Volatile Organic Compounds (GC) by Method NWTPHGX

Analyte	Result ug/l	Qualifier	RDL ug/l	Dilution	Analysis date / time	Batch
Gasoline Range Organics-NWTPH	ND		100	1	06/19/2018 10:47	WG1126367
(S) a,a,a-Trifluorotoluene(FID)	*96.9*		*77.0-122*		*06/19/2018 10:47*	WG1126367

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	06/19/2018 19:07	WG1126623
Toluene	ND		1.00	1	06/19/2018 19:07	WG1126623
Ethylbenzene	ND		1.00	1	06/19/2018 19:07	WG1126623
Total Xylenes	ND		3.00	1	06/19/2018 19:07	WG1126623
(S) Toluene-d8	*97.6*		*80.0-120*		*06/19/2018 19:07*	WG1126623
(S) Dibromofluoromethane	*101*		*76.0-123*		*06/19/2018 19:07*	WG1126623
(S) a,a,a-Trifluorotoluene	*101*		*80.0-120*		*06/19/2018 19:07*	WG1126623
(S) 4-Bromofluorobenzene	*105*		*80.0-120*		*06/19/2018 19:07*	WG1126623

Semi-Volatile Organic Compounds (GC) by Method NWTPHDX-NO SGT

Analyte	Result ug/l	Qualifier	RDL ug/l	Dilution	Analysis date / time	Batch
Diesel Range Organics (DRO)	389		200	1	06/20/2018 20:06	WG1125904
Residual Range Organics (RRO)	358		250	1	06/20/2018 20:06	WG1125904
(S) o-Terphenyl	*102*		*52.0-156*		*06/20/2018 20:06*	WG1125904

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	06/19/2018 19:42	WG1125905
Residual Range Organics (RRO)	ND		250	1	06/19/2018 19:42	WG1125905
(S) o-Terphenyl	*88.9*		*52.0-156*		*06/19/2018 19:42*	WG1125905

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

Volatile Organic Compounds (GC) by Method NWTPHGX

	Result	Qualifier	RDL	Dilution	Analysis	Batch
Analyte	ug/l		ug/l		date / time	
Gasoline Range Organics-NWTPH	ND		100	1	06/19/2018 11:10	WG1126367
(S) a,a,a-Trifluorotoluene(FID)	*97.2*		*77.0-122*		*06/19/2018 11:10*	WG1126367

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

	Result	Qualifier	RDL	Dilution	Analysis	Batch
Analyte	ug/l		ug/l		date / time	
Benzene	ND		1.00	1	06/19/2018 19:26	WG1126623
Toluene	ND		1.00	1	06/19/2018 19:26	WG1126623
Ethylbenzene	ND		1.00	1	06/19/2018 19:26	WG1126623
Total Xylenes	ND		3.00	1	06/19/2018 19:26	WG1126623
(S) Toluene-d8	*98.3*		*80.0-120*		*06/19/2018 19:26*	WG1126623
(S) Dibromofluoromethane	*99.9*		*76.0-123*		*06/19/2018 19:26*	WG1126623
(S) a,a,a-Trifluorotoluene	*101*		*80.0-120*		*06/19/2018 19:26*	WG1126623
(S) 4-Bromofluorobenzene	*103*		*80.0-120*		*06/19/2018 19:26*	WG1126623

Semi-Volatile Organic Compounds (GC) by Method NWTPHDX-NO SGT

	Result	Qualifier	RDL	Dilution	Analysis	Batch
Analyte	ug/l		ug/l		date / time	
Diesel Range Organics (DRO)	1110		200	1	06/20/2018 20:26	WG1125904
Residual Range Organics (RRO)	970		250	1	06/20/2018 20:26	WG1125904
(S) o-Terphenyl	*102*		*52.0-156*		*06/20/2018 20:26*	WG1125904

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

	Result	Qualifier	RDL	Dilution	Analysis	Batch
Analyte	ug/l		ug/l		date / time	
Diesel Range Organics (DRO)	ND		200	1	06/19/2018 20:01	WG1125905
Residual Range Organics (RRO)	ND		250	1	06/19/2018 20:01	WG1125905
(S) o-Terphenyl	*90.3*		*52.0-156*		*06/19/2018 20:01*	WG1125905

Volatile Organic Compounds (GC) by Method NWTPHGX

Analyte	Result ug/l	Qualifier	RDL ug/l	Dilution	Analysis date / time	Batch
Gasoline Range Organics-NWTPH	ND		100	1	06/19/2018 11:32	WG1126367
(S) a,a,a-Trifluorotoluene(FID)	*97.9*		*77.0-122*		*06/19/2018 11:32*	WG1126367

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	06/19/2018 19:46	WG1126623
Toluene	ND		1.00	1	06/19/2018 19:46	WG1126623
Ethylbenzene	ND		1.00	1	06/19/2018 19:46	WG1126623
Total Xylenes	ND		3.00	1	06/19/2018 19:46	WG1126623
(S) Toluene-d8	*97.2*		*80.0-120*		*06/19/2018 19:46*	WG1126623
(S) Dibromofluoromethane	*102*		*76.0-123*		*06/19/2018 19:46*	WG1126623
(S) a,a,a-Trifluorotoluene	*103*		*80.0-120*		*06/19/2018 19:46*	WG1126623
(S) 4-Bromofluorobenzene	*108*		*80.0-120*		*06/19/2018 19:46*	WG1126623

Semi-Volatile Organic Compounds (GC) by Method NWTPHDX-NO SGT

Analyte	Result ug/l	Qualifier	RDL ug/l	Dilution	Analysis date / time	Batch
Diesel Range Organics (DRO)	1150		200	1	06/20/2018 20:46	WG1125904
Residual Range Organics (RRO)	1060		250	1	06/20/2018 20:46	WG1125904
(S) o-Terphenyl	*97.2*		*52.0-156*		*06/20/2018 20:46*	WG1125904

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	06/19/2018 20:21	WG1125905
Residual Range Organics (RRO)	ND		250	1	06/19/2018 20:21	WG1125905
(S) o-Terphenyl	*90.2*		*52.0-156*		*06/19/2018 20:21*	WG1125905

MW4D-061318

Collected date/time: 06/13/18 14:00

SAMPLE RESULTS - 05

L1002145

Volatile Organic Compounds (GC) by Method NWTPHGX

	Result	Qualifier	RDL	Dilution	Analysis	Batch
Analyte	ug/l		ug/l		date / time	
Gasoline Range Organics-NWTPH	ND		100	1	06/19/2018 11:54	WG1126367
(S) a,a,a-Trifluorotoluene(FID)	*97.7*		*77.0-122*		*06/19/2018 11:54*	WG1126367

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

	Result	Qualifier	RDL	Dilution	Analysis	Batch
Analyte	ug/l		ug/l		date / time	
Benzene	ND		1.00	1	06/19/2018 20:05	WG1126623
Toluene	ND		1.00	1	06/19/2018 20:05	WG1126623
Ethylbenzene	ND		1.00	1	06/19/2018 20:05	WG1126623
Total Xylenes	ND		3.00	1	06/19/2018 20:05	WG1126623
(S) Toluene-d8	*93.9*		*80.0-120*		*06/19/2018 20:05*	WG1126623
(S) Dibromofluoromethane	*102*		*76.0-123*		*06/19/2018 20:05*	WG1126623
(S) a,a,a-Trifluorotoluene	*102*		*80.0-120*		*06/19/2018 20:05*	WG1126623
(S) 4-Bromofluorobenzene	*104*		*80.0-120*		*06/19/2018 20:05*	WG1126623

Semi-Volatile Organic Compounds (GC) by Method NWTPHDX-NO SGT

	Result	Qualifier	RDL	Dilution	Analysis	Batch
Analyte	ug/l		ug/l		date / time	
Diesel Range Organics (DRO)	1160		200	1	06/20/2018 21:06	WG1125904
Residual Range Organics (RRO)	1170		250	1	06/20/2018 21:06	WG1125904
(S) o-Terphenyl	*101*		*52.0-156*		*06/20/2018 21:06*	WG1125904

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

	Result	Qualifier	RDL	Dilution	Analysis	Batch
Analyte	ug/l		ug/l		date / time	
Diesel Range Organics (DRO)	ND		200	1	06/19/2018 20:40	WG1125905
Residual Range Organics (RRO)	ND		250	1	06/19/2018 20:40	WG1125905
(S) o-Terphenyl	*92.7*		*52.0-156*		*06/19/2018 20:40*	WG1125905

Volatile Organic Compounds (GC) by Method NWTPHGX

Analyte	Result ug/l	Qualifier	RDL ug/l	Dilution	Analysis date / time	Batch
Gasoline Range Organics-NWTPH	ND		100	1	06/19/2018 12:16	WG1126367
(S) a,a,a-Trifluorotoluene(FID)	*98.1*		*77.0-122*		*06/19/2018 12:16*	WG1126367

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	06/19/2018 20:25	WG1126623
Toluene	ND		1.00	1	06/19/2018 20:25	WG1126623
Ethylbenzene	ND		1.00	1	06/19/2018 20:25	WG1126623
Total Xylenes	ND		3.00	1	06/19/2018 20:25	WG1126623
(S) Toluene-d8	*98.0*		*80.0-120*		*06/19/2018 20:25*	WG1126623
(S) Dibromofluoromethane	*101*		*76.0-123*		*06/19/2018 20:25*	WG1126623
(S) a,a,a-Trifluorotoluene	*99.5*		*80.0-120*		*06/19/2018 20:25*	WG1126623
(S) 4-Bromofluorobenzene	*106*		*80.0-120*		*06/19/2018 20:25*	WG1126623

Semi-Volatile Organic Compounds (GC) by Method NWTPHDX-NO SGT

Analyte	Result ug/l	Qualifier	RDL ug/l	Dilution	Analysis date / time	Batch
Diesel Range Organics (DRO)	204		200	1	06/20/2018 21:26	WG1125904
Residual Range Organics (RRO)	335		250	1	06/20/2018 21:26	WG1125904
(S) o-Terphenyl	*91.2*		*52.0-156*		*06/20/2018 21:26*	WG1125904

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	06/19/2018 21:00	WG1125905
Residual Range Organics (RRO)	ND		250	1	06/19/2018 21:00	WG1125905
(S) o-Terphenyl	*84.5*		*52.0-156*		*06/19/2018 21:00*	WG1125905

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	06/19/2018 14:33	WG1126623
Toluene	ND		1.00	1	06/19/2018 14:33	WG1126623
Ethylbenzene	ND		1.00	1	06/19/2018 14:33	WG1126623
Total Xylenes	ND		3.00	1	06/19/2018 14:33	WG1126623
(S) Toluene-d8	*86.2*		*80.0-120*		*06/19/2018 14:33*	WG1126623
(S) Dibromofluoromethane	*106*		*76.0-123*		*06/19/2018 14:33*	WG1126623
(S) a,a,a-Trifluorotoluene	*98.9*		*80.0-120*		*06/19/2018 14:33*	WG1126623
(S) 4-Bromofluorobenzene	*112*		*80.0-120*		*06/19/2018 14:33*	WG1126623

Method Blank (MB)

(MB) R3318914-3 06/19/18 06:43

Analyte	MB Result ug/l	MB Qualifier	MB MDL ug/l	MB RDL ug/l
Gasoline Range Organics-NWTPH	U		31.6	100
(S) a,a,a-Trifluorotoluene(FID)	*98.2*			*77.0-122*

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

(LCS) R3318914-1 06/19/18 05:36 • (LCSD) R3318914-2 06/19/18 05:59

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 %
Gasoline Range Organics-NWTPH	5500	5580	5820	102	106	72.0-134			4.06	20
(S) a,a,a-Trifluorotoluene(FID)				*102*	*103*	*77.0-122*				

L1002299-02 Original Sample (OS) • Matrix Spike (MS) • Matrix Spike Duplicate (MSD)

(OS) L1002299-02 06/19/18 13:23 • (MS) R3318914-4 06/19/18 13:45 • (MSD) R3318914-5 06/19/18 14:07

Analyte	Spike Amount ug/l	Original Result ug/l	MS Result ug/l	MSD Result ug/l	MS Rec. %	MSD Rec. %	Dilution	Rec. Limits %	MS Qualifier	MSD Qualifier	RPD %	RPD Limits %
Gasoline Range Organics-NWTPH	5500	ND	3390	3400	61.6	61.8	1	23.0-159			0.380	20
(S) a,a,a-Trifluorotoluene(FID)					*96.9*	*97.8*		*77.0-122*				

Method Blank (MB)

(MB) R3319176-3 06/19/18 13:06

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	*96.7*			*80.0-120*
(S) Dibromofluoromethane	*106*			*76.0-123*
(S) a,a,a-Trifluorotoluene	*100*			*80.0-120*
(S) 4-Bromofluorobenzene	*107*			*80.0-120*

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

(LCS) R3319176-1 06/19/18 11:48 • (LCSD) R3319176-2 06/19/18 12:08

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 %
Benzene	25.0	29.2	29.1	117	117	69.0-123			0.327	20
Ethylbenzene	25.0	24.0	23.7	95.9	94.8	77.0-120			1.14	20
Toluene	25.0	25.2	24.2	101	96.9	77.0-120			4.07	20
Xylenes, Total	75.0	72.7	70.6	96.9	94.1	77.0-120			2.93	20
(S) Toluene-d8				*96.0*	*94.0*	*80.0-120*				
(S) Dibromofluoromethane				*101*	*101*	*76.0-123*				
(S) a,a,a-Trifluorotoluene				*99.9*	*98.9*	*80.0-120*				
(S) 4-Bromofluorobenzene				*104*	*106*	*80.0-120*				

Method Blank (MB)

(MB) R3319741-1 06/20/18 15:09

Analyte	MB Result ug/l	MB Qualifier	MB MDL ug/l	MB RDL ug/l
Diesel Range Organics (DRO)	U		66.7	200
Residual Range Organics (RRO)	U		83.3	250
(S) o-Terphenyl	*102*			*52.0-156*

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

(LCS) R3319741-2 06/20/18 15:29 • (LCSD) R3319741-3 06/20/18 15:48

Analyte	Spike Amount ug/l	LCS Result ug/l	LCSD Result ug/l	LCS Rec. %	LCSD Rec. %	Rec. Limits %	LCS Qualifier	LCSD Qualifier	RPD %	RPD Limits %
Diesel Range Organics (DRO)	750	845	864	113	115	50.0-150			2.19	20
Residual Range Organics (RRO)	750	709	699	94.5	93.2	50.0-150			1.40	20
(S) o-Terphenyl				*107*	*104*	*52.0-156*				

Method Blank (MB)

(MB) R3319186-1 06/19/18 15:33

Analyte	MB Result ug/l	MB Qualifier	MB MDL ug/l	MB RDL ug/l
Diesel Range Organics (DRO)	U		66.7	200
Residual Range Organics (RRO)	U		83.3	250
(S) o-Terphenyl	*89.2*			*52.0-156*

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

(LCS) R3319186-2 06/19/18 15:52 • (LCSD) R3319186-3 06/19/18 16:11

Analyte	Spike Amount ug/l	LCS Result ug/l	LCSD Result ug/l	LCS Rec. %	LCSD Rec. %	Rec. Limits %	LCS Qualifier	LCSD Qualifier	RPD %	RPD Limits %
Diesel Range Organics (DRO)	750	904	884	121	118	50.0-150			2.29	20
Residual Range Organics (RRO)	750	771	759	103	101	50.0-150			1.58	20
(S) o-Terphenyl				*92.2*	*97.0*	*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, the sample preparation volume or weight values differ from the standard, 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
	The remainder of this page intentionally left blank, there are no qualifiers applied to this SDG.

ACCREDITATIONS & LOCATIONS

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

State Accreditations

Alabama	40660
Alaska	17-026
Arizona	AZ0612
Arkansas	88-0469
California	2932
Colorado	TN00003
Connecticut	PH-0197
Florida	E87487
Georgia	NELAP
Georgia [1]	923
Idaho	TN00003
Illinois	200008
Indiana	C-TN-01
Iowa	364
Kansas	E-10277
Kentucky [1,6]	90010
Kentucky [2]	16
Louisiana	AI30792
Louisiana [1]	LA180010
Maine	TN0002
Maryland	324
Massachusetts	M-TN003
Michigan	9958
Minnesota	047-999-395
Mississippi	TN00003
Missouri	340
Montana	CERT0086
Nebraska	NE-OS-15-05
Nevada	TN-03-2002-34
New Hampshire	2975
New Jersey–NELAP	TN002
New Mexico [1]	n/a
New York	11742
North Carolina	Env375
North Carolina [1]	DW21704
North Carolina [3]	41
North Dakota	R-140
Ohio–VAP	CL0069
Oklahoma	9915
Oregon	TN200002
Pennsylvania	68-02979
Rhode Island	LAO00356
South Carolina	84004
South Dakota	n/a
Tennessee [1,4]	2006
Texas	T 104704245-17-14
Texas [5]	LAB0152
Utah	TN00003
Vermont	VT2006
Virginia	460132
Washington	C847
West Virginia	233
Wisconsin	9980939910
Wyoming	A2LA

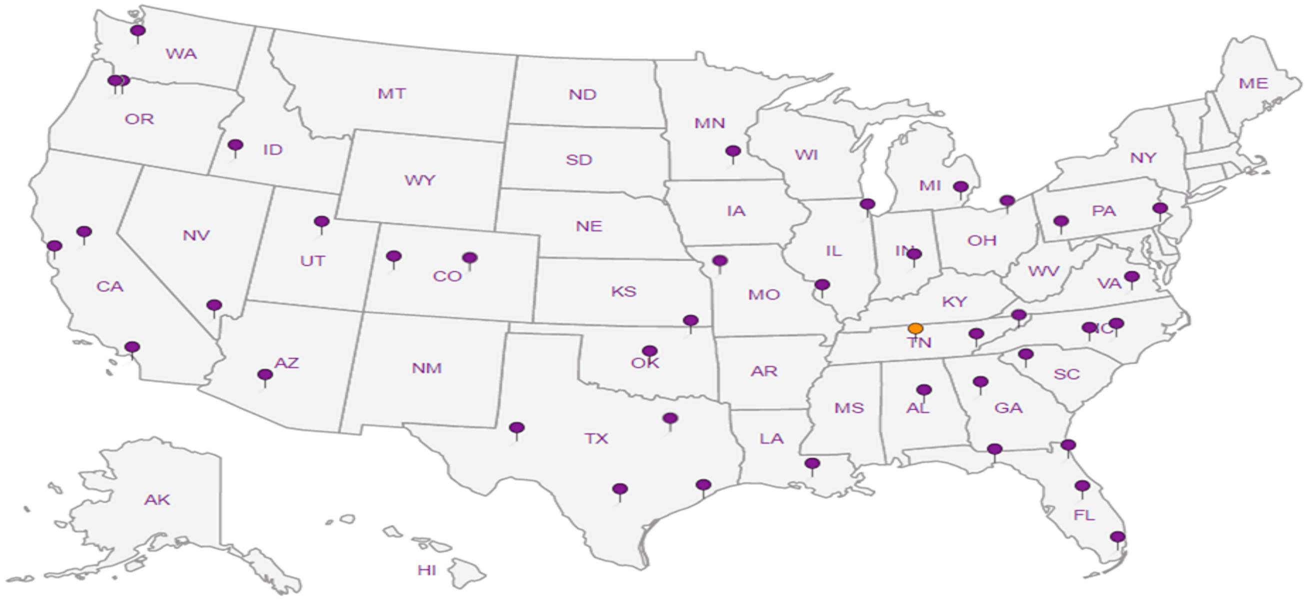
Third Party Federal Accreditations

A2LA – ISO 17025	1461.01
A2LA – ISO 17025 [5]	1461.02
Canada	1461.01
EPA–Crypto	TN00003
AIHA-LAP,LLC EMLAP	100789
DOD	1461.01
USDA	P330-15-00234

[1] Drinking Water [2] Underground Storage Tanks [3] Aquatic Toxicity [4] Chemical/Microbiological [5] Mold [6] Wastewater 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.



Company Name/Address: **TRC- BNSF Region 1** 19874 141st Pl NE Woodinville, WA 98072	Billing Information: Keith Woodburne 19874 141st Pl NE Woodinville, WA 98072	Chain of Custody Page 1 of 1 ESC L·A·B S·C·I·E·N·C·E·S YOUR LAB OF CHOICE 12065 Lebanon Rd Mount Juliet, TN 37122 Phone: 615-758-5858 Phone: 800-767-5859 Fax: 615-758-5859
Report to: Amanda Meugniot	Email To: ameugniot@trcsolutions.com	L# L1002145 F039
Project Description: BNSF- Leavenworth	City/State Collected: Leavenworth, WA	Acctnum:
Phone: 425-489-1938 Fax:	Client Project # 296562	Lab Project #
Collected by (print): Kaelin Newman	Site/Facility ID #	P.O. #
Collected by (signature): Immediately Packed on Ice N____ Y ✓	*Rush?* (Lab MUST Be Notified) ____ Same Day .... 200% ____ Next Day .... 100% ____ Two Day .... 50% ____ Three Day 25%	Date Results Needed Email? ___No ___Yes FAX? ___No ___Yes

Template:

Prelogin:

TSR:

PB:

Shipped Via:

Analysis / Container / Preservative

Sample ID	Comp/Grab	Matrix *	Depth	Date	Time	No. of Cntrs	NWTPHDXLVI w/ SGT 40ml Amb-HCl	NWTPHDXLVI w/o SGT 40mlAmb-HCl	NWTPHGX 40mlAmb HCl	V8260C 40mlAmbHCl BTEX ONLY	Rem./Contaminant	Sample # (lab only)
MW1-061318	Grab	GW	N/A	6/13/18	2032	8	X	X	X	X		-01
MW2-061318	↓	↓	↓	6/13/18	2205	↓	↓	↓	↓	↓		02
MW3-061318	↓	↓	↓	6/13/18	1513	↓	↓	↓	↓	↓		03
MW4-061318	↓	↓	↓	6/13/18	1632	↓	↓	↓	↓	↓		04
MW40-061318	↓	↓	↓	6/13/18	1400	7	↓	↓	↓	↓		05
MW6-061318	↓	↓	↓	6/13/18	1349	8	↓	↓	↓	↓		06
Trip Blank										X		07

* Matrix: SS - Soil GW - Groundwater WW - WasteWater DW - Drinking Water OT - Other________

pH ______ Temp ______

Flow ______ Other ______

Remarks: 7724 8311 9912

Relinquished by : (Signature)	Date: 6/14/18	Time: 1400	Received by: (Signature)	Samples returned via: ☐ UPS ☒ FedEx ☐ Courier ☐ ____	Hold #
Relinquished by : (Signature)	Date:	Time:	Received by: (Signature)	Temp: 5.5 3 °C Bottles Received: 47	Condition: (lab use only) OK COC Seal Intact: ___Y ___N ✓ NA
Relinquished by : (Signature)	Date:	Time:	Received for lab by: (Signature)	Date: 6/15/18 Time: 845	pH Checked: NCF:

ESC LAB SCIENCES

Cooler Receipt Form

Client: BNSFITRC SDG# L1002145

Cooler Received/Opened On: 6/15/18 Temperature: 5.5

Received By: Alexandra Murtaugh

Signature:

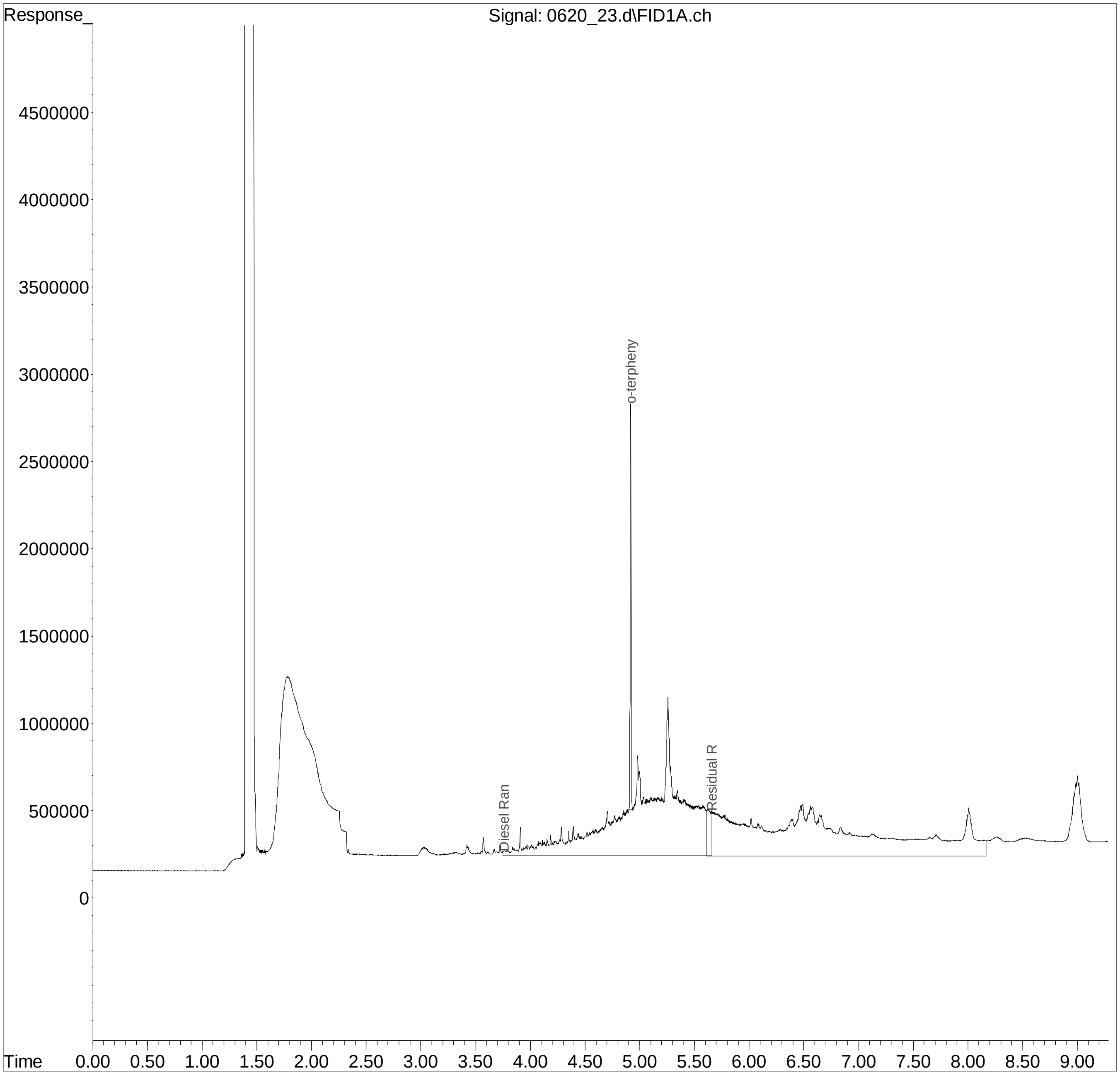
Receipt Check List	NP	Yes	No
COC Seal Present / Intact?	✓		
COC Signed / Accurate?		✓	
Bottles arrive intact?		✓	
Correct bottles used?		✓	
Sufficient volume sent?		✓	
If Applicable			
VOA Zero headspace?		✓	
Preservation Correct / Checked?			

```
                              Quantitation Report    (QT Reviewed)

Data Path : C:\msdchem\1\data\062018\
Data File : 0620 23.d
Signal(s) : FID1A.ch
Acq On    : 20 Jun 2018   7:46 pm
Operator  : 773
Sample    : L1002145-01 1x WG1125904 40-2
Misc      : water M.I.s on ranges are corrections
ALS Vial  : 14   Sample Multiplier: 0.05
InstName  : SVGC27

Integration File: events.e
Quant Time: Jun 21 12:15:03 2018
Quant Method : C:\msdchem\1\methods\EP27E29R.M
Quant Title  :
QLast Update : Tue May 29 16:19:46 2018
Response via : Initial Calibration
Integrator: ChemStation

Volume Inj.  :
Signal Phase :
Signal Info  :
DataAcq Meth:EPH27Z2.M
```

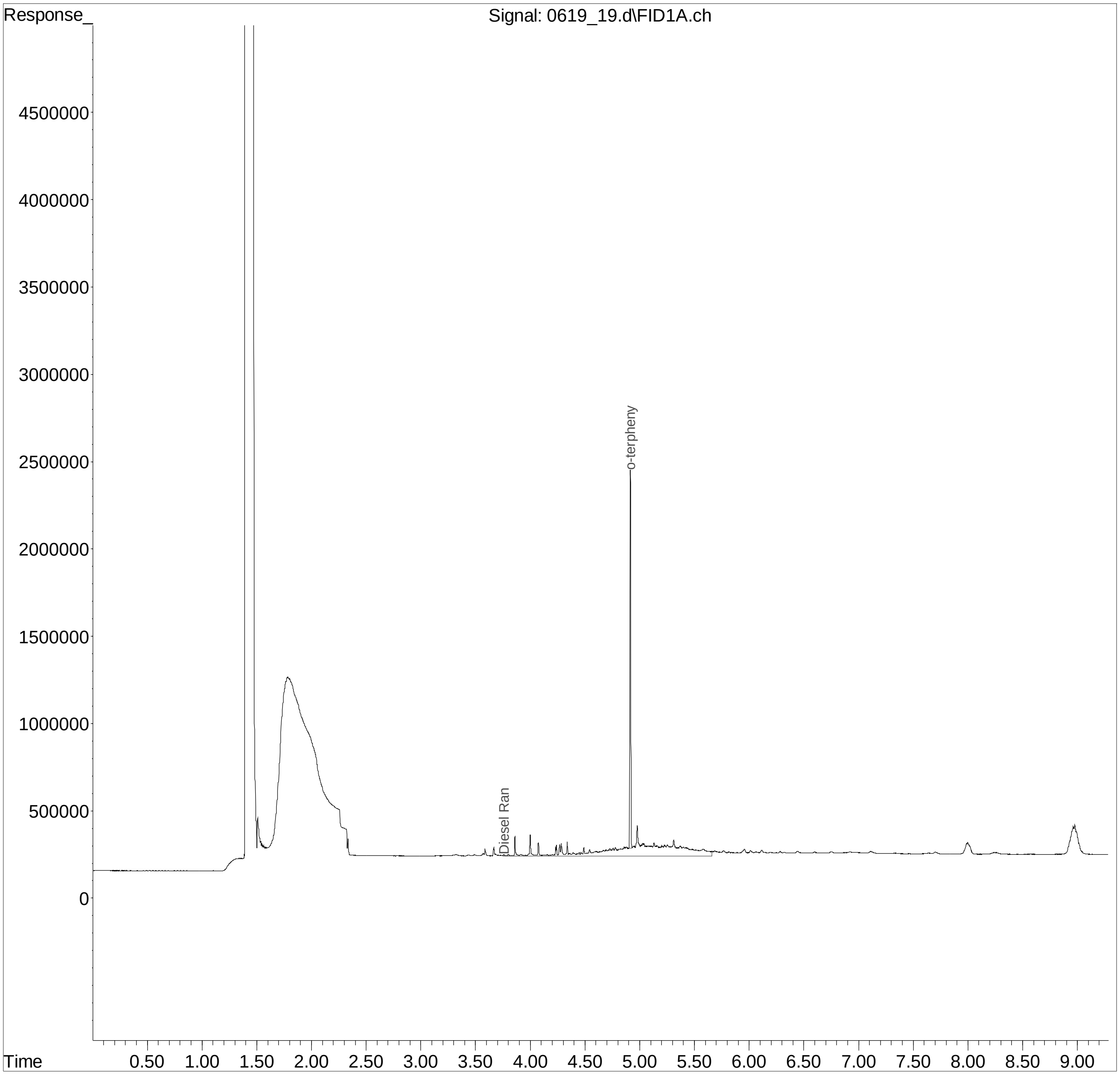


Quantitation Report   (QT Reviewed)

```
Data Path : C:\msdchem\1\data\061918\
Data File : 0619 19.d
Signal(s) : FID1A.ch
Acq On    : 19 Jun 2018   7:23 pm
Operator  : 773
Sample    : L1002145-01 1x WG1125905 42-2
Misc      : water M.I.s on ranges are corrections
ALS Vial  : 17   Sample Multiplier: 0.0476
InstName  : SVGC27

Integration File: events.e
Quant Time: Jun 19 23:24:55 2018
Quant Method : C:\msdchem\1\methods\EP27E29R.M
Quant Title  :
QLast Update : Tue May 29 16:19:46 2018
Response via : Initial Calibration
Integrator: ChemStation

Volume Inj.  :
Signal Phase :
Signal Info  :
DataAcq Meth:EPH27Z2.M
```

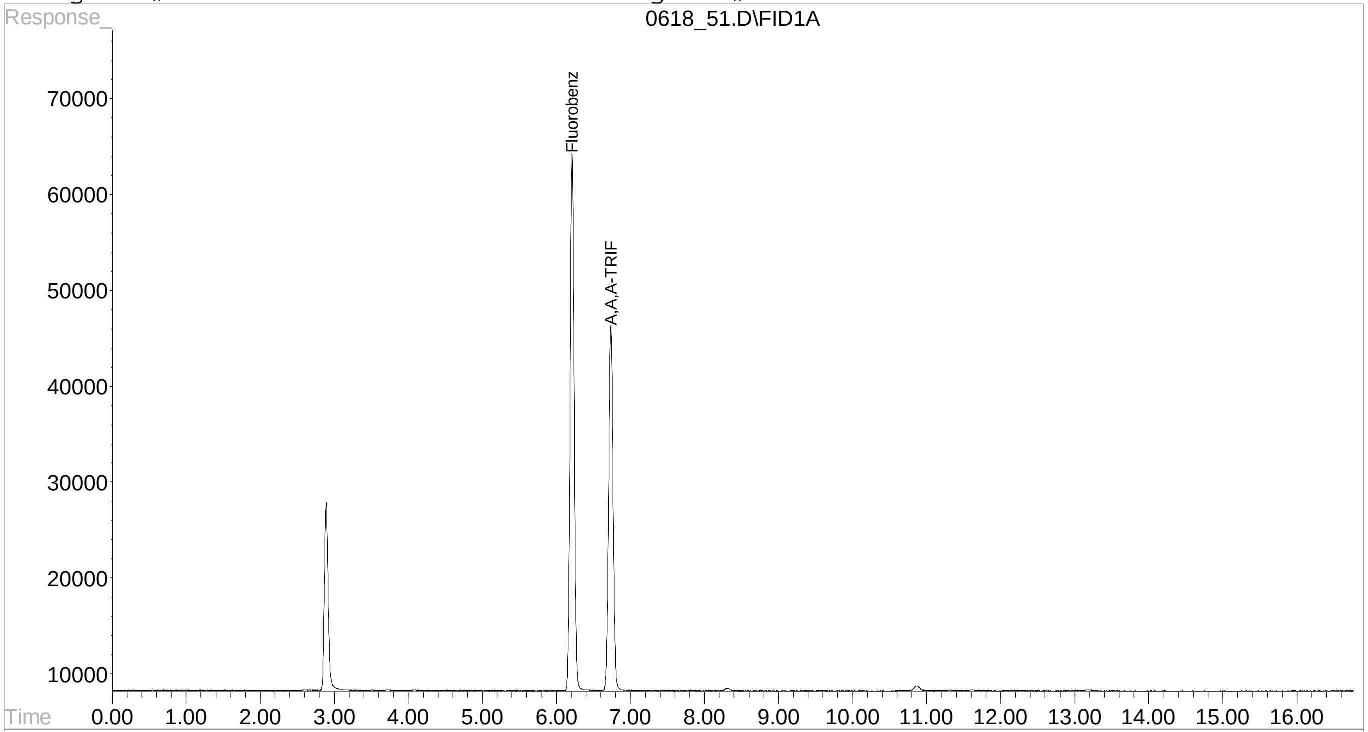


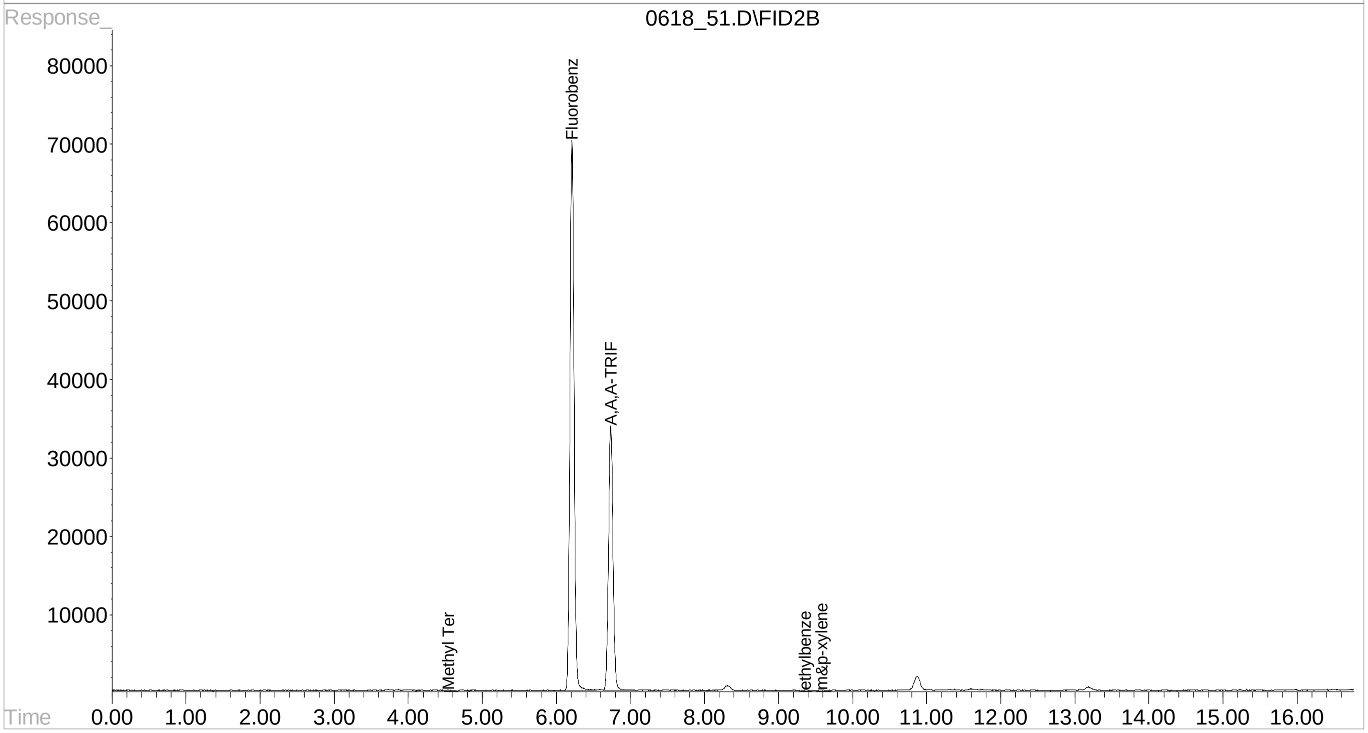
```
                                    Quantitation Report    (QT Reviewed)

Signal #1 : C:\HPCHEM\1\DATA\061818\0618 51.D\FID1A.CH   Vial: 49
Signal #2 : C:\HPCHEM\1\DATA\061818\0618 51.D\FID2B.CH
Acq On    : 19 Jun 2018  10:25 am                      Operator: 605
Sample    : L1002145-01 1x WG1126367                   Inst    : VOCGC1
Misc      : SOIL                                       Multiplr: 1.00
IntFile Signal #1: BTEX.E       IntFile Signal #2: EVENTS3.E
Quant Time: Jun 20  7:39 2018  Quant Results File: BG01K16Q.RES

Quant Method : C:\HPCHEM\1\METHODS\BG01K16Q.M (Chemstation Integrator)
Title        : WIS GRO VOCGC01
Last Update  : Fri Nov 17 09:32:59 2017
Response via : Single Level Calibration
DataAcq Meth : GC1BG.M

Volume Inj.     :
Signal #1 Phase :                    Signal #2 Phase:
Signal #1 Info  :                    Signal #2 Info :
```



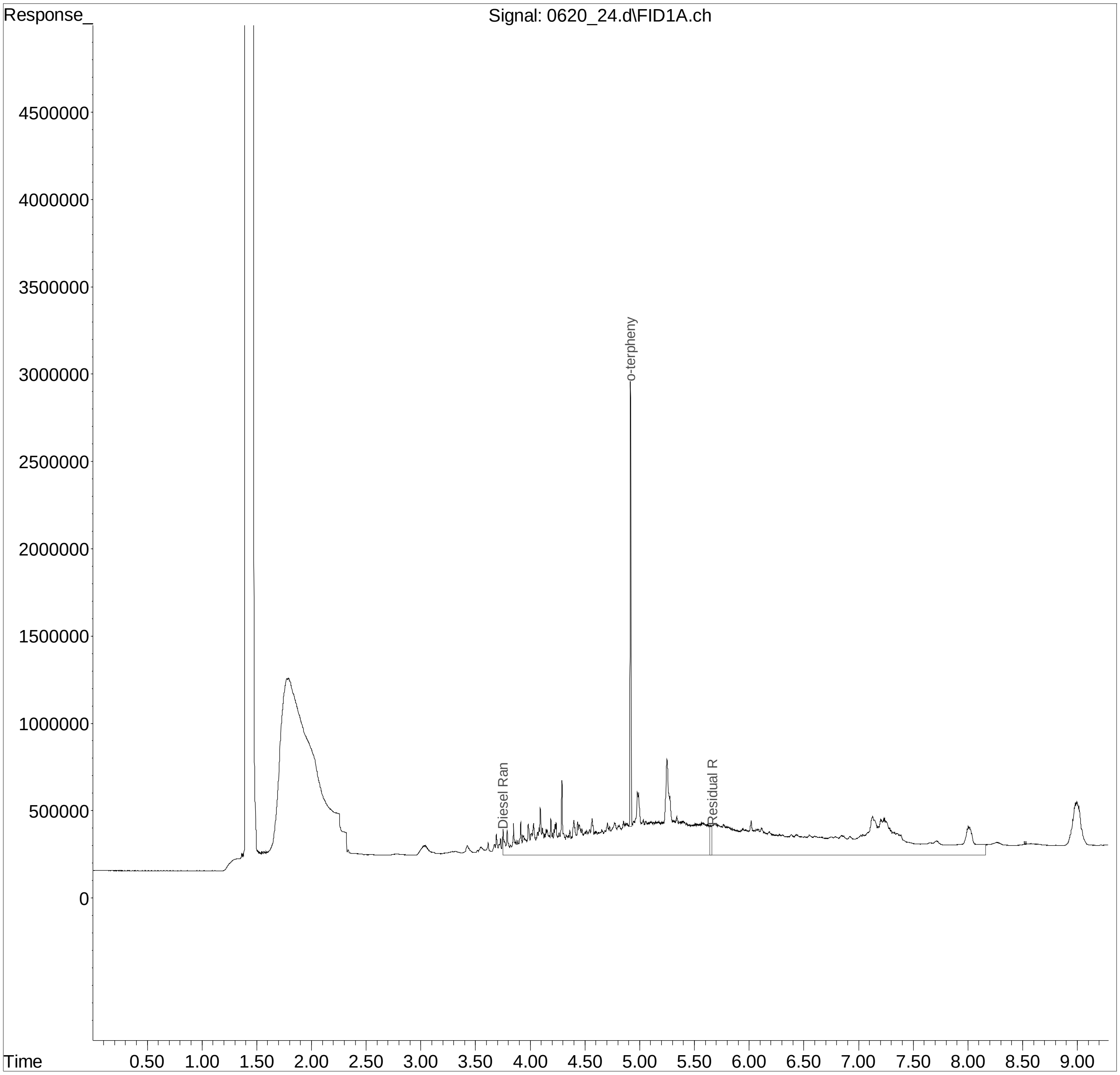


```
                    Quantitation Report    (QT Reviewed)

Data Path : C:\msdchem\1\data\062018\
Data File : 0620 24.d
Signal(s) : FID1A.ch
Acq On    : 20 Jun 2018   8:06 pm
Operator  : 773
Sample    : L1002145-02 1x WG1125904 40-2
Misc      : water M.I.s on ranges are corrections
ALS Vial  : 15   Sample Multiplier: 0.05
InstName  : SVGC27

Integration File: events.e
Quant Time: Jun 21 12:15:46 2018
Quant Method : C:\msdchem\1\methods\EP27E29R.M
Quant Title  :
QLast Update : Tue May 29 16:19:46 2018
Response via : Initial Calibration
Integrator: ChemStation

Volume Inj.  :
Signal Phase :
Signal Info  :
DataAcq Meth:EPH27Z2.M
```

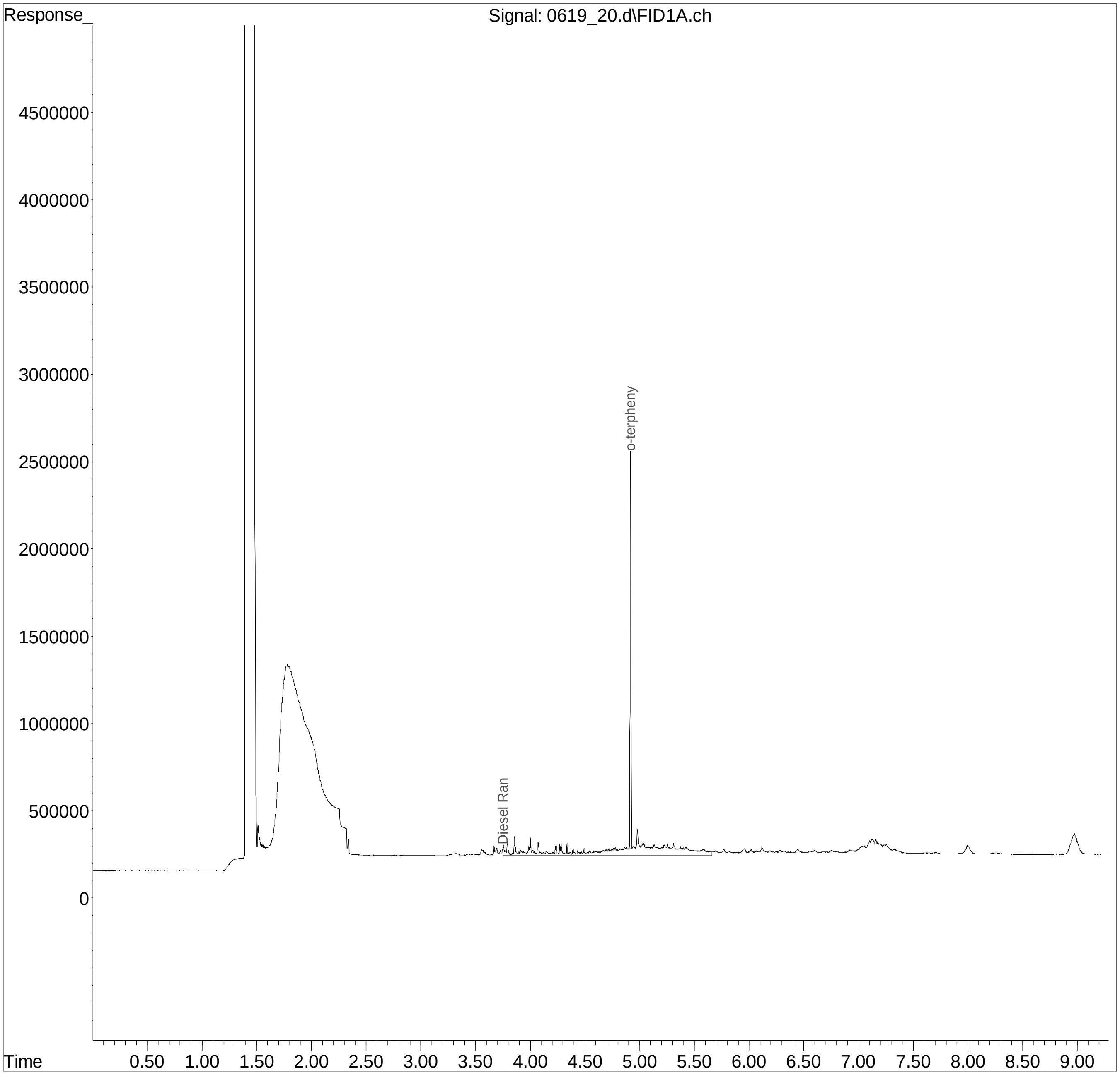


```
                              Quantitation Report    (QT Reviewed)

Data Path : C:\msdchem\1\data\061918\
Data File : 0619 20.d
Signal(s) : FID1A.ch
Acq On    : 19 Jun 2018   7:42 pm
Operator  : 773
Sample    : L1002145-02 1x WG1125905 42-2
Misc      : water M.I.s on ranges are corrections
ALS Vial  : 18   Sample Multiplier: 0.0476
InstName  : SVGC27

Integration File: events.e
Quant Time: Jun 19 23:25:31 2018
Quant Method : C:\msdchem\1\methods\EP27E29R.M
Quant Title  :
QLast Update : Tue May 29 16:19:46 2018
Response via : Initial Calibration
Integrator: ChemStation

Volume Inj.  :
Signal Phase :
Signal Info  :
DataAcq Meth:EPH27Z2.M
```

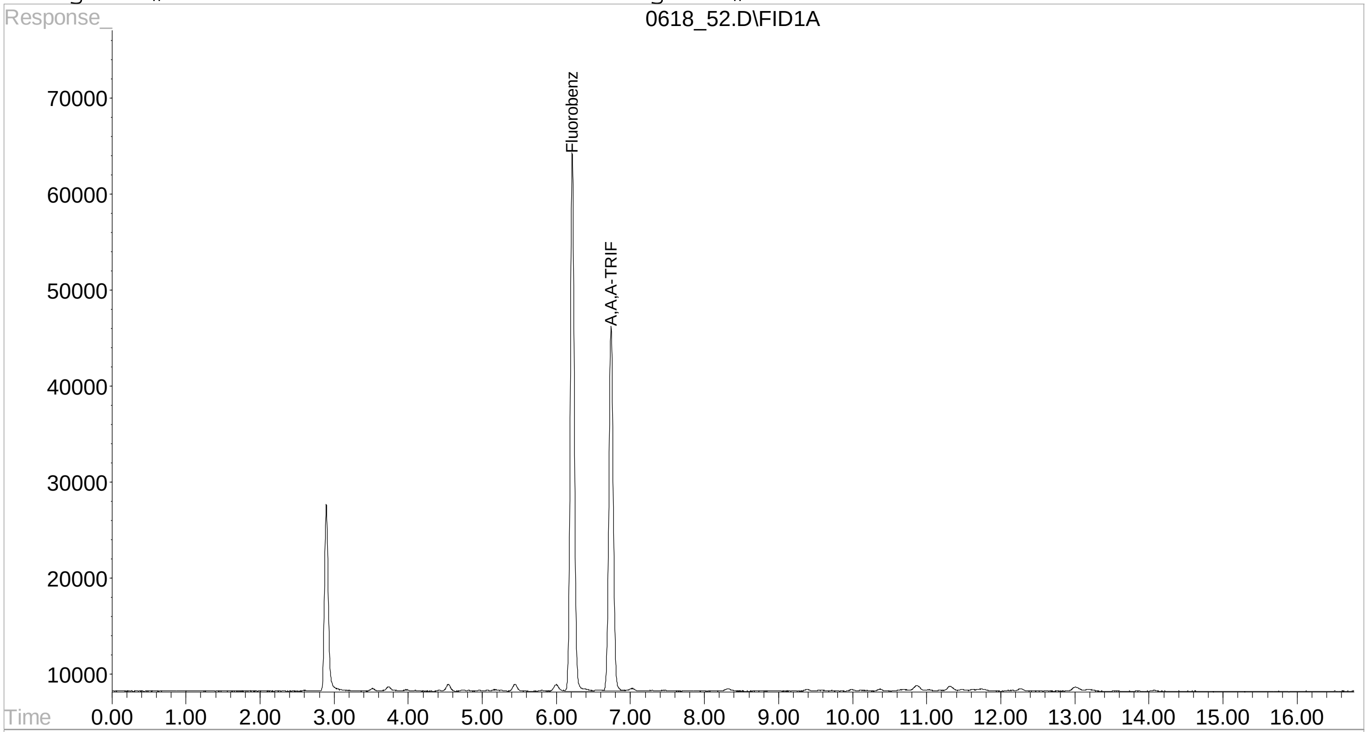


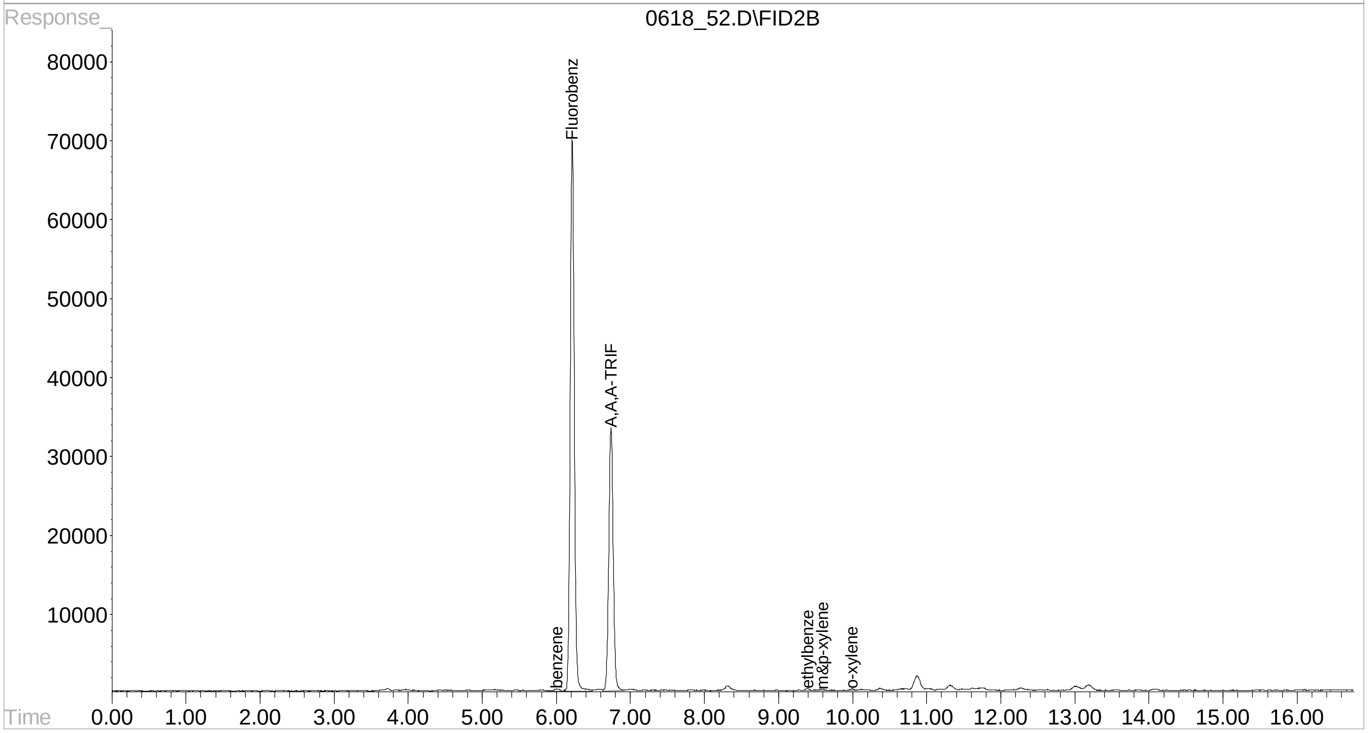
```
                                      Quantitation Report    (QT Reviewed)

  Signal #1 : C:\HPCHEM\1\DATA\061818\0618 52.D\FID1A.CH   Vial: 50
  Signal #2 : C:\HPCHEM\1\DATA\061818\0618 52.D\FID2B.CH
  Acq On    : 19 Jun 2018  10:47 am                      Operator: 605
  Sample    : L1002145-02 1x WG1126367                   Inst    : VOCGC1
  Misc      : SOIL                                       Multiplr: 1.00
  IntFile Signal #1: BTEX.E       IntFile Signal #2: EVENTS3.E
  Quant Time: Jun 20  7:39 2018  Quant Results File: BG01K16Q.RES

  Quant Method : C:\HPCHEM\1\METHODS\BG01K16Q.M (Chemstation Integrator)
  Title        : WIS GRO VOCGC01
  Last Update  : Fri Nov 17 09:32:59 2017
  Response via : Single Level Calibration
  DataAcq Meth : GC1BG.M

  Volume Inj.     :
  Signal #1 Phase :                     Signal #2 Phase:
  Signal #1 Info  :                     Signal #2 Info :
```



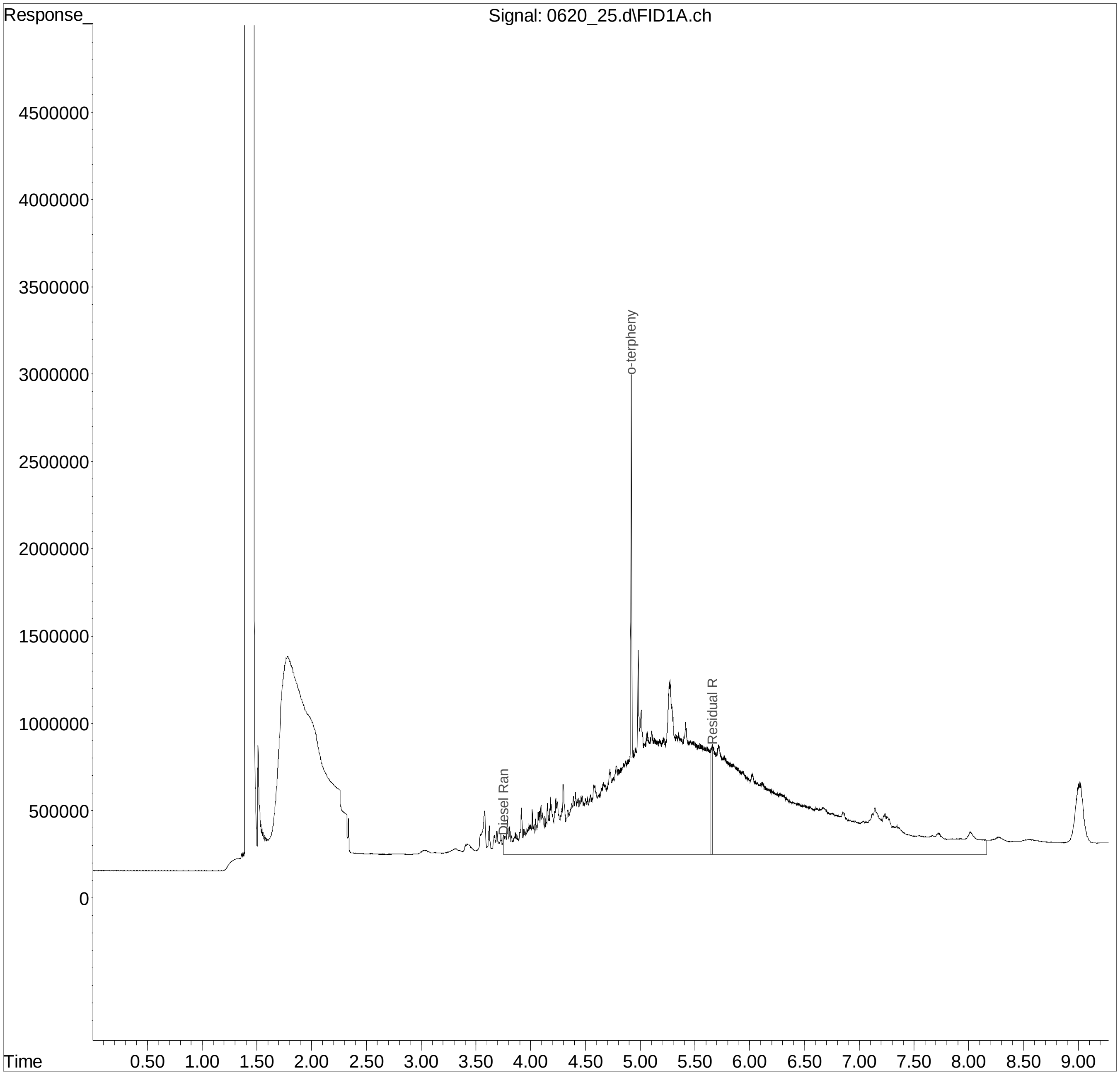


Quantitation Report (QT Reviewed)

```
Data Path : C:\msdchem\1\data\062018\
Data File : 0620 25.d
Signal(s) : FID1A.ch
Acq On    : 20 Jun 2018   8:26 pm
Operator  : 773
Sample    : L1002145-03 1x WG1125904 40-2
Misc      : water M.I.s on ranges are corrections
ALS Vial  : 16   Sample Multiplier: 0.05
InstName  : SVGC27

Integration File: events.e
Quant Time: Jun 21 12:16:29 2018
Quant Method : C:\msdchem\1\methods\EP27E29R.M
Quant Title  :
QLast Update : Tue May 29 16:19:46 2018
Response via : Initial Calibration
Integrator: ChemStation

Volume Inj.  :
Signal Phase :
Signal Info  :
DataAcq Meth:EPH27Z2.M
```

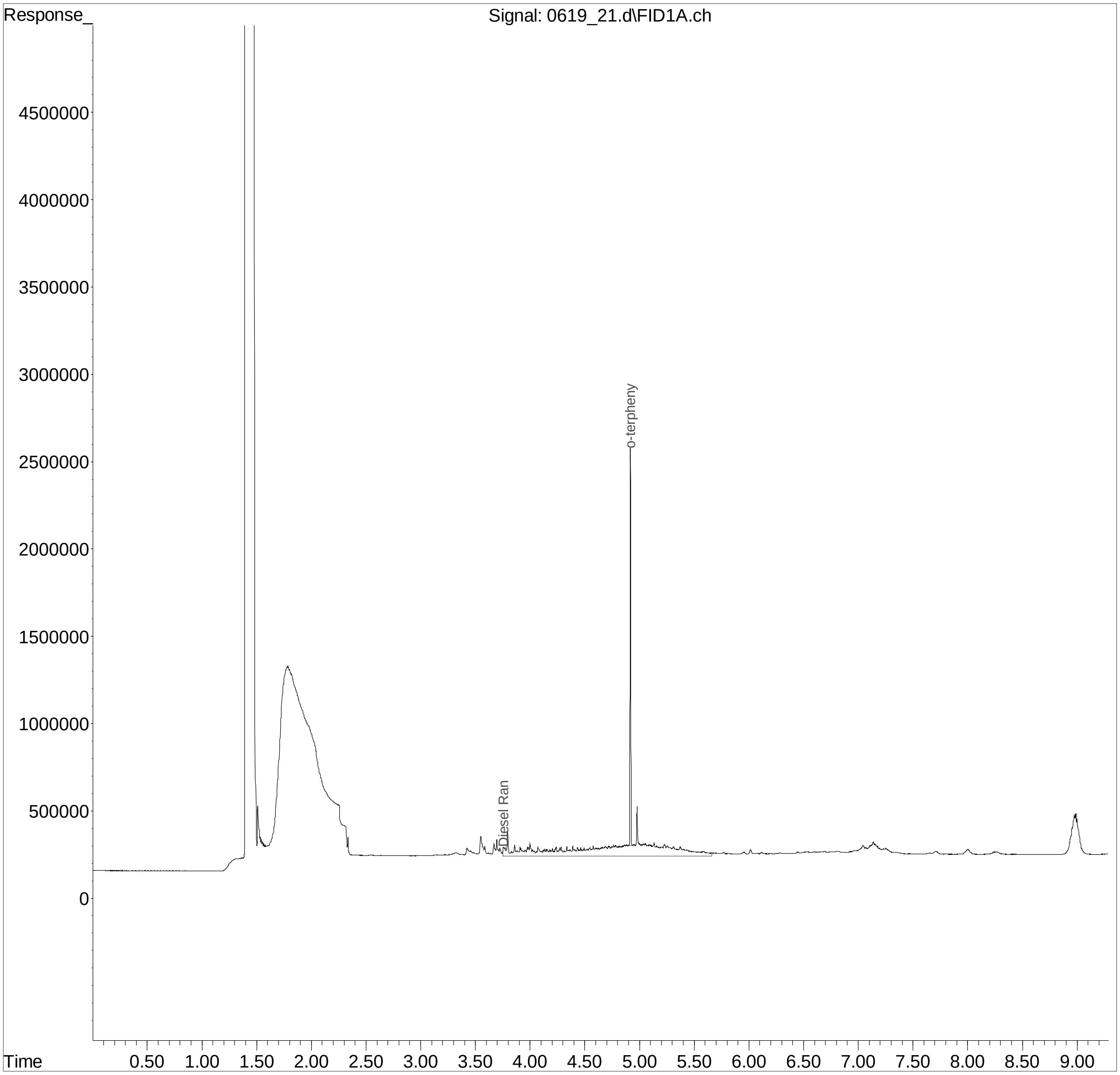


```
                        Quantitation Report    (QT Reviewed)

Data Path : C:\msdchem\1\data\061918\
Data File : 0619 21.d
Signal(s) : FID1A.ch
Acq On    : 19 Jun 2018   8:01 pm
Operator  : 773
Sample    : L1002145-03 1x WG1125905 42-2
Misc      : water M.I.s on ranges are corrections
ALS Vial  : 19   Sample Multiplier: 0.0476
InstName  : SVGC27

Integration File: events.e
Quant Time: Jun 19 23:26:08 2018
Quant Method : C:\msdchem\1\methods\EP27E29R.M
Quant Title  :
QLast Update : Tue May 29 16:19:46 2018
Response via : Initial Calibration
Integrator: ChemStation

Volume Inj.  :
Signal Phase :
Signal Info  :
DataAcq Meth:EPH27Z2.M
```

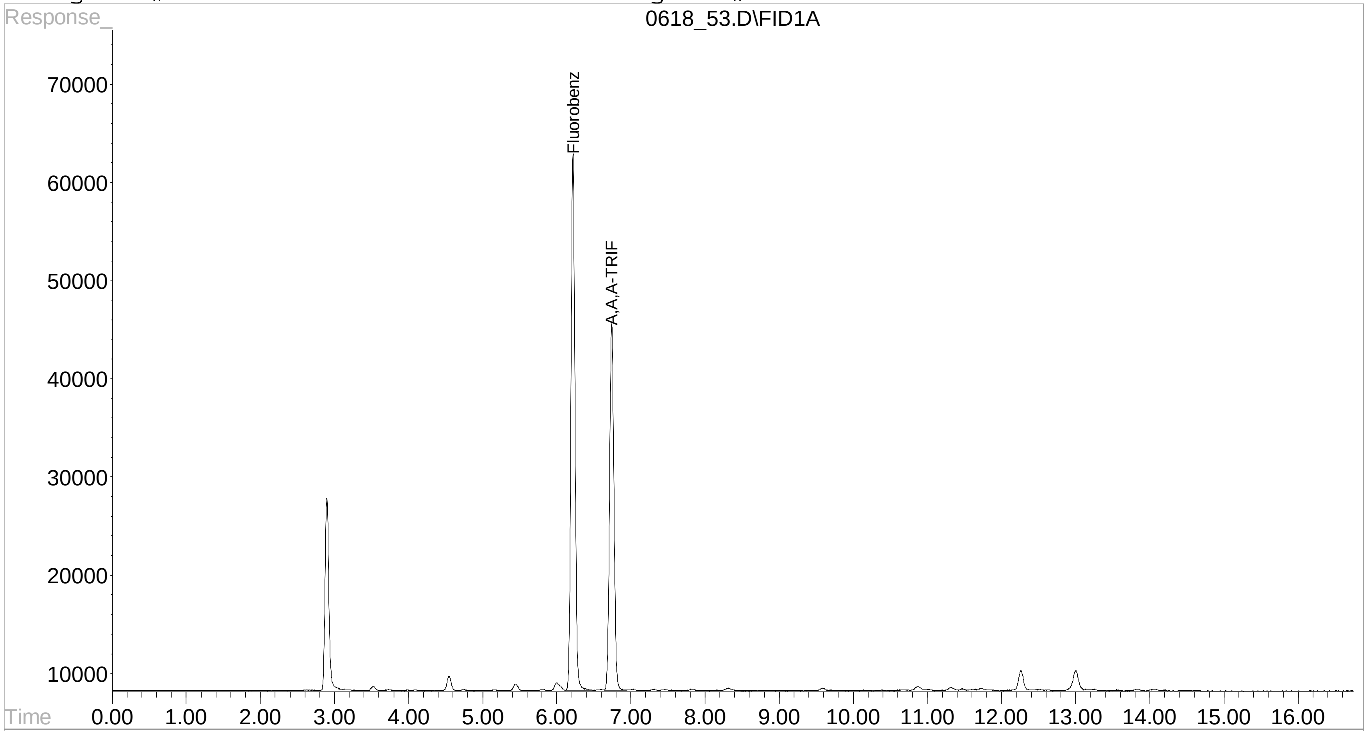


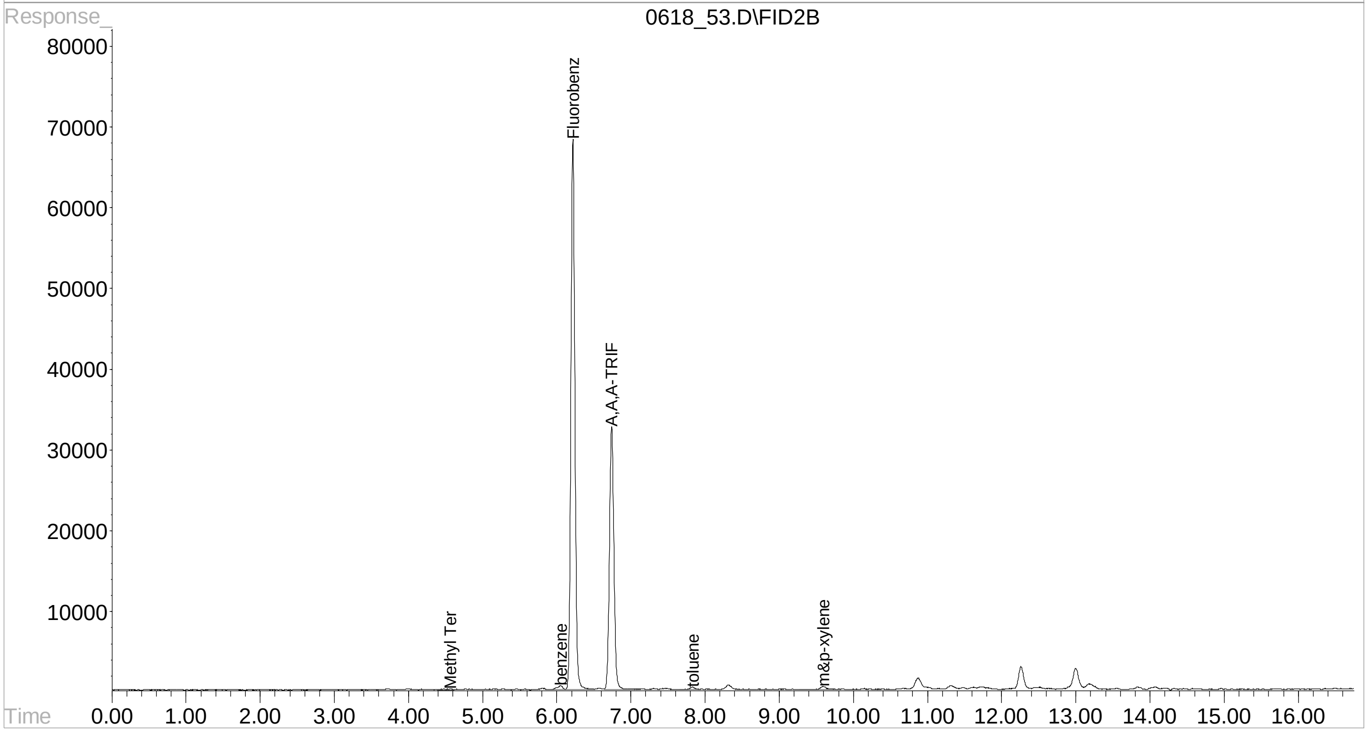
```
                          Quantitation Report    (QT Reviewed)

Signal #1 : C:\HPCHEM\1\DATA\061818\0618 53.D\FID1A.CH   Vial: 51
Signal #2 : C:\HPCHEM\1\DATA\061818\0618 53.D\FID2B.CH
Acq On    : 19 Jun 2018  11:10 am                      Operator: 605
Sample    : L1002145-03 1x WG1126367                   Inst    : VOCGC1
Misc      : SOIL                                       Multiplr: 1.00
IntFile Signal #1: BTEX.E       IntFile Signal #2: EVENTS3.E
Quant Time: Jun 20  7:39 2018  Quant Results File: BG01K16Q.RES

Quant Method : C:\HPCHEM\1\METHODS\BG01K16Q.M (Chemstation Integrator)
Title        : WIS GRO VOCGC01
Last Update  : Fri Nov 17 09:32:59 2017
Response via : Single Level Calibration
DataAcq Meth : GC1BG.M

Volume Inj.     :
Signal #1 Phase :                   Signal #2 Phase:
Signal #1 Info  :                   Signal #2 Info :
```



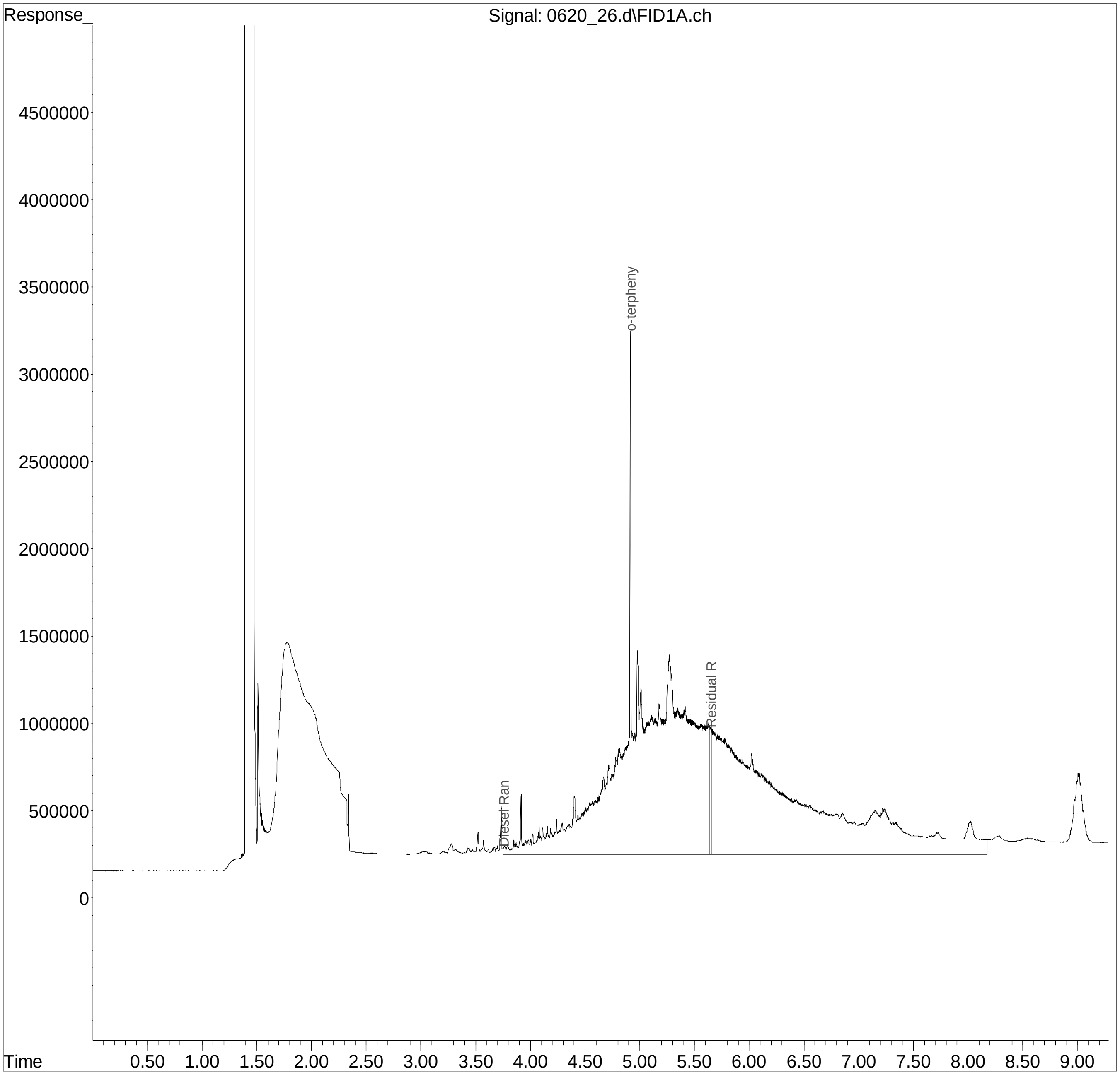


```
                          Quantitation Report    (QT Reviewed)

Data Path : C:\msdchem\1\data\062018\
Data File : 0620 26.d
Signal(s) : FID1A.ch
Acq On    : 20 Jun 2018   8:46 pm
Operator  : 773
Sample    : L1002145-04 1x WG1125904 40-2
Misc      : water M.I.s on ranges are corrections
ALS Vial  : 17   Sample Multiplier: 0.05
InstName  : SVGC27

Integration File: events.e
Quant Time: Jun 21 12:17:03 2018
Quant Method : C:\msdchem\1\methods\EP27E29R.M
Quant Title  :
QLast Update : Tue May 29 16:19:46 2018
Response via : Initial Calibration
Integrator: ChemStation

Volume Inj.  :
Signal Phase :
Signal Info  :
DataAcq Meth:EPH27Z2.M
```

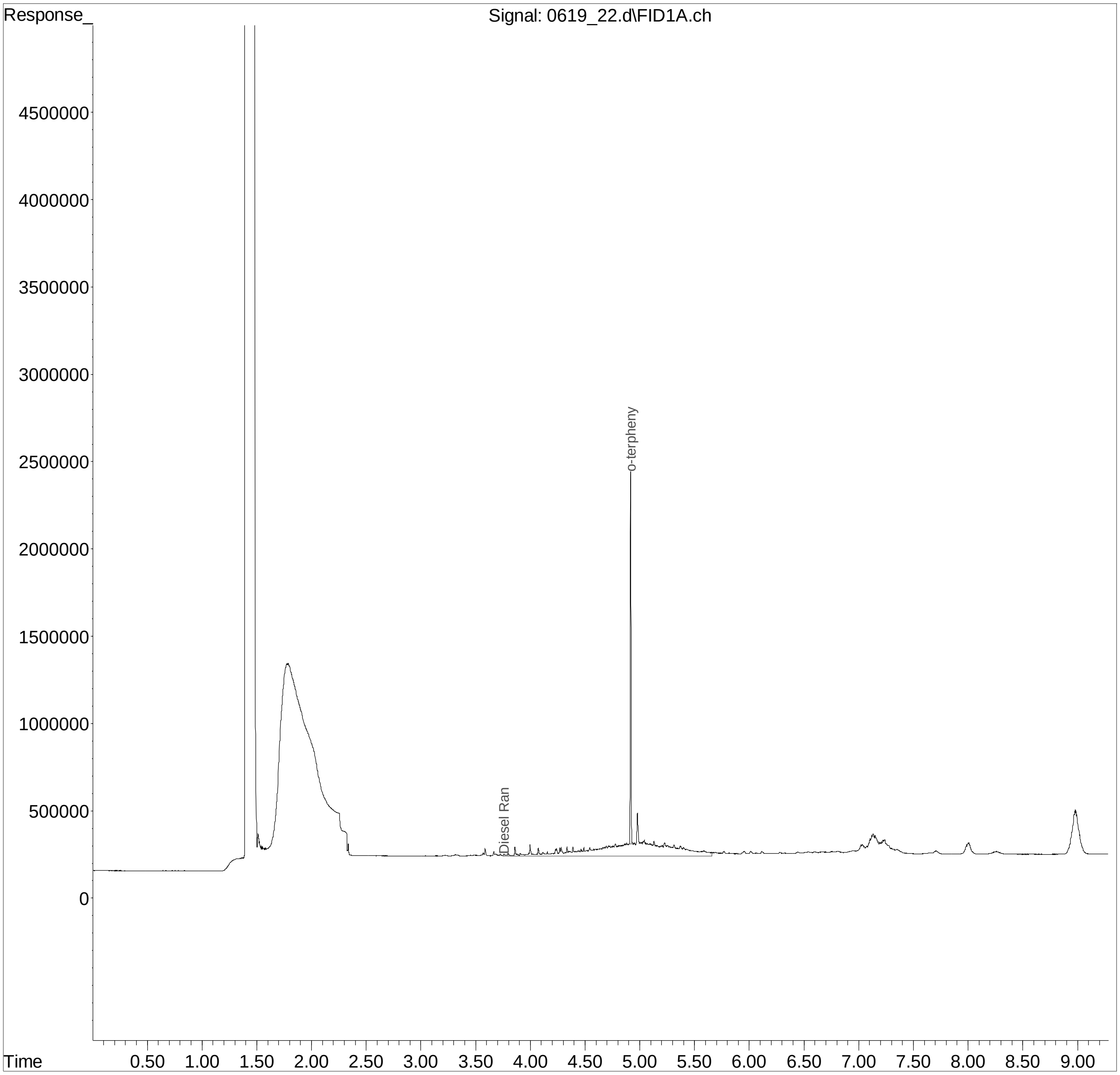


Quantitation Report   (QT Reviewed)

```
Data Path : C:\msdchem\1\data\061918\
Data File : 0619 22.d
Signal(s) : FID1A.ch
Acq On    : 19 Jun 2018   8:21 pm
Operator  : 773
Sample    : L1002145-04 1x WG1125905 41-2
Misc      : water M.I.s on ranges are corrections
ALS Vial  : 20   Sample Multiplier: 0.0488
InstName  : SVGC27

Integration File: events.e
Quant Time: Jun 19 23:26:51 2018
Quant Method : C:\msdchem\1\methods\EP27E29R.M
Quant Title  :
QLast Update : Tue May 29 16:19:46 2018
Response via : Initial Calibration
Integrator: ChemStation

Volume Inj.  :
Signal Phase :
Signal Info  :
DataAcq Meth:EPH27Z2.M
```

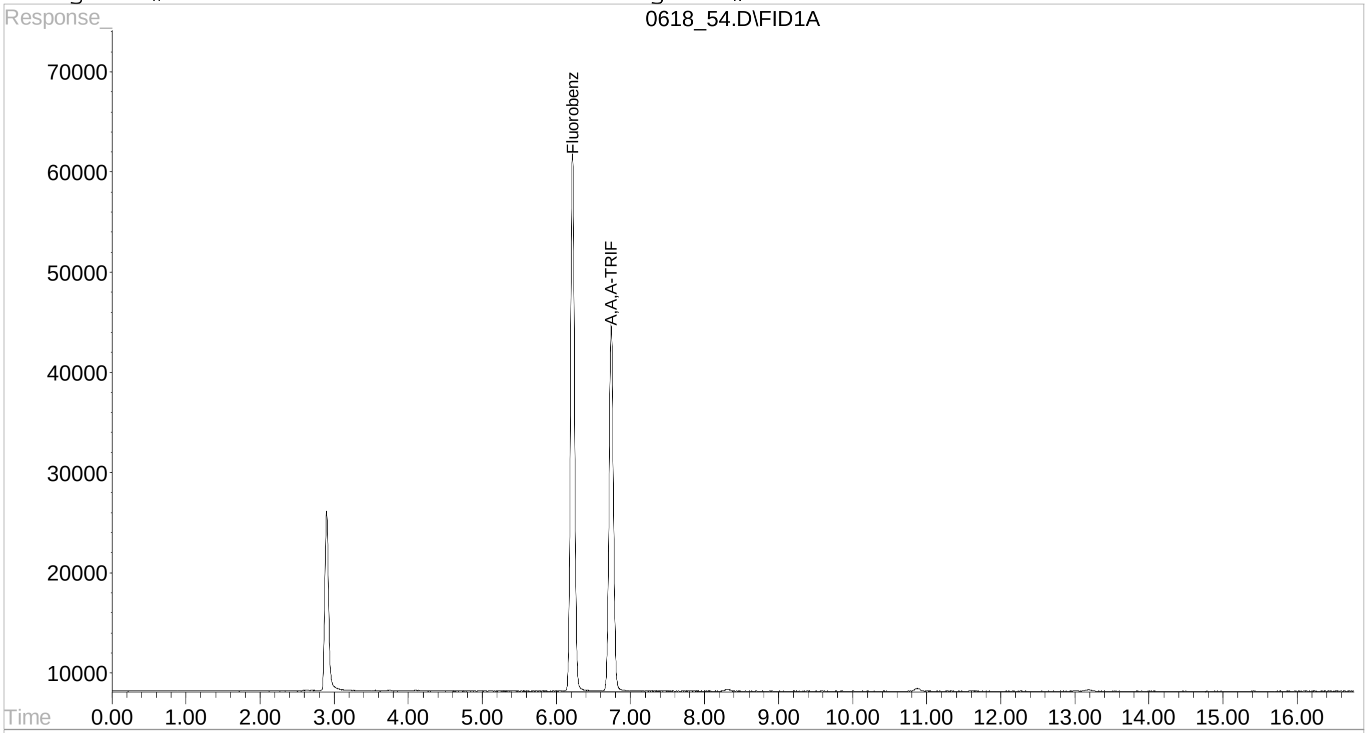


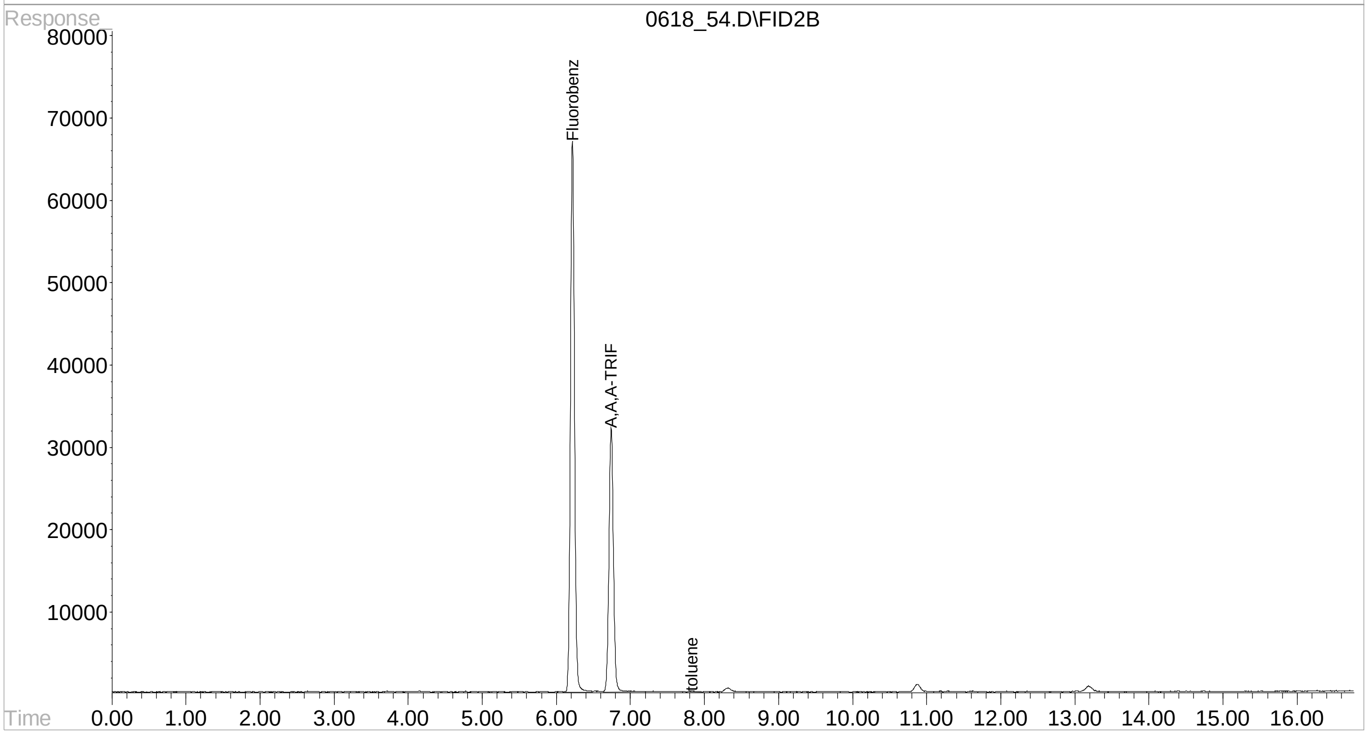
```
                                   Quantitation Report    (QT Reviewed)

Signal #1 : C:\HPCHEM\1\DATA\061818\0618 54.D\FID1A.CH   Vial: 52
Signal #2 : C:\HPCHEM\1\DATA\061818\0618 54.D\FID2B.CH
Acq On    : 19 Jun 2018  11:32 am                      Operator: 605
Sample    : L1002145-04 1x WG1126367                   Inst    : VOCGC1
Misc      : SOIL                                       Multiplr: 1.00
IntFile Signal #1: BTEX.E       IntFile Signal #2: EVENTS3.E
Quant Time: Jun 20  7:39 2018  Quant Results File: BG01K16Q.RES

Quant Method : C:\HPCHEM\1\METHODS\BG01K16Q.M (Chemstation Integrator)
Title        : WIS GRO VOCGC01
Last Update  : Fri Nov 17 09:32:59 2017
Response via : Single Level Calibration
DataAcq Meth : GC1BG.M

Volume Inj.     :
Signal #1 Phase :                   Signal #2 Phase:
Signal #1 Info  :                   Signal #2 Info :
```



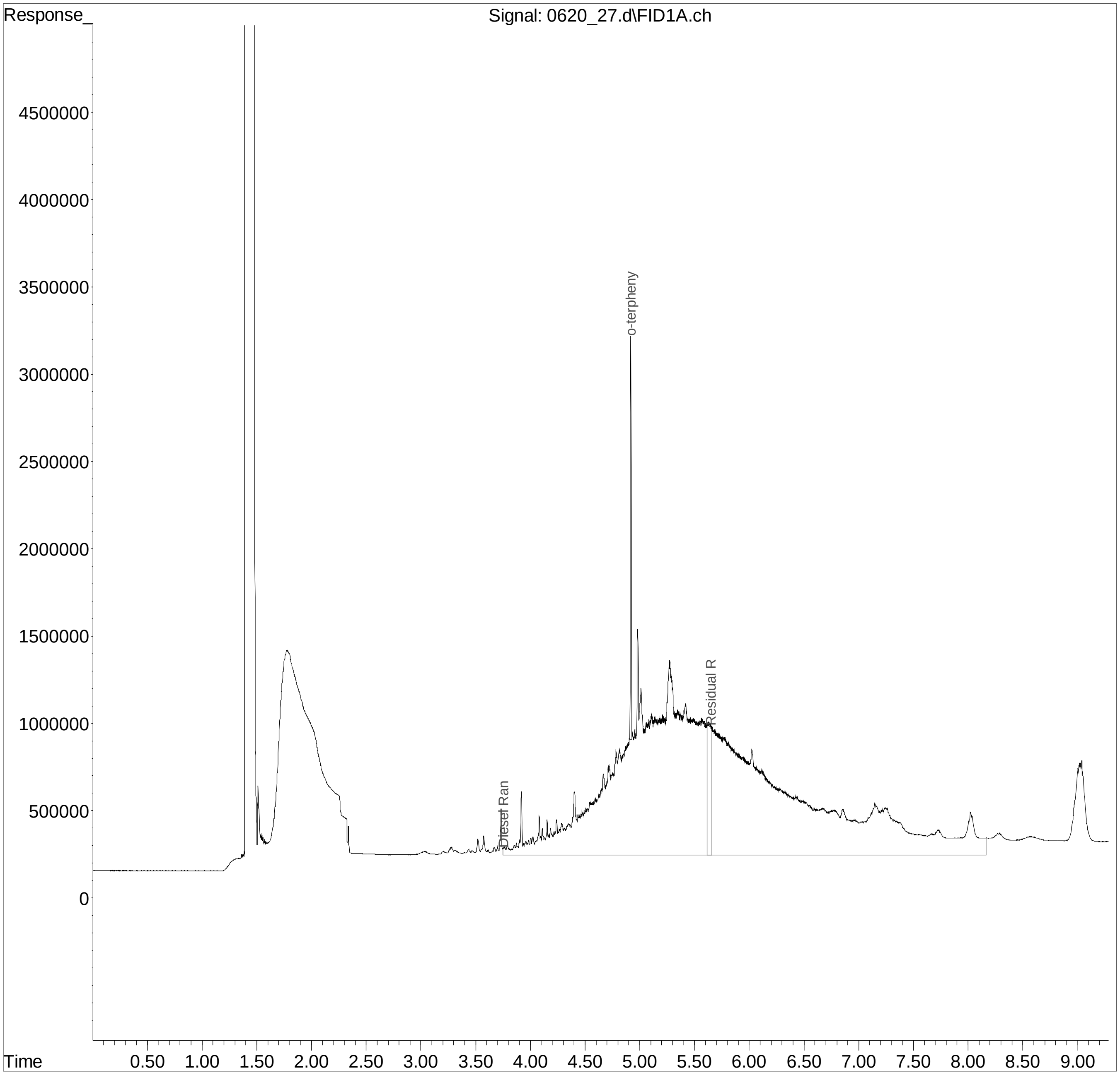


Quantitation Report   (QT Reviewed)

```
Data Path : C:\msdchem\1\data\062018\
Data File : 0620 27.d
Signal(s) : FID1A.ch
Acq On    : 20 Jun 2018   9:06 pm
Operator  : 773
Sample    : L1002145-05 1x WG1125904 40-2
Misc      : water M.I.s on ranges are corrections
ALS Vial  : 18   Sample Multiplier: 0.05
InstName  : SVGC27

Integration File: events.e
Quant Time: Jun 21 12:17:39 2018
Quant Method : C:\msdchem\1\methods\EP27E29R.M
Quant Title  :
QLast Update : Tue May 29 16:19:46 2018
Response via : Initial Calibration
Integrator: ChemStation

Volume Inj.  :
Signal Phase :
Signal Info  :
DataAcq Meth:EPH27Z2.M
```

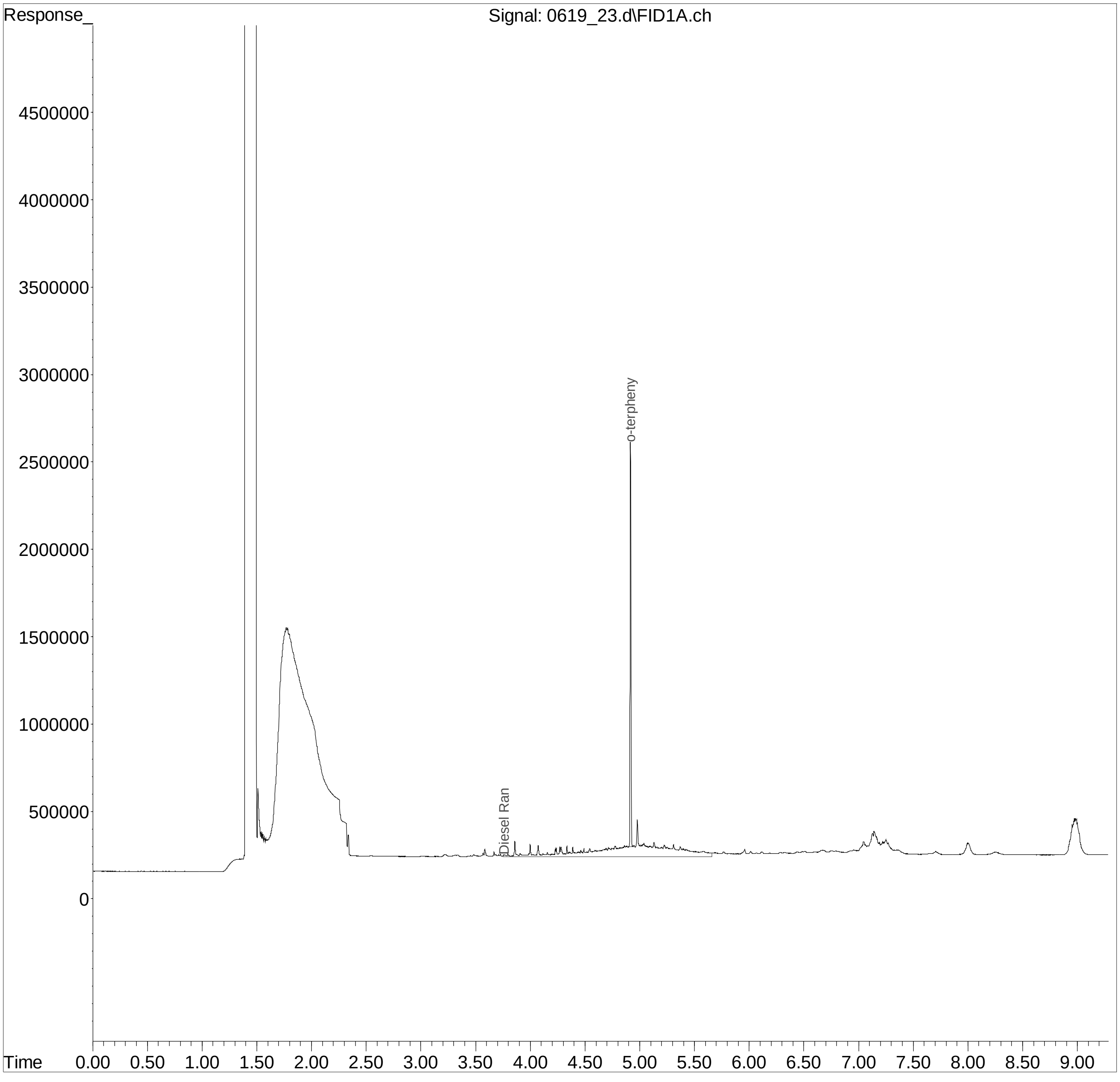


Quantitation Report (QT Reviewed)

```
Data Path : C:\msdchem\1\data\061918\
Data File : 0619 23.d
Signal(s) : FID1A.ch
Acq On    : 19 Jun 2018   8:40 pm
Operator  : 773
Sample    : L1002145-05 1x WG1125905 41-2
Misc      : water M.I.s on ranges are corrections
ALS Vial  : 21   Sample Multiplier: 0.0488
InstName  : SVGC27

Integration File: events.e
Quant Time: Jun 19 23:27:31 2018
Quant Method : C:\msdchem\1\methods\EP27E29R.M
Quant Title  :
QLast Update : Tue May 29 16:19:46 2018
Response via : Initial Calibration
Integrator: ChemStation

Volume Inj.  :
Signal Phase :
Signal Info  :
DataAcq Meth:EPH27Z2.M
```

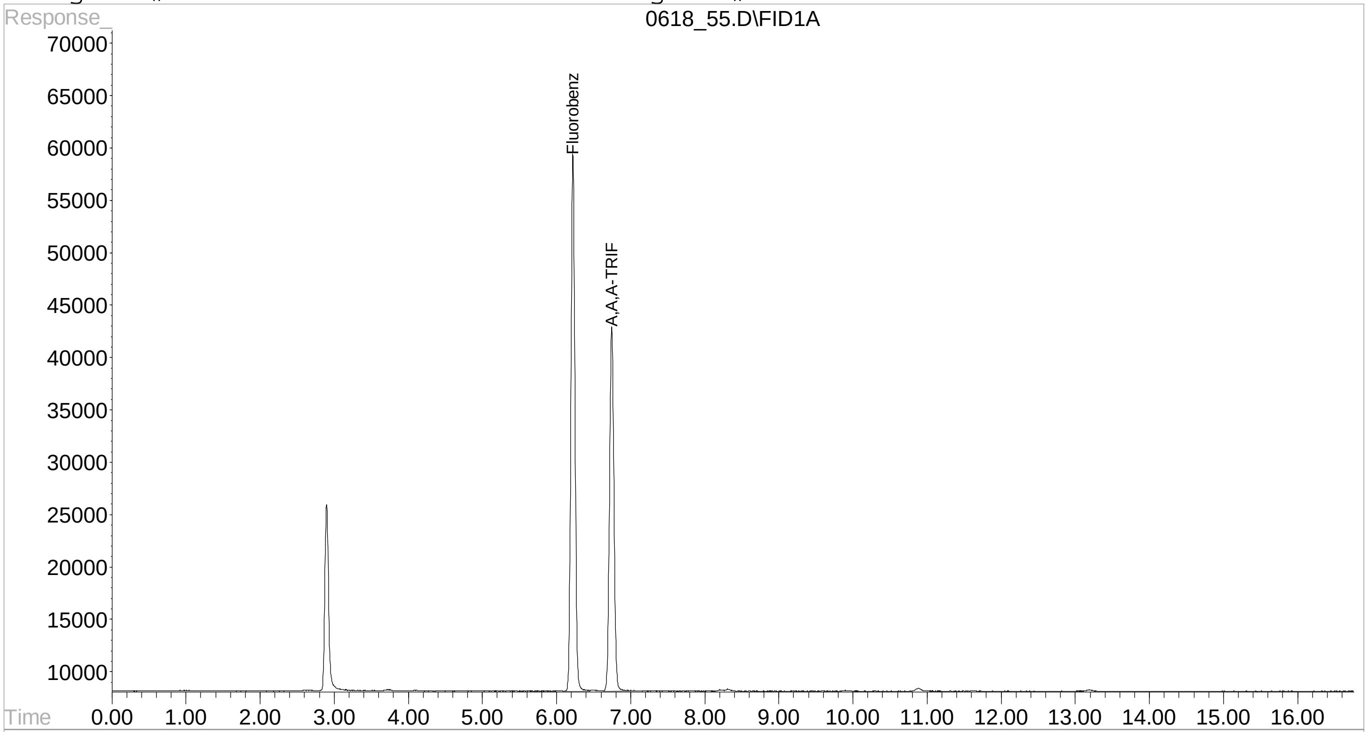


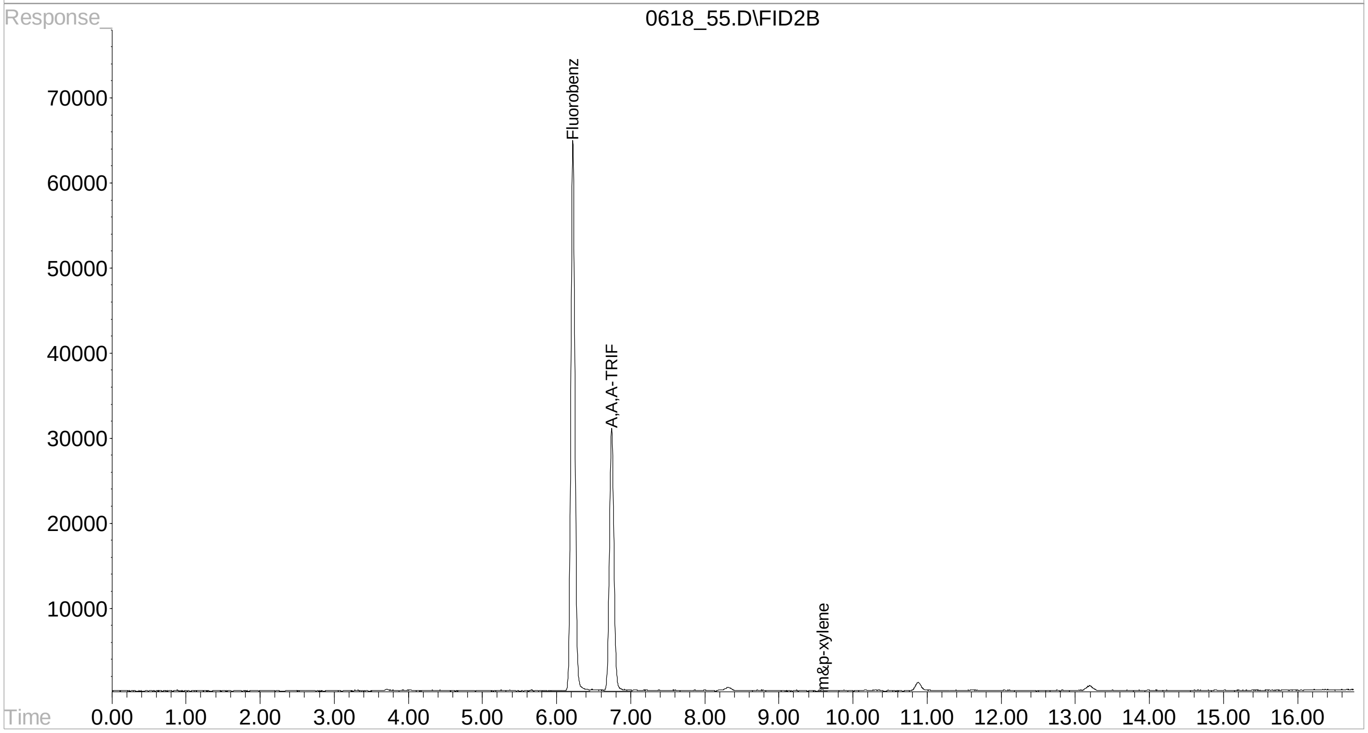
```
                                  Quantitation Report    (QT Reviewed)

Signal #1 : C:\HPCHEM\1\DATA\061818\0618 55.D\FID1A.CH   Vial: 53
Signal #2 : C:\HPCHEM\1\DATA\061818\0618 55.D\FID2B.CH
Acq On    : 19 Jun 2018  11:54 am                      Operator: 605
Sample    : L1002145-05 1x WG1126367                   Inst    : VOCGC1
Misc      : SOIL                                       Multiplr: 1.00
IntFile Signal #1: BTEX.E       IntFile Signal #2: EVENTS3.E
Quant Time: Jun 20  7:39 2018  Quant Results File: BG01K16Q.RES

Quant Method : C:\HPCHEM\1\METHODS\BG01K16Q.M (Chemstation Integrator)
Title        : WIS GRO VOCGC01
Last Update  : Fri Nov 17 09:32:59 2017
Response via : Single Level Calibration
DataAcq Meth : GC1BG.M

Volume Inj.     :
Signal #1 Phase :                      Signal #2 Phase:
Signal #1 Info  :                      Signal #2 Info :
```



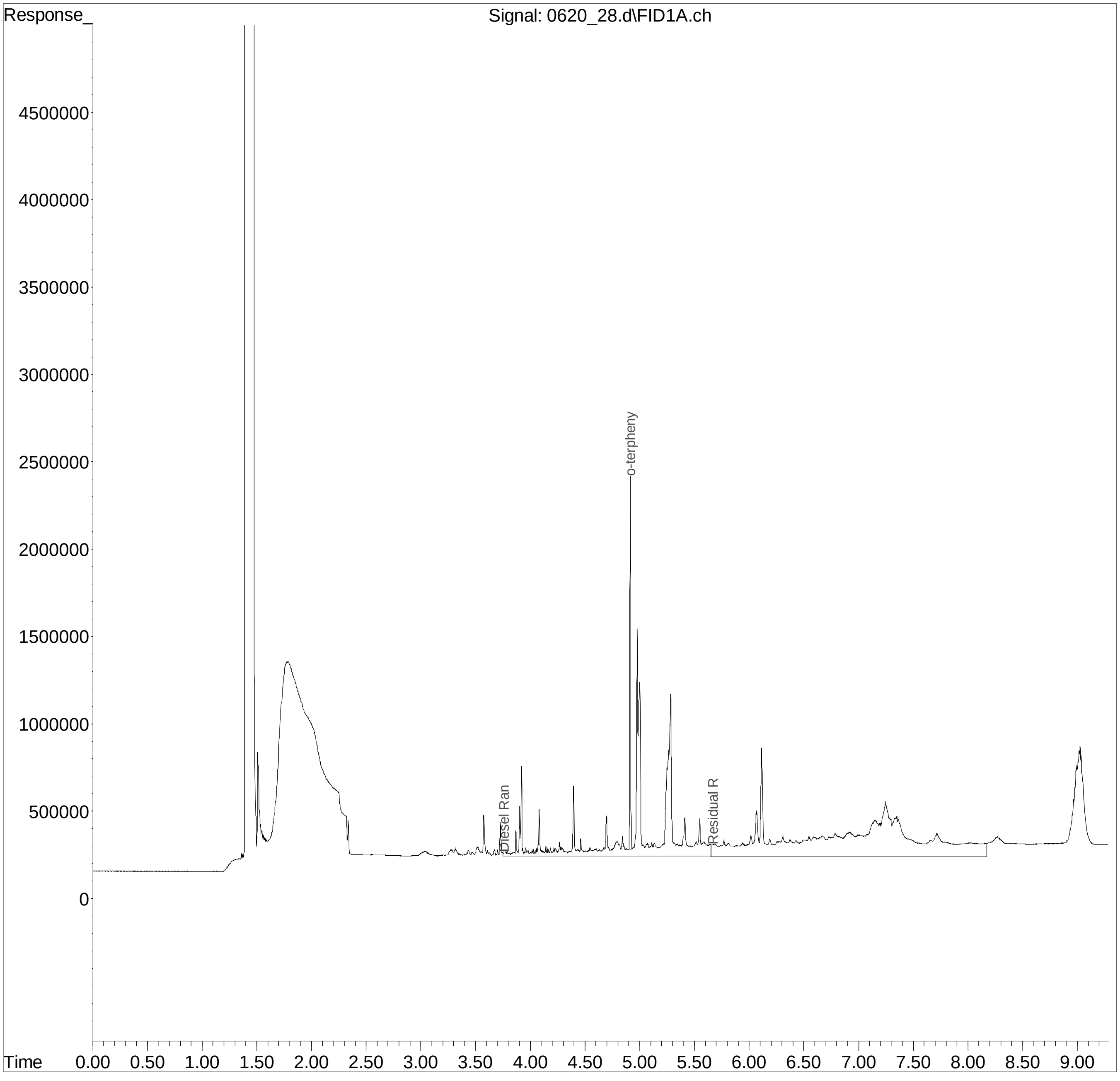


Quantitation Report (QT Reviewed)

```
Data Path : C:\msdchem\1\data\062018\
Data File : 0620 28.d
Signal(s) : FID1A.ch
Acq On    : 20 Jun 2018   9:26 pm
Operator  : 773
Sample    : L1002145-06 1x WG1125904 40-2
Misc      : water M.I.s on ranges are corrections
ALS Vial  : 19   Sample Multiplier: 0.05
InstName  : SVGC27

Integration File: events.e
Quant Time: Jun 21 12:19:05 2018
Quant Method : C:\msdchem\1\methods\EP27E29R.M
Quant Title  :
QLast Update : Tue May 29 16:19:46 2018
Response via : Initial Calibration
Integrator: ChemStation

Volume Inj.  :
Signal Phase :
Signal Info  :
DataAcq Meth:EPH27Z2.M
```

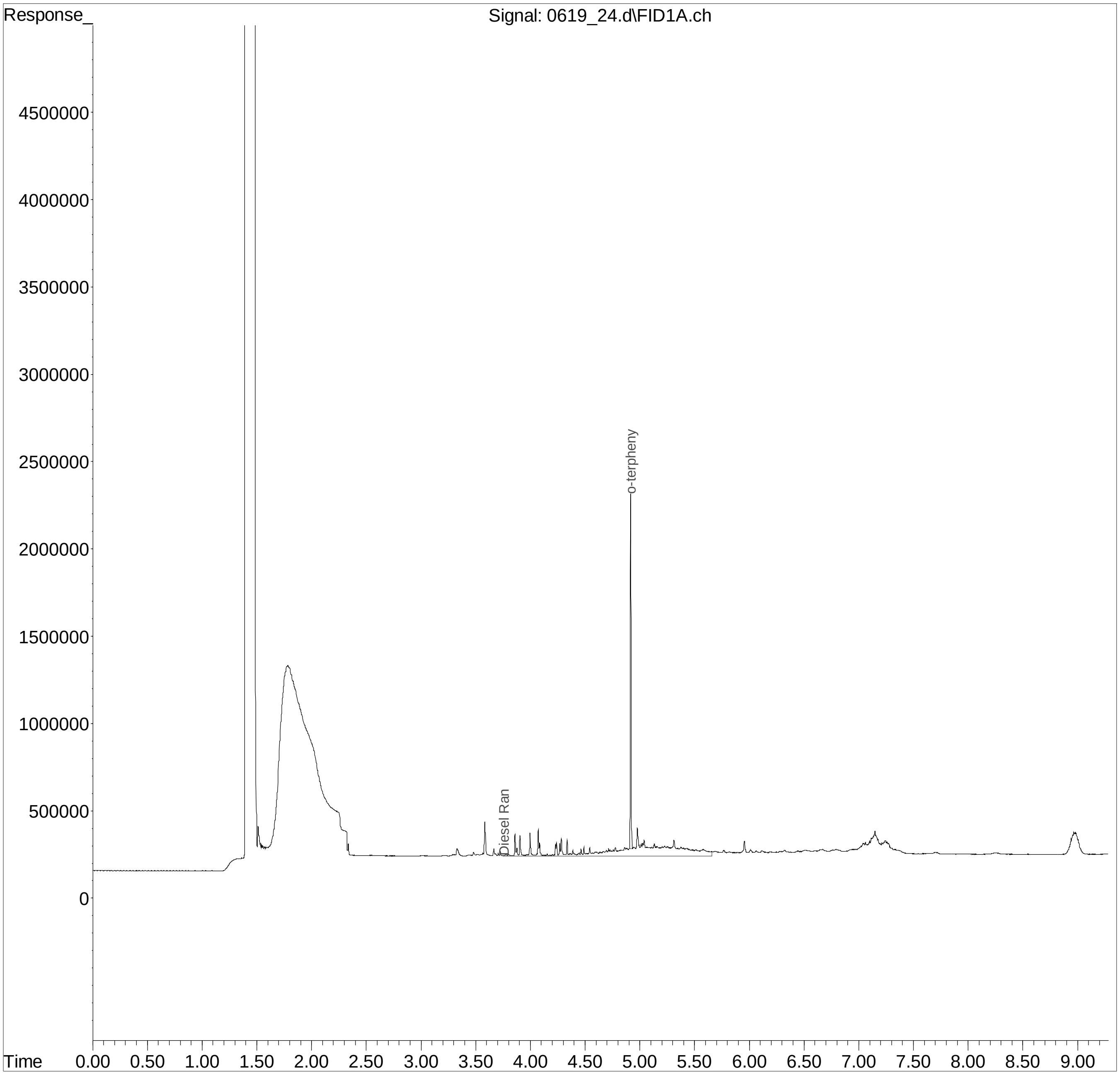


```
                              Quantitation Report    (QT Reviewed)

Data Path : C:\msdchem\1\data\061918\
Data File : 0619 24.d
Signal(s) : FID1A.ch
Acq On    : 19 Jun 2018   9:00 pm
Operator  : 773
Sample    : L1002145-06 1x WG1125905 40-2
Misc      : water M.I.s on ranges are corrections
ALS Vial  : 22   Sample Multiplier: 0.05
InstName  : SVGC27

Integration File: events.e
Quant Time: Jun 19 23:28:11 2018
Quant Method : C:\msdchem\1\methods\EP27E29R.M
Quant Title  :
QLast Update : Tue May 29 16:19:46 2018
Response via : Initial Calibration
Integrator: ChemStation

Volume Inj.  :
Signal Phase :
Signal Info  :
DataAcq Meth:EPH27Z2.M
```

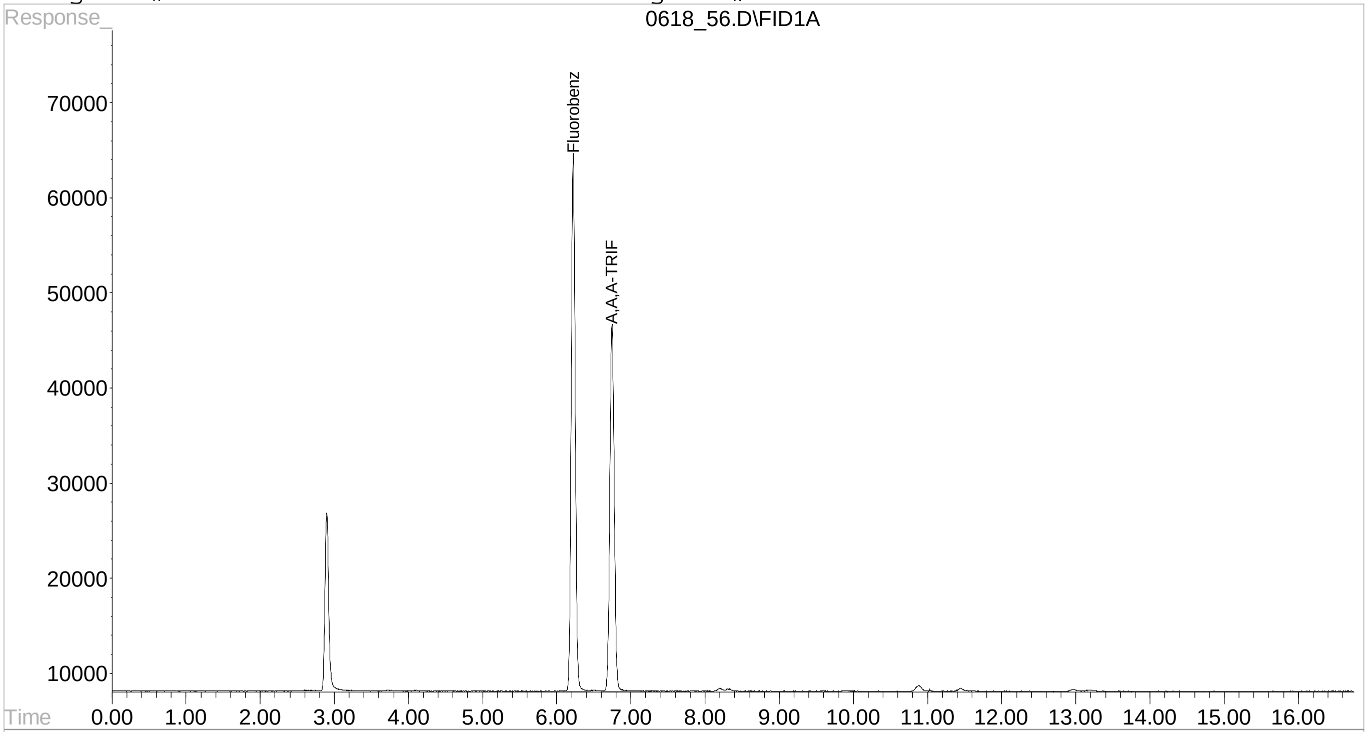


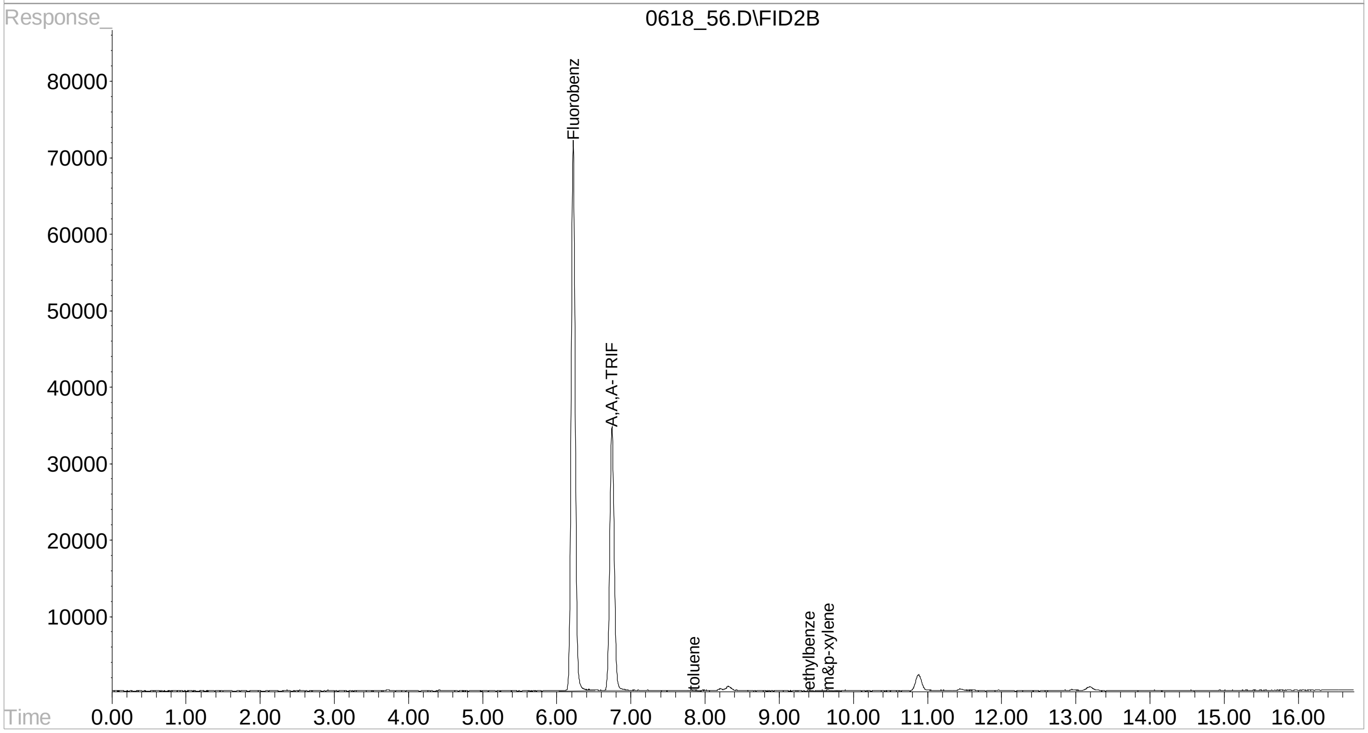
```
                                         Quantitation Report    (QT Reviewed)

  Signal #1 : C:\HPCHEM\1\DATA\061818\0618 56.D\FID1A.CH   Vial: 54
  Signal #2 : C:\HPCHEM\1\DATA\061818\0618 56.D\FID2B.CH
  Acq On    : 19 Jun 2018  12:16 pm                      Operator: 605
  Sample    : L1002145-06 1x WG1126367                   Inst    : VOCGC1
  Misc      : SOIL                                       Multiplr: 1.00
  IntFile Signal #1: BTEX.E       IntFile Signal #2: EVENTS3.E
  Quant Time: Jun 20  7:39 2018  Quant Results File: BG01K16Q.RES

  Quant Method : C:\HPCHEM\1\METHODS\BG01K16Q.M (Chemstation Integrator)
  Title        : WIS GRO VOCGC01
  Last Update  : Fri Nov 17 09:32:59 2017
  Response via : Single Level Calibration
  DataAcq Meth : GC1BG.M

  Volume Inj.     :
  Signal #1 Phase :                   Signal #2 Phase:
  Signal #1 Info  :                   Signal #2 Info :
```





APPENDIX C

CAP INSPECTION

Cap Inspection Log

BNSF Glacier Park East Site
Leavenworth, Washington

Inspection Date: June 13, 2018
Inspected by: K. Newman, TRC

Inspection Area	Observations
1. Asphalt Concrete Pavement	
a. Presence of cracks greater than 1/8" wide	-NOTE: Large cracks were sealed by a professional asphalt contractor on June 13, 2018. -Along the western edge, northern edge, southern edge, southern corner, and northeastern corner up to ~0.25" wide, 6-15" long, and up to 0.25" deep (Photos #1-4, 10-12). -Along the northern edge ~0.75" wide, 9' long, and 0.25" deep (Photo #5). -One crack running north-south from MW-2 northward is up to 0.75" wide, 85' long, and up to 0.25" deep (Photo #8-9).
b. Sub-base material exposed	Sub-base exposed in the northeast corner (Photo #3). Deeper cracks near the northeast corner and cap edge by steps down to MW-1 are at least 0.5" deep and nearly exposing sub-base material.
c. Pavement edge deterioration	Pavement edge deterioration along the northeastern corner and eastern cap edge.
d. General appearance	Good to fair.
2. Catch Basin	
a. Structural Condition/General Appearance	Good, no water flow through pipe.
b. Sediment Accumulation, approximate	Water in vault, unable to observe any sediment (Photo #6).
3. Grit Chamber	
a. Structural Condition/General Appearance	Good, no water flow into the chamber, approximately 6 inches of water in large corrugated pipe.
b. Sediment Accumulation, approximate	Water in grit chamber, unable to observe sediment.
4. Vault	
a. Structural Condition/General Appearance	Good, no water observed.
b. Sediment Accumulation, approximate	<0.5" sediment observed (Photo #7).

Appendix C
Cap Inspection Photograph Log

Photo 1: View looking south along western edge of cap, along slope break (post-crack fill).

Photo 2: View looking east along southern edge of cap (post-crack fill).

Photo 3: Subbase exposed in northeastern corner of cap (pre-crack fill).

Photo 4: View looking east toward northeastern corner of cap. Cracks developing and elongating as a result of root expansion (post-crack fill).

TRC Job No.	Photographs Taken By:	Page No.	Client:	Site Name & Address:
296562	K. Newman	1 of 3	BNSF Railway Company	Glacier Park East Site Leavenworth, WA

Appendix C
Cap Inspection Photograph Log

 Photo 5: View looking west of crack ~9 feet long along northern edge of cap (post-crack fill).	 Photo 6: View inside catch basin located on asphalt cap, water not observed to be flowing into the grit chamber.
 Photo 7: View inside vault.	 Photo 8: North-South trending crack in cap approximately 85 feet in length (pre-crack fill).

Appendix C
Cap Inspection Photograph Log

Photo 9: North-South trending crack in cap approximately 85 feet in length (post-crack fill).

Photo 10: View looking northeast in northeast corner of cap (pre-crack fill).

Photo 11: View looking northeast in northeast corner of cap (post-crack fill).

Photo 12: View looking east in towards slope in northeast corner of cap (post-crack fill).