COMPLIANCE MONITORING AND CONTINGENCY RESPONSE PLAN

Parcel 15 (Portac) Cleanup Phase 1

Prepared for: Port of Tacoma

Project No. 210158 • June 10, 2022   FINAL

earth + water

Aspect CONSULTING

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Aspect Consulting, LLC

6/10/2022

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Acronyms

Aspect	Aspect Consulting, LLC
CAP	Cleanup Action Plan
CMCRP	Compliance Monitoring and Contingency Response Plan
CUL	Cleanup Level
Ecology	Washington State Department of Ecology
EDR	Engineering Design Report
LEL	lower explosive limit
mg/kg	milligrams/kilograms
mg/L	milligrams per liter
µg/L	micrograms per liter
MLLW	mean lower low water
MTCA	Model Toxics Control Act
PCP	pentachlorophenol
POC	point of compliance
PQL	practical quantitation limit
PRB	permeable reactive barrier
QAPP	Quality Assurance Project Plan
REL	remediation levels
SAP	Sampling Analysis Plan
WAC	Washington Administrative Code

1 Introduction

Aspect Consulting, LLC (Aspect) has prepared this Compliance Monitoring and Contingency Response Plan (CMCRP) on behalf of the Port of Tacoma (Port) for implementation of the Cleanup Action Plan (CAP; Ecology, 2021) at the Parcel 15 (Portac) property (Site). The Port entered Agreed Order No. DE 15816 (Agreed Order) with the Washington State Department of Ecology (Ecology) on June 23, 2021, to implement the Phase 1 Cleanup activities.

This CMCRP is required by the Agreed Order to outline the environmental compliance monitoring program to document that cleanup standards are met and determine whether contingent remedial actions must be implemented. This CMCRP is prepared in accordance with the Washington State Model Toxics Control Act (MTCA) compliance monitoring requirements in Washington Administrative Code (WAC) 173-340-410.

1.1 Organization

The CMCRP is organized in the following sections:

- **Section 2** summarizes the cleanup actions, contaminants of concern, and cleanup standards defined in the CAP.
- **Section 3** presents estimated restoration time frames to achieve the groundwater cleanup level (CUL) for arsenic downgradient of the permeable reactive barrier (PRB) as a basis of groundwater compliance monitoring.
- **Section 4** defines the stormwater outfall monitoring and groundwater monitoring that comprise the compliance monitoring plan for the Site.
- **Section 5** outlines the potential contingent remedial actions and the evaluation of compliance monitoring results to determine whether they are necessary.

A Sampling and Analysis Plan (SAP) and Quality Assurance Project Plan (QAPP) for the compliance monitoring plan is included as Appendix A. A backup estimate of groundwater restoration time frame is included as Appendix B.

2 Cleanup Action Plan

The Site is located at 4215 State Route 509 – North Frontage Road in an industrial area between Interstate 5 and Commencement Bay in Tacoma, Washington, and is shown relative to surrounding physical features on Figure 1. The Site consists of two historical use areas: the former sawmill area (Sawmill) in the southwestern portion of the property, and the former log yard area (Log Yard) occupying the majority of the Site. The Site, Sawmill, and Log Yard areas are shown on Figure 2.

2.1 Cleanup Actions

The CAP will be implemented in two phases. The Phase 1 Cleanup-constructed elements are stormwater conveyance system improvements and a permeable reactive barrier (PRB). The stormwater conveyance system improvements will prevent Site groundwater from entering two stormwater pipes discharging to Wapato Creek. The stormwater conveyance system improvements are solids removal from pipes, trenchless pipe repair, stormwater vault replacement, and outfall upgrades. The PRB will intercept Site groundwater and immobilize arsenic from groundwater discharging to Wapato Creek. The PRB will be 664 linear feet (ft) long oriented perpendicular to groundwater flow and be fully penetrating by keying into a continuous clay unit at approximately 23 ft deep. The PRB will be 2 ft thick and backfilled with 20 percent zero-valent iron (ZVI) and constructed using conventional excavation and biopolymer slurry methods. The engineering design and criteria of the Phase 1 Cleanup is in the Engineering Design Report (EDR; Aspect, 2022).

The second phase of cleanup will be implemented concurrent with a future development of the Site under an Agreed Order Amendment or Consent Decree.

2.2 Contaminants of Concern

The Site contaminants of concern (COCs) are arsenic in the Log Yard and pentachlorophenol (PCP) in the Sawmill. Methane gas is identified as a Site-associated contaminant in the Log Yard and portions of the Sawmill that will be managed through institutional controls (ICs).

2.3 Cleanup Standards

The CAP established cleanup standards for the Site consisting of CULs, points of compliance (POC), and remediation levels (RELs).

2.3.1 Cleanup Levels

The CULs for each medium are selected as the most stringent of the MTCA levels or applicable or relevant and appropriate requirement (ARAR) concentrations, unless the natural background concentration is higher than that criterion.

2.3.1.1 Soil

The most-stringent screening level for soil was selected as the CUL for the two Site COCs, as follows:

- **Arsenic CUL = 20 milligrams per kilogram (mg/kg)**, based on the MTCA Method A for unrestricted land use and industrial use.
- **PCP CUL = 328 mg/kg**, based on the MTCA Method C cancer screening value.

2.3.1.2 Groundwater and Surface Water

Groundwater at the Site is non-potable, and current and future Site use will be industrial. The highest beneficial use of Site groundwater is discharge to marine waters. The Site groundwater CULs are protective of surface water, as follows

- **Arsenic CUL = 5 µg/L**, based on the MTCA Method A groundwater cleanup level, which is based on the natural background level of arsenic in groundwater[1].
- **PCP CUL = 1 µg/L**, based on the practical quantitation limit (PQL).

2.3.1.3 Air

Methane gas in soil at the Site poses a potential risk for indoor air quality for potential future use scenarios at the Site. The MTCA Air Quality Guidance (WAC 173-340) sets a standard of 10 percent of the lower explosive limit (LEL) for all volatile organic compounds (VOCs). Therefore, the CUL for methane in air at the Site is:

- **Methane CUL = 0.5 percent by volume**, based on an LEL of 5 percent by volume.

2.3.2 Points of Compliance

POCs are the locations within the Site where the cleanup levels must be met.

2.3.2.1 Soil POC

Soil CULs for the Site in both the Log Yard and Sawmill are the standard POC in MTCA - between 0 and 15 ft below ground surface throughout the Site. Soil sampling is not anticipated during CAP implementation, unless for contaminated soil management during activities that disturb the cap and disturb contaminated soils (e.g., cap maintenance or future Site redevelopment).

2.3.2.2 PCP in Groundwater POC

A standard POC for groundwater will be applied to PCP in the Sawmill. PCP consistently exceeds the CUL at MW-2R, which is located in the former dip tank excavation. Groundwater compliance monitoring will be conducted at MW-2R until PCP CULs cleanup levels are achieved.

2.3.2.3 Arsenic in Groundwater and Surface Water POC

The CAP includes a Log Yard conditional POC located along the eastern shoreline of Wapato Creek and as close as practicable downgradient from the source areas and before discharge to surface water, in accordance with WAC 173-340-720(8)(c). The existing monitoring wells MW-7, MW-9, and MW-12 do not fully intercept the groundwater

[1] The *Natural Background Groundwater Arsenic Concentrations in Washington State* published by Ecology in January 2022 (Publication 14-09-044) concluded the current standard of 5 µg/L is at the low end of the statewide natural background range (4.9–14.6 µg/L) and recommended the study results be considered when revising the groundwater cleanup levels for arsenic.

treated by the PRB. Three new monitoring wells MW-15, MW-17 and MW-19 will be installed closer to the PRB and completed to fully intercept the groundwater transport pathway to Wapato Creek. These new monitoring wells will be the groundwater POC monitoring wells for arsenic at the Site.

Compliance with the surface water CUL will be measured at Log Yard stormwater outfalls OF-2 and OF-3. The stormwater conveyance system improvements will prevent Site groundwater from entering two stormwater pipes, which discharge to Wapato Creek at outfalls OF-2 and OF-3. Therefore, OF-2 and OF-3 are also groundwater conditional POC locations for surface water protection.

2.3.3 Remediation Levels

The groundwater compliance monitoring for the Log Yard includes groundwater RELs for arsenic to determine if contingent remedial actions are necessary. The PRB is expected to control and ultimately reduce arsenic concentrations in groundwater at the conditional POC wells.

As defined in the CAP, a REL exceedance is a sustained stable or increasing trend in groundwater arsenic concentration downgradient of the PRB. Groundwater compliance monitoring results from the three groundwater POC monitoring wells, MW-15, MW-17 and MW-19 will determine compliance with the groundwater REL.

The groundwater compliance monitoring and methods for evaluating compliance with RELs is discussed in Section 4.

3 Groundwater Restoration Time Frame

The Feasibility Study concluded that no remedial alternatives could achieve the groundwater CUL for arsenic at a standard POC (GSI, 2018b; GSI, 2019). Therefore, a conditional POC was established for evaluating compliance with the groundwater CUL for arsenic. Now that the remedial design is complete, the estimated time frame to achieve CULs at the conditional POC monitoring wells was estimated as a basis of PRB performance expectations and monitoring (Section 4), and a temporal basis of contingent remedial actions (Section 5).

The time frame to achieve the groundwater CUL for approximately 25 ft downgradient, was estimated using two different methods: 1) one-dimensional (1D) reactive transport modeling, and 2) a batch flushing model.

The 1D reactive transport modeling was conducted as part of the geochemical evaluation task of treatability testing. The 1D reactive transport modeling simulated groundwater transport along a flow path where the water can react with soils over a defined distance. Using the average Darcy flux of 0.05 ft/day, the time to reach the groundwater CUL 25 ft downgradient of the PRB is 25 to 30 years, depending on the ferrihydrite concentration in the soil. The methods and all input parameters of the 1D reactive transport modeling are included in the Treatability Testing Report (Appendix B of EDR).

A second method to assess the restoration time frame used a mixed linear reservoir or “batch flush” model to estimate the number of groundwater pore volumes that must be flushed through a volume of aquifer to meet the CUL. The batch flush model assumes a linear partitioning of a contaminant from aquifer solids to groundwater (Zheng and Bennett, 2002). Due to this assumption, this model is highly dependent on the partition coefficient (K_d) input. The average saturated soil concentration of 2.1 mg/kg and the average and maximum MW-14 groundwater concentrations of 68 and 126 μg/L were used to calculate two K_d values of 17 and 31 liters per kilogram. The estimated restoration time frame for a distance 25 ft downgradient of PRB is 38 and 70 years for arsenic K_d values of 17 and 31 L/kg, respectively (Appendix B).

To estimate restoration time frame at the groundwater POC locations, the restoration time frame for a pore flushing length of 10 ft was also estimated. The estimated restoration time frame for a distance 10 ft downgradient of PRB is 15 and 28 years for arsenic K_d values of 17 and 31 L/kg, respectively.

Neither of the models accounts for attenuation associated with tidal flushing or terminal electron acceptor processes at the groundwater interface with Wapato Creek. The estimates are also highly dependent on the uncertainty in Site-specific arsenic K_d.

These restoration time frame estimates establish PRB performance expectations and justify the groundwater POC locations approximately 10 ft downgradient of PRB to identify the need for potential contingency actions and achieve a more reasonable restoration time frame.

4 Compliance Monitoring Plan

The CAP requires implementation of a comprehensive monitoring plan to document that cleanup standards are met and determine whether contingent remedial actions must be implemented. The environmental compliance monitoring consists of stormwater outfall monitoring and groundwater monitoring. The compliance monitoring SAP, comprising the Field Sampling Plan (FSP) and QAPP, is included in Appendix A. All compliance monitoring results will be reported to Ecology in the Site Compliance Monitoring Report described in Section 6.

4.1 Stormwater Outfall Monitoring

Upon the completion of Phase 1 Cleanup construction, monitoring of stormwater outfalls OF-2 and OF-3 will be conducted to evaluate compliance with the surface water CUL of 5 µg/L arsenic (Figure 2). The stormwater outfall monitoring will be conducted when Wapato Creek elevation is below the stormwater pipe invert elevations defined when the tide elevation in the Sitcum Waterway is below 9 ft mean lower low water (MLLW)[2]. Samples collected from stormwater outfalls will be analyzed for total and dissolved arsenic.

Stormwater outfall monitoring will be conducted after Phase 1 Cleanup construction and once during the following dry season to confirm compliance with the surface water CUL of 5 µg/L arsenic. All stormwater outfall monitoring details are included in the SAP/QAPP in Appendix A. The anticipated schedule for stormwater outfall monitoring is included in Section 6.

4.2 Groundwater Monitoring

This section describes the groundwater compliance monitoring plan for the Site, which includes existing monitoring wells to be decommissioned and new monitoring wells to be installed at the onset of implementing groundwater compliance monitoring.

4.2.1 Monitoring Well Decommissioning

The Site monitoring well network and construction details are included in Table 1. Monitoring wells that do not serve a compliance monitoring objective will be decommissioned. The following existing monitoring wells will be decommissioned:

- **MW-1, MW-3, MW-4** in the former dip tank area in the Sawmill are all in compliance with groundwater CULs and are redundant with MW-2R for groundwater elevation monitoring.
- **MW-5R and MW-6R** in the Sawmill exhibit low-level concentrations of PCP. However, they are approximately 500 ft from Wapato Creek, which allows natural attenuation before discharge to Wapato Creek.

[2] The Commencement Bay, Sitcum Waterway, NOAA Station ID 9446484 will be referenced for tide elevations.

- **B-5R** in the Sawmill is downgradient of the PRB, is in compliance with groundwater CULs, and is not a POC location.

All monitoring wells will be decommissioned by a licensed driller in accordance with the requirements of WAC 173-160-460.

4.2.2 Monitoring Well Installation

Six new groundwater monitoring wells will be installed for groundwater monitoring (Figure 3). Three of these monitoring wells (MW-15, MW-17, and MW-19) will be installed approximately 10 ft downgradient of the PRB and serve as groundwater POC locations. Two locations (MW-16 and MW-18 will be installed upgradient of the PRB to monitor influent groundwater quality. One monitoring well, MW-20, will be installed at the northern Site boundary to expand the monitoring well in this area of the Site.

These new monitoring wells will establish three PRB performance monitoring transects comprising one upgradient monitoring well and one POC monitoring well located approximately 10 ft downgradient of the PRB (Figure 3).

The POC monitoring wells downgradient of the PRB will be screened discretely in the silty sand soils where the groundwater transport to Wapato Creek occurs. The well construction will utilize 5-ft screen lengths to discretely monitor this unit, which ranges in thickness from 5 to 7 ft. The estimated screen intervals are in Table 2.

One monitoring well, MW-20, will be installed at the northern Site boundary to expand the monitoring well network and interpretation of groundwater flow direction in this area of the Site. The estimated well construction details in Table 2 are based on the water level observed in Remedial Investigation temporary boring TB-1 (GSI, 2018a).

The proposed monitoring well locations are shown on Figure 3 and estimated well construction details are outlined in Table 2. All monitoring well installation details are included in the SAP/QAPP in Appendix A. All new monitoring wells will be constructed in accordance with WAC 173-160 by a licensed driller.

4.2.3 Log Yard Groundwater Compliance Monitoring

Upon the completion of Phase 1 Cleanup construction, semiannual groundwater monitoring of the six groundwater monitoring wells (two monitoring wells each at three PRB performance monitoring transects) will be conducted. The groundwater compliance monitoring will be conducted when tide elevation in the Sitcum Waterway is below 9 ft MLLW. The groundwater compliance will include analysis of total and dissolved arsenic, in addition to geochemical parameters of dissolved metals, ferrous iron, anions, alkalinity, and total organic carbon (TOC) to evaluate PRB performance (Table 3).

Groundwater compliance monitoring will be conducted at a semiannual frequency for 5 years after Phase 1 Cleanup construction (a total of 10 events). After 2 years, the groundwater compliance monitoring analysis will be revisited in the Annual Site Compliance Monitoring Report. It is anticipated that samples will only be analyzed for total and dissolved arsenic (no geochemical parameters), subject to Ecology approval.

The arsenic results from groundwater compliance monitoring will be analyzed to evaluate compliance with the groundwater REL and the need for any contingency actions discussed in Section 5. The evaluation of arsenic in groundwater concentrations will use the Mann-Kendall test to differentiate between increasing and decreasing trends and random water quality variation. This evaluation will be conducted after 5 years.

The new groundwater monitoring well MW-20 will be sampled semiannually for the first year and analyzed for total and dissolved arsenic. The results and recommendations to continue sampling MW-20 will be reported in the first Annual Site Compliance Monitoring Report, which will require Ecology approval.

The groundwater compliance monitoring results, and recommended changes to future monitoring will be outlined in the Annual Site Compliance Monitoring Report. All groundwater monitoring details are included in the SAP/QAPP in Appendix A. The anticipated schedule for the first 2 years of groundwater compliance monitoring and reporting is included in Section 6.

4.2.4 Sawmill Groundwater Compliance Monitoring

Groundwater monitoring of Sawmill location MW-2R will be conducted semiannually for PCP to monitor natural attenuation and confirm compliance with the groundwater CUL of 1 µg/L PCP. Sawmill groundwater monitoring will be conducted until four consecutive results confirm compliance with the groundwater CUL. All Site groundwater monitoring details are included in the SAP/QAPP in Appendix A. The anticipated schedule for Site groundwater monitoring is included in Section 6.

5 Contingent Remedial Actions

The CAP includes three potential contingency remedial actions. This section defines those potential contingent remedial actions and the evaluation of compliance monitoring results to determine whether they are necessary.

5.1 Contingent Conveyance System Improvements

Stormwater outfall monitoring will be conducted after Phase 1 Cleanup construction and once during the following dry season to confirm compliance with the surface water CUL of 5 µg/L arsenic. If the CUL is still exceeded, then contingent conveyance system improvements will be implemented.

The contingent conveyance system improvement will consist of trenchless pipe repair of the stormwater pipe upgradient of the section repaired during Phase 1 Cleanup construction. Before implementing this contingency, sampling of stormwater from the upstream pipe reach entering the stormwater vault may be conducted to verify the source of arsenic in the outfall is the upstream pipe reach.

5.2 Contingent Perched Groundwater Treatment

Groundwater compliance monitoring in the Log Yard will be conducted semiannually for 2 years, and annual monitoring thereafter. After 2 years, the trend analysis of arsenic concentrations from groundwater POC monitoring wells MW-15, MW-17, and MW-19, will be conducted to determine if there are any REL exceedances and assess the PRB performance. The evaluation of PRB performance monitoring results will evaluate the need for the contingent perched groundwater treatment beginning in year 5.

For existing monitoring wells MW-7, MW-9, and MW-12, the currently available eight arsenic results collected during the Remedial Investigation (GSI, 2018a) and PRDI activities are shown in time-series plots in Appendix C. There is significant variability in these results and the Mann Kendall test determined that no trends exist for the current results serving as a baseline to PRB construction. Consistency in tide elevation during groundwater compliance monitoring is intended to reduce variability and compliance monitoring results.

If the evaluation of Log Yard groundwater compliance monitoring indicates there is an REL exceedance in year 5, the first contingency action will be to evaluate the REL exceedance and assess if contingent actions should be taken for protection of the groundwater to surface water pathway. An evaluation report will be submitted to Ecology to document conclusions and recommend additional data collection and/or a contingent remedial action, if necessary.

The CAP defined a contingent groundwater collection and treatment system for perched groundwater to reduce the flux of arsenic toward the PRB. This contingency action would capture perched water with a French drain-type collection system. Perched water would be treated *in situ* (i.e., in collector vaults) and then re-infiltrated within the groundwater plume area at or upgradient of the PRB. The contingency evaluation report may identify and evaluate other potential contingent actions, if appropriate based on the groundwater compliance monitoring results.

5.3 Contingent Management of Soil Vapors

There is methane gas in soil within the Log Yard and portions of the Sawmill. The methane gas is associated with decomposition of wood waste present in the Log Yard area and natural organic matter deposits in Site soils. Under current land uses, no management controls are required. However, in the event that buildings or other enclosed structures are constructed at the Site, an evaluation will be needed to determine if the condition still exists and if so, to define soil gas management methods to prevent gas accumulation in the new structures.

The goal of soil gas management would be to prevent any potential explosions by limiting any exceedance of the 5 percent methane LEL in any buildings or enclosed structures. Potential preventative measures would include installation of a robust vapor barrier with venting during building construction to prevent methane vapor intrusion, and regular indoor air monitoring to confirm air quality standards are being met. The trigger of this contingency action will be the Port’s decision of a land use change; Ecology would be notified of this decision and the proposed contingency action plan at that time.

6 Reporting and Schedule

Compliance monitoring and evaluation of contingent remedial actions will be reported to Ecology in an Annual Site Compliance Monitoring Report. All compliance monitoring results will be uploaded to Ecology's Electronic Information Management (EIM) System by submittal of the Annual Site Compliance Monitoring Report. The estimated schedule of compliance monitoring for the two years after Phase 1 Cleanup construction is outlined in Table 4 below.

Table 4. Compliance Monitoring Schedule (Years 0 to 2)

Activity	Estimated Completion Date
Phase 1 Cleanup Construction	October, 2022
Monitoring Well Installation	October, 2022
Compliance Monitoring Event #1	November, 2022
Compliance Monitoring Event #2	May, 2023
Annual Compliance Monitoring Report #1	August, 2023
Compliance Monitoring Event #3	November, 2023
Compliance Monitoring Event #4	May, 2024
Annual Compliance Monitoring Report #2	August, 2024

7 References

Aspect Consulting, LLC (Aspect), 2021, Remedial Design Work Plan, Parcel 15 (Portac), Tacoma, Washington, December 9, 2021.

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Zheng C., Bennett G., 2002, Applied Contaminant Transport Modeling, 2nd Edition.

8 Limitations

Work for this project was performed for the Port of Tacoma (Client), and this report was prepared in accordance with generally accepted professional practices for the nature and conditions of work completed in the same or similar localities, at the time the work was performed. This report does not represent a legal opinion. No other warranty, expressed or implied, is made.

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TABLES

Table 1. Site Groundwater Monitoring Well Network

Project No. 210158, Port of Tacoma Parcel 15, Tacoma, Washington

Well ID	Location	Well Type	Date Drilled	Casing Diameter (inches)	Casing Material	Total Depth of Boring (ft bgs)	Screen Length (ft)	Top of Screen (ft bgs)	Bottom of Screen (ft bgs)
HC-1	Log Yard	Monitoring Well	8/30/1989	2	Sch 40 PVC	7.8	1	5	6
HC-2	Log Yard	Monitoring Well	8/30/1989	2	Sch 40 PVC	10.5	5	4	9
B-1R	Log Yard	Monitoring Well	8/30/1989	2	Sch 40 PVC	19	5	12	17
B-3R	Log Yard	Monitoring Well	8/31/1989	2	Sch 40 PVC	16	5	11	16
B-5R	Sawmill	Monitoring Well	8/30/1989	2	Sch 40 PVC	17	5	11	16
B-6R	Log Yard	Monitoring Well	8/31/1989	2	Sch 40 PVC	16.5	5	11	16
MW-1	Sawmill	Monitoring Well	4/30/2008	2	Sch 40 PVC	15	10	5	15
MW-2R	Sawmill	Monitoring Well	4/22/2009	2	Sch 40 PVC	16.5	10	5	15
MW-3	Sawmill	Monitoring Well	9/8/2008	2	Sch 40 PVC	15	10	5	15
MW-4	Sawmill	Monitoring Well	9/8/2008	2	Sch 40 PVC	15	10	5	15
MW-5R	Sawmill	Monitoring Well	Unknown	2	Sch 40 PVC	15	10	5	15
MW-6R	Sawmill	Monitoring Well	4/22/2009	2	Sch 40 PVC	16.5	9	5	14
NLR-PORTAC-16	Log Yard	Piezometer	1/16/2014	0.75	Sch 40 PVC	20	2.5	12	14.5
NLR-PORTAC-17	Log Yard	Piezometer	1/16/2014	0.75	Sch 40 PVC	20	2.5	15.3	17.8
NLR-PORTAC-18	Log Yard	Piezometer	1/16/2014	0.75	Sch 40 PVC	20	2.5	15	17.5
MW-7	Log Yard	Monitoring Well	5/11/2016	2	Sch 40 PVC	15	10	5	15
MW-8	Log Yard	Monitoring Well	5/9/2016	2	Sch 40 PVC	16	10	6	16
MW-9	Log Yard	Monitoring Well	5/11/2016	2	Sch 40 PVC	15	10	5	15
MW-10	Log Yard	Monitoring Well	5/11/2016	2	Sch 40 PVC	20	10	7	17
MW-11	Log Yard	Monitoring Well	5/11/2016	2	Sch 40 PVC	20	10	7	17
MW-12	Log Yard	Monitoring Well	5/12/2016	2	Sch 40 PVC	15	10	5	15
MW-13	Log Yard	Monitoring Well	5/10/2016	2	Sch 40 PVC	20	10	7	17
MW-14	Log Yard	Monitoring Well	11/16/2021	2	Sch 40 PVC	25	10	15	25

Notes:

ft bgs - feet below ground surface

Monitoring Well has no compliance monitoring objective and will be decommissioned.

Table 2. New Monitoring Well Construction Details

Project No. 210158, Port of Tacoma Parcel 15, Tacoma, Washington

Well ID	Location	Sub-Location	Screen Length (ft)	Bottom of PRB (ft MLLW)	Estimated Bottom of Screen (ft MLLW)	Estimated Top of Screen (ft MLLW)
MW-15	PRB Monitoring Transect #1	~10' downgradient of PRB	5	4.5	4	9
MW-16	PRB Monitoring Transect #2	~5' upgradient of PRB	10	3.4	4	14
MW-17		~10' downgradient of PRB	5		4	9
MW-18	PRB Monitoring Transect #3	~5' upgradient of PRB	10	3.2	4	14
MW-19		~10' downgradient of PRB	5		4	9
MW-20	North Site boundary	--	10	--	5	15

Notes:

ft bgs - feet below ground surface

Table 3. Compliance Monitoring Program

Project No. 210158, Port of Tacoma Parcel 15, Tacoma, Washington

Location ID	Area	Site COCs		Geochemical Parameters[4]				
		PCP	Arsenic[1]	Dissolved Metals[2]	Ferrous Iron	Anions[3]	Alkalinity	TOC
		EPA 8270E SIM	EPA 6020	EPA 6020	SM3500Fe	EPA 300	SM2320B	SM5310
Compliance Monitoring								
OF-2	Log Yard	-	x	-	-	-	-	-
OF-3	Log Yard	-	x	-	-	-	-	-
MW-15	Log Yard	-	x	x	x	x	x	x
MW-17	Log Yard	-	x	x	x	x	x	x
MW-19	Log Yard	-	x	x	x	x	x	x
MW-2R	Sawmill	x	-	-	-	-	-	-
PRB Performance Monitoring								
MW-14	Upgradient of PRB	-	x	x	x	x	x	x
MW-16	Upgradient of PRB	-	x	x	x	x	x	x
MW-18	Upgradient of PRB	-	x	x	x	x	x	x
MW-20	Upgradient of PRB	-	x	-	-	-	-	-

Notes:

1- Total and dissolved metals

2- As, Ca, Fe, K, Mg, Mn, Na

3- Chloride, Sulfate, Bromide, Ortho-Phosphate (as P), Fluoride, Nitrate + Nitrite (as N)

4- Analysis of geochemical parameters for PRB performance evaluation will only be conducted for the first 2 years.

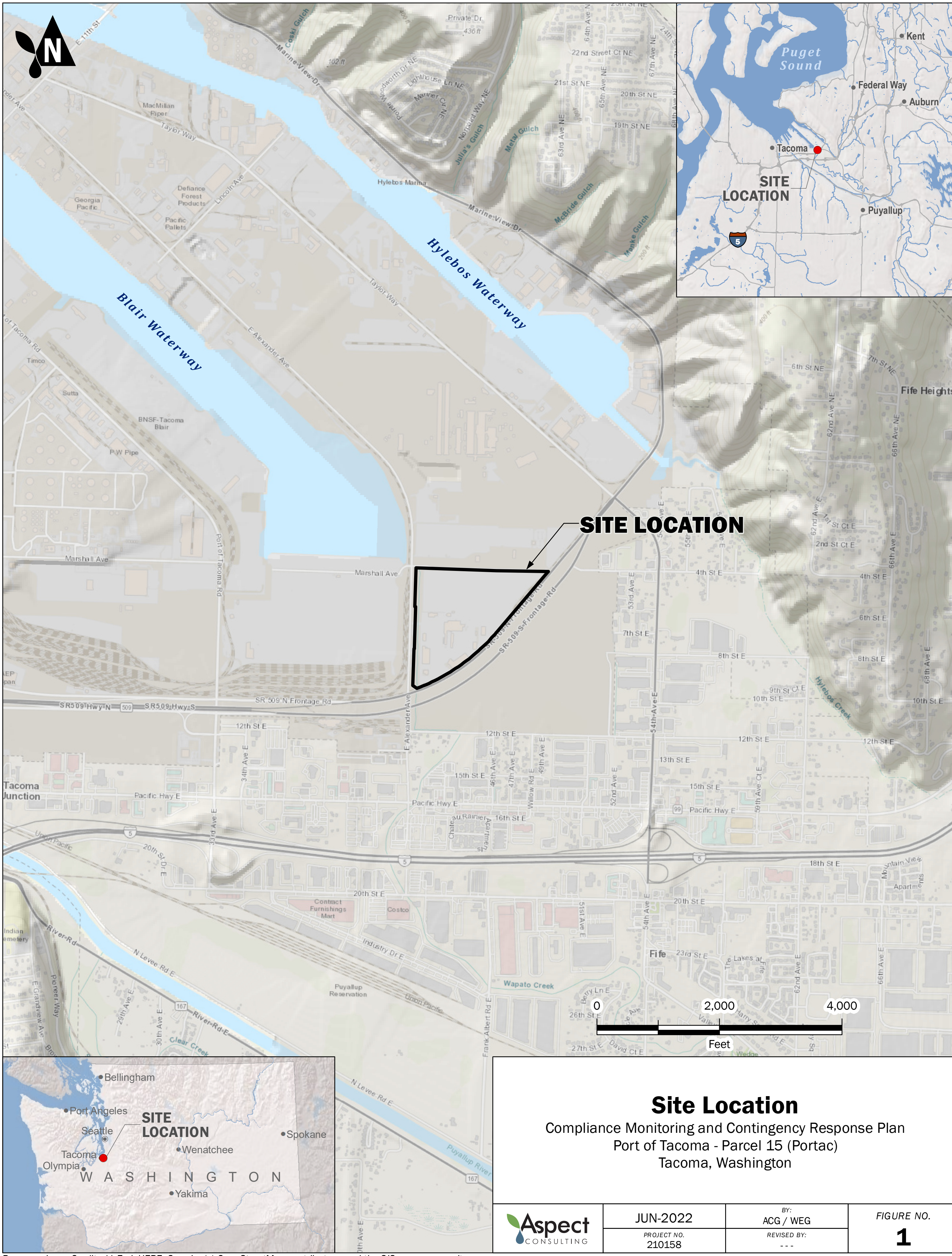
MNA - monitored natural attenuation

POC - Point of Compliance

PRB - Permeable Reactive Barrier

PCP - Pentachlorophenol

FIGURES



Site Location

Compliance Monitoring and Contingency Response Plan
Port of Tacoma - Parcel 15 (Portac)
Tacoma, Washington

Aspect CONSULTING	JUN-2022	BY: ACG / WEG	FIGURE NO.
	PROJECT NO. 210158	REVISED BY: - - -	1

GIS Path: G:\projects\PortofTacoma\PortacParcel15_210158\Delivered\Compliance Monitoring and Contingency Response Plan\01 Site Location.mxd || Coordinate System: NAD 1983 StatePlane Washington North FIPS 4601 Feet || Date Saved: 6/7/2022 || User: bgrimm || Print Date: 6/7/2022

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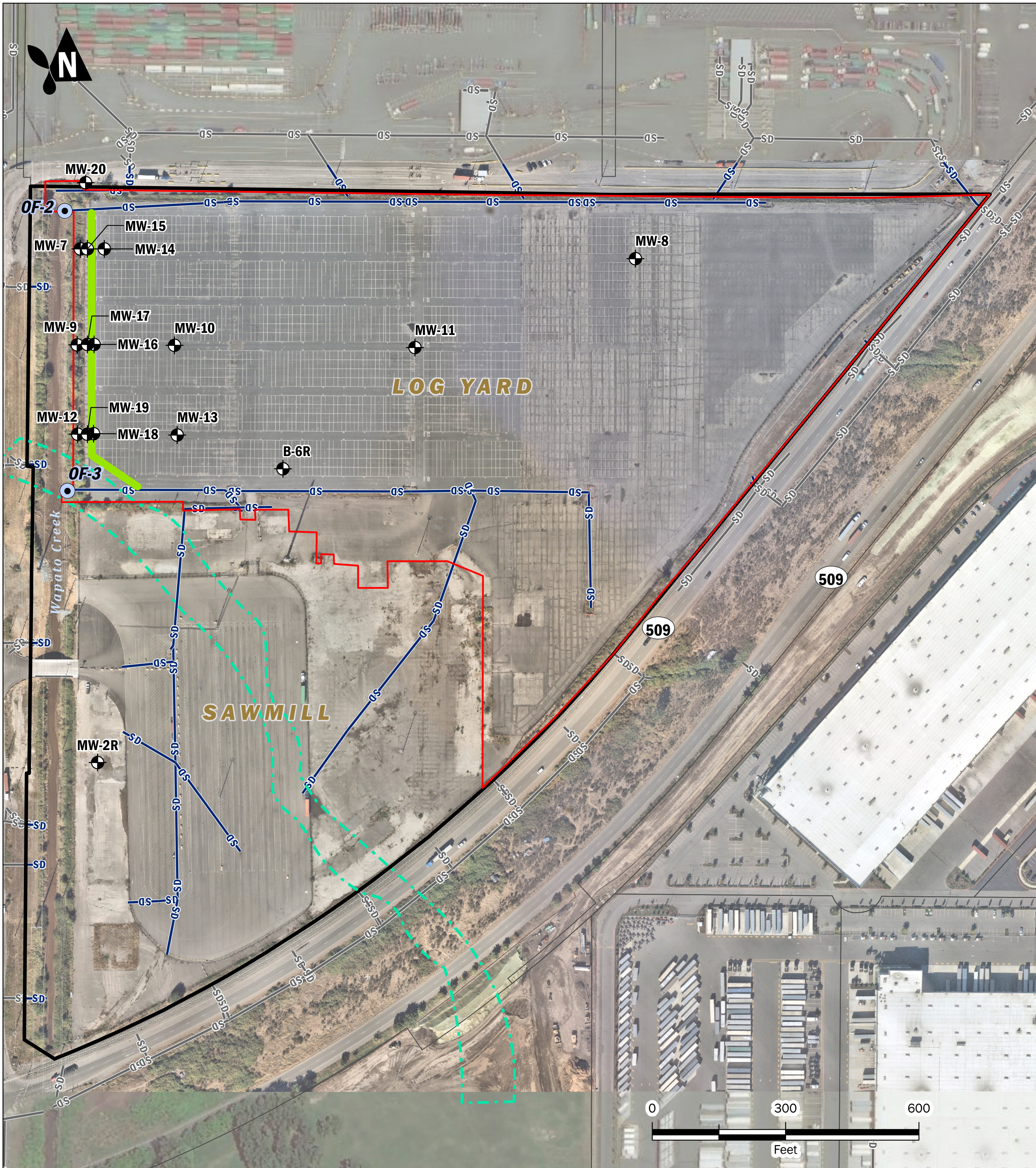

Explorations
Stormwater Outfall
Storm Pipe
Cap
PRB Alignment
Former Creek Channel
Port Parcel 15

Notes:
- Tax parcels modified for cartographic purposes.
- Storm pipes have faded, grey symbology outside area of interest.

Site Plan

Compliance Monitoring and Contingency Response Plan
Port of Tacoma - Parcel 15 (Portac)
Tacoma, Washington

Aspect CONSULTING

JUN-2022	BY: ACG / WEG	FIGURE NO.
PROJECT NO. 210158	REVISED BY: DIM / WEG	2

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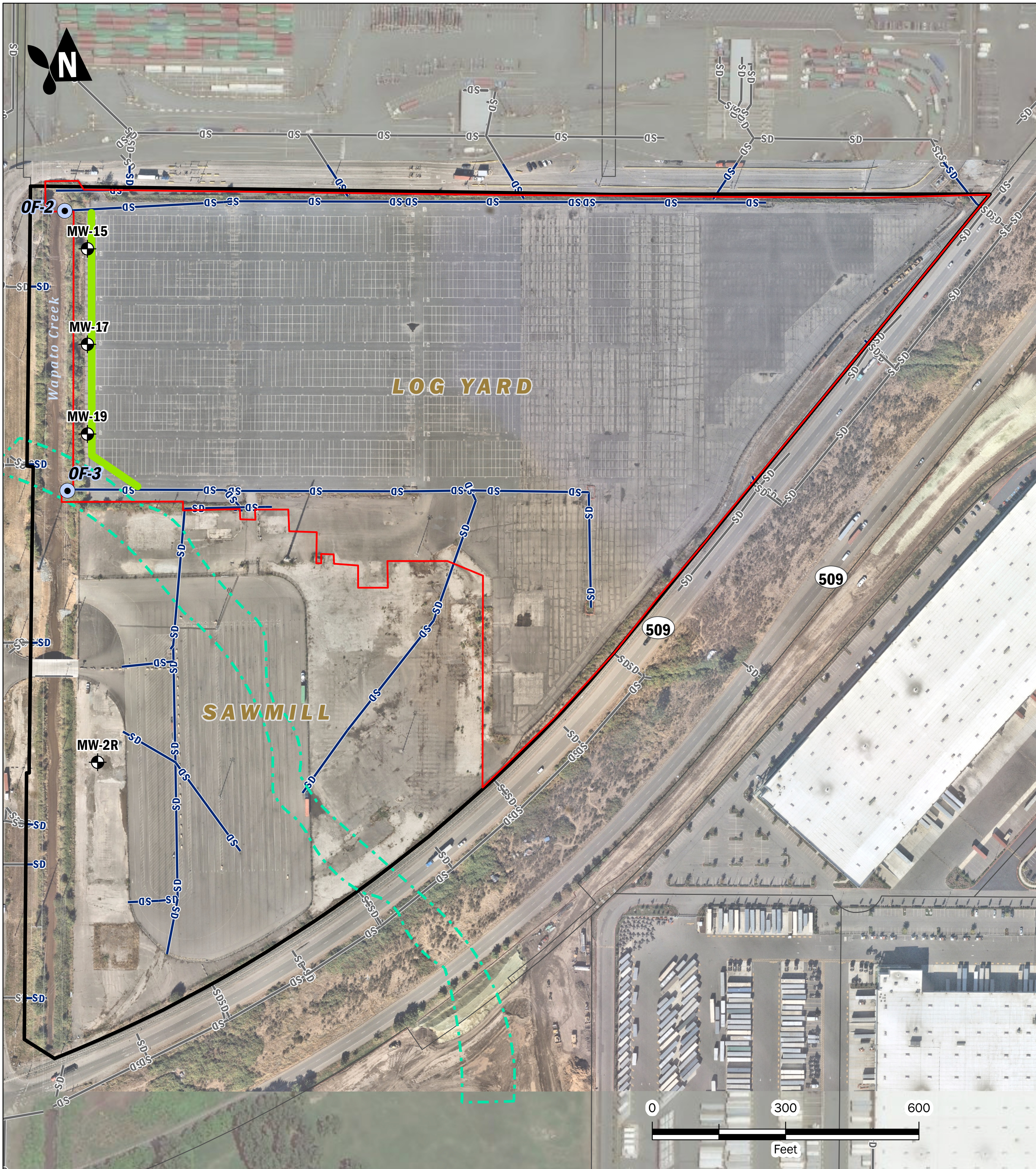
GIS Path: G:\projects\PortofTacoma\PortacParcel15_210158\Delivered\Compliance Monitoring and Contingency Response Plan\02 Site Plan.mxd || Coordinate System: NAD 1983 StatePlane Washington South FIPS 4602 Feet || Date Saved: 6/7/2022 || User: bgrimm || Print Date: 6/7/2022



GIS Path: G:\projects\PortofTacoma\PortacParcel15_210158\Delivered\Compliance Monitoring and Contingency Response Plan\03 Points of Compliance Locations.mxd || Coordinate System: NAD 1983 StatePlane Washington South FIPS 4602 Feet || Date Saved: 6/7/2022 || User: bgrimm || Print Date: 6/7/2022

Monitoring Well
Stormwater Outfall
Storm Pipe
Cap
PRB Alignment
Former Creek Channel
Port Parcel 15
Pierce County Tax Parcel

Notes:
- Tax parcels modified for cartographic purposes.
- Storm pipes have faded, grey symbology outside area of interest.

Points of Compliance Locations

Compliance Monitoring and Contingency Response Plan
Port of Tacoma - Parcel 15 (Portac)
Tacoma, Washington

Aspect CONSULTING	JUN-2022	BY: ACG / WEG	FIGURE NO. 3
	PROJECT NO. 210158	REVISED BY: DIM / WEG	

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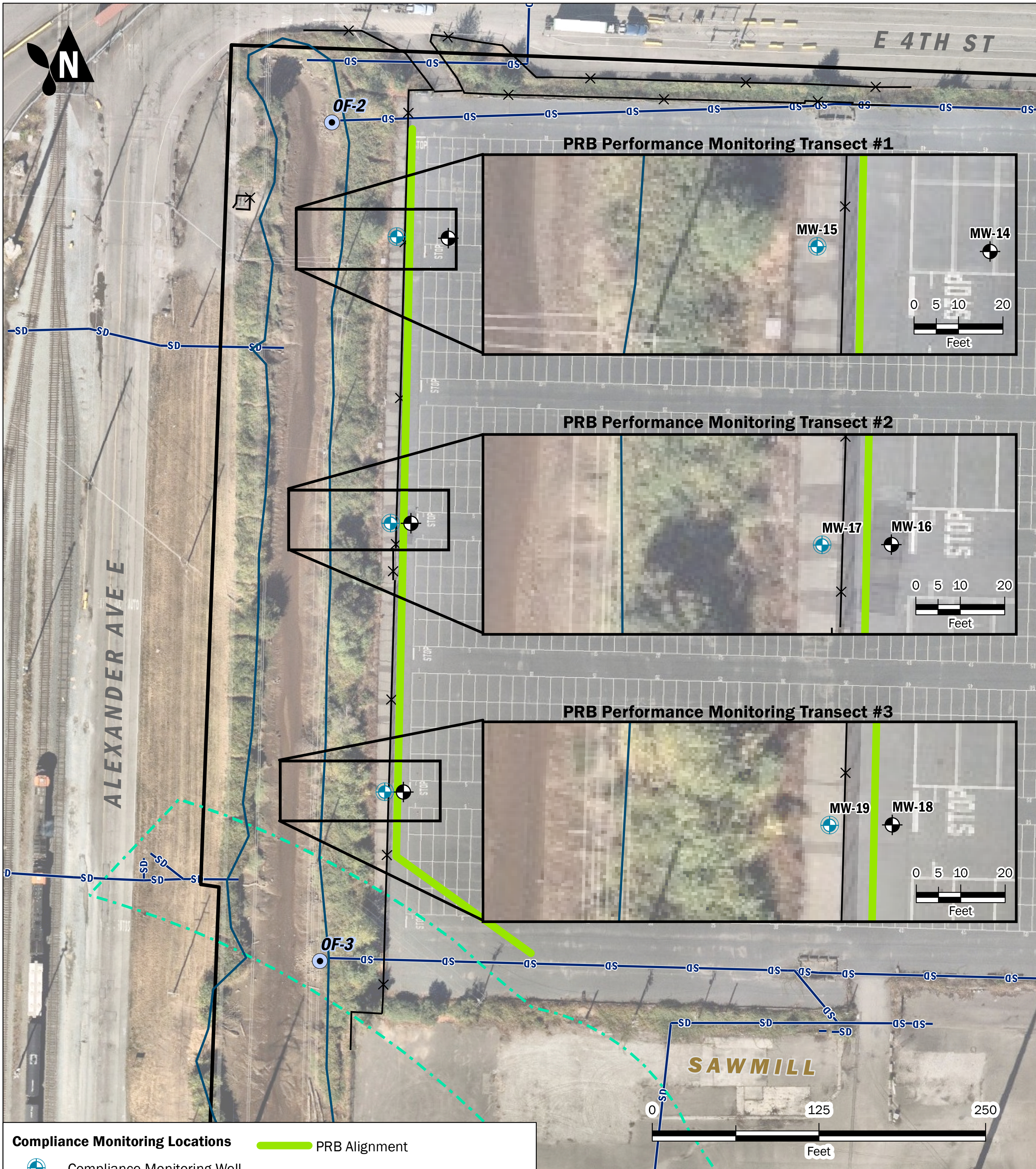


Compliance Monitoring Locations

Compliance Monitoring Well

Stormwater Outfall

Groundwater Monitoring Wells

Monitoring Well Upgradient of PRB

PRB Alignment

Ordinary High Water Mark

Fence

SD Storm Pipe

Former Creek Channel

Port Parcel 15

Note: PRB = Permeable Reactive Barrier

PRB Performance Monitoring Well Locations

Compliance Monitoring and Contingency Response Plan
Port of Tacoma - Parcel 15 (Portac)
Tacoma, Washington

Aspect CONSULTING	JUN-2022	BY: ACG / WEG	FIGURE NO.
	PROJECT NO. 210158	REVISED BY: DIM / WEG	4

GIS Path: G:\projects\PortofTacoma\PortacParcel15_210158\Delivered\Compliance Monitoring and Contingency Response Plan\04 PRB Performance Monitoring Well Locations.mxd || Coordinate System: NAD 1983 StatePlane Washington South FIPS 4602 Feet || Date Saved: 6/7/2022 || User: bgrimm || Print Date: 6/7/2022

APPENDIX A

Sampling and Analysis Plan/Quality Assurance Project Plan (SAP/QAPP)

Contents

List of Tables

List of Attachments

A1 Introduction

Aspect Consulting, LLC (Aspect) prepared this Sampling and Analysis Plan (SAP) for the Port of Tacoma (Port) Parcel 15 (Portac) property (Site). This SAP is Appendix A to the Compliance Monitoring and Contingency Response Plan (CMCRP) to meet the requirements of Agreed Order No. DE 15816 (Agreed Order) between the Washington State Department of Ecology (Ecology) and the Port.

The purpose of this SAP is to ensure that field sample collection, handling, and laboratory analysis will generate data that meet project-specific data quality objectives (DQOs) in accordance with the Model Toxics Control Act (MTCA) requirements (Washington Administrative Code [WAC] 173-340-350).

This SAP comprises two major components: a Field Sampling Plan (FSP) defining field protocols and a Quality Assurance Project Plan (QAPP) defining analytical protocols. Aspect personnel and subcontracted analytical laboratory personnel performing the sampling and analysis activities will adhere to the requirements of the FSP and QAPP.

The FSP and QAPP are presented below in Section A2 and Section A3, respectively.

A2 Field Sampling Plan

Field investigation and sampling procedures to be followed during the Phase 1 Cleanup compliance monitoring is described in the following sections.

A2.1 Monitoring Well Installation and Development

Six new groundwater monitoring wells will be installed for groundwater monitoring (Figure 3). Three of these monitoring wells (MW-15, MW-17, and MW-19) will be installed approximately 10 feet downgradient of the PRB and serve as groundwater POC locations. Two locations (MW-16 and MW-18) will be installed upgradient of the PRB to monitor influent groundwater quality. One monitoring well, MW-20, will be installed at the northern Site boundary to expand the monitoring well network in this area of the Site.

All new monitoring wells are shown on Figure 3 of the CMCRP. Following installation, each monitoring well will be developed and surveyed by a licensed surveyor.

A2.1.1 Well Installation

The monitoring wells will be constructed in accordance with WAC 173-160 by a licensed driller. The wells will be completed with an appropriate protective seal, typically a concrete surface seal with a monument flush-mounted at grade. An As-Built Well Completion Diagram will be completed by the field geologist (see Attachment A-1).

The three new monitoring wells downgradient of the PRB (MW-15, MW-17, and MW-19) will be screened with 5- foot screen lengths to discretely monitor the silty sand soils intercepted by the PRB. The two new monitoring wells upgradient of the PRB (MW-16 and MW-18) and MW-20 will be constructed with 10 foot screens. The estimated screen intervals are in Table 2 of the CMCRP.

The planned monitoring wells will have the following configuration: 2-inch-diameter, threaded Schedule 40 PVC slotted screen and blank casing. The well filter pack and slot size will be determined based on evaluation of the available formation grain size data relative to commercially available well construction materials. Final well construction details will be determined in the field.

A2.1.2 Well Development

The monitoring wells will be developed to remove fine-grained material from inside the well casing and filter pack and to improve hydraulic communication between the well screen and the surrounding water-bearing formation. Monitoring well development will be extended to target sorption equilibrium of arsenic with the filter pack.

The field geologist will document well development activities using the form in Attachment A-1. Well development will be performed by gently surging the entire length of the well screen using a submersible electric pump. Each well will be developed until visual turbidity is reduced to minimal levels. Development will continue for at least 55 gallons and 30 casing volumes to accelerate arsenic sorption equilibrium of the filter pack. Groundwater produced during well development will be collected in drums and secured on the Site for profiling and nonhazardous disposal at a permitted disposal facility.

A2.1.3 Surveying

The completed monitoring will be surveyed (horizontal and vertical) by a Washington-state licensed surveyor. The monitoring well casing elevation and ground surface elevation will be surveyed to the nearest 0.01 foot. Measurements will be taken at the "notched" or "marked" spot at the top edge of the open PVC casing. Where not yet marked, the highest point on the casing will be surveyed and marked.

A2.2 Groundwater Sampling

All groundwater sampling will be conducted when the tide elevation in the Sitcum Waterway is below 9 feet MLLW[1].

A2.2.1 Groundwater Level Monitoring and Well Inspection

Depth-to-groundwater measurements will be conducted in the wells using an electric well sounder, graduated to 0.01 foot. Water level measurements will be completed before groundwater sampling. All water levels will be recorded in the field notes.

A2.2.2 Groundwater Sampling from Monitoring Wells

For Log Yard groundwater compliance monitoring, sampling of 6 groundwater monitoring wells (2 monitoring wells at 3 PRB performance monitoring transects) will be conducted semiannually. Groundwater samples will be analyzed for total and dissolved

[1] The Commencement Bay, Sitcum Waterway, NOAA Station ID 9446484 will be referenced for tide elevations.

arsenic, in addition to geochemical parameters of dissolved metals, ferrous iron, anions, alkalinity and total organic carbon (Tables A-1 and A-3).

The new groundwater monitoring well MW-20 will be sampled semiannually for the first year and analyzed for total and dissolved arsenic. The first Annual Site Compliance Monitoring Report will identify any continued groundwater monitoring to be conducted at MW-20.

Groundwater monitoring of Sawmill location MW-2R will be conducted semiannually for pentachlorophenol (PCP; Tables A-1 and A-3).

Groundwater samples will be collected using low-flow techniques with peristaltic pumps and polyethylene tubing. In the event that turbidity bias in groundwater arsenic results is suspected for one or more wells, the use of passive diffusion samplers will be employed in consultation with Ecology.

Aspect field staff will document groundwater sampling using the form shown in Attachment A-1. During sampling activities, the field staff will minimize the introduction of air to the monitoring well water column, the water purged from the well, and the collected groundwater samples.

Prior to sample collection, the static water level in the well will be measured. The sample intake will be set at the mid-point of the screen. The well will then be purged at flow rates less than 0.5 liter per minute. The flow rate will be adjusted to achieve minimal drawdown (e.g., < 0.3 feet) during sampling. The following field parameters will be monitored using a YSI multiparameter meter and flow-through cell:

- Temperature
- pH
- Electrical conductance
- Dissolved oxygen (DO)
- Oxidation-reduction potential (Eh)

These field parameters will be recorded on the Groundwater Sampling Record form (Appendix A-1) at 5-minute intervals throughout well purging until they stabilize. Stabilization is defined as three successive readings where the parameter values vary by less than 10 percent (or 0.5 mg/L dissolved oxygen if the readings are below 1 mg/L). However, no more than three well casing volumes will be purged prior to groundwater sample collection.

Once purging is complete, the groundwater samples will be collected using the same low flow rate. Samples will be collected by directly filling laboratory supplied pre-cleaned containers (Table A-1). Samples for dissolved metals analyses will be filtered in the field using a disposable in-line 0.45-micron filter (changed for each well).

A2.2.4 Groundwater Sample Identification

Each groundwater sample will be assigned a unique sample identification number that includes the well number (no hyphen) and the 8-digit date on which the sample was collected. For example, a groundwater sample collected from monitoring well MW-7 on December 31, 2022, would be identified as MW7-123122.

A2.3 Stormwater Outfalls

A2.3.1 Stormwater Outfall Sampling

Monitoring of stormwater outfalls OF-2 and OF-3 will be conducted to evaluate compliance with the surface water CUL of 5 ug/L arsenic. Stormwater outfall monitoring will be conducted after Phase 1 Cleanup construction and once during the following dry season. The stormwater outfall monitoring will be conducted when Wapato Creek elevation is below the stormwater pipe invert elevations defined when the tide elevation in the Sitcum Waterway is below 9 ft MLLW.

Water samples will be collected by a peristaltic pump from Log Yard outfalls OF-2 and OF-3 by the field representative. Prior to sampling, the following field parameters will be monitored using a YSI multiparameter meter and flow-through cell.

- Temperature
- pH
- Electrical conductance
- Dissolved oxygen (DO)
- Oxidation-reduction potential (Eh)

These field parameters, as well as observations of surface water discharge will be recorded in field notes by the field representative. Once field parameter collection and observations are complete, the surface water samples will be collected by directly filling laboratory supplied pre-cleaned containers.

Samples will be analyzed for total and dissolved arsenic (Tables A-1 and A-3). Samples for dissolved metals will be field filtered using a disposable 0.45-micron filter (changed for each sample location).

A2.3.2 Stormwater Outfall Sample Identification

Each surface water sample will be assigned a unique sample identification number that includes the outfall number (no hyphen) and the 8-digit date to which the sample was collected. For example, a surface water sample collected from outfall OF-2 on December 31, 2022, would be identified as OF2-123122.

A2.3 Sample Custody and Field Documentation

A2.3.1 Sample Custody

Upon collection, samples will be placed upright in a cooler. Ice or blue ice will be placed in each cooler to meet sample preservation requirements. Inert cushioning material will be placed in the remaining space of the cooler as needed to limit movement of the sample containers. If the sample coolers are shipped (not hand carried) to the laboratory, the chain-of-custody (COC) form will be placed in a waterproof bag within the cooler for shipment.

After collection, samples will be maintained in Aspect's custody until formally transferred to the analytical laboratory courier or the shipper. For purposes of this work, custody of the samples is defined as follows:

- In plain view of the field representatives
- Inside a cooler that is in plain view of the field representative, or
- Inside any locked space such as a cooler, locker, car, or truck to which the field representative has the only immediately available key(s)

A COC record provided by the laboratory will be initiated at the time of sampling for all samples collected. The record will be signed by the field representative and others who subsequently take custody of the sample. Couriers or other professional shipping representatives are not required to sign the COC form; however, shipping receipts will be collected and maintained in project files as a part of custody documentation. A copy of the COC form with appropriate signatures will be kept by Aspect's project manager.

Upon sample receipt, the laboratory will fill out a cooler receipt form to document sample delivery conditions. A designated sample custodian will accept custody of the shipped samples and will verify that the COC form matches the samples received. The laboratory will notify the Aspect project manager, as soon as possible, of any issues noted with the sample shipment or custody.

A2.3.2 Field Documentation

While conducting field work, the field representative will document pertinent observations and events, specific to each activity, on field forms (e.g., groundwater sampling form, etc.) and/or in a field notebook, and, when warranted, provide photographic documentation of specific sampling efforts. Field notes will include a description of the field activity, sample descriptions, and associated details such as the date, time, and field conditions.

A2.4 Decontamination and Investigative-Derived Waste Management

All non-disposable sampling equipment (e.g., water level indicator) will be decontaminated before collection of each sample. The decontamination sequence consists of a scrub with a non-phosphate (Alconox) solution, followed by a tap water (potable) rinse, and then a thorough spraying with deionized or distilled water.

Investigation-derived waste (IDW) soil generated during well installation, and water generated during monitoring well development and sampling will be placed in labeled Department of Transportation-approved drums. The drums will be temporarily consolidated on the Site and disposed of at a permitted off-Site disposal facility as nonhazardous waste in accordance with Washington Administrative Code (WAC) 173-303. Non-hazardous waste designation will be verified with analytical results.

A3 Quality Assurance Project Plan

This QAPP identifies QC procedures and criteria required to ensure that data collected during the Phase 1 cleanup activities are of acceptable quality to achieve project objectives. Specific protocols and criteria are also set forth in this QAPP for data quality evaluation, upon the completion of data collection, to determine the level of completeness and usability of the data. The project personnel performing or overseeing the sampling and analysis activities will adhere to the requirements of the FSP and this QAPP.

A3.1 Purpose of the QAPP

As stated in Ecology's *Guidelines for Preparation of Quality Assurance Project Plans for Environmental Studies* (Ecology Publication No. 04-03-030, July 2004), specific goals of this QAPP are as follows:

- Focus project manager and project team to factors affecting data quality during the planning stage of the project
- Facilitate communication among field, laboratory, and management staff as the project progresses
- Document the planning, implementation, and assessment procedures for QA/QC activities for the investigation
- Ensure that the DQOs are achieved
- Provide a record of the project to facilitate final report preparation

The DQOs for the project include both qualitative and quantitative objectives, which define the appropriate type of data and specify the tolerable levels of potential decision errors. The DQOs will be used as a basis for establishing the quality and quantity of data needed to support the environmental assessment. To ensure that the DQOs are achieved, this QAPP details aspects of data collection including analytical methods, QA/QC procedures, and data quality reviews. This QAPP describes both quantitative and qualitative measures of data to ensure that the DQOs are achieved. DQOs dictate data collection rationale, sampling, and analysis designs that are presented in the main body of the CMCRP, along with the sample collection procedures presented in the FSP (Section A2) of this SAP.

A3.2 Project Organization and Responsibilities

The project consultant team involved with data generation includes representatives from Aspect and Fremont Analytical Inc (Fremont). Key individuals and their roles on this project are as follows:

Project Manager – Adam Griffin, PE, Aspect. The project manager is responsible for the successful completion of all aspects of this project, including day-to-day management, production of reports, acting as liaison with the Port, and coordination with the project team members. The project manager is also responsible for resolution of non-conformance issues, is the lead author on project plans and reports, and provides regular, up-to-date progress reports and other requested project information to the Port and Ecology.

Project Engineer – Delia Massey, PE, Aspect. The project engineer is responsible for overseeing the field sampling program outlined in this plan, including collecting representative samples and ensuring that they are handled properly prior to transfer of custody to the project laboratory. The project engineer will manage procurement of necessary field supplies, assure that monitoring equipment is operational and calibrated in accordance with the specifications provided herein, and act as the Site Health and Safety Officer.

Data Quality Manager –Aspect. The data quality manager is responsible for developing data quality objectives, selecting analytical methods, coordinating with the analytical laboratory, overseeing laboratory performance, and approving QA/QC procedures. The data quality manager is also responsible for conducting QA validation of the analytical data reports received from the project laboratory.

Laboratory Project Manager –Fremont. The laboratory project manager is responsible for ensuring that all laboratory analytical work complies with project requirements. The laboratory project manager also, while acting as liaison with the project manager, field manager, and data quality manager, fulfills project needs on the analytical laboratory work. This responsibility applies to work the laboratory project manager subcontracts to another laboratory.

A3.3 Analytical Methods and Reporting Limits

Analytical methodologies applied to the analyses of samples collected during the data gaps work are in accordance with the following documents:

- USEPA Methods for Chemical Analysis of Water and Wastes, EPA-600/4-79-020, March 1983 and updates.
- Standard Methods for the Examination of Water and Wastewater, American Public Health Association, 20th Edition, 1995.

Table A-1 lists the laboratory analytical methods for groundwater and surface water analyses to be performed during compliance monitoring activities, along with sample containers, preservation, and analytical holding times for each analysis.

A3.3.1 Method Detection Limit and Method Reporting Limit

The method detection limit (MDL) is the minimum concentration of a compound that can be measured and reported with a 99 percent confidence that the analyte concentration is greater than zero. MDLs are established by the laboratory using prepared samples, not samples of environmental media.

The method reporting limit (MRL) is defined as the lowest concentration at which a chemical can be accurately and reproducibly quantified, within specified limits of precision and accuracy, for a given environmental sample. The MRL can vary from sample to sample depending on sample size, sample dilution, matrix interferences, moisture content, and other sample-specific conditions. As a minimum requirement for organic analyses, the MRL should be equivalent to or greater than the concentration of the lowest calibration standard in the initial calibration curve. The expected MRLs are summarized in Table A-3 for water samples.

A3.4 Data Quality Objectives

The precision, accuracy, representativeness, comparability, completeness, and sensitivity (collectively, the PARCCS parameters) are dictated by the DQOs, project requirements, and intended uses of the data. For this project, the analytical data must be of sufficient technical quality to determine whether contaminants are present and, if present, whether their concentrations are greater than or less than applicable screening criteria.

The quality of data generated through this work will be assessed against the Measurement Quality Indicators (MQIs) set forth in this QAPP. Specific QC parameters associated with each of the MQIs are summarized in Table A-2. Specific MQI goals and evaluation criteria (i.e., MDLs, MRLs, percent recovery [%R] for accuracy measurements, relative percent difference [RPD] for precision measurements) are defined in Table A-3. Definitions of these parameters and the applicable QC procedures are presented below.

A3.4.1 Precision

Precision measures the reproducibility of measurements under a given set of conditions. Specifically, it is a quantitative measure of the variability of a group of measurements compared with their average values. Analytical precision is measured through matrix spike/matrix spike duplicate (MS/MSD) samples and laboratory control samples/laboratory control sample duplicate (LCS/LCSD) for organic analysis, and through laboratory duplicate samples for inorganic analyses.

Analytical precision is quantitatively expressed as the RPD between the LCS/LCSD, MS/MSD, or laboratory duplicate pairs and is calculated with the following formula:

$$RPD\ (\%) = 100 \times \frac{|S - D|}{(S + D)/2}$$

where:
S = analyte concentration in sample
D = analyte concentration in duplicate sample

Analytical precision measurements will be carried out at a minimum frequency of 1 per 20 samples for each matrix sampled, or 1 per laboratory analysis group. Laboratory precision will be evaluated against laboratory quantitative RPD performance criteria provided with the laboratory's analytical data report. If the control criteria are not met, the laboratory will supply a justification of why the limits were exceeded and implement the appropriate corrective actions. The RPD will be evaluated during data review and validation. The data reviewer will note deviations from the specified limits and will comment on the effect of the deviations on reported data.

Precision is also measured through collection of field duplicates. Field duplicates will be collected at a frequency of 1 per 20 samples for each groundwater sampling round. Field duplicate samples will be analyzed for COCs only (i.e., not geochemical parameters).

A3.4.2 Accuracy

Accuracy measures the closeness of the measured value to the true value. The accuracy of chemical test results is assessed by "spiking" samples with known standards (surrogates, blank spikes, or matrix spikes) and establishing the average recovery. Accuracy is quantified as the %R. The closer the %R is to 100 percent, the more accurate the data.

Surrogate recovery will be calculated as follows:

$$Recovery\ (\%) = \frac{MC}{SC}\ x\ 100$$

where:
SC = spiked concentration
MC = measured concentration

Matrix spike (MS) percent recovery will be calculated as follows:

$$Recovery\ (\%) = \frac{MC - USC}{SC}\ x\ 100$$

where:
SC = spiked concentration
MC = measured concentration
USC = unspiked sample concentration

Accuracy measurements on MS samples will be carried out at a minimum frequency of 1 in 20 samples per matrix analyzed. Blank spikes will also be analyzed at a minimum frequency of 1 in 20 samples per matrix analyzed. Surrogate recoveries for organic compounds will be determined for each sample analyzed for respective compounds. Laboratory accuracy will be evaluated against the laboratory's quantitative MS and surrogate spike recovery performance criteria as provided with the laboratory's analytical data report. If the control criteria are not met, the laboratory will supply a justification of why the limits were exceeded and implement the appropriate corrective actions. Percent recoveries will be evaluated during data review and validation, and the data reviewer will comment on the effect of the deviations on the reported data.

A3.4.3 Representativeness

Representativeness measures how closely the measured results reflect the actual concentration or distribution of the chemical compounds in the matrix sampled. The FSP sampling techniques and sample handling protocols (e.g., homogenizing, storage, preservation, and use of duplicates and blanks) have been developed to ensure representative samples. Sampling locations are described in Section 3 and shown on Figures 2 and 3 of the CMCRP. The field sampling procedures are described in the FSP (Section A2) of this SAP.

A3.4.4 Comparability

Comparability is a qualitative parameter expressing the confidence with which one data set can be compared with another. This goal will be achieved through the use of standard techniques to collect samples, USEPA-approved standard methods to analyze samples, and consistent units to report analytical results. Data comparability also depends on data quality. Data of unknown quality cannot be compared.

A3.4.5 Completeness

Completeness is defined as the percentage of measurements made that are judged to be valid. Results will be considered valid if the precision, accuracy, and representativeness objectives are met and if MRLs are sufficient for the intended uses of the data. Completeness is calculated as follows:

$$Completeness\ (\%) = \frac{V}{P} x\ 100$$

where:
V = number of valid measurements
P = number of measurements taken

Valid and invalid data (i.e., data qualified with the R flag [rejected]) will be identified during data validation. The target completeness goal for this project is 95 percent.

A3.5 Quality Control Procedures

Field and laboratory QC procedures are outlined below.

A3.5.1 Field Quality Control

Beyond the use of standard sampling and decontamination protocols defined in the FSP, field QC procedures include maintaining the field instruments used. Field instruments (e.g., YSI multiparameter instrument or equivalent meter for measuring field parameters during groundwater sampling) are maintained and calibrated regularly prior to use, in accordance with manufacturer recommendations.

Field duplicates indicate both field and lab precision. Therefore, the results may have more variability than laboratory replicates, which measure only lab performance. The tolerance limit for relative percent differences between the field duplicates will be ±35 percent. If the precision values are outside this limit, a replicate sample may be run by the laboratory.

A3.5.2 Laboratory Quality Control

The laboratories' analytical procedures must meet requirements specified in the respective analytical methods or approved laboratory standard operating procedures (SOPs), e.g., instrument performance check, initial calibration, calibration check, blanks, surrogate spikes, internal standards, and/or labeled compound spikes. Specific laboratory QC analyses required for this project will, at a minimum, consist of the following:

- Instrument tuning, instrument initial calibration, and calibration verification analyses as required in the analytical methods and the laboratory SOPs;
- Laboratory and/or instrument method blank measurements at a minimum frequency of 5 percent (1 per 20 samples) or in accordance with method requirements, whichever is more frequent; and
- Accuracy and precision measurements as defined in Table A-3, at a minimum frequency of 5 percent (1 per 20 samples) or in accordance with method requirements, whichever is more frequent. In cases where a pair of MS/MSD or MS/laboratory duplicate analyses are not performed on a project sample, a set of LCS/LCSD analyses will be performed to provide sufficient measures for analytical precision and accuracy evaluation.

The laboratory's QA officers are responsible for ensuring that the laboratory implements the internal QC and QA procedures detailed Fremont's Quality Assurance Manual.

A3.6 Corrective Actions

If routine QC audits by the laboratory result in detection of unacceptable conditions or data, actions specified in the laboratory SOPs will be taken. Specific corrective actions are outlined in each SOP used and can include the following:

- Identifying the source of the violation
- Reanalyzing samples if permitted by holding time criteria
- Resampling and analyzing
- Evaluating and amending sampling and analytical procedures
- Accepting but qualifying data to indicate the level of uncertainty

If unacceptable conditions occur, the laboratory will contact Aspect's project manager to discuss the issues and determine the appropriate corrective action. Corrective actions taken by the laboratory during analysis of samples for this project will be documented by the laboratory in the case narrative associated with the affected samples.

In addition, the project data quality manager will review the laboratory data generated for this investigation to ensure that project DQOs are met. If the review indicates that non-conformances in the data have resulted from field sampling, field documentation procedures, laboratory analytical, or laboratory documentation procedures, the impact of those non-conformances on the overall project data usability will be assessed. Appropriate actions, including re-sampling and/or re-analysis of samples, may be recommended to the project manager to achieve project objectives.

A3.7 Data Reduction, Quality Review, and Reporting

All data will undergo a QA/QC evaluation at the laboratory, which will then be reviewed by the Aspect database manager and the project data quality manager. Initial data reduction, evaluation, and reporting at the laboratory will be carried out in full compliance with the method requirement and laboratory SOPs. The laboratory internal review will include verification (for correctness and completeness) of electronic data deliverable (EDD) accompanying each laboratory report. The Aspect database manager will verify the completeness and correctness of all laboratory deliverables (i.e., laboratory report and EDDs) before data validation.

A3.7.1 Minimum Data Reporting Requirements

The following sections identify general and specific requirements for analytical data reporting to provide sufficient deliverables for project documentation and data quality assessment.

General Requirements

The following requirements apply to laboratory reports for all types of analyses:

- A cover page signed by the laboratory director, the laboratory QA officer, or his/her designee to certify the eligibility of the reported contents and the conformance with applicable analytical methodology.
- Definitions of abbreviations, data flags, and data qualifiers used in the report.
- Cross reference of field sample names and laboratory sample identity for all samples in the sample delivery group (SDG).
- Completed COC document signed and dated by parties who acquired and received the samples.
- Completed sample receipt document with record of cooler temperature and sample conditions upon receipt at the laboratory. Anomalies such as inadequate sample preservation, inconsistent bottle counts, and sample container breakage, and communication record and corrective actions in response to the anomalies, will be documented and incorporated in the sample receipt document. The document will be initialed and dated by personnel that complete the document.
- Case narrative that addresses any anomalies or QC outliers in relation to sample receiving, sample preparation, and sample analysis on samples in the SDG. The narrative will be presented separately for each analytical method and each sample matrix.
- All pages in the report are to be paginated. Any insertion of pages after the laboratory report is issued will be paginated with starting page number suffixed with letters (e.g., pages inserted between pages 134 and 135 should be paginated as 134A, 134B, etc.)
- Any resubmitted or revised report pages will be submitted to Aspect with a cover page stating the reason(s) and scope of the resubmission or revision, and signed by the laboratory director, QA officer, or the designee.

Specific Requirements

The following presents specific requirements for laboratory reports:

- Sample results will be evaluated and reported down to the MRLs.

- Method blank results.
- LCS and LCSD (if MSD analysis is not performed) results with laboratory acceptance criteria for %R and RPD.
- Surrogate spike results with laboratory acceptance criteria for %R.
- MS and MSD results with laboratory acceptance criteria for %R and RPD. In cases where MS/MSD analyses were not performed on a project sample, LCS/LCSD analyses should be performed and reported instead.
- Internal standard (as applicable) results: Internal standard results are in field samples, QC analyses, and associated calibration verification analyses.

A3.8 Data Quality Verification and Validation

Reported analytical results will be qualified by the laboratory to identify QC concerns in accordance with the specifications of the analytical methods. Additional laboratory data qualifiers may be defined and reported by the laboratory to more completely explain QC concerns regarding a particular sample result. All data qualifiers will be defined in the laboratory's case narrative associated with each case.

The project data quality manager, or other as directed by Aspect, will conduct an independent Level II (or Stage 2a as defined in USEPA, 2009) data verification and validation for all chemical data submitted by the analytical laboratories during the independent environmental assessment, following the guidance below:

- USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Superfund Data Review, Office of Superfund Remediation and Technical Innovation, U.S. Environmental Protection Agency, January 2010, USEPA 540/R-10/011.
- USEPA Contract Laboratory Program National Functional Guidelines for Superfund Organic Methods Data Review, Office of Superfund Remediation and Technical Innovation, U.S. Environmental Protection Agency, June 2008, USEPA-540-R-08-01.

The data validation will examine and verify the following parameters against the method requirements and laboratory control limits specified in Table A-3:

- Sample management and holding times
- Laboratory and field blank results
- Detection and reporting limits
- Laboratory replicate results
- MS/MSD results
- LCS and/or standard reference material results

- Field duplicate results
- Surrogate spike recovery (organic analyses only)

Data qualifiers will be assigned based on the outcome of the data validation. Data qualifiers are limited to and defined as follows:

- J - The associated numerical value is an estimate of the approximate concentration of the analyte in the sample.
- UJ - The analyte was not detected above the reported quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.
- R - The sample results are rejected due to serious deficiencies in the ability to analyze the sample and meet QC criteria. The presence or absence of the analyte cannot be verified.
- DNR - Do not report from this analysis; the result for this analyte is to be reported from an alternative analysis.

In cases of multiple analyses (such as an undiluted and a diluted analysis) performed on one sample, the optimal result will be determined and only the determined result will be reported for the sample.

The scope and findings of the data validation will be documented and discussed in the Data Validation Report(s), which will be included in the Data Report.

A3.9 Preventative Maintenance Procedures and Schedules

Preventative maintenance in the laboratory will be the responsibility of the laboratory personnel and analysts. This maintenance includes routine care and cleaning of instruments and inspection and monitoring of carrier gases, solvents, and glassware used in analyses. Details of the maintenance procedures are addressed in the respective laboratory SOPs.

Precision and accuracy data are examined for trends and excursions beyond control limits to determine evidence of instrument malfunction. Maintenance will be performed when an instrument begins to change, as indicated by the degradation of peak resolution, shift in calibration curves, decrease in sensitivity, or failure to meet one or another of the method-specific QC criteria.

Maintenance and calibration of instruments used in the field for sampling (e.g., YSI meter for measuring field parameters during groundwater sampling) will be conducted regularly in accordance with manufacturer recommendations prior to use.

A3.10 Performance and System Audits

The Aspect project manager has the responsibility for reviewing the performance of the laboratory QA program; this review will be achieved through regular contact with the analytical laboratory’s project manager. To ensure comparable data, all samples of a given matrix to be analyzed by each specified analytical method will be processed consistently by the same analytical laboratory.

A3.11 Data and Records Management

Records will be maintained documenting all activities and data related to field sampling and chemical analyses.

A3.11.1 Field Documentation

The Aspect project manager will ensure that the field team receives and understands the final approved version of this QAPP, the Site Health and Safety Plan, and the SAP prior to the initiation of field activities and that all approved plans are followed at all times. Field documents will be maintained in the project file.

A3.11.2 Analytical Data Management

Raw data received from the analytical laboratory will be reviewed, entered into a computerized database, and verified for consistency and correctness. The database will be updated based on data review and independent validation if necessary.

The following field data will be included in the database:

- Sample location coordinates
- Sample type (i.e., groundwater)
- Groundwater sampling depth interval

Information regarding whether concentrations represent total phase (unfiltered samples) or dissolved phase (filtered samples) will be compiled and stored in the database. Data will be submitted to Ecology's Environmental Information Management (EIM) database once data have been reviewed and validated.

A4 References

ASTM, ASTM D2487 17, Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System).

US Environmental Protection Agency (USEPA), 2008, Contract Laboratory Program National Functional Guidelines for Superfund Organic Methods Data Review, Office of Superfund Remediation and Technical Innovation, U.S. Environmental Protection Agency, June 2008, USEPA-540-R-08-01.

USEPA, 2009, Guidance for Labeling Externally Validated Laboratory Analytical Data for Superfund Use, January 13 2009. EPA 540-R-08-005.

USEPA, 2010, Contract Laboratory Program National Functional Guidelines for Inorganic Superfund Data Review, Office of Superfund Remediation and Technical Innovation, U.S. Environmental Protection Agency, January 2010, USEPA 540/R-10/011.

TABLES

Table A-1. Analytical Methods, Sample Containers, Preservation, and Holding Times

Project No. 210158, Port of Tacoma Parcel 15 (Portac), Tacoma, Washington

Sample Matrix	Analytical Parameter	Analytical Method	Sample Container	No. Containers	Field Filtered?	Preservation Requirements	Holding Time
Water	Total Arsenic	EPA 6020B	500-mL polyethylene bottle	1	N	4°C ±2°C, HNO3 pH < 2	6 months
Water	Dissolved Arsenic	EPA 6020B	500-mL polyethylene bottle	1	Y	4°C ±2°C, HNO3 pH < 2	6 months
Water	Pentachlorophenol	SW8270E-SIM	1-L Amber glass bottle	1	N	4°C ±2°C	7 days
Water	Total Metals (Arsenic, Calcium, Iron, Magnesium, Manganese, Potassium, Sodium)	EPA 6020B	500-mL polyethylene bottle	1	N	4°C ±2°C, HNO3 pH < 2	6 months
Water	Dissolved Metals (Arsenic, Calcium, Iron, Magnesium, Manganese, Potassium, Sodium)	EPA 6020B	500-mL polyethylene bottle	1	Y	4°C ±2°C, HNO3 pH < 2	6 months
Water	Anions (Bromide, Chloride, Fluoride, Nitrate as Nitrogen, Nitrite as Nitrogen, Orthophosphate as phosphate, Sulfate)	EPA 300.0	500-mL polyethylene bottle	1	N	4°C ±2°C	NO3, NO2, PO4 - 48hours; Others - 28 days
Water	Alkalinity	SM2320B	500-mL polyethylene bottle	1	N	4°C ±2°C	28 days
Water	Total Organic Carbon (TOC)	SM5310	250-mL amber glass	1	N	4°C ±2°C, H2SO4 pH < 2	28 days
Water	Ferrous Fe (Fe +2)	SM3500Fe-BM	500-mL amber glass	1	N	4°C ±2°C, HCl pH < 2, avoid headspace	24 hours

Table A-2. QC Parameters Associated with PARCCS

Project No. 210158, Port of Tacoma Parcel 15 (Portac), Tacoma, Washington

Data Quality Indicators	QC Parameters
Precision	RPD values of:
	(1) LCS/LCS Duplicate
	(2) MS/MSD
	(3) Field Duplicates
Accuracy/Bias	Percent Recovery (%R):
	(1) LCS
	(2) MS
	(3) Surrogate Spikes
	Results of:
	(1) Method (Preparation) Blank
	(2) Equipment Rinsate Blank (if appropriate)
Representativeness	Results of All Blanks
	Sample Integrity (Chain-of-Custody and Sample Receipt Forms)
	Holding Times
Comparability	Sample-specific Reporting Limits
	Sample Collection Methods
	Laboratory Analytical Methods
Completeness	Data Qualifiers
	Laboratory Deliverables
	Requested/Reported Valid Results
Sensitivity	MDLs and MRLs

Notes:

LCS – laboratory control sample

MDL – method detection limit

MRL – method reporting limit

MS/MSD – matrix spike/matrix spike duplicate

PARCCS = precision, accuracy, representativeness, comparability, completeness, and sensitivity

Table A-3. Measurement Quality Indicators for Water Samples

Project No. 210158, Port of Tacoma Parcel 15 (Portac), Tacoma, Washington

Analyte Name	MDL(A)	MRL	LCS/LCS %R(A)	RPD (%)	Surrogate %R(A)
Metals by EPA 6020 (µg/L)					
Arsenic	0.13	1.0	85-115	≤20	NA
Calcium	20	200	85-115	≤20	NA
Iron	17	100	85-115	≤20	NA
Magnesium	15.2	100	85-115	≤20	NA
Manganese	0.59	5	85-115	≤20	NA
Potassium	9.7	200	85-115	≤20	NA
Sodium	14.9	200	85-115	≤20	NA
Pentachlorphenol by EPA 8270E SIM (µg/L)					
Pentachlorophenol	0.148	0.50	18.5-129	≤30	NA
Anions by EPA 300 (µg/L)					
Bromide	0.0642	0.40	90-100	≤20	NA
Chloride	0.0313	0.1	90-100	≤20	NA
Fluoride	0.0239	0.08	90-100	≤20	NA
Nitrate as Nitrogen	0.0167	0.1	90-100	≤20	NA
Nitrite as Nitrogen	0.0176	0.1	90-100	≤20	NA
Orthophosphate (as PO4)	0.248	0.525	90-100	≤20	
Sulfate	0.149	0.6	90-100	≤20	NA
Alkalinity by SM2320B (mg/L)					
Alkanlity, Total (as calcium carbonate)	0.788	2.50	88.3-113	≤20	NA
Total Organic Carbon by SM3510 (mg/L)					
Total Organic Carbon	0.138	0.50	93.1-106	≤20	NA
Ferrous Iron by SM3500Fe (mg/L)					
Ferrous Fe (Fe +2)	0.029	0.10	85-115	≤20	NA

Notes:

(A) – Based on current laboratory control criteria. Some values may vary slightly between instruments and can be subject to change as the laboratory updates the charted values periodically.

%R – percent recovery

LCS/LCSD – laboratory control samples and laboratory control sample duplicate

MDL – method detection limit

MRL – method reporting limit

n/a – not applicable

RPD – relative percent difference

µg/L – microgram per liter

ATTACHMENT A-1

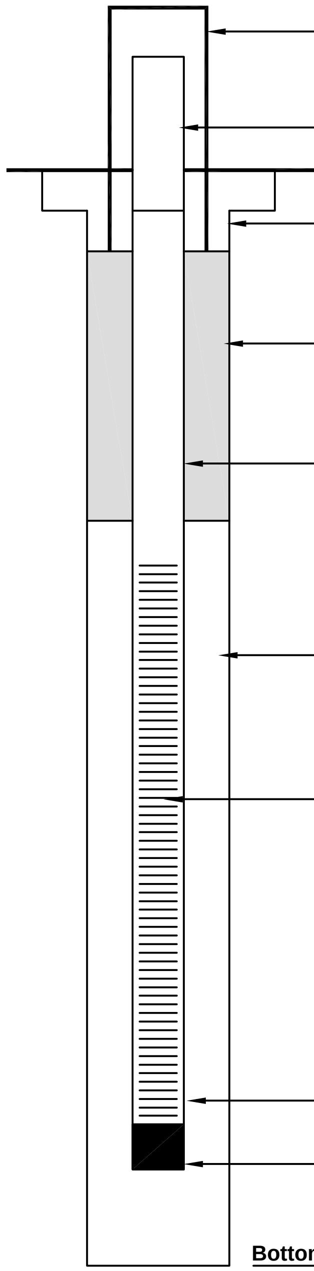
Field Forms

As-Built Well Completion Diagram

Project Number:	Boring/Monitoring Well Number: Sheet: of:
Project:	Location:
Elevation:	Drilling Contractor:
Drilling Method and Equipment Used:	Logged By:
Water Levels:	Completion Start: Finish:

Ecology Well ID ________________

Soil Type/ Depth	**Completion Depths**



Monument Type/Height ______________________

Well Cap Type ______________________

Surface Seal Material ______________________

Seal Material ______________________
(list NSF/ANSI certification)

Well Casing ID ______________________

Type of Casing ______________________

Type of Connection ______________________

Filter Pack/Size ______________________

Filter Pack Interval ______________________

Well Screen ID ______________________

Type of Screen ______________________

Slot Size ______________________

Screen Interval ______________________

Centralizers ______________________

Diameter of Borehole ______________________

Sump ______________________

Bottom of Boring ______________________

Aspect consulting earth+water www.aspectconsulting.com *a limited liability company*	Materials Used:	Screen:
	Sand:	Bentonite:
	Blank:	Monument:
	Concrete:	Other:

Q:_ACAD Standards\Standard Details\Well Diagram.dwg

Field Staff:

DAILY REPORT

Date: **Project Name:** **Project Number:** **Weather:** **Arrival on site:** **Departure from site:**	Equipment used: Calibration:

Aspect CONSULTING

Sample number ______________________

GROUNDWATER SAMPLING RECORD

WELL NUMBER: _______ **Page:**____ **of** ____

Project Name: ______________________ Project Number: ______________________

Date: ______________________

Sampled by: ______________________

Measuring Point of Well: ______________________

Screened Interval (ft. TOC) ______________________

Filter Pack Interval (ft. TOC) ______________________

Starting Water Level (ft TOC): ______________________

Casing Stickup (ft): ______________________

Total Depth (ft TOC): ______________________

Casing Diameter (inches): ______________________

Casing Volume ___________ (ft Water) x ___________ (Lpfv)(gpf) = ___________ (L)(gal)

Casing volumes: 3/4"= 0.02 gpf 2" = 0.16 gpf 4" = 0.65 gpf 6" = 1.47 gpf

3/4"= 0.09 Lpf 2" = 0.62 Lpf 4" = 2.46 Lpf 6" = 5.56 Lpf

Sample Intake Depth (ft TOC): ___________

PURGING MEASUREMENTS

Time	Cumul. Volume (gal or L)	Purge Rate (gpm or Lpm)	Water Level (ft)	Temp. (°C)	Specific Conductance (µS/cm)	Dissolved Oxygen (mg/L)	pH	ORP (mv)	Turbidity (NTU)	Comments
Criteria:		Typical 0.1-0.5 Lpm	Stable	na	± 3%	± 10%	± 0.1	± 10 mV	± 10%	

Total Gallons Purged: ______________________ Total Casing Volumes Removed: ______________

Ending Water Level (ft TOC): ______________________ Ending Total Depth (ft TOC): ______________

SAMPLE INVENTORY

Time	Volume	Bottle Type	Quantity	Filtration	Preservation	Appearance		Remarks
						Color	Turbidity & Sediment	

METHODS

Parameters measured with (instrument model & serial number): ______________________

Purging Equipment: ______________________ Decon Equipment: ______________________

Disposal of Discharged Water: ______________________

Observations/Comments: ______________________

____

WELL DEVELOPMENT RECORD

WELL NUMBER:

Project Name: ______
Project Number: ______
Date: ______
Starting Water Level (ft TOC): ______
Developed by: ______
Casing Stickup (ft BGS): ______
Measuring Point of Well: ______
Total Depth (ft TOC): ______
Screened Interval (ft. BGS): ______
Casing Diameter (inches):
Filter Pack Interval (ft. BGS):

Casing Volume: ft Water x gpf =
Casing volumes: 2" = 0.16 gpf 4" = 0.65 gpf 6" = 1.47 gpf

DEVELOPMENT MEASUREMENTS

Elapsed Time (min)	Cumul. Vol. (gallons)	Purge Rate (gpm)	Temp. (C or F)	pH	Specific Conductance (µmhos/cm)	Turbidity (NTU)	Imhoff Cone (ml/L)	Comments

Total Discharge (gallons): ______
Total Casing Volumes Removed (gallons): ______

Ending Water Level (ft TOC): ______
Ending Total Depth (ft TOC): ______

METHODS

Cleaning Equipment: ______
Development Equipment: ______
Disposal of Discharged Water: ______
Observations/Comments: ______

APPENDIX B

Groundwater Restoration Time Frame Analysis

Groundwater Restoration Time Frame Analysis

This appendix presents an analysis to provide a relative comparison of estimated restoration time frames for Site groundwater at the conditional point of compliance (POC). The analysis employs a mixed linear reservoir or "batch flush" model to estimate the number of groundwater pore volumes that must be flushed through a volume of aquifer to meet a specific cleanup level, assuming linear partitioning of a contaminant from aquifer solids to groundwater (Zheng and Bennett, 2002). The analysis is applied to estimate the time for measured concentrations of a representative contaminant to reach the cleanup level (CUL) at distances of 10 and 25 feet downgradient of the permeable reactive barrier. The absolute values of the estimated restoration time frames will vary with input parameter assumptions.

The batch flush calculation is as follows:

$$t = -\ln\left(\frac{CUL}{C_o}\right) * PV_t * R_f$$

Where:

- t = restoration time frame (year)
- C_o = Starting contaminant concentration micrograms per Liter (µg/L)
- CUL = Cleanup level = ending contaminant concentration (µg/L)
- PV_t = time to flush one groundwater pore volume through contaminated zone[1] (year)

  R_f = Retardation factor = $R_f = 1 + K_d * \frac{\rho_b}{n}$

  - K_d = Linear partition coefficient for the contaminant liters per kilogram (L/kg)
  - ρ_b = bulk density of aquifer material kilograms per liter (kg/L)
  - n = Aquifer porosity (dimensionless)

Table B-1 presents the analysis including parameter estimates.

For purposes of this comparative analysis, the following hydrogeologic parameter estimates are applied for both POC scenarios:

- The average hydraulic gradient is determined from measurements from eight water level monitoring events spanning wet and dry season conditions (2016-

[1] Elemental pore volume length divided by average groundwater velocity through that pore volume. Pore volume length must be equal between scenarios to provide a relative comparison of restoration time frames.

2022), with an average of 0.006 feet/foot over the four rounds (refer to Appendix G, Section 2.2).

- The aquifer hydraulic conductivity (K) estimate is the average K value for the Site, based on grain-size analysis of saturated soils (Appendix G, Section 2.1). The average K is 8.3 feet per day.
- Aquifer bulk density of 1.5 kg/L and saturated porosity of 0.43, both of which are default values in MTCA (WAC 173-340-747(4)).

Using these parameters, an average groundwater velocity of 173 feet per year is estimated for the Site

The estimated partition coefficient (K_d) for arsenic was obtained from the downgradient concentration of arsenic in soil (2.1 milligrams per kilogram), and the maximum concentration of arsenic in groundwater at MW-14 (126 µg/L). Using this Site-specific data, the estimated arsenic K_d is 17 L/kg. Using the same arsenic concentration in soil and the average concentration of arsenic in MW-14 (68 µg/L), the estimated arsenic K_d is 31 L/kg.

Based on the distance from the PRB to the existing monitoring wells MW-7, MW-9, and MW-12, a pore volume length of 25 feet was selected. The estimated restoration time frame for a distance 25 feet downgradient of PRB is 38 and 70 years for arsenic K_d values of 17 and 31 L/kg, respectively (Table B-1).

To estimate restoration time frame at the proposed compliance monitoring locations, the restoration time frame for a pore flushing length of 10 feet was also estimated. The estimated restoration time frame for a distance 10 feet downgradient of PRB is 15 and 28 years for arsenic K_d values of 17 and 31 L/kg, respectively (Table B-1).

FINAL

Table B-1. Relative Comparison of Restoration Time Frame Estimates for Conditional Point of Compliance

Project No. 210158, Port of Tacoma Parcel 15 (Portac), Tacoma, Washington

Batch Flush Model Calculations (Zheng and Bennett, 2002)

Equation: $t = -\ln(Ct/Co) * PV_t * Rf$

where:

t = time to reach cleanup level = restoration time frame (years)

Ct = concentration at time t = Preliminary Cleanup Level (ug/L)

Co = Initial concentration (ug/L)

PV_t = time to flush 1 pore volume (years)

Rf = retardation factor = 1 + (Kd * p_b / n)

Kd = partition coefficient (L/kg)

p_b = aquifer bulk density (g/cc = kg/L)

n = porosity (dimensionless)

Use arsenic as indicator hazardous substance for this analysis.

Refer to text for discussion of analysis assumptions

Estimate of Average Groundwater Velocity at Site

Average Horizontal Gradient in ft/ft	Hydraulic Conductivity in cm/sec	Effective Porosity	Groundwater Velocity in ft/year
0.006	3.E-03	0.1	173

Low Kd			**High Kd**		
For Pore Flusing Distance of 25 feet					
CUL (Ct) =	5	ug/L	CUL (Ct) =	5	ug/L
Co =	**68**	**ug/L**	**Co =**	**68**	**ug/L**
PV length =	25	ft	PV length =	25	ft
PV_t(b) =	0.1	year	PV_t(b) =	0.1	year
Kd =	17	L/kg	Kd(c) =	31	L/kg
p_b =	1.5	kg/L	p_b =	1.5	kg/L
n =	0.25	-	n =	0.25	-
Rf =	101	-	Rf =	186	-
Estimated Restoration Time Frame =	**38**	**years**	**Estimated Restoration Time Frame =**	**70**	**years**
For Pore Flusing Distance of 10 feet					
CUL (Ct) =	5	ug/L	CUL (Ct) =	5	ug/L
Co =	**68**	**ug/L**	**Co =**	**68**	**ug/L**
PV length =	10	ft	PV length =	10	ft
PV_t(b) =	0.1	year	PV_t(b) =	0.1	year
Kd =	17	L/kg	Kd(c) =	31	L/kg
p_b =	1.5	kg/L	p_b =	1.5	kg/L
n =	0.25	-	n =	0.25	-
Rf =	101	-	Rf =	186	-
Estimated Restoration Time Frame =	**15**	**years**	**Estimated Restoration Time Frame =**	**28**	**years**

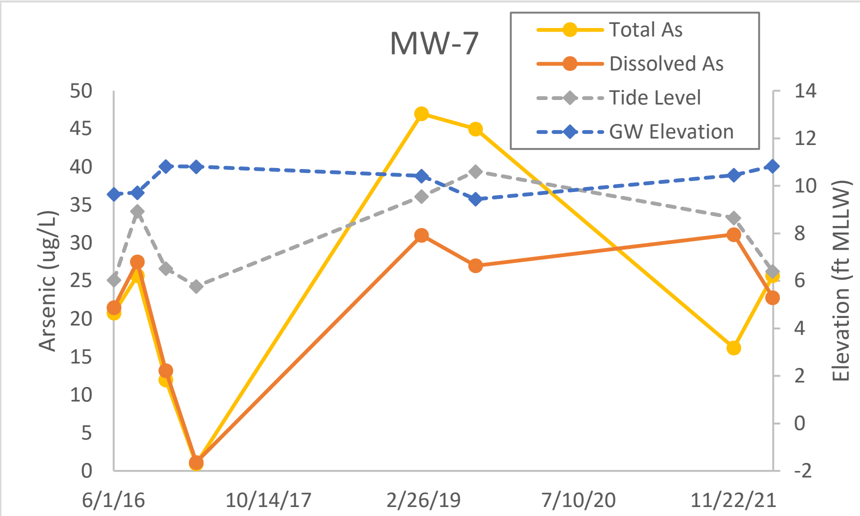
Notes:

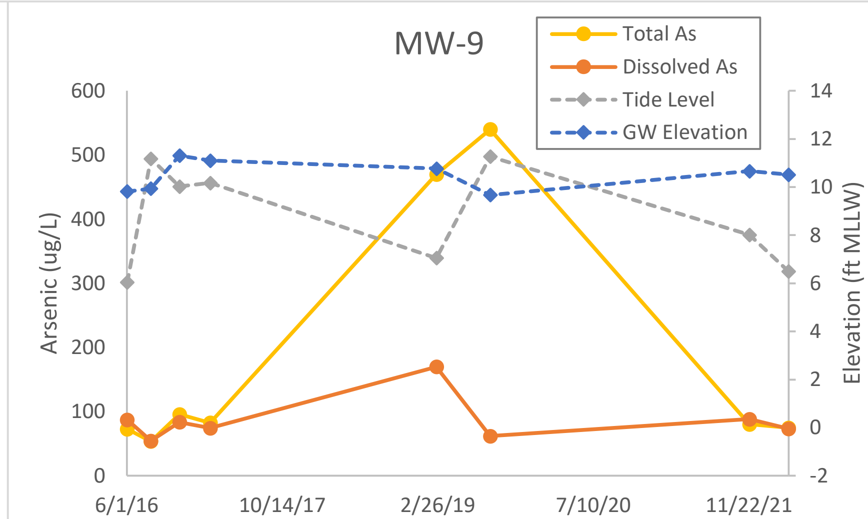
(b) Calculated based on groundwater velocity and pore volume (PV) length

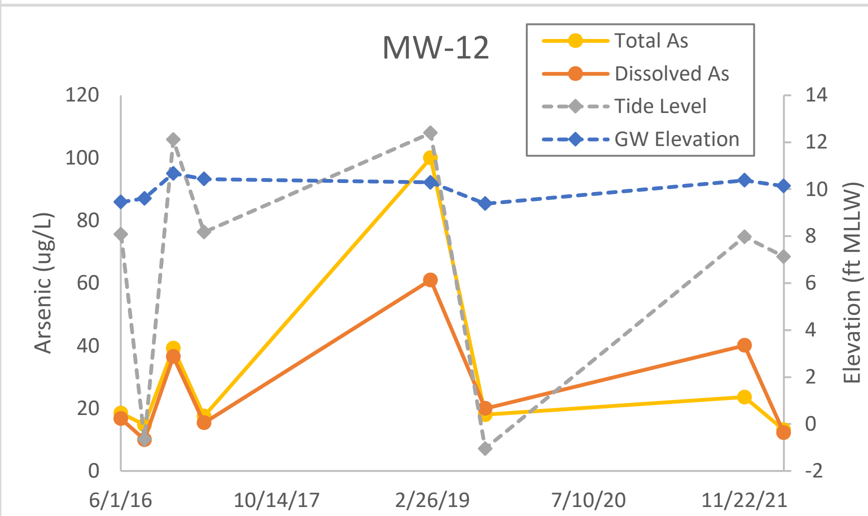
(c) Calculated based on downgradient soil As concentration (2.1 mg/kg) and upgradient groundwater As concentration (68 ug/L).

APPENDIX C

MW-7, MW-9, and MW-12 Arsenic Trend Plots







Notes:

1) EPA Method 1638 was used for arsenic analysis from May 2016 through February 2017. EPA Method 6020B was used for arsenic analysis from February 2019 to present.