ENGINEERING DESIGN REPORT
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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KPFF Consulting Engineers is responsible for the stormwater conveyance system improvements engineering design. Aspect Consulting, LLC is responsible for the permeable reactive barrier engineering design.

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Acronyms

Aspect	Aspect Consulting, LLC
BGS	Below Ground Surface
CAP	Cleanup Action Plan
CIPP	Cured-In-Place Pipe
CMCRP	Compliance Monitoring and Contingency Response Plan
CMMP	Contaminated Media Management Plan
CRA	Willamette Cultural Resources Associates, LTD
CUL	Cleanup level
DAHP	Washington State Department of Archaeological and Historic Preservation
Ecology	Washington State Department of Ecology
EDR	Engineering Design Report
HPA	Hydraulic Project Approval
JARPA	Joint Aquatic Resources Permit Application
KPFF	KPFF Consulting Engineers
MLLW	mean lower low water
OHWM	ordinary high water mark
OMMP	Operations, Maintenance, and Monitoring Plan
PRB	permeable reactive barrier
PRDI	pre-remedial design investigation
PTOI	Puyallup Tribe of Indians
RCC	roller compacted concrete
RDWP	Remedial Design Work Plan
SPCC	spill prevention, control and countermeasures
TESC	Temporary Erosion and Sedimentation Control
USACE	U.S. Army Corps of Engineers
WDFW	Washington State Department of Fish and Wildlife
ZVI	zero-valent iron
µg/L	micrograms per liter

1 Introduction

Aspect Consulting, LLC (Aspect) has prepared this Engineering Design Report (EDR) 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; Figure 1). 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 Portac Phase 1 Cleanup activities (referred to herein as the "Phase 1 Cleanup"). The second phase of cleanup identified in the CAP is construction of a low-permeability cap and will be implemented concurrent with a future development of the Site under an Agreed Order Amendment or Consent Decree.

A Final Remedial Design Work Plan (RDWP) approved by Ecology described the pre-remedial design investigation (PRDI) activities necessary to complete the Phase 1 Cleanup remedial design (Aspect, 2021). The PRDI activities were conducted in November and December 2021 and results reported to Ecology in a PRDI Technical Memorandum (PRDI Tech Memo), which included PRB length and depth recommendations for Ecology concurrence prior to preparation of this EDR (Aspect, 2022a). The PRDI Tech Memo is included in Appendix A.

This EDR is for Phase 1 Cleanup construction of stormwater conveyance improvements and a permeable reactive barrier (PRB). The stormwater conveyance system improvements will eliminate Site groundwater from entering two stormwater pipes discharging to Wapato Creek. The stormwater conveyance system improvements consist of solids removal from pipes, trenchless pipe repair, stormwater vault replacement, and outfall upgrades (including inline check valves). 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.

This EDR deliverable is required by the Agreed Order and will be approved by Ecology prior to the Phase 1 Cleanup construction. This EDR describes the engineering design of the Phase 1 Cleanup construction elements for stormwater conveyance improvements and PRB.

Deliverables required by the Agreed Order consisting of the Compliance Monitoring and Contingency Response Plan (CMCRP), Contaminated Media Management Plan (CMMP), and Operations, Maintenance, and Monitoring Plan (OMMP) have been prepared as separate reports. The CMCRP details the monitoring to be conducted to evaluate compliance with cleanup standards, and potential contingency actions for the Site (Aspect, 2022b). The CMMP describes the management requirements for contaminated soil and water to be generated during and after Phase 1 Cleanup construction, and during future Site activities (Aspect, 2022c). The OMMP describes remedy maintenance activities to be completed after Phase 1 Cleanup construction to ensure cleanup actions are functioning as designed (Aspect, 2022d).

1.1 Organization

The EDR is organized in the following sections:

- **Section 2** summarizes the PRDI results as a basis of engineering design. The PRDI Tech Memo is also included as Appendix A.
- **Section 3** describes the actions taken and permits obtained to comply with all applicable substantive requirements as outlined in the RDWP (Aspect, 2021).
- **Section 4** outlines the stormwater conveyance system improvement engineering design for the Phase 1 Cleanup.
- **Section 5** outlines the PRB engineering design for the Phase 1 Cleanup.
- **Section 6** outlines the Ecology deliverable schedule for Phase 1 Cleanup construction activities.

The EDR also compiles additional Phase 1 Cleanup information and supplemental plans required by the Agreed Order as Appendices:

- **Appendix A –** The PRDI Tech Memo.
- **Appendix B –** The Treatability Testing Report includes the results of flow-through column testing and geochemical evaluation conducted to design the PRB and is summarized in Section 2.1.2.
- **Appendix C –** A Cultural Resources Assessment Report prepared by Willamette Cultural Resources Associates, LTD (Willamette CRA) includes historical research, archaeological monitoring observations from PRDI activities, and recommendations for archaeological monitoring during construction and is summarized in Section 3.2.3.
- **Appendix D –** The PRB Design Calculations presents all engineering design criteria for the PRB (Section 5). The PRB design values are summarized in Table 1.
- **Appendix E –** The Joint Aquatic Resources Permit Application (JARPA) figures submitted to the U.S. Army Corps of Engineers (USACE) on October 1, 2021, to obtain a Department of the Army permit for work below ordinary high water mark (OHWM) of Wapato Creek.
- **Appendix F –** Communication with permitting authorities, and associated permits, to demonstrate compliance with all applicable state and local substantive requirements.

2 Pre-Remedial Design Investigation Summary

The PRDI activities were conducted in November and December 2021 and the results reported to Ecology in the PRDI Tech Memo are included in Appendix A. This section summarizes the PRDI results as a basis of engineering design.

2.1 Permeable Reactive Barrier Design Investigation

The completed PRB Alignment Investigation and Treatability Testing achieved the objectives outlined in the RDWP (Aspect, 2021):

1. Develop the basis of PRB dimensions (length, depth, and width).
2. Develop the basis of PRB composition (ZVI percentage content and backfill [ZVI and sand] specifications).
3. Evaluate Site groundwater quality at the PRB alignment, and in the presence of ZVI.

The following sections summarize the PRDI results.

2.1.1 PRB Alignment Investigation

Investigation was conducted from November 15 to 19, 2021, at six boring locations (AB-01 through AB-06) as shown on Figure 3. At each of the six boring locations, three distinct borings approximately 2 ft apart and configured in a triangle were advanced at each AB- boring location. The three points at each boring location were used to:

1. Advance a **hydraulic profiling tool (HPT)** to 30 ft below ground surface (ft. bgs) at each boring and evaluate the feasibility of keying the PRB into a clay unit. The HPT borings identified a clay unit at all borings serving as a basis of PRB depth.

2. Advance a **soil boring to collect continuous core** to 25 ft. bgs for lithology logging, mineralogical field data, and soil sampling. The soil boring results are reported in Appendix A, and corroborate the clay unit basis of PRB depth.

3. Collect **discrete groundwater samples** at three discrete depth intervals to evaluate any depth discrete groundwater quality basis of PRB design.

Additionally, a new groundwater monitoring well MW-14 was installed upgradient of the PRB alignment, east of MW-7 on November 16, 2021 (Figure 3). The MW-14 location produced groundwater for the treatability testing (flow-through column testing) remedial design and establishes a basis of PRB influent arsenic concentration for PRB engineering design.

2.1.1.1 PRB Alignment Conclusions

The PRB Alignment Investigation confirmed the PRB alignment along the western extent of the Site and adjacent to Wapato Creek. The PRB alignment is perpendicular to groundwater flow and intercepts arsenic-containing groundwater prior to discharge to Wapato Creek. Based on the PRB Alignment Investigation results, a PRB on the north side of the Site would not be perpendicular to groundwater flow and not in a downgradient position (Appendix A).

The PRB depth is established at the clay unit encountered at AB-02, AB-03, and AB-04 and illustrated on Figures 7 and 8.

The length of the PRB adjacent to Wapato Creek will span from the stormwater pipe at the northern terminus, to the bank of the former Wapato Creek channel to the south. The southern PRB alignment will be a different orientation for approximately 123 ft in order to be perpendicular to groundwater flow and to be keyed into the same clay unit on the bank of the former Wapato Creek channel (Figure 6).

2.1.2 Treatability Testing

Treatability testing was conducted to evaluate the PRB technology under Site-specific conditions. The objectives of treatability testing were to determine the PRB composition and evaluate groundwater quality at the PRB alignment and in the presence of ZVI. All results are reported in the Treatability Testing Report in Appendix B and summarized in the following sections. The treatability testing consisted of flow-through column testing and geochemical evaluations.

2.1.2.1 Column Testing

Flow-through column testing was conducted to:

1. Verify ZVI reactivity in the presence of Site groundwater.
2. Collect basis of design parameters (reaction rate and arsenic uptake capacity) for determining PRB width and iron composition.
3. Evaluate secondary water quality factors that may impact PRB performance (i.e., mineral precipitation).

The column testing was conducted at the Site using MW-14 groundwater generated from low-flow pumping as the column influent. The initial dissolved arsenic concentration in MW-14 was 21.3 µg/L, which was too low for meeting column test objectives. Therefore, an inflatable packer was set at the middle of the MW-14 screen and sample intake above packer, which proved successful at increasing arsenic concentration in column influent.

Column operation began on November 29, 2021, and continued for a total of 8 days until December 6, 2021. Three columns were operated with a test variable of ZVI percentage (by mass): 10 percent ZVI (C10), 20 percent ZVI (C20), and a control column (CC). The columns were set up in a vertical position with the influent at the bottom and effluent at the top for up-flow, and each column was constructed with two evenly spaced sample ports. Influent Site groundwater and effluent from each column was sampled five times during the test and were analyzed for metals and geochemical parameters. The same influent was used for all three columns. The sample ports were sampled four times and analyzed for total and dissolved arsenic. In total, 109, 91, and 98 pore volumes of MW-14 groundwater were routed through the CC, C10, and C20, respectively. A total MW-14 groundwater volume of 172 gallons was used in the column test.

The flow-through column testing verified ZVI reactivity and effective removal of arsenic from Site groundwater. Influent-dissolved arsenic from MW-14 ranged from 43.8

micrograms per liter (µg/L; Day 2) to 126 µg/L (Day 8), and total arsenic ranged from 44.3 µg/L (Day 2) to 91.2 µg/L (Day 4). Effluent concentrations of dissolved arsenic on Day 8 were 8.72 µg/L in the C10, and 5.38 µg/L in the C20.

Column testing results were used to calculate first-order arsenic reaction using the Day 8 results as the most representative of steady-state conditions. Estimated reaction rate and required PRB residence time are presented in the PRB Design Calculations in Appendix D and summarized below in Section 4.

2.1.2.2 Geochemical Evaluation

A geochemical evaluation was performed to evaluate mineral precipitation in the PRB and potential impact on effective arsenic treatment. The geochemical evaluation also included 1D arsenic transport modeling to predict groundwater quality downgradient of the PRB.

The Geochemist's Workbench® (GWB) SpecE8 modeling program (release 12) and Eh-pH diagrams were utilized to predict whether the precipitating minerals within the PRB are arsenic-sequestering or non-arsenic-sequestering. The modeling was conducted in four steps:

1. Check column groundwater sample equilibrium using cation and anion balance.
2. Estimate mineral saturation indices using column groundwater results water chemistry, and create Eh-pH diagrams.
3. Estimate rate of precipitation for minerals most likely to precipitate given results from Step 2.
4. Use X-ray diffraction (XRD) and scanning electron microscopy (SEM) of spent column test media to verify predicted mineral forms.

Results show that in general, aside from the host minerals present in the sand/ZVI column media (e.g., quartz, feldspars, micas, amphibole), abundant arsenic-sequestering minerals, like Fe-oxides/oxyhydroxides and likely siderite, are present in the solids. These data suggest that the likelihood of passivation and/or cementing of arsenic-sequestering minerals with non-arsenic sequestering minerals in the PRB is relatively low.

2.1.2.3 Treatability Testing Results

The conclusions of treatability testing are as follows:

1. Column testing verifies the reactivity of ZVI in the presence of Site groundwater, and the effective removal of arsenic from groundwater. There was a lower As concentration in C20 effluent than in C10 effluent, indicating increased arsenic uptake rates in C20.
2. Equilibrium speciation modeling on column influent and effluent samples estimates saturation indices within the PRB for Fe-oxide/oxyhydroxide minerals which are an order of magnitude greater than carbonate mineral species estimates.
3. The XRD and SEM results show the presence of mostly Fe-oxides/oxyhydroxides and little evidence of significant Ca- or Mg-bearing carbonate precipitation.

4. The combined mineral formation rate for predicted minerals in ambient groundwater (not including iron corrosion products) was predicted to be on the order of 0.11 cubic centimeters per liter (cm^3/L), or 0.011 percent volume.
5. The 1D transport simulation predicts timeframe to reach 5 µg/L in groundwater 25 ft downgradient of the PRB is about 25 years assuming an average Darcy's groundwater flux of 0.047 ft/day. This geochemical modeling prediction is discussed in the context of groundwater cleanup standards, and potential contingency actions in the CMCRP (Aspect, 2022b).

2.2 Site Monitoring

The Agreed Order requires that semiannual groundwater monitoring and annual cap inspections be initiated upon its effective date. Two groundwater monitoring events were conducted on November 22, 2021, and March 29, 2022 during remedial design (Table 2). Groundwater samples were collected from MW-7, MW-9, MW-12, B-5R and MW-14 in the Log Yard area and from MW-2R in the Sawmill area in accordance with RDWP (Aspect, 2021).

The Agreed Order-required cap inspection was also conducted during the PRDI activities on December 17, 2021, and is reported in the OMMP (Aspect, 2022d).

3 Substantive Requirement Compliance

The Phase 1 Cleanup will comply with all applicable federal, state, and local requirements, including requirements to obtain the necessary permits or approvals, except as required in RCW 70.105D.090. The Agreed Order identifies that the Port has a continuing obligation to comply with federal, state, and local requirements, although the Agreed Order did not identify any federal, state, or local requirements as being applicable to the Phase 1 Cleanup. The RDWP identified the substantive requirements determined to be applicable to this Phase 1 Cleanup (Aspect, 2021). This section summarizes the compliance with these substantive requirements.

3.1 Federal

Modifications to the existing outfalls below the OHWM in Wapato Creek requires a permit from the USACE. The Joint Aquatic Resources Permit Application (JARPA) form and figures were submitted to the USACE on October 1, 2021, to obtain a Department of the Army permit for work below the OHWM of Wapato Creek (Appendix F). Supporting JARPA documentation includes an Endangered Species Act (ESA) Biological Evaluation (BE), Essential Fish Habitat (EFH) Analysis, and ESA Section 7 consultation with the National Marine Fisheries Service and U.S. Fish and Wildlife Service. Section 7 documentation and consultation is required for the USACE to provide the Department of the Army permit.

The USACE, Seattle District confirmed JARPA receipt and assigned project reference number of NWS-2021-950 and project name of Tacoma, Port of (Parcel 15 Cleanup Phase 1) on October 1, 2021. Nationwide Permit 38 authorization was received from USACE on May 20, 2022 and is included in Appendix F.

3.2 State

3.2.1 SEPA

The Phase 1 Cleanup activities comply with State Environmental Policy Act (SEPA), Chapter 43.21C RCW by conducting a review in accordance with applicable regulatory requirements, including WAC 197-11-268, and Ecology Policy 130A (Ecology, 2004). Ecology determined that the Phase 1 Cleanup activities will not have a probable significant adverse impact on the environment and issued a Determination of Nonsignificance (DNS) on March 25, 2021.

3.2.2 Hydraulic Project Approval

The Phase 1 Cleanup activities are exempt from obtaining a Washington State Department of Fish and Wildlife (WDFW) Hydraulic Project Approval (HPA) but will comply with HPA substantive requirements. The Port delivered a project notice letter to WDFW that describes how the Phase 1 Cleanup activities will comply with HPA substantive requirements. The letter was delivered on May 6, 2022 and outlines how the Phase 1 Cleanup will comply with HPA substantive requirements of avoiding and minimizing adverse impacts to the aquatic environment and is summarized in Section 4.8.

The WDFW responded on May 17, 2022 confirming review of the letter and compliance with HPA substantive requirements (Appendix F).

3.2.3 Cultural Resources

The Phase 1 Cleanup complies with the Washington State Department of Archaeological and Historic Preservation (DAHP) substantive requirements. The Port has consulted directly with the Puyallup Tribe of Indians (PTOI) throughout the Phase 1 Cleanup remedial design activities. Archaeological monitoring was conducted by Willamette CRA during the PRDI activities in accordance with the Ecology Inadvertent Discovery Plan in the RDWP (Aspect, 2021). The archaeological monitoring of PRDI activities identified no cultural resources.

Willamette CRA prepared and submitted a Cultural Resources Assessment to PTOI with background research and the PRDI archaeological monitoring observations on April 19, 2022 (Appendix C). As recommended in the Cultural Resources Assessment, archaeological monitoring of excavated soils from the PRB and stormwater vault replacement will be conducted to ensure protection of any cultural resources encountered. The Port will continue its direct consultation with PTOI throughout the Phase 1 Cleanup activities and comply with all DAHP substantive requirements.

3.2.4 Construction Stormwater

The Phase 1 Cleanup will comply with Washington State Department of Ecology Water Quality standards for managing stormwater on contaminated sites. The Phase 1 Cleanup will require a Notice of Intent (NOI) and issuance of a Construction Stormwater General Permit (CSWGP) before commencing construction activities. The NOI will indicate the project will be zero discharge, and all construction-generated water will be managed through permitted discharge to sanitary sewer or off-Site permitted disposal.

The CSWGP NOI was submitted on April 15, 2022 (NOI No. 39064) and is currently in public notice review. The CSWGP will be issued prior to Phase 1 Cleanup construction activities and will be included in the contract documents.

3.3 Local

3.3.1 Site Development and Shoreline Permits

The Phase 1 Cleanup is exempt from obtaining a City of Tacoma (City) Site Development Permit, Shoreline Permit, and Stormwater Site Plan but will comply with these local permit substantive requirements. A Stormwater Pollution Prevention Plan (SWPPP) will be prepared for the Phase 1 Cleanup activities to comply with City Stormwater substantive requirements.

The Port completed a pre-development application to the City describing the Phase 1 Cleanup activities. The City provided land use, zoning, shoreline, critical area review, and environmental services advisory comments, which are all incorporated into the project and will comply with all City substantive requirements (Appendix F).

3.3.2 Discharge Permit

Water generated during the Phase 1 Cleanup construction will be managed in accordance with the City of Tacoma Special Approved Discharge (SAD) Authorization No. 22-007.

The draft SAD is included in Appendix F and the final permit will be issued once a Contractor has been selected. The SAD Authorization requirements are incorporated into the construction specifications.

4 Stormwater Conveyance System Improvements

Improvements to the stormwater conveyance system is one of two primary components of the cleanup action selected in the CAP (Ecology, 2021). The stormwater system to be improved consists of a 30-inch diameter storm pipe at the north end of the Site that discharges to outfall OF-2 and a 36-inch diameter storm pipe at the south end of the Log Yard area that discharges to outfall OF-3 (Figure 4). The improvements to these stormwater conveyance system features consist of:

- Removal of accumulated debris and solids in the stormwater system
- Trenchless pipe repair of the pipe section between the outfalls and spill containment vaults, distances of approximately 354 and 346 linear feet
- Removal of the existing spill containment vaults and replacement with new section of pipe and stormwater vaults
- Installation of tide gates (inline check valves) at outfalls OF-2 and OF-3 to prevent tidal backflow from Wapato Creek

A CCTV camera survey will be completed prior to any improvements, after debris removal, and after trenchless pipe repair for verification. Before implementing these improvements, construction erosion and sediment controls will be established, and all utilities will be protected. The existing fence along Wapato Creek will be removed temporarily, and a temporary stormwater bypass to the sanitary sewer manhole in the discharge permit will be installed to manage stormwater during construction as discussed in Section 4.3.

4.1 Performance Objectives

The CAP identified groundwater infiltration into the stormwater system as a preferential pathway for arsenic migration to Wapato Creek. Groundwater infiltration into the storm drain system is occurring due to pipe damage, deterioration, and/or pipe joint displacement likely caused by heavy equipment and log handling operations within the Log Yard area. The performance objectives of the stormwater conveyance system improvements are:

1. Cutoff groundwater seepage into vaults and into pipe length from vault to outfalls.
2. Achieve groundwater and surface cleanup level (CUL) of 5 µg/L arsenic in discharge from outfalls OF-2 and OF-3 discharge.

Monitoring of the outfalls will be conducted after construction of the stormwater conveyance system improvements. The CMCRP includes all details of compliance monitoring (Aspect, 2022b).

4.2 Engineering Design Criteria

The Port operates as a secondary permittee under the Phase 1 Municipal Stormwater General Permit (MS4), Ecology National Pollutant Discharge Elimination System (NPDES) Permit WAR044200. This is accomplished by adhering to the requirements of the Port of Tacoma's Stormwater Management Guidance Manual (Manual) and the City of Tacoma Stormwater Management Manual (2016 SWMM). The Port is responsible for reviewing the project and ensuring conformance to the Manual and Ecology NPDES Permit WAR44200. However, the Manual is intended to complement the 2016 City of Tacoma SWMM and other Ecology-approved stormwater management manuals as applicable.

4.3 Construction Stormwater Management

The stormwater conveyance system improvements will occur during the dry season limiting construction stormwater generation and therefore management. Temporary Erosion and Sedimentation Control (TESC) plans are part of the contract documents. The TESC plans provide at-a-minimum guidance to the contractor regarding sequencing constraints and potential best management practices (BMPs) to implement. The BMPs include, but are not limited to, silt fence, straw wattles, inlet protection, supersak/sandbagging and cofferdams, and baker tanks for treatment and discharge to sanitary sewer, including temporary discharge pipes and stormwater bypass. The contractor shall also develop a Stormwater Pollution Prevention Plan (SWPPP) in accordance with Department of Ecology Construction Stormwater General Permit and the Port of Tacoma Phase I Municipal Stormwater Permit. All construction stormwater generated during Phase 1 Cleanup construction will be discharged to the sanitary sewer in accordance with SAD Authorization No. 22-007.

4.4 Solids Removal

The removal of debris and solids from the stormwater pipes is necessary to conduct the trenchless pipe repair and achieve performance objectives. Solids will be removed from both pipe sections between the vault and the outfall.

This will be accomplished by jetting, vactoring, or a combination of both methods. Work to remove solids must also avoid and minimize adverse impacts to the aquatic environment by capturing any liquid wastes generated during the process and discharging to the sanitary sewer. The solids and debris, and any water produced will be disposed of by the contractor in accordance with management requirements described in the CMMP (Aspect, 2022c).

4.5 Trenchless Pipe Repair

Trenchless pipe repair of existing stormwater pipes will be completed between outfalls OF-2 and OF-3 and the stormwater vaults. The trenchless pipe repair methods were selected from an assessment of the four pipe lining methods:

- Cured-In-Place-Pipe (CIPP) Lining
- Pipe Bursting
- Slip Lining
- Internal Pipe Coating

The CIPP lining was determined most suitable for the Phase 1 Cleanup project. The CIPP methods are well demonstrated and can be effectively implemented at the Site. The CIPP lining will be implemented using either ultraviolet (UV) CIPP or conventional CIPP methods. Volatile organic compounds are an emission with both UV and conventional CIPP lining. This environmental consideration will be managed by the contractor in accordance with their spill prevention, control and countermeasures (SPCC) plan.

CIPP lining installation will need equipment and personnel below OHWM during installation at low tide. Winching equipment will be operated at the outfall to pull the lining material into place within the existing pipe. Other lining installation equipment will be operated from the upland manhole.

The UV CIPP is a technology that has not yet been widely adopted by local contractors as standard. The UV CIPP method is advantageous as it can complete the pipe repair quicker, however; there are fewer qualified contractors who can perform it. Therefore, the project construction specifications will include either UV CIPP or conventional CIPP method.

4.5.1 Ultraviolet CIPP Lining

The UV CIPP method has advantages of a generally higher production rate and also a faster cure rate. For UV CIPP, the ultraviolent light acts as the catalyst that hardens the liner. The curing occurs when a light train is pulled through the expanded liner at a constant speed. For typical pipe lengths, curing can be done in under an hour using UV CIPP. The resin used for UV CIPP is more gel-like and has a longer shelf life than the resin used in conventional CIPP methods and is typically delivered to the Site impregnated in the liner. The faster UV CIPP cure time is advantageous when repairing pipes during limited low tide windows.

UV-cured liners generally provide a stronger finished product than conventional cured liners. The UV curing provides a more consistent cure, limiting chance for lowered strengths. The higher-strength UV pipes are particularly advantageous when the pipe to be repaired has significant degradation as the liner strength of the cured pipe allows for longer spans. One disadvantage of the UV liners is they are less flexible and not ideal for projects with bends or angles, which is not required for either pipe on this project.

4.5.2 Conventional CIPP Lining

The conventional CIPP curing methods typically involve mixing the resin and fully impregnating the liner with the resin on Site. Some curing methods require the addition of a catalyst to the resin mix. Once impregnated, the liner is then set in place inside the existing pipe. Finally, pressure is applied to keep the liner firm against the existing pipe wall. The pipe is then cured with either steam, hot water, or ambient temperature. Steam or hot water cure require coordination of boilers and an adequate water source to achieve curing. For ambient cures, there is no additional curing equipment needed. The conventional CIPP curing takes several hours and varies significantly by pipe diameter, pipe length, and curing method. The longer curing duration will have to fit within low tide cycles.

4.6 Vault Replacement

The two existing stormwater vaults east of outfalls OF-2 and OF-3 will be removed and replaced with new vaults.

The new vaults are concrete with internal dimensions 8 ft wide, 16 ft long and at least 4 ft deep. The concrete vault will be divided into four chambers by internal concrete walls and removable flashboards (wood or other material).

Surface water will enter the vault via a 30-inch by 48-inch metal grate and into three chambers:

1. Water enters a primary sediment removal chamber for maximum sediment and debris retention.

2. A secondary sediment chamber is similar in size to the primary sediment chamber and creates a second step for removal of sediment in the stormwater runoff. Since this chamber should collect a smaller portion of the sediment in the runoff, it may be filled with large-diameter rock or gravel to slow water velocities and deposit smaller sediment particles.

3. Finally, the treatment chamber allows for the addition of stormwater treatment cage and media, in the event that it is required by future site uses. The treatment chamber is approximately 8 ft wide and 11 ft long. The discharge chamber will have a 15-inch-diameter outlet, providing capacity for conveyance of runoff from up to 3 acres during a 25-year storm event. The treatment chamber is sized for the existing catchment area, as upland property to the east will be treated separately by way of a separate catchment point, which is not part of this project. Stormwater from upland catchment areas will not pass through the replacement treatment vault but bypass through to the outfall.

The old vaults will be disposed of off Site by the contractor in accordance with all local and state regulations. Any incidental soil excavated during the vault removal and replacement will be managed by the contractor in accordance with requirements in the CMMP (Aspect, 2022c). The new stormwater vault will be underlain by 12 inches of gravel backfill. Excavated soils that meet reuse criteria defined in the CMMP can also be used to backfill the stormwater vault replacement area.

Any stormwater captured in the pipes upgradient of the vaults during construction will be temporarily routed to the sanitary sewer via a bypass and will be discharged according to conditions of SAD Authorization No. 22-007.

4.7 Outfall Upgrades

The cleanup includes maintenance and repair of stormwater outfalls OF-2 and OF-3 located below OHWM of Wapato Creek. The figures showing outfall upgrades submitted with the JARPA are included in Appendix E.

The outfall upgrades will place riprap to repair scour holes at existing outfall pads and to prevent future erosion. The riprap will be placed using an excavator from the top of the bank during low tide. Riprap repair will not extend beyond the existing riprap footprint.

The outfall upgrades also include the installation of tide check valves at OF-2 and OF-3 to prevent tidal backflow from Wapato Creek. This work will be completed during low tide.

4.8 Work Below OHWM

The trenchless pipe repairs and outfall upgrades require work be conducted below OHWM of Wapato Creek. The work will be conducted in accordance with USACE permit conditions and will comply with HPA substantive requirements (Appendix F). The project is designed to avoid and minimize adverse impacts to the aquatic environment in the following ways:

- Work below the OHWM will occur during the WDFW-approved in-water work window when juvenile salmonids are unlikely to be present.
- Work will occur during dry periods of low-flow/low-tide to the greatest extent practicable.
- Fish exclusion protocols will be implemented prior to in-water work.
- In-water work will occur in isolation of natural stream flow (e.g., cofferdams, etc.) to avoid and minimize turbidity and sedimentation within Wapato Creek.
- The contractor will be required to prepare an erosion and sediment control (ESC) plan and a SPCC plan prior to the start of work activities.
- All stockpile and excavation areas will be protected from the release of sediment.
- Clean rock material will be used.
- Garbage and other deleterious debris will be removed from the shoreline where work occurs.

4.9 Operations and Maintenance

Once the stormwater conveyance system improvements are complete, operations and maintenance will be completed by the Port to ensure the stormwater conveyance system improvements are performing as intended. Routine inspection of vaults and outfall will be conducted and may yield maintenance activity such as removal of debris and general vault cleanout. This operations and maintenance responsibility is required under the Port’s Phase 1 Municipal Stormwater permit (MS4) and is described in the OMMP for the Phase 1 Cleanup (Aspect, 2022d).

4.10 Outfall Monitoring

Surface water compliance is based on the stormwater discharging from outfalls OF-2 and OF-3 into Wapato Creek. Once the stormwater conveyance system improvements are complete, stormwater sampling at the outfalls will be conducted to assess performance of stormwater conveyance system improvements and evaluate compliance with CULs. Samples will be collected from outfalls OF-2 and OF-3 when the tide is below 9 ft MLLW, which is below the outfall invert elevations. The details of outfall monitoring and potential contingency action are included in the CMCRP (Aspect, 2022b).

5 Permeable Reactive Barrier

The PRB will intercept Site groundwater and immobilize arsenic from groundwater discharging to Wapato Creek, addressing the groundwater to surface water pathway at the Site. The PRB Alignment Investigation results established the basis of PRB alignment (length and depth) shown in Figure 5. The Treatability Testing results establish the basis of PRB width and composition established in this section.

The PRB will be 664 linear ft long, approximately 23 ft deep, and 2 ft thick and backfilled with 20 percent ZVI. The ZVI backfill will be placed to elevation 14 ft MLLW, 2.8 ft higher than the maximum groundwater elevation observed on the PRB alignment accommodating potentially higher groundwater elevations in the future. The PRB will be fully penetrating and keyed at least 6 inches into a continuous clay unit. The PRB design outlined in this section satisfies the requirements for the PRB cleanup action element in the CAP, and requirements of the Agreed Order.

5.1 Performance Objectives

The PRB is designed to meet the following performance objectives:

- Intercept arsenic-contaminated groundwater discharging to Wapato Creek and immobilize arsenic within the PRB thereby removing arsenic from groundwater transport.
- Achieve the groundwater remediation levels (RELs) downgradient of the PRB in the short term, to be first evaluated after five years of compliance monitoring.
- Maintain PRB hydraulic conductivity greater than the aquifer soils hydraulic conductivity.

Groundwater compliance monitoring to evaluate PRB performance is discussed in the CMCRP (Aspect, 2022b).

5.2 ZVI and PRB Technology

The PRB technology relies on groundwater flow through an emplaced zone of permeable reactive medium. This results in the passive treatment of groundwater as it flows through the medium, making it essentially a “barrier” to contaminant transport during the PRB lifetime. As established in the PRDI Tech Memo, the selection and design of the PRB technology is premised on two fundamentals (Appendix A):

1. A PRB is oriented perpendicular to groundwater flow for treatment and downgradient groundwater quality improvement efficiency.
2. A PRB is applicable to downgradient dissolved-phase groundwater plume treatment and not applicable to source treatment.

PRBs containing zero-valent iron (ZVI) have been installed since 1995 to treat groundwater contaminated with chlorinated solvents and metals. The effective removal of arsenic from groundwater by ZVI has been demonstrated extensively in the literature (i.e., Su and Puls, 2001a; Su and Puls, 2001b; Melitas et al, 2002; Kober et al, 2005; Su 2007). Performance of a ZVI-based PRB designed specifically to treat arsenic is also effectively demonstrated when groundwater was intercepted by the reactive medium (Wilkin et al, 2009; Beak and Wilkin, 2009). The primary removal mechanisms were found to include adsorption to and coprecipitation with fresh forms of iron that are produced as the ZVI corrodes, such as oxides, sulfides, carbonates, and carbonate/sulfate green rusts (i.e., Beak and Wilkin 2009). The studies referenced above demonstrate that the reactions involved are numerous, complex, and highly dependent on Site-specific conditions, warranting treatability testing.

The completed treatability testing verifies the effective removal of arsenic from Site groundwater using ZVI and evaluated the Site-specific geochemistry. The Treatability Testing Report includes geochemical evaluation of reactions and arsenic-attenuating mechanisms based on column testing results (Appendix B). The PRDI considered known ZVI PRB technology failure mechanisms of:

1. Incomplete PRB hydraulic capture of the target groundwater plume,
2. Incomplete treatment due to ZVI passivation from excessive mineral precipitation, or
3. Inadequate residence times due to porosity plugging from minerals, gas production and/or fines migration.

Arsenic-containing groundwater flow at the Site is vertically constrained by the clay unit established during the PRDI, allowing the PRB to key into the clay unit and fully intercept the target groundwater. The PRDI Tech Memo established the basis of PRB length to intercept groundwater flow discharging to Wapato Creek to the maximum extent practicable.

Avoiding failure mechanisms 2) and 3) was a basis for treatability testing, which determined that the predominant minerals being formed are arsenic-attenuating, and the predicted mineral formation rates were not excessive (Appendix B).

5.3 Engineering Design Criteria

This section summarizes the PRB design criteria. All design assumptions and calculations are included in Appendix D, and the design criteria values are listed in Table 2.

5.3.1 Aquifer Hydraulics

The soils in the PRB alignment consist mostly of silty sand (SP) and sand with silt (SP-SM) shown in cross section Figures 7 and 8. Grain-size analyses were conducted on saturated soil samples collected from PRDI boring AB-03, and TBS005-17-18, and TBS007-16.5-17.5 during the Remedial Investigation (GSI, 2017). These results were used to estimate hydraulic conductivity (K) using the HydrogeoSieveXL (version 2.3.5) program[1], which calculated an average hydraulic conductivity (K) of approximately 8.3 ft/day and a maximum K of 17.4 ft/day.

[1] J.F. Devlin Software, http://www.people.ku.edu/~jfdevlin/Software.html.

The horizontal hydraulic gradient in the PRB area was estimated using water levels collected during eight monitoring events from 2016 through 2022. A three-point hydraulic gradient was calculated for each monitoring event using upgradient well B-1R and downgradient wells MW-7 and MW-9 (Figure 3). The average horizontal hydraulic gradient of 0.006 ft/ft was estimated from this method. Additionally, the horizontal hydraulic gradient of 0.004 ft/ft was estimated from the December 2021 potentiometric surface contours. The higher estimate 0.006 ft/ft was selected as a conservative PRB design value as it results in faster seepage velocities and shorter PRB residence time estimates.

The maximum groundwater elevation was based on water levels at monitoring wells near the PRB alignment. New monitoring well MW-14 had the highest groundwater elevation, at 11.2 ft MLLW.

The clay unit had an elevation of 4.0 ft MLLW at MW-14, resulting in a saturated thickness of 7.2 ft, a value used for estimating groundwater flux and arsenic loading to the PRB.

The groundwater flux per unit area (Darcy's flux), was calculated from the hydraulic conductivity and the horizontal hydraulic gradient. The estimated average Darcy flux in the aquifer is 0.05 ft/day and the estimated maximum Darcy flux in the aquifer is 0.1 ft/day.

The effective porosity of the silty sand and sand with silt in the vicinity of the PRB is estimated to be 10 percent based on Site geology and tracer testing conducted at other sites in similar soils. Therefore, the estimated average groundwater seepage velocity is 0.5 ft/day, which will be used for predictions of downgradient groundwater quality improvements discussed in the CMCRP (Aspect, 2022b). The estimated maximum groundwater seepage velocity is 1 ft/day, which will be used as a conservative value for calculating PRB residence time and required thickness.

Using the saturated thickness of 7.2 ft, and the total PRB length of 664 ft, the cross-sectional area of the PRB is 4,781 ft^2. Using the average Darcy's flux, the estimated total groundwater flow through the PRB is 1.2 gallons per minute (gpm).

5.3.2 Influent Groundwater Quality

The influent arsenic concentration was based on analytical results from upgradient monitoring well MW-14 with average and maximum dissolved arsenic concentrations of 68 µg/L and 126 µg/L, respectively. The average and maximum total arsenic concentrations at MW-14 are 60 µg/L and 91 µg/L, respectively.

The arsenic loading rate to the PRB is based on the maximum dissolved arsenic concentration at MW-14 of 126 µg/L and the groundwater flow of 1.2 gpm. The PRB arsenic loading rate is 20 pounds of arsenic over 30 years.

5.3.3 ZVI and As Chemistry

Based on the literature discussed in Section 5.2 and the Treatability Testing Report (Appendix B), the most important mechanisms of arsenic uptake include the interaction of dissolved arsenic with iron-containing corrosion products of ZVI. Arsenic will be taken up primarily via adsorption (surface complex formation) and coprecipitation reactions of arsenate and arsenite with iron mineral phases. The arsenic uptake rate estimates used for PRB design are bulk estimates that do not differentiate between individual mechanisms.

Column testing can be used to estimate total arsenic uptake capacity by ZVI if the columns are operated until breakthrough of arsenic. Breakthrough was not observed with the estimated 91 and 98 pore volume operation of C10 and C20 columns so a literature-derived value of 1.0 mg As/g ZVI for Connelly GPM ZVI was used in the PRB design calculations (Nikolaidis et al., 2003). Literature review supporting this estimate as a conservative value is in Appendix D.

Using the total arsenic uptake capacity of 1.0 mg As / g ZVI, the calculated ZVI demand for the PRB is 10 tons, which corresponds to 1.6 percent ZVI by weight, or 1.3 percent ZVI by volume. A minimum of 10 percent ZVI by mass is necessary to avoid contact inefficiency in the PRB. The treatability testing determined that the C20 had a slightly better removal rate without any negative secondary effects like an increase in pH. Therefore, the PRB will be constructed with 20 percent by mass ZVI resulting an estimated lifetime based on arsenic uptake capacity of greater than 30 years.[2]

The reaction kinetics for arsenic uptake were estimated from the two ports and effluent arsenic concentration in the columns. A first-order reaction rate of 3.9 day^{-1} was estimated from the C20 on Day 8 of column testing and was used in the PRB design. Literature review supporting this estimate as a conservative value is in Appendix D.

5.3.4 PRB Hydraulics

Applying the continuity equation, the groundwater flow in the PRB is the same as the aquifer. Therefore, the same estimated average Darcy flux of 0.05 ft/day, and estimated maximum Darcy flux of 0.1 ft/day was assumed for PRB groundwater flow.

The minimum residence time to achieve the CUL of 5 µg/L was calculated based on the maximum MW-14 dissolved arsenic concentration of 126 µg/L and the first-order uptake rate of 3.9 day^{-1}. The minimum residence time in the PRB was estimated to be 19 hours. For comparison, the C20 residence time on Day 8 was 2 hours, which achieved an effluent concentration of 5.38 ug/L (Appendix B).

The anticipated porosity reductions within the PRBs due to mineral fouling were estimated as less than 1 percent based on geochemical modeling reported in the Treatability Testing Report (Appendix B). A total porosity loss of 10 percent was assumed as a conservative estimate (Zhang and Gillham, 2005). Therefore, the initial effective mobile porosity of 40 percent will decrease to 30 percent over 30 years. The initial and final maximum seepage velocity in the PRB was calculated as 0.25 ft/day and 0.33 ft/day, respectively.

[2] Based solely on the estimated arsenic uptake rate of 1.0 mg arsenic/g ZVI and the estimated arsenic loading rate, there is an estimated 350 years of arsenic uptake capacity with 20% ZVI backfill. However, reactive lifetime is determined by the complex mineralization in all aqueous chemistry and ZVI corrosion products, not just arsenic uptake. Further, the PRB technology has only been demonstrated for 20 to 30 years so this estimate of 350 years is provided as a basis of ZVI percentage backfill and not as an estimated design lifetime.

The PRB minimum width of the PRB of 3 inches was calculated from the minimum residence time of 20 hours and the final maximum seepage velocity of 0.33 ft/day.

The total pore volume of the PRB was calculated as 28,610 gallons, based on the initial mobile porosity of 40 percent. Assuming the initial seepage velocity, a calculated pore volume rate of 22 pore volumes per year, or approximately 650 pore flushes of the PRB will occur over 30 years.

5.4 PRB Dimensions

This section provides details on the PRB alignment and dimensions.

5.4.1 Parallel to Wapato Creek

The primary section of the PRB is parallel to Wapato Creek and oriented north to south (Figure 5). This section is perpendicular to groundwater flow and will be 541 ft long and verified during construction at five control points (CP-1 through CP-5; Table 3). The section terminus at CP-1 will end before encountering the former Wapato Creek channel deposits. The northern section terminus at CP-5 will be set back 10 ft from the stormwater pipe.

The PRB will be located as far west as possible while still allowing construction on the existing roller compacted concrete (RCC) cap. The centerline of the PRB is approximately 15 ft east of the western edge of RCC cap.

5.4.2 Adjacent to former Wapato Creek channel

Groundwater flow at the Site is west towards Wapato Creek and has a southwestern component, especially in the areas adjacent to the former Wapato Creek channel. Therefore, the southern PRB alignment will be a different orientation for approximately 123 ft to be perpendicular to groundwater flow and keyed into the clay unit north of the former Wapato Creek channel (Figure 5). This PRB alignment intercepts groundwater flow from upgradient before reaching the former Wapato Creek deposits where there is no evidence of high arsenic concentrations in the groundwater in the alluvial creek deposits and groundwater is brackish due to influence from Wapato Creek (Appendix A).

There will be two control points (CP-0 and CP-1) that define this section of the PRB. The western terminus at CP-1 will be at the intersection of the existing bank of the Wapato Creek and the former Wapato Creek channel. The eastern terminus at CP-0 will be 10 ft from the stormwater pipe. Given the consistent occurrence and elevation of clay unit at all borings outside the alluvial creek deposits, this PRB section will be constructed based on the CP-02 control point depth (Table 3) and keying into the clay unit verified during construction.

5.4.3 Depth

The clay unit does not transport groundwater flow and does not contribute groundwater discharge to Wapato Creek. The clay unit acts as an aquitard to the arsenic-contaminated groundwater flow in the overlying silty sands. The clay unit is the basis of PRB depth, and the bottom of the PRB will be keyed into the clay unit a minimum of 6 inches. The depth of the control points will vary based on the depth to clay unit. The depth of the PRB at CP-0, CP-1, and CP-02 will is based on the 21-ft depth to the clay unit at AB-02. The depth of the PRB at CP-03 is based on the 23.5-ft depth to the clay unit at AB-03. The depth of the PRB at CP-4 and CP-5 is based on the 22-ft depth to the clay unit at AB-04.

5.4.4 Thickness

The PRB will be constructed using a 24-inch excavator bucket resulting in a constructed thickness of at least 24 inches. This is common PRB thickness and provides a significant safety factor of 8 for the estimated required thickness of 3 inches to achieve arsenic CUL of 5 ug/L.

5.5 PRB Composition

The PRB composition consists of reactive backfill below the water table and a layer of inert (sand) backfill above the water table.

5.5.1 Reactive Backfill

The PRB reactive backfill will consist of 20 percent ZVI and 80 percent sand by mass, as determined in Section 5.3.3. Section 5.3.1 establishes the maximum groundwater elevation at 11.2 ft MLLW. A safety factor of 2.8 ft was applied to maximum groundwater elevation to account for tidal influence of Wapato Creek and sea level rise due to climate change. The top of PRB reactive backfill will be 14.0 ft MLLW (Figure 7).

The Connelly-GPM, Inc (Connelly) CC-1004 specification ZVI used for column testing will also be used for PRB reactive backfill. The ZVI will be mixed with an imported clean sand with a fines content of <5 percent passing a 200 sieve. The native saturated soils used for estimating hydraulic conductivity have a fines content ranging from 27 percent to >60 percent passing a 200 sieve. The grain-size analysis of native soils, Connelly CC-1004, and three acceptable sands from local quarries is shown on Figure 9. The contractor will select the sand material that meets the construction specifications for material acceptance.

The total estimated quantity of ZVI by mass is 188 tons, and the total quantity of sand by mass is 942 tons for the reactive backfill.

5.5.2 Inert Backfill

Above 14 ft MLLW, the PRB will be backfilled with inert sand. The sand will be placed up to 22.5 ft MLLW. Above 22.5 ft MLLW, the trench will be backfilled with gravel base course, and the surface restored with 4-inch hot mix asphalt (HMA) tied into the existing RCC cap.

5.6 Construction Method

All PRB construction methods were assessed for the PRB remedial design. PRBs can be constructed using continuous trenching equipment, soil mixing, and conventional excavation with sheet piling or biopolymer slurry. The most cost efficient and effective installation method for this Site is using a biopolymer slurry to keep the trench open while the reactive material is tremied into place. The biopolymer will maintain the dimensions of the trench without requiring shoring and does not require dewatering. This will also allow for placement of two discrete backfills: the reactive backfill to only be installed in the saturated zone, with inert backfill placed above the water table. The PRB construction will consist of the following general steps:

- A 5-foot-wide section of the RCC cap will be cut along the entire PRB alignment. The estimated 2 to 3 ft of underlying crushed rock base course will be excavated, and temporarily stockpiled for reuse. The concrete will be disposed of off Site by the contractor in accordance with local and state regulations.
- All fill and native soils underlying the crushed rock base course will be excavated to depth and hauled off Site for disposal at LRI Subtitle D Landfill.
- As the excavation proceeds, a biopolymer slurry will be emplaced to keep the trench open between excavation and backfill. The biopolymer slurry will biodegrade once the backfill is placed.
- Imported sand and Connelly CC-1004 will be mixed on Site to 20 percent ZVI and placed as backfill to 14 ft MLLW. Off-Site mixing will be avoided to prevent granular convection of the sand and ZVI during transport.
- Finally, the inert sand will be backfilled to elevation 22.5 ft MLLW
- The excavated crushed rock base course will then be backfilled to approximately 4 inches below existing Site grade. The surface will be restored with 4 inches of HMA finished to existing grade tied into the existing RCC cap.

All excavated fill and native soils, and any water generated during construction will be managed by the contractor in accordance with requirements in the CMMP (Aspect, 2022c).

5.7 PRB Performance Monitoring

Six new monitoring wells will be installed to evaluate groundwater compliance, five of which (MW-15 through MW-19) will be for PRB performance monitoring and one of which (MW-20) will be for interpretation of groundwater flow. All PRB performance monitoring wells are shown on Figure 10.

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. The new 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. Monitoring well MW-20 will be installed at the northern Site boundary with a 10-ft screen from approximately 15 to 5 ft MLLW. Well construction details are included in Appendix A to the CMCRP (Aspect, 2022b). These new monitoring wells will be sampled prior to PRB construction.

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. MW-20 will be sampled semiannually for the first year and analyzed for total and dissolved arsenic.

Monitoring wells that do not serve a compliance monitoring objective will be decommissioned. A total of six monitoring wells (B-5R, MW-1, MW-3, MW-4, MW-5R, and MW-6R) will be decommissioned. Full details of well decommissioning and rationale are included in the CMCRP.

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 PRB performance monitoring will be conducted when tide elevation in the Sitcum Waterway is below 9 ft MLLW. The PRB performance monitoring will include analysis of total and dissolved arsenic, in addition to geochemical parameters of arsenic speciation, dissolved metals, ferrous iron, anions, alkalinity, and total organic carbon (TOC) to evaluate PRB performance.

After five years of semiannual PRB monitoring, the downgradient monitoring wells will be evaluated by trend analysis to compare to remediation levels, and evaluate need for potential contingency actions. A restoration timeframe estimate to reach CULs, PRB performance monitoring, and potential contingency actions are defined in the CMCRP (Aspect, 2022b).

6 Reporting and Schedule

The estimated schedule for the EDR, and the deliverables required by the Agreed Order are included in Table 4.

Table 4. Schedule of Ecology Deliverables for Phase 1 Cleanup Construction

Ecology Deliverable	Ecology Due Date
Final EDR, CMCRP, CMMP, and OMMP	June 10, 2022
Agreed Order Progress Report	July 23, 2022
Phase 1 Cleanup Construction Completion Report	December 19, 2022

The Phase 1 Cleanup construction will be conducted during the dry season to minimize water management. It is anticipated that construction will be completed by October 2022; the construction schedule is subject to CSWGP permit issuance, and contractor selection and schedule

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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. PRB Design Criteria

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

Parameter	Value	Unit
Aquifer Hydraulics		
Avg. Hydraulic Conductivity (K)	3E-03	cm/sec
	8.3	ft/d
Max Hydraulic Conductivity (K)	6E-03	cm/sec
	17.4	ft/d
Horizontal Hydraulic Gradient	0.006	ft/ft
Aquifer Mobile Porosity	10%	
Maximum Groundwater Elevation	11.5	ft MLLW
Maximum Saturated Thickness	7.2	ft
Aquifer Cross Sectional Area	4781	ft^2
Avg. K - Darcy Flux	0.05	ft/d
Avg. K - Seepage Velocity	0.5	ft/d
	173	ft/yr
Max K - Darcy Flux	0.1	ft/d
Max K - Seepage Velocity	1.0	ft/d
	362	ft/yr
Avg. K - Total Groundwater Flow through PRB	227	ft^3/day
	1.2	gal/min
Arsenic Loading		
Max Influent Arsenic Concentration	126	ug/L
Avg. Influent Arsenic Concentration	68	ug/L
Arsenic Loading Rate	1.8E-03	lb As/day
Arsenic Loading in 30 years	20	lbs As
ZVI and Arsenic Chemistry		
Target Effluent Arsenic Concentration	5	ug/L
Arsenic Uptake Capacity	1.0E-03	lb As/lb ZVI
Arsenic Uptake Capacity	1.0	mg As/g ZVI
Arsenic First Order Reaction Rate	3.9	/day
Total ZVI Demand	19,513	lb ZVI
	10	tons ZVI
	1.6%	of PRB by weight
	1.3%	of PRB by volume
PRB Residence Time (to achieve 5 ug/L effluent)	0.8	days
	20	hrs
PRB Hydraulics		
Design Lifetime	30	yrs
Initial Mobile Porosity	0.4	
Porosity Reduction in PRB	0.1	
Final Mobile Porosity	0.3	
Max K - Initial PRB Seepage Velocity	0.25	ft/d
Max K - Final PRB Seepage Velocity	0.33	ft/d
Minimum PRB Thickness	3	inch
Total Pore Volume of PRB	28,610	gal
Pore Volume Rate	0.059	pore volumes/day
	22	pore volumes/year
PRB Design		
Top of PRB Elevation	14	ft
Minimum PRB Elevation	3.5	ft
PRB Length	664	ft
PRB Backfill Depth	10.5	ft
PRB Thickness	2	ft
Cross Sectional Area - PRB Backfilll	6,972	ft^2
Cross Sectional Area - Saturated PRB Backfill	4,781	ft^3
PRB Volume - PRB Backfill	13,944	ft^3
PRB Volume - Saturated PRB Backfill	9,562	ft^3
ZVI Content	20%	by weight
ZVI Bulk Density	160	lb/ft^3
Sand Bulk Density	125	lb/ft^3
Assumed Constructed Width for Quantity Estimation	2.5	ft
Assumed Constructed Volume for Quantity Estimation	17,430	ft
Sand Quantity	942	tons
	15,075	ft^3
ZVI Quantity	188	tons
	2,355	ft^3

Notes:

Highlighted parameters and values are calculated

Table 2. Groundwater Analytical Results

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

FINAL

Analyte	Unit	Cleanup Level (ug/L)	MW-2R 11/22/2021	MW-2R 03/28/2022	B-5R 11/22/2021	B-5R 03/28/2022	MW-7 11/22/2021	MW-7 03/28/2022	MW-9 11/22/2021	MW-9 03/28/2022	MW-12 11/22/2021	MW-12 03/28/2022
Dissolved Metals												
Arsenic	ug/L	5	--	--	**3.05 J**	< 1.00 U	**31.1**	**22.8**	**88.4**	**73.4**	**40.1**	**12.2**
Calcium	ug/L		--	--	**45,600 J**	**16,300**	**77,200 J**	**25,800**	**82,500 J**	**60,100**	**100,000 J**	**68,000**
Iron	ug/L		--	--	**28,600**	**26,500**	**56,800**	**101,000**	**190,000**	**201,000**	**147,000**	**112,000**
Magnesium	ug/L		--	--	**37,100**	**15,500**	**49,000**	**9,970**	**61,600**	**59,400**	**50,600**	**47,400**
Manganese	ug/L		--	--	**1,130**	**799**	**2,500**	**1,190**	**3,230**	**2,630**	**7,190**	**5,900**
Nickel	ug/L		--	--	< 130 U	--	< 130 U	--	< 130 U	--	< 130 U	--
Potassium	ug/L		--	--	**21,900 J**	**9,010**	**29,800 J**	**12,600**	**33,000 J**	**26,100**	**47,900 J**	**39,300**
Sodium	ug/L		--	--	--	**52,600**	--	**6,110 J**	--	**129,000**	--	**181,000**
Total Metals												
Arsenic	ug/L		--	--	< 2.63 U	< 12.5 U	**16.2**	**25.7**	**80.4**	**74.9**	**23.6**	**13.1**
Calcium	ug/L		--	--	**38,200 J**	**18,000**	**66,400 J**	**28,300**	**71,600 J**	**64,900**	**92,400 J**	**71,700**
Iron	ug/L		--	--	**27,800**	**30,200**	**53,100**	**108,000**	**198,000**	**207,000**	**136,000**	**122,000**
Magnesium	ug/L		--	--	**26,300**	**16,700**	**31,100**	**12,100**	**45,100**	**58,400**	**38,100**	**47,600**
Manganese	ug/L		--	--	**862**	**832**	**1,720**	**1,250**	**2,500**	**2,740**	**5,480**	**6,120**
Nickel	ug/L		--	--	< 60 U	--	< 300 U	--	< 300 U	--	< 300 U	--
Potassium	ug/L		--	--	**13,500 J**	**9,610**	18,800 UJ	**12,700**	**22,400 J**	**26,200**	**36,000 J**	**41,500**
Sodium	ug/L		--	--	--	**53,400**	--	**9,090 J**	--	**123,000**	--	**181,000**
SVOCs												
Pentachlorophenol	ug/L	1	**14.6**	**9.73**	--	--	--	--	--	--	--	--
Conventionals												
Alkalinity, Total (as CaCO3)	mg/L		--	--	**195**	**201**	**294**	**136**	**573**	**650**	**662**	**684**
Bromide	mg/L		--	--	**1.24**	< 0.400 U	**0.287**	< 0.400 U	**0.900**	**2.12**	**0.804**	**2.00**
Chloride	mg/L		--	--	**370**	**26.9**	**34.7**	**5.32**	**74.1**	**86.9**	**79.5**	**95.4**
Fluoride	mg/L		--	--	**0.293**	**0.361**	**0.487**	**0.658**	**0.772**	**1.03**	**0.877**	**1.06**
Nitrate-Nitrite (as N)	mg/L		--	--	< 0.010 U	< 0.110 U	< 0.010 U	< 0.110 U	< 0.200 UJ	< 0.550 U	< 0.050 UJ	< 0.550 U
Phosphorus	mg/L		--	--	**1.18**	< 5.25 U	**1.24**	< 5.25 U	**1.81**	< 5.25 U	**1.66**	< 5.25 U
Sulfate	mg/L		--	--	**29.0**	< 0.600 U	**48.9**	**9.68**	< 0.100 U	< 3.00 U	**0.110**	< 3.00 U
Total Organic Carbon	mg/L		--	--	**10.7**	**12.0**	**28.6**	**26.8**	**79.3**	**88.7**	**83**	**87.5**
Field Parameters												
Temperature	deg C		**12.7**	**11.1**	**15.6**	**14.7**	**15.6**	**13.3**	**14.1**	**13**	**14.2**	**13.4**
Specific Conductance	uS/cm		**629.8**	**656.4**	**1675**	**493.8**	**818**	**599.1**	**1604**	**1856**	**1680**	**1816**
Dissolved Oxygen	mg/L		**10.1**	**64.4**	**2.2**	**6.18**	**1.8**	**0.5**	**2**	**0.25**	**1.8**	**0.25**
pH	pH units		**11.86**	**10.08**	**6.47**	**3.71**	**6.42**	**5.97**	**6.72**	**6.51**	**6.85**	**6.52**
Oxidation Reduction Potential	mV		**27.4**	**101.1**	**88.3**	**90.3**	**81**	**48.5**	**71.2**	**-98**	**70.8**	**27.7**
Turbidity	NTU		**NM**	**14.4**	**NM**	**25.8**	**NM**	**3.01**	**NM**	**4.54**	**NM**	**15.5**
Iron, Ferrous, Fe+2	mg/L		--	--	**45.6**	**37.0**	**76.4**	**143**	**267**	**242**	**196**	**153**

Notes

a) Sampled with packer at middle of screen and sample intake at 16 ft bgs

Bold - Analyte Detected

Blue Shading - exceeds Groundwater Cleanup Level (as selected in Cleanup Action Plan)

NM - Not measured. Turbidimeter not functioning.

J - Analyte was positively identified. The reported result is an estimate.

U - Analyte was not detected at or above the reported result.

Table 2. Groundwater Analytical Results

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

Analyte	Unit	MW-14 11/19/2021	MW-14[a] 11/24/2021	MW-14 03/28/2022
Dissolved Metals				
Arsenic	ug/L	**21.2**	**48.7**	**77.0**
Calcium	ug/L	--	--	**113,000**
Iron	ug/L	--	--	**121,000**
Magnesium	ug/L	--	--	**88,300**
Manganese	ug/L	--	--	**3,100**
Nickel	ug/L	--	--	--
Potassium	ug/L	--	--	**31,800**
Sodium	ug/L	--	--	**200,000**
Total Metals				
Arsenic	ug/L	**22.9**	**49.9**	**80.9**
Calcium	ug/L	**76,700 J**	--	**108,000**
Iron	ug/L	**105,000**	--	**130,000**
Magnesium	ug/L	**32,000**	--	**90,500**
Manganese	ug/L	**2,070**	--	**3,220**
Nickel	ug/L	--	--	--
Potassium	ug/L	**29,400**	--	**34,800**
Sodium	ug/L	**186,000**	--	**202,000**
SVOCs				
Pentachlorophenol	ug/L	--	--	--
Conventionals				
Alkalinity, Total (as CaCO3)	mg/L	**608**	--	--
Bromide	mg/L	**0.986**	--	**2.11**
Chloride	mg/L	**36.2**	--	**120**
Fluoride	mg/L	**1.44**	--	**1.02**
Nitrate-Nitrite (as N)	mg/L	< 0.55 U	--	< 0.550 U
Phosphorus	mg/L	< 2.62 U	--	< 5.25 U
Sulfate	mg/L	**15.9**	--	< 3.00 U
Total Organic Carbon	mg/L	**59**	--	**78.1**
Field Parameters				
Temperature	deg C	**16.4**	**17**	**15.4**
Specific Conductance	uS/cm	**1327**	**1857**	**2422**
Dissolved Oxygen	mg/L	**2.2**	**1.2**	**0.22**
pH	pH units	**6.49**	**6.76**	**6.67**
Oxidation Reduction Potential	mV	**-95.8**	**103.9**	**-64.6**
Turbidity	NTU	**23.6**	**53.9**	**10.2**
Iron, Ferrous, Fe+2	mg/L	**157**	--	**171**

Notes

a) Sampled with packer at middle of screen and sample intake at 16 ft bgs

Bold - Analyte Detected

Blue Shading - exceeds Groundwater Cleanup Level (as selected in Cleanup Action Plan)

NM - Not measured. Turbidimeter not functioning.

J - Analyte was positively identified. The reported result is an estimate.

U - Analyte was not detected at or above the reported result.

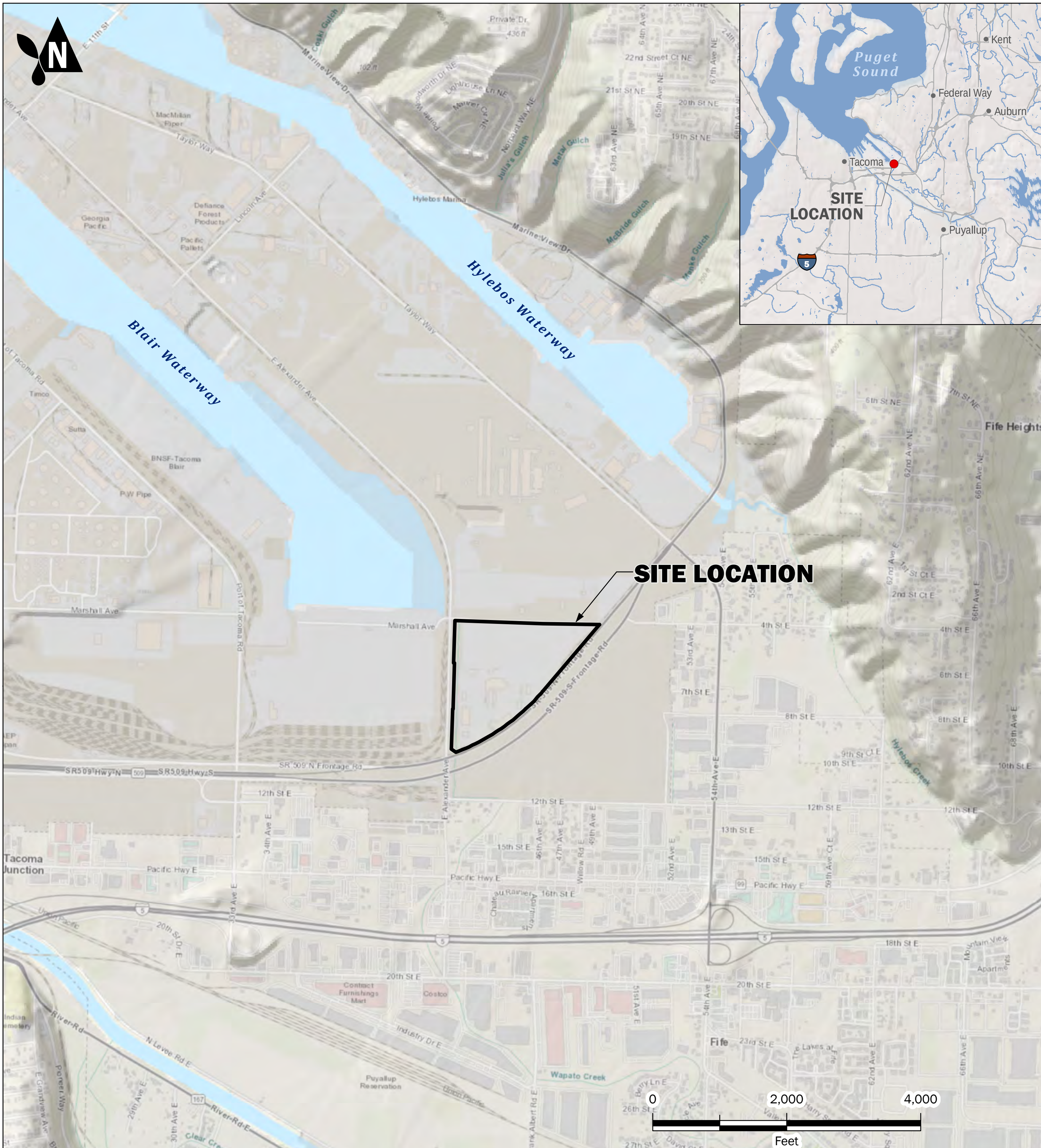
Table 3. PRB Control Points

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

Control Point Number	PRB Alignment Boring	X	Y	Bottom of Excavation and PRB Backfill (elevation ft MLLW)	Top of ZVI and Sand Backfill (elevation ft MLLW)	Bottom of ZVI and Sand Backfill (elevation ft MLLW)
CP-0	--	-122.3717	47.25176842	3.2	14.0	22.5
CP-1	--	-122.3721	47.25196124	3.2		
CP-2	AB-02	-122.3721	47.25208942	3.2		
CP-3	AB-03	-122.3721	47.25264649	3.4		
CP-4	AB-04	-122.3721	47.2532403	4.5		
CP-5	--	-122.3721	47.25345798	4.5		

`

FIGURES



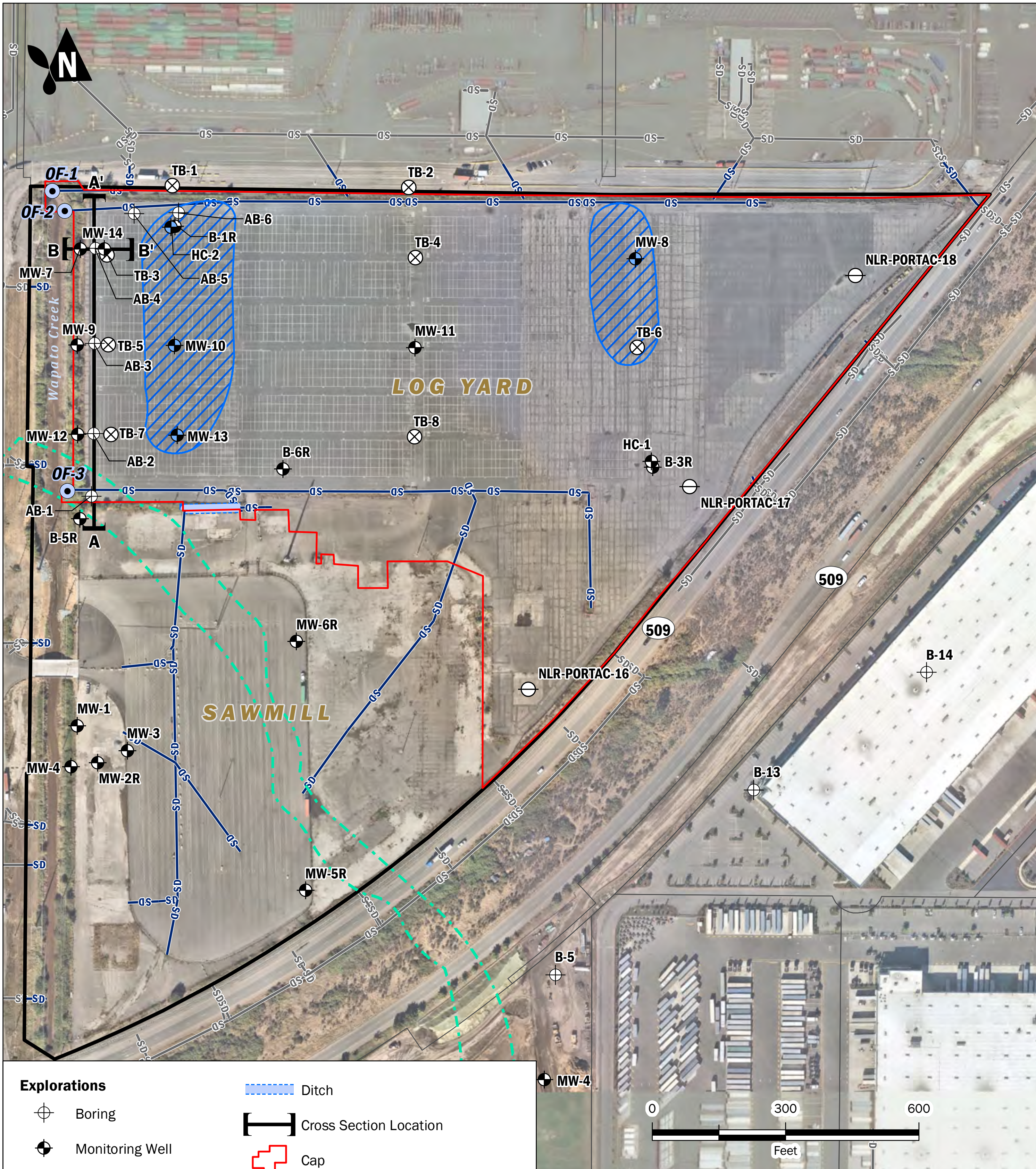
Site Location

Engineering Design Report
Port of Tacoma - Parcel 15 (Portac)
Tacoma, Washington

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

GIS Path: G:\projects\PortofTacoma\PortacParcel15_210158\Delivered\Engineering Design Report\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

Basemap Layer Credits || Esri, HERE, Garmin, (c) OpenStreetMap contributors, and the GIS user community
Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community



Explorations

- Boring
- Monitoring Well
- Perched Monitoring Well
- Piezometer
- Temporary Boring

Site Features

- Stormwater Outfall
- Storm Pipe
- Ditch
- Cross Section Location
- Cap
- Former Creek Channel
- Observed Perched Zone
- Port Parcel 15
- Pierce County Tax Parcel

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

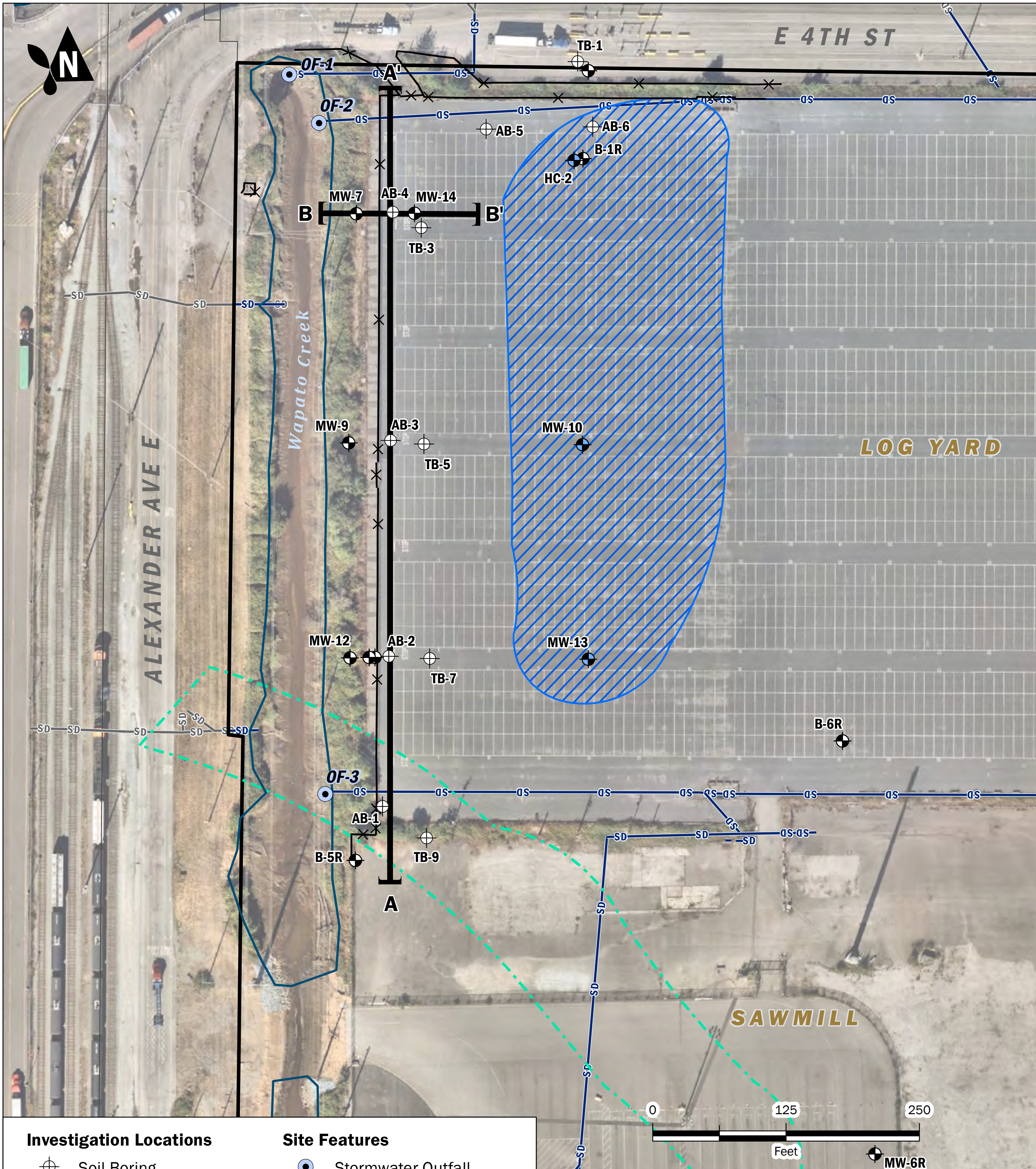
Site Plan

Engineering Design Report
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

GIS Path: G:\projects\PortofTacoma\PortacParcel15_210158\Delivered\Engineering Design Report\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

Basemap Layer Credits || Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



Investigation Locations

- Soil Boring
- Monitoring Well
- Perched Monitoring Well
- Ordinary High Water Mark
- Fence
- Cross Section Location

Site Features

- Stormwater Outfall
- Storm Pipe
- Former Creek Channel
- Observed Perched Zone
- Port Parcel 15
- Pierce County Tax Parcel

Note: Storm pipes have faded, grey symbology outside area of interest.

PRB Alignment Investigation Locations

Engineering Design Report
Port of Tacoma - Parcel 15 (Portac)
Tacoma, Washington

Aspect CONSULTING

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

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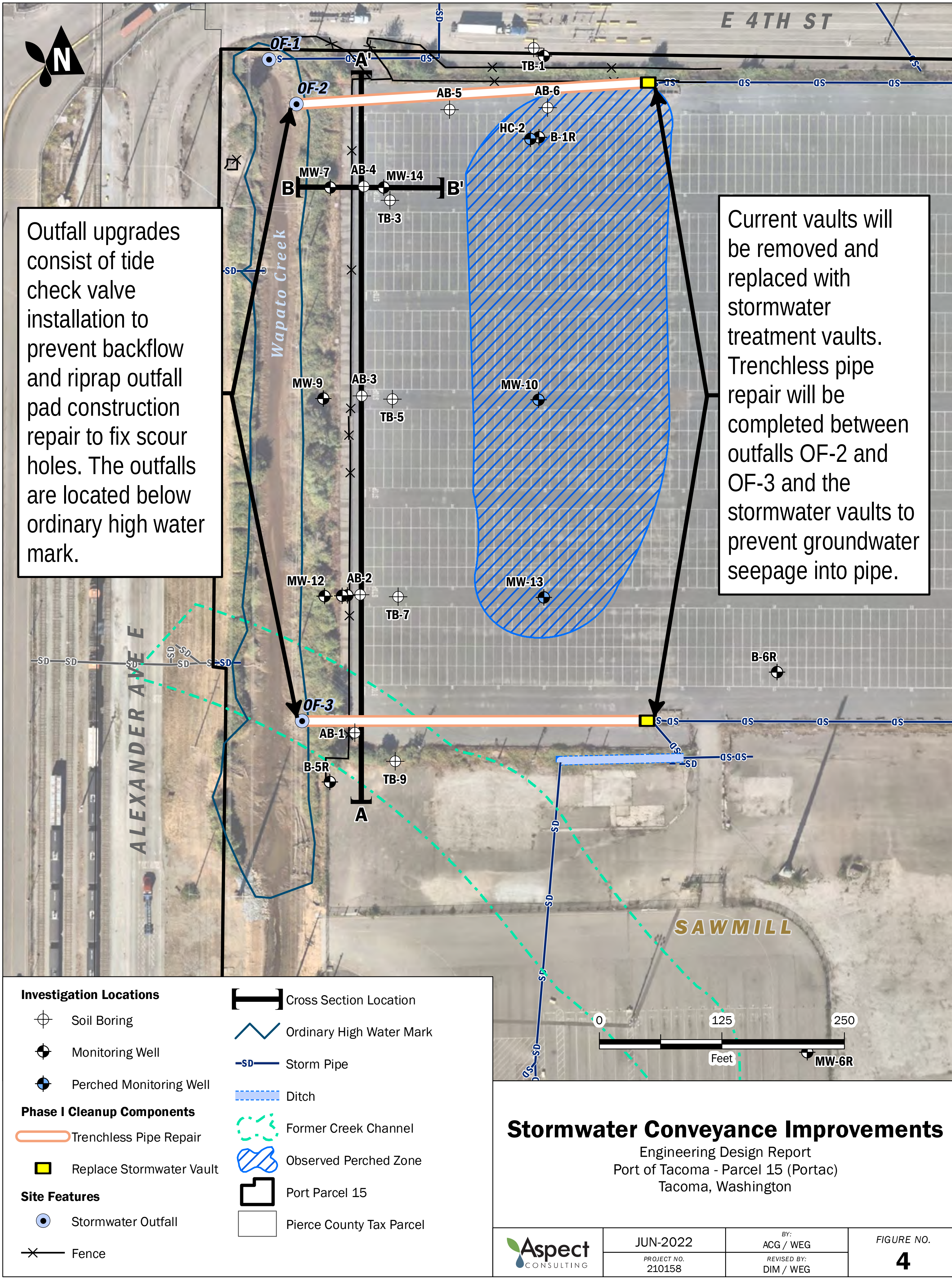
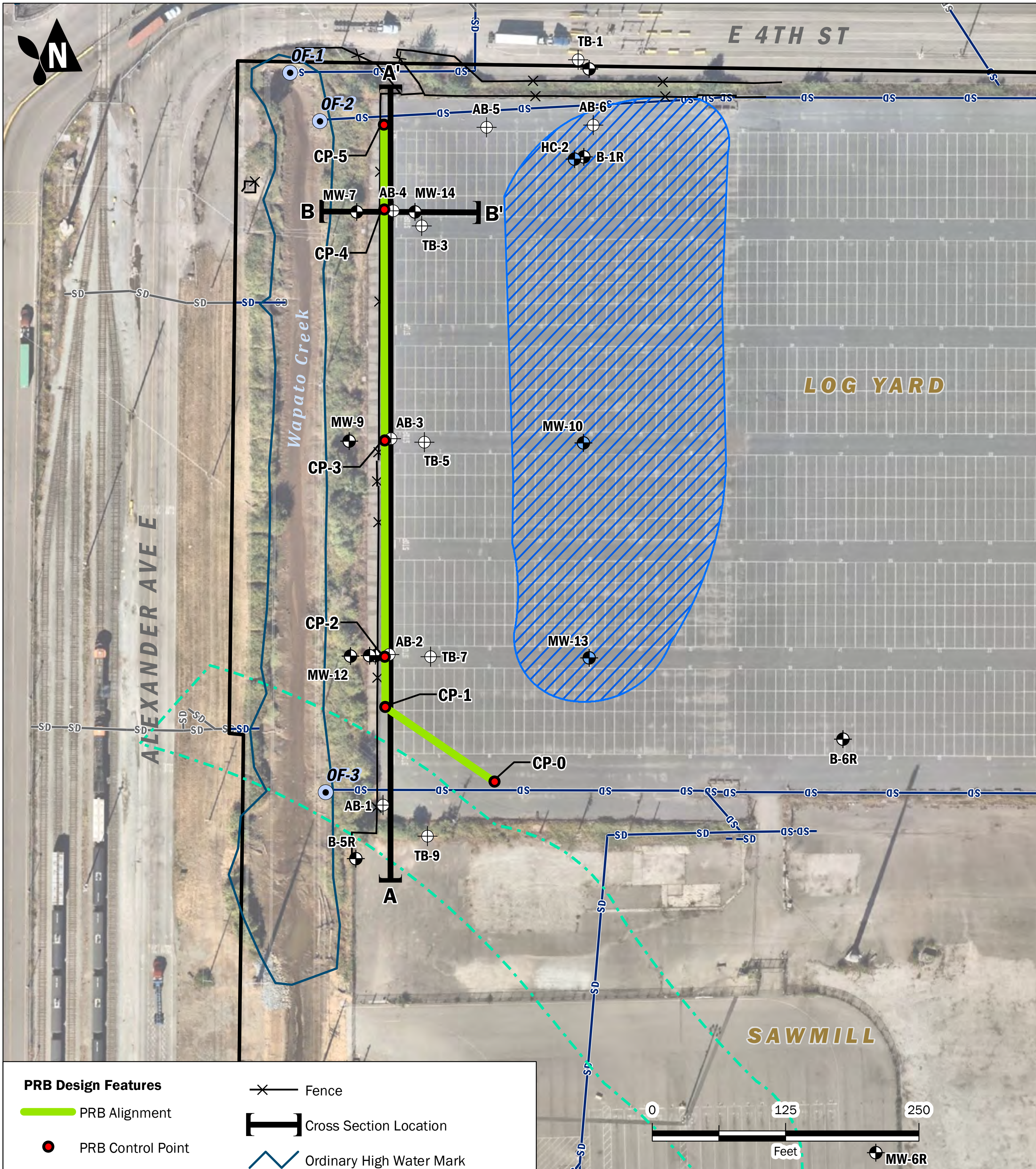


Stormwater Conveyance Improvements

Engineering Design Report
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



PRB Design Features

- PRB Alignment
- PRB Control Point

Investigation Locations

- Soil Boring
- Monitoring Well
- Perched Monitoring Well

Site Features

- Stormwater Outfall
- Fence
- Cross Section Location
- Ordinary High Water Mark
- Storm Pipe
- Former Creek Channel
- Observed Perched Zone
- Port Parcel 15

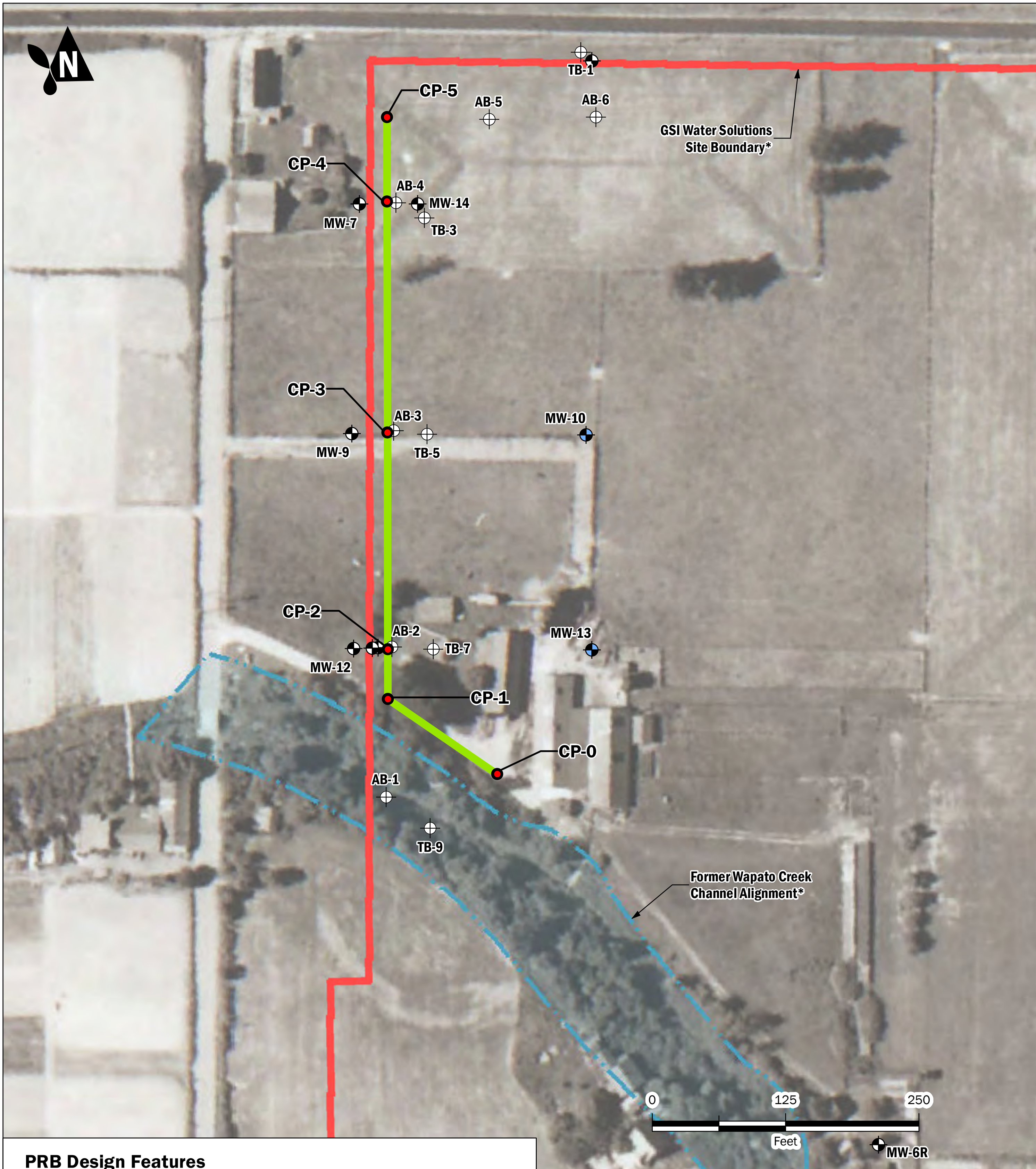
Notes:
- PRB = Permeable Reactive Barrier
- Storm pipes have faded, grey symbology outside area of interest.

PRB Plan View

Engineering Design Report
Port of Tacoma - Parcel 15 (Portac)
Tacoma, Washington

Aspect CONSULTING	JUN-2022	BY: ACG / WEG	FIGURE NO.
	PROJECT NO. 210158	REVISED BY: DIM / WEG	5

GIS Path: G:\projects\PortofTacoma\PortacParcel15_210158\Delivered\Engineering Design Report\05 PRB Plan View.mxd || Coordinate System: NAD 1983 StatePlane Washington South FIPS 4602 Feet || Date Saved: 6/7/2022 || User: bgrimm || Print Date: 6/7/2022



PRB Design Features

PRB Alignment

PRB Control Point

Investigation Locations

Soil Boring

Monitoring Well

Perched Monitoring Well

Notes:
- PRB = Permeable Reactive Barrier
* 1940 Aerial image, red site boundary line, and blue former Wapato Creek channel alignment from "Figure 2-1, 1940 Aerial Photograph Showing Former Location of Wapato Creek," Remedial Investigation Report, Parcel 15, Tacoma, WA, by GSI Water Solutions, Inc., 2017. Aerial is for graphical depiction only, not design purposes.

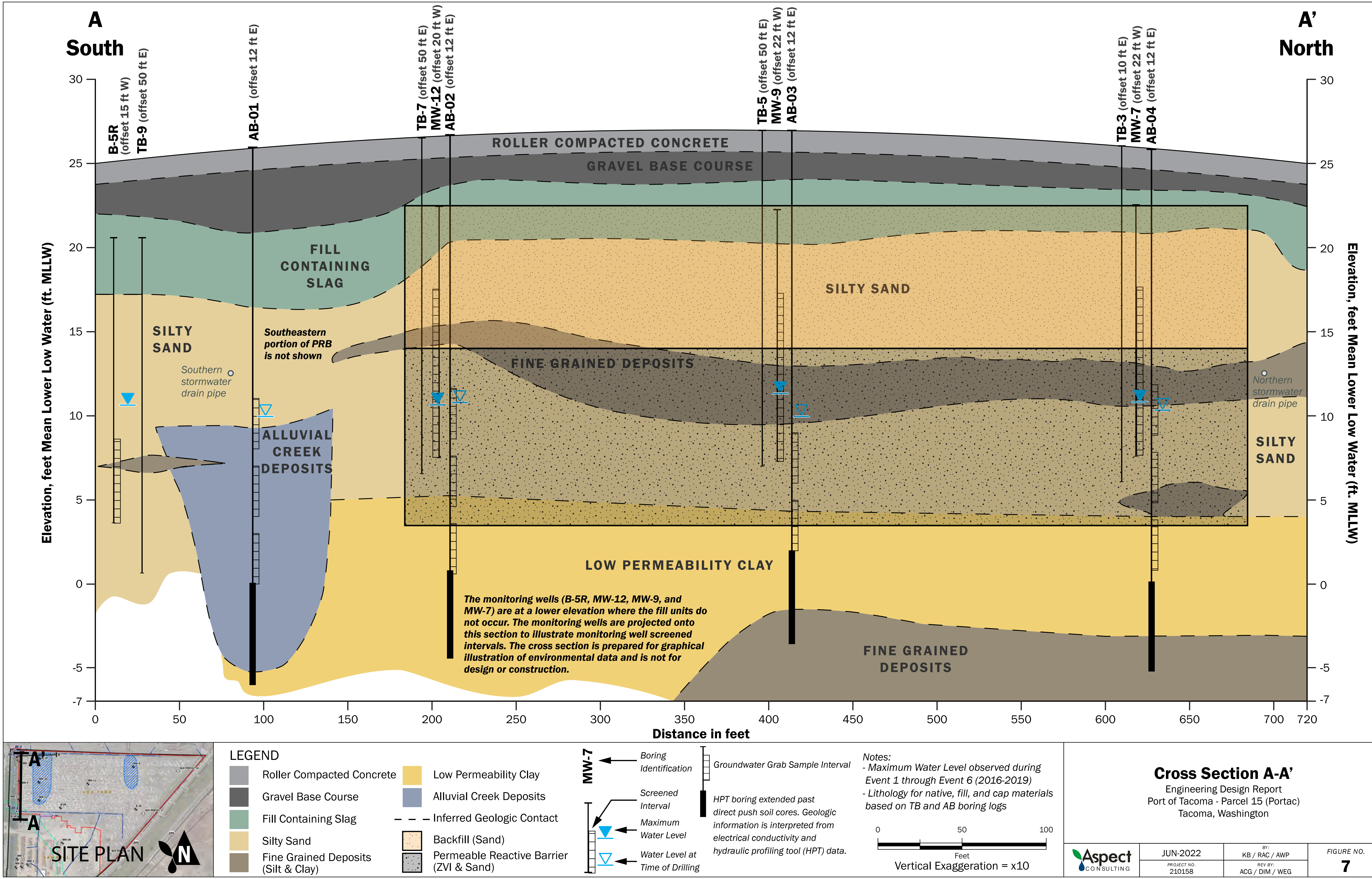
PRB Plan View with 1940 Aerial

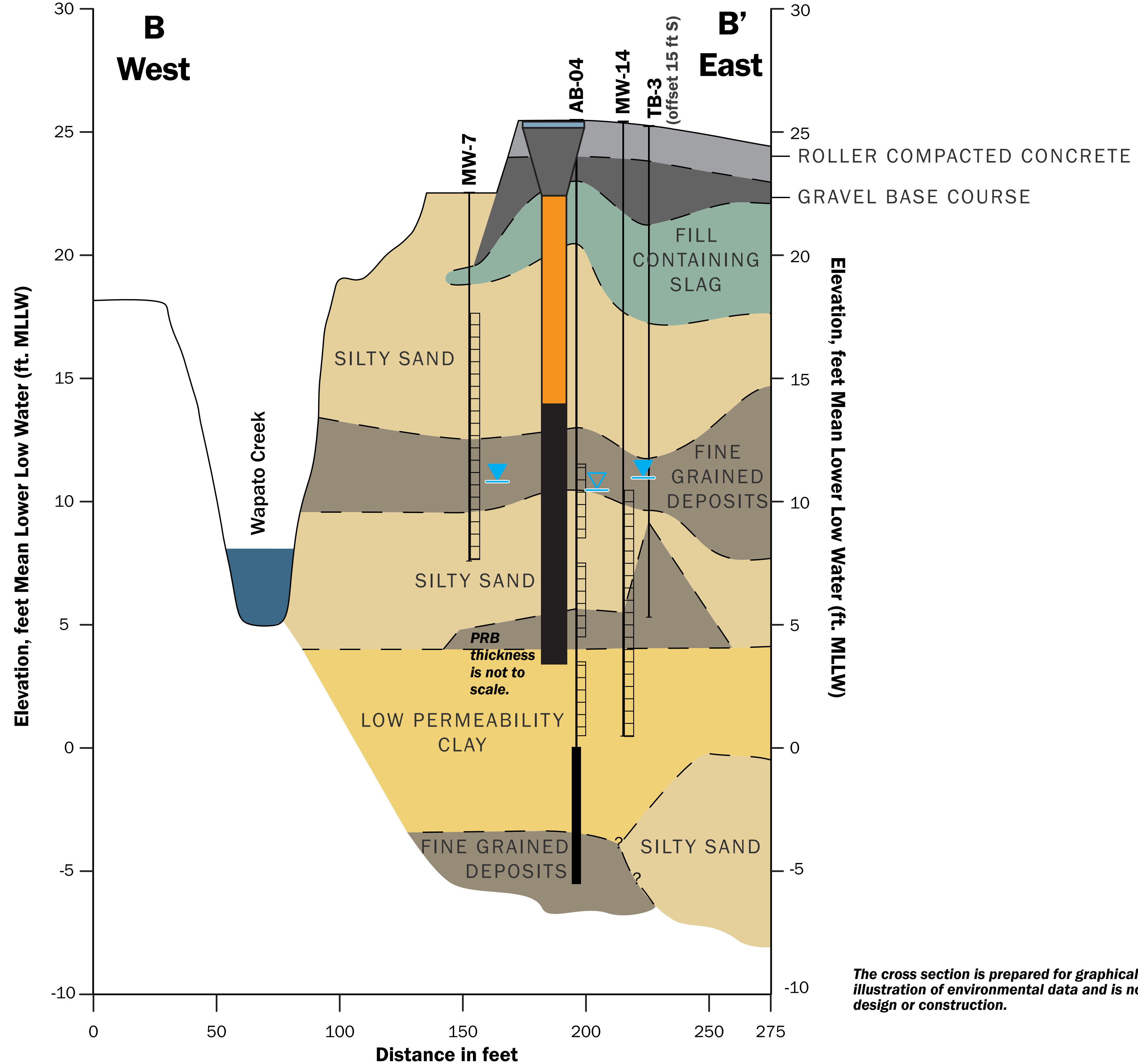
Engineering Design Report
Port of Tacoma - Parcel 15 (Portac)
Tacoma, Washington

Aspect CONSULTING

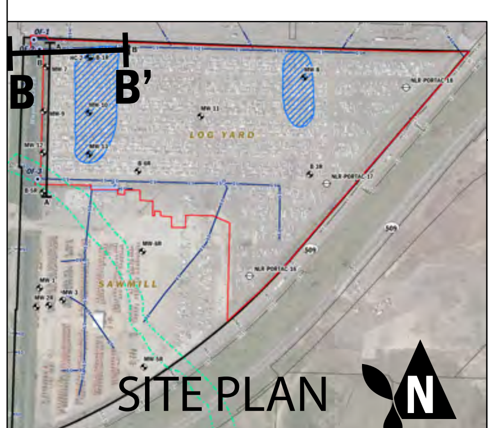
JUN-2022	BY: DIM / WEG	FIGURE NO. 6
PROJECT NO. 210158	REVISED BY: ACG / DIM / WEG	

GIS Path: G:\projects\PortofTacoma\PortacParcel15_210158\Delivered\Engineering Design Report\06 PRB Plan View with 1940 Aerial.mxd || Coordinate System: NAD 1983 StatePlane Washington South FIPS 4602 Feet || Date Saved: 6/7/2022 || User: bgrimm || Print Date: 6/7/2022


A
South
A'
North
B-5R (offset 15 ft W)
TB-9 (offset 50 ft E)
AB-01 (offset 12 ft E)
TB-7 (offset 50 ft E)
MW-12 (offset 20 ft W)
AB-02 (offset 12 ft E)
TB-5 (offset 50 ft E)
MW-9 (offset 22 ft W)
AB-03 (offset 12 ft E)
TB-3 (offset 10 ft E)
MW-7 (offset 22 ft W)
AB-04 (offset 12 ft E)
ROLLER COMPACTED CONCRETE
GRAVEL BASE COURSE
FILL CONTAINING SLAG
SILTY SAND
SILTY SAND
SILTY SAND
Southeastern portion of PRB is not shown
Southern stormwater drain pipe
Northern stormwater drain pipe
FINE GRAINED DEPOSITS
ALLUVIAL CREEK DEPOSITS
LOW PERMEABILITY CLAY
FINE GRAINED DEPOSITS
The monitoring wells (B-5R, MW-12, MW-9, and MW-7) are at a lower elevation where the fill units do not occur. The monitoring wells are projected onto this section to illustrate monitoring well screened intervals. The cross section is prepared for graphical illustration of environmental data and is not for design or construction.
Elevation, feet Mean Lower Low Water (ft. MLLW)
Elevation, feet Mean Lower Low Water (ft. MLLW)
30
25
20
15
10
5
0
-5
-7
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
720
Distance in feet
A'
A
SITE PLAN
N
LEGEND
Roller Compacted Concrete
Gravel Base Course
Fill Containing Slag
Silty Sand
Fine Grained Deposits (Silt & Clay)
Low Permeability Clay
Alluvial Creek Deposits
Inferred Geologic Contact
Backfill (Sand)
Permeable Reactive Barrier (ZVI & Sand)
MW-7
Boring Identification
Screened Interval
Maximum Water Level
Water Level at Time of Drilling
Groundwater Grab Sample Interval
HPT boring extended past direct push soil cores. Geologic information is interpreted from electrical conductivity and hydraulic profiling tool (HPT) data.
Notes:
- Maximum Water Level observed during Event 1 through Event 6 (2016-2019)
- Lithology for native, fill, and cap materials based on TB and AB boring logs
0
50
100
Feet
Vertical Exaggeration = x10
Cross Section A-A'
Engineering Design Report
Port of Tacoma - Parcel 15 (Portac)
Tacoma, Washington
Aspect CONSULTING
JUN-2022
PROJECT NO.
210158
BY:
KB / RAC / AWP
REV BY:
ACG / DIM / WEG
FIGURE NO.
7



The cross section is prepared for graphical illustration of environmental data and is not for design or construction.



LEGEND

- Roller Compacted Concrete
- Gravel Base Course
- Fill Containing Slag
- Silty Sand
- Fine Grained Deposits (Silt & Clay)
- Low Permeability Clay
- Inferred Geologic Contact
- Asphalt
- Backfill (Sand)
- Permeable Reactive Barrier (ZVI & Sand)

MW-7 — *Boring Identification*

Screened Interval

Maximum Water Level

Water Level at Time of Drilling

Groundwater Grab Sample Interval

HPT boring extended past direct push soil cores. Geologic information is interpreted from electrical conductivity and hydraulic profiling tool (HPT) data.

Notes:
- Maximum Water Level observed during Event 1 through Event 6 (2016-2019)
- Lithology for native, fill, and cap materials based on TB and AB boring logs

0 50 100
Feet
Vertical Exaggeration = x10

Cross Section B-B'
Engineering Design Report
Port of Tacoma - Parcel 15 (Portac)
Tacoma, Washington

Aspect CONSULTING

JUN-2022	BY: KB / RAC / AWP	FIGURE NO.
PROJECT NO. 210158	REV BY: ACG / DIM / WEG	8

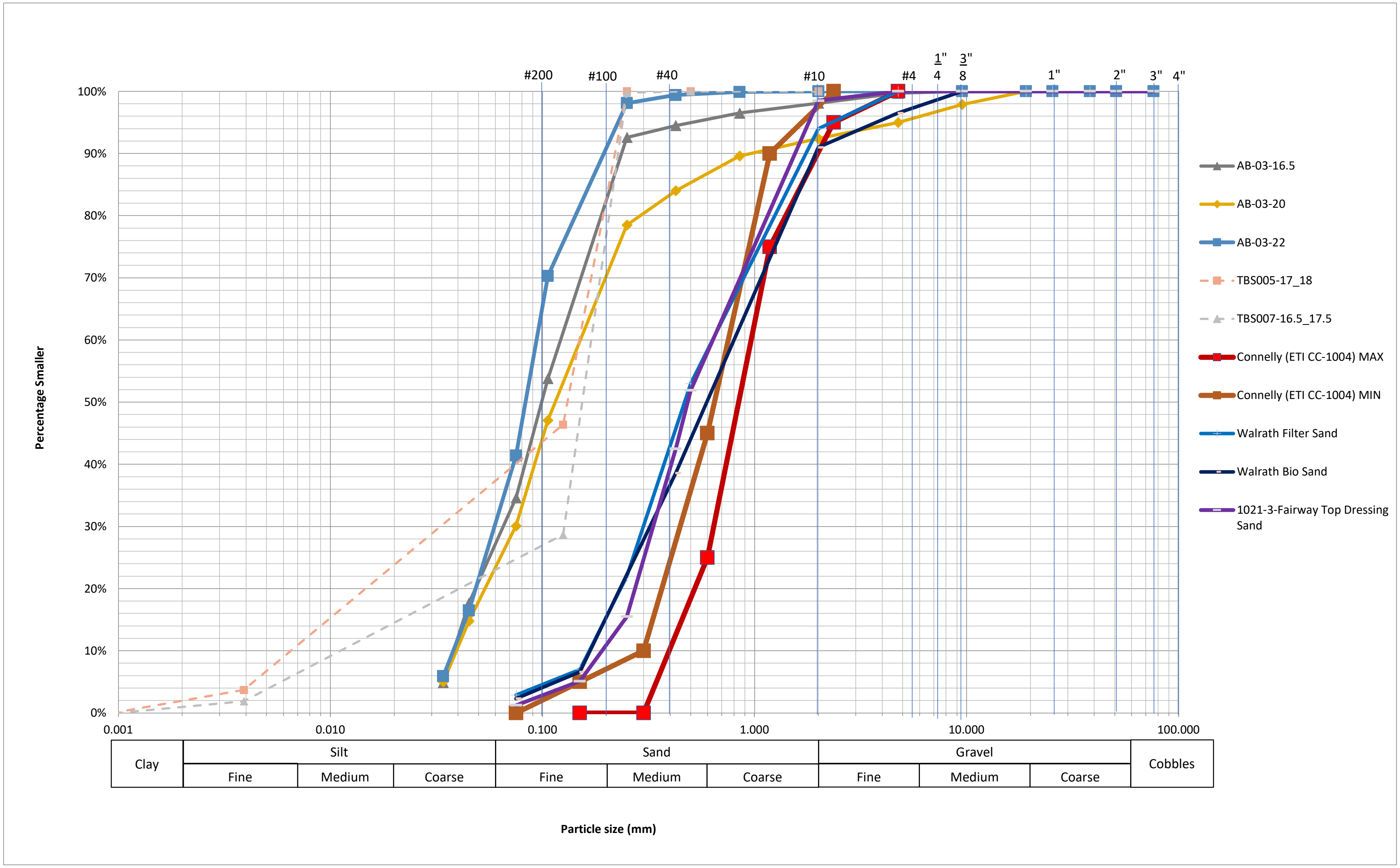
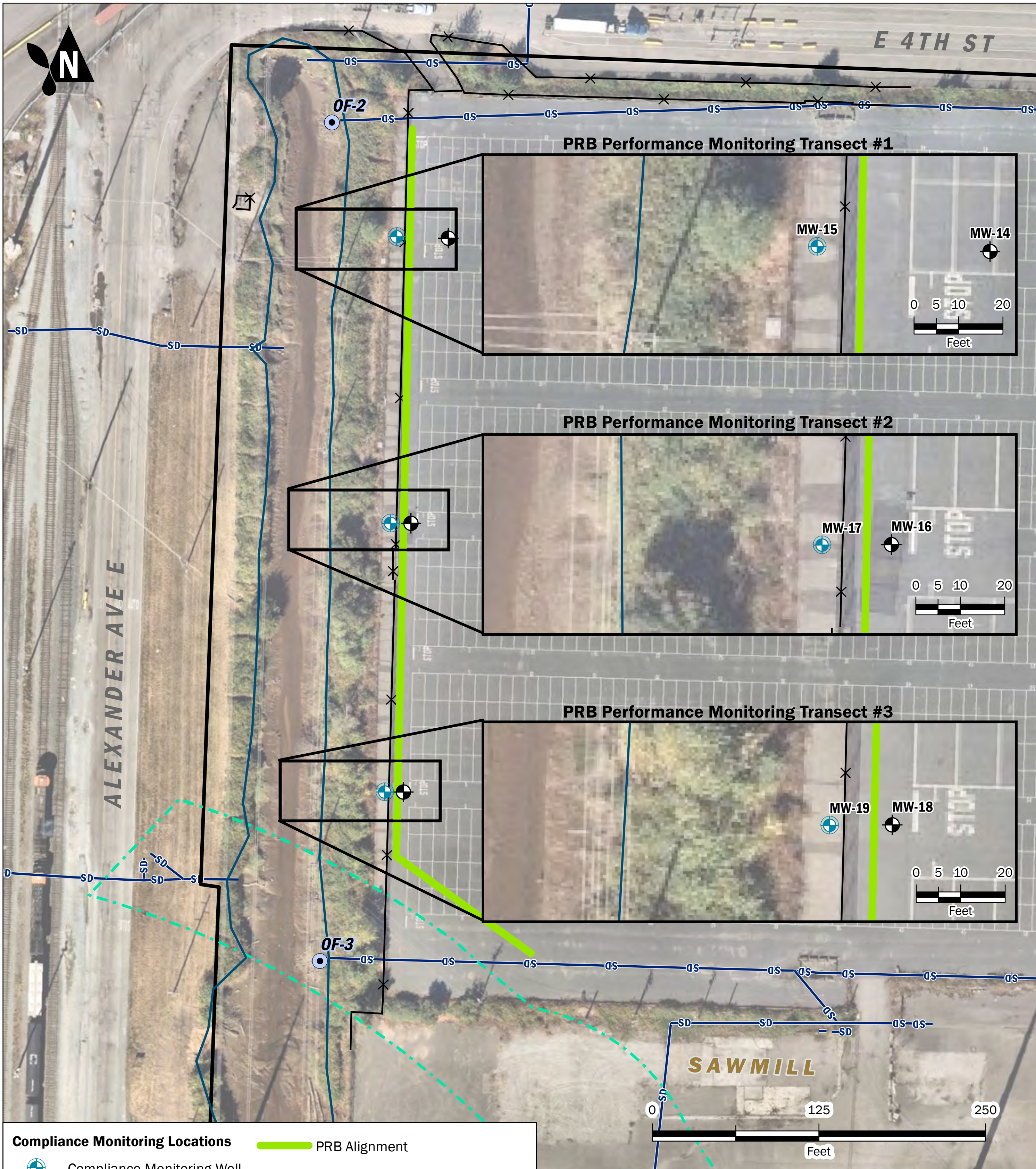


Figure 9

Grain-Size Analysis

Engineering Design Report

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



Compliance Monitoring Locations

Compliance Monitoring Well

Stormwater Outfall

Groundwater Monitoring Wells

Monitoring Well Upgradient of PRB

PRB Alignment

Ordinary High Water Mark

Fence

Storm Pipe

Former Creek Channel

Port Parcel 15

Note: PRB = Permeable Reactive Barrier

PRB Performance Monitoring Well Locations

Engineering Design Report
Port of Tacoma - Parcel 15 (Portac)
Tacoma, Washington

Aspect CONSULTING

JUN-2022	BY: ACG / WEG	FIGURE NO. 10
PROJECT NO. 210158	REVISED BY: DIM / WEG	

GIS Path: G:\projects\PortofTacoma\PortacParcel15_210158\Delivered\Engineering Design Report\10 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

Pre-Remedial Design Investigation (PRDI) Technical Memorandum

Aspect CONSULTING

DRAFT MEMORANDUM

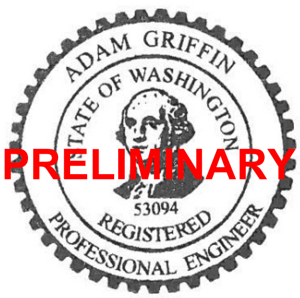
Project No. 210158

January 17, 2022

To: Andrew Smith, Washington State Department of Ecology

cc: Stanley Sasser, Rob Healy, and Norman Gilbert; Port of Tacoma

From:



Adam Griffin, PE
Associate Engineer
agriffin@aspectconsulting.com

Delia Massey, PE
Project Engineer
dmassey@aspectconsulting.com

Re: **Pre-Remedial Design Investigation (PRDI) Technical Memorandum**
Parcel 15 (Portac) Cleanup Phase 1

Aspect Consulting, LLC (Aspect) prepared this Pre-Remedial Design Investigation (PRDI) Technical Memorandum (Memo) 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 consisting of two construction elements—stormwater conveyance improvements and a permeable reactive barrier (PRB). The Remedial Design Work Plan (RDWP) outlined the pre-remedial design investigation (PRDI) activities necessary to complete the Phase 1 Cleanup remedial action and described three PRDI tasks for the PRB remedial design (Aspect, 2021):

1. PRB Alignment Investigation
2. Treatability Testing
3. Contingent Groundwater Investigation

This PRDI Technical Memo presents the results of the PRB Alignment Investigation completed in November 2021 and recommendations for the Contingent Groundwater Investigation task. The Treatability Testing task is ongoing, and the recommendations herein are not subject to Treatability Testing results. This PRDI Technical Memo also recommends the PRB dimensions of length and depth for Ecology approval prior to continuing remedial design activities and preparing the Agreed

Order-required Engineering Design Report (EDR). All final PRDI results will be reported in the EDR.

PRB Alignment Investigation Results

The PRB Alignment Investigation was conducted from November 15 to 19, 2021 in accordance with the Final RDWP. The completed six boring locations (AB-01 through AB-06) and new monitoring well (MW-14) are shown on Figure 1. Boring location AB-01 was completed to the south side of the stormwater pipe because of overhead power line clearance at the location identified in the RDWP.

At each of the six boring locations, the roller compacted concrete (RCC) was cored for investigation at three distinct points. The points were approximately 2 feet apart and configured in a triangle. The three points at each location were used to:

1. Advance a hydraulic profiling tool (HPT)

2. Collect continuous core for lithology logging, mineralogical field data, and soil sampling

3. Collect grab groundwater samples at three discrete depth intervals

One boring location collectively refers to the group of three points (i.e., AB-01 has HPT, soil core, and grab groundwater results). All boring locations were advanced using direct-push drilling technology. All drilling was conducted by a Washington state licensed driller, Cascade Drilling and Technical Services (Cascade).

The 18 boreholes (three cores at six different boring locations) were decommissioned with hydrated granular bentonite in accordance with requirements of Chapter 173-160 WAC and the cored surface restored with high-strength concrete, matching the construction of the existing RCC cap. The following sections discuss the results of each boring.

Soil Borings

Continuous core was collected from soil borings for lithology logging, mineralogical field data, and soil sampling in accordance with the methods outlined in the RDWP (Aspect, 2021). All soil borings were advanced to 25 feet below ground surface (ft. bgs), which is the CAP-approximated PRB depth dimension.

Soils were classified in accordance with American Society for Testing and Materials (ASTM) Method D 2488. Soil descriptions, field screening results, and other relevant details (e.g., staining, debris, odors, etc.) were recorded on the boring logs and reviewed by a licensed geologist, and are included as Appendix A. Fourteen soil samples were collected and submitted to Fremont Analytical (laboratory) for analysis of total arsenic by EPA Method 6020B. All samples were collected from depths greater than 15 ft bgs, below the water table. The total arsenic results in soil are in Table 1.

Soil from each boring was screened using a low-limit handheld x-ray fluorescence (XRF) spectrometer at 2.5-foot intervals or less for estimated arsenic, iron, and manganese concentration. The XRF results are tabulated in Appendix B.

Soils from location AB-03 at 3 depth intervals (16.5, 20, and 22 ft. bgs) were submitted to the laboratory for grain size analysis (GSA) by Method ASTM D422. The GSA results are plotted in Appendix C. This plot also includes GSA results from the Remedial Investigation (GSI, 2018) and the zero valent iron (ZVI) media used for Treatability Testing (Connelly ET CC-1004).

Cross sections A-A’ and B-B’ from the RDWP have been updated based on the new soil borings and included as Figures 2 and 3 and discussed in the recommendations below.

Hydraulic Profiling Tool (HPT)

The HPT tooling was advanced to 30 ft. bgs, 5 ft. beyond the CAP-approximated PRB depth of 25 feet deep[1]. The HPT tooling and instrumentation was operated by Cascade Drilling and the HPT Final Data Report is included as Appendix D.

The HPT tooling measures the following parameters at a vertical resolution of 0.05 feet:

- **Electrical Conductivity (EC)** in units of millisiemens per meter (mS/m) – The EC correlates inversely with soil grain size – i.e., decreasing grain size equals increasing EC response. The EC value is also influenced by specific conductivity of the water in the saturated zone.
- **Absolute Piezometric Pressure** in units of pounds per square inch (psi) – This value is constant in the vadose zone and increases linearly with hydrostatic pressure in the saturated zone. The absolute piezometric pressure measurement pinpoints the groundwater table, illustrated on the HPT logs as a red dot and compiled below in Table 5.
- **HPT Flow Max** in units of milliliters per minute (mL/min) – The HPT operates by injecting clean water targeting a constant flow rate into the formation through an injection port on the side of the HPT tooling. The HPT Flow Max is the injection flow rate.
- **HPT Pressure Max** in units of psi – The back pressure required to maintain the HPT injection flow rate.

The HPT logs also include a **Corrected HPT Pressure**, which corrects the **HPT Pressure Max** values for hydrostatic pressure obtained from the **Absolute Piezometric Pressure**. The HPT measurements all allow estimation of hydraulic conductivity (K) in units of feet per day (ft./d) using the HPT software (Appendix D).

It is critical to note that the HPT-estimated K values are not accurate absolute estimates. The HPT-estimated K values are useful for relative comparisons across the depth of a boring, and relative comparison of K at different borings.

The EC, Corrected HPT Pressure, and estimated K values are compiled for all six borings by depth and elevation and presented in Figures 4a-4c. For relative comparisons, all values are plotted on logarithmic scale, so the basis of recommendations below are based on order-of-magnitude (greater than 10x) differences.

[1] The Agreed Order PRB description includes “key into the underlying low-permeability silts” (Section VII.A Work to be Performed).

Discrete Groundwater Sampling

Groundwater grab samples were collected at each of the six boring locations. The groundwater grab samples were collected using a decontaminated stainless steel drive point screen. The tip of the sampling tool was advanced to the lower depth of the desired groundwater sampling interval. The driller then retracted the drive rods to expose 3 feet of groundwater sample screen to the subsurface. Grab groundwater samples were collected from the following depths at each boring:

- 14 to 17 ft. bgs[2]
- 18 to 21 ft. bgs
- 22 to 25 ft. bgs

Groundwater sampling was completed using a peristaltic pump and low-flow sampling techniques in accordance with the RDWP. Disposable tubing was placed down the drive rods to the mid-point of the sample screen. All sample locations were purged for at least 15 minutes, and up to a maximum of 30 minutes to reduce sample turbidity. Only 9 of the 17 samples collected achieved a turbidity less than 1,000 nephelometric turbidity unit (NTUs).

Field parameters (temperature, pH, electrical conductance, dissolved oxygen [DO], and oxidation-reduction potential [ORP]) were measured during purging and sample collection. All grab groundwater samples were analyzed for total and dissolved arsenic (field-filtered). To evaluate water quality changes with depth—total metals, anions, alkalinity, total organic carbon, and ferrous Fe were analyzed at all three discrete samples from two borings (AB-01 and AB-04) in accordance with the RDWP[3].

The unvalidated laboratory analytical results are combined with the EC, HPT Pressure Max, and HPT Flow Max plots for each boring in Appendix E. Unvalidated laboratory analytical results and field parameters at the time of sample collection are presented in Table 2. The laboratory analytical reports are included in Appendix F. The field parameters recorded during sample purging can be found in Appendix G. The final validated results will be reported in the EDR.

Monitoring Well Installation

On November 16, 2021, the new monitoring well (MW-14) was installed using hollow-stem auger drilling and completed with a screened interval from 15 to 25 ft. bgs, in accordance with the RDWP. The monitoring well was constructed with 2-inch-diameter, threaded Schedule 40 PVC, 0.010-inch slot (10-slot) screen, and blank casing. The well was completed with an annular seal consisting of bentonite chips above the filter pack and an 8-inch traffic-rated monument.

Site Monitoring Results

The Agreed Order requires that semiannual groundwater monitoring and annual cap inspections be initiated upon its effective date. The RDWP outlined two groundwater monitoring events (Events 7 and 8) to be conducted during remedial design and concurrent with PRDI activities. On November 22, 2021, groundwater samples were collected from Logyard monitoring wells MW-7, MW-9,

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[2] This shallowest sample interval did not produce water at AB-03 and was therefore not sampled.
[3] Total phosphorous was analyzed in lieu of ortho-phosphate due to laboratory equipment failure. This change in analytical method does not impact data evaluation or PRDI objectives.

MW-12, B-5R, MW-14 and Sawmill monitoring well MW-2R in accordance with the RDWP (Event 7).

The unvalidated analytical results from Site Monitoring (Event 7) are reported in Table 3 and the laboratory analytical reports are included in Appendix F. Groundwater sampling forms are included in Appendix G. Additionally, the results are reported in Appendix H along with Event 1 through 6 analytical results reported by GSI Water Solutions, Inc. (GSI, 2018; GSI, 2019a; GSI, 2019b).

The Site monitoring scope in the RDWP was expanded to include a Site-wide groundwater elevation monitoring event conducted on December 17th, 2021 (see Table 4). The groundwater elevations are presented in Table 4 and a groundwater elevation contour map presented in Figure 5. Groundwater elevation contour maps presented in the Remedial Investigation Report are included in Appendix I for reference (GSI, 2018).

The final validated analytical results will be reported in the EDR and the Compliance Monitoring and Contingency Response Plan (CMCRP).

PRB Design Recommendations

The Agreed Order Work to be Performed requires construction of

"…a Permeable Reactive Barrier (PRB) parallel to Wapato Creek along the westernmost boundary of the Log Yard cap and along a portion of the northwestern boundary. The PRB will extend to below the streambed of Wapato Creek and will be expected to key into the underlying low permeability silts."

The CAP approximated a PRB dimension of 1,000 feet long comprised of roughly 700 feet parallel to Wapato Creek and roughly 300 feet perpendicular to Wapato Creek on the north side of the Site.

The PRB description in the Agreed Order and CAP served as the basis of the RDWP and PRB alignment investigation. Locations AB-01 through AB-04 were completed on the western portion of the Site parallel to Wapato Creek, and locations AB-05 and AB-06 on the northern portion of the Site.

PRB technology is used to intercept and remediate a contaminated groundwater plume. There are two PRB selection fundamentals that are a necessary basis to the PRB design recommendations:

1. A PRB is oriented perpendicular to groundwater flow for treatment efficiency and to improve downgradient water quality.

2. A PRB is not applicable for source remediation; it is used for downgradient dissolved-phase groundwater plume treatment.

PRB parallel to Wapato Creek

The PRB will be constructed parallel to Wapato Creek and will treat arsenic in groundwater before groundwater discharges to Wapato Creek. The orientation perpendicular to groundwater flow and the alignment at the furthest downgradient position on Site is ideal for the PRB technology.

Depth of PRB parallel to Wapato Creek

All Remedial Investigation borings were advanced to less than 20 ft. deep and encountered a silty sand at the total depths (GSI, 2018). The new borings were advanced to 25 ft. bgs to determine if a low-permeability unit exists below 20 feet that the PRB could be "keyed" into. Borings AB-02, AB-03, and AB-04 (and AB-05 and AB-06 along the northern portion) all encountered a low permeability clay unit at a depth between 20 and 22 ft. bgs[4]. The Remedial Investigation identified clay in shallower borings and grouped silts and clays into a "fine grained deposits" for geologic cross-sections (GSI, 2018). The low permeability clay encountered during the PRB Alignment Investigation is a fine grained deposit, but mapped as different unit on cross sections on Figures 2 and 3.

The clay unit occurs at an elevation ranging from 4.0 to 5.3 ft. elevation mean lower low water (MLLW) at borings AB-02, AB-03 and AB-04 on the PRB alignment parallel to Wapato Creek (Figure 2). The compilation of the HPT data in Appendix E illustrates this consistent elevation of the clay unit at AB-02, AB-03, and AB-04. The EC value exceeds 100 mS/m at the elevation ranging from 3 to 5 feet MLLW (Appendix E - Figure E.1) where clays are identified with EC generally exceeding 20 mS/m.

Based on the HPT results and the soil logging, the top of the clay unit is at or below the bottom elevation of Wapato Creek. The clay unit does not contribute groundwater flow that would discharge to Wapato Creek and acts as an aquitard to the arsenic-contaminated groundwater flow in the overlying silty sands. The clay unit serves as the basis of PRB depth. This basis achieves the Agreed Order requirement of PRB depth to be below the streambed of Wapato Creek (5 feet MLLW) and keyed into a low-permeability unit. Assuming PRB construction 6 inches into the clay unit, the proposed depth of the PRB is outlined below based on boring locations to be used as control points during construction.

Table 5. Proposed PRB Depth Control Points

	AB-02	AB-03	AB-04
Ground Surface Elevation (ft. elevation MLLW)	25.84	27.22	25.48
Depth to Groundwater from HPT Absolute Piezometric Pressure (ft. bgs)	16.20	17.55	15.95
Depth to Top of Clay (ft. bgs)	20.5	23.0	21.5
Top of Clay Elevation (ft. elevation MLLW)[5]	5.3	4.2	4.0
Proposed PRB Depth (ft. bgs)	**21**	**23.5**	**22**

[4] Location AB-01 was installed in the former Wapato Creek alluvial deposits and the geology observed was significantly different than all other borings (AB-02 through AB-06). The alluvial creek deposits were observed at the total AB-01 depth of 25 ft bgs; the AB-01 HPT encountered a low-permeability material at a depth of 31 ft. bgs based on the EC response.

[5] The Top of Clay Elevation is 4.0 and 3.3 ft. elevation MLLW at borings AB-05 and AB-06, respectively.

Length of PRB parallel to Wapato Creek

The PRB will be constructed at the furthest downgradient position at the Site at the western extent of the existing RCC cap and be approximately 660 linear feet. The southern end of the PRB will be keyed into the low permeability clay unit aligned on the bank of the former Wapato Creek channel (Figure 6). Given the consistent occurrence and elevation of the low permeability clay unit at all borings outside the alluvial creek deposits, the PRB south of AB-02 will be constructed based on the AB-02 control point depth (Table 5) and keying into the clay unit verified during construction.

Groundwater flow at the Site is west towards Wapato Creek and has a southwestern component, especially in the areas adjacent to the former Wapato Creek channel (Figure 6 and Appendix I). Therefore, the southern PRB alignment will be a different orientation for approximately 80 feet to be perpendicular to groundwater flow and keyed into the low permeability clay unit north of the former Wapato Creek channel (Figure 6).

This PRB alignment intercepts groundwater flow from upgradient before reaching the alluvial creek deposits observed at AB-01. Location AB-01 is positioned at the southern extent of the fill containing slag and existing RCC cap, and there is no evidence of high arsenic concentrations in the groundwater in the alluvial creek deposits[6]. Further, groundwater in the shallow AB-01 sample is brackish due to influence from Wapato Creek[7]. High salinity of groundwater in the alluvial creek deposits could prevent corrosion of ZVI, and render it ineffective for arsenic treatment.

The northern end of the PRB will terminate as close to the stormwater pipe as practical. Assuming a 10 ft. lateral setback of PRB from the stormwater pipe, the distance from northern PRB terminus to the existing RCC cap and potential fill containing slag is approximately 25 linear feet, which is 3.8 percent of the PRB length. If there is a southwestern groundwater flow component in this northwestern corner of the Site, the arsenic flux in groundwater across these 25 linear feet is less than 3.8 percent of the arsenic flux in groundwater across the planned PRB length of 660 feet.

Constructing the PRB section beyond the stormwater pipe would require a design integrated with the conveyance system improvements and present significant constructability challenges[8]. The associated construction cost would be highly disproportionate to the estimated environmental benefit to construct the PRB 25 feet further north. The planned stormwater conveyance system improvements will address the most significant pathway of discharge of arsenic-contaminated groundwater to Wapato Creek by cutting off groundwater seepage into the stormwater pipe.

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[6] Dissolved arsenic concentrations in the two shallow grab groundwater samples from AB-01 were below the cleanup level, and the 14.2 ug/L result from the 22 to 25 ft bgs sample is likely biased high due to the high sample turbidity (>1,000 NTUs). The arsenic concentration in groundwater at permanent monitoring well B-5R located approximately 60 feet southwest of AB-01 has never exceeded the cleanup level (Appendix H).

[7] Brackish groundwater is indicated by the specific conductance and Na, K, and Mg concentrations in the AB-01 14-17 ft grab groundwater sample (Table 2), in addition to the electrical conductivity at this same depth (Appendix E.1).

[8] The southern PRB orientation and terminus may also prevent the need to disconnect overhead power lines. The northern PRB terminus will also prevent the need to shutdown and reconnect the high-security fencing controls and electrical panel, and close the tenant's primary Site entry point.

Evaluation of Borings AB-05 and AB-06 Results

A PRB on the northern boundary of the Site would not be perpendicular to groundwater flow, and not in a downgradient position. There is no evidence of a northern groundwater flow component at the Site. A PRB on the northern portion of the Site would be parallel to groundwater flow and rely on a flow-focusing effect to intercept groundwater. The quantity of groundwater intercepted by a PRB parallel to groundwater flow would be negligible compared to the groundwater intercepted by the planned PRB oriented perpendicular to groundwater flow. If there is a southwestern groundwater flow component on this northern portion of the Site, then groundwater from the northern portion of the Site would ultimately be treated by the planned PRB oriented perpendicular to groundwater flow and adjacent to Wapato Creek.

Boring locations AB-05 and AB-06 were installed approximately 100 and 200 feet east of the planned PRB adjacent to Wapato Creek. The Remedial Investigation geochemical testing and fate and transport evaluation demonstrate that significant attenuation of arsenic[9] occurs on the flow path from the perched water zone to Wapato Creek where AB-05 and AB-06 were installed (GSI, 2018). Additionally, the area where AB-05 and AB-06 were installed is the perched water zone where saturation of fill containing slag acts as the source of arsenic to groundwater. The higher arsenic concentrations in groundwater in these areas may not be effectively treated with ZVI. If treatment of this high arsenic concentration perched groundwater could be achieved through emplacement of ZVI in a PRB, it would likely become re-contaminated and it’s unlikely to improve downgradient groundwater quality discharging to Wapato Creek.

A PRB on this northern portion of the Site is not suited for the PRB technology and based on these conclusions, no PRB is proposed on the northern portion of the Site (Figure 6). The planned stormwater conveyance system improvements will address the most significant pathway of discharge of arsenic-contaminated groundwater to Wapato Creek in this northern portion of the Site by cutting off groundwater seepage into the stormwater pipe. The PRB adjacent to Wapato Creek will treat effectively at the most downgradient position, and prior to discharge to Wapato Creek.

Summary

Based on the results of the PRB Alignment Investigation presented herein, there are no additional remedial design data gaps to warrant the contingent groundwater investigation task outlined in the RDWP. The consistent occurrence and elevation of the low permeability clay unit that the PRB will be keyed into is a reliable basis to establish additional control points for PRB construction depth. The Remedial Investigation results combined with the AB-01 results yield no basis for PRB construction in the alluvial creek deposits, and support the southern PRB terminus. Based on costs to construct the PRB beyond the stormwater pipe that are highly disproportionate to the environmental benefit, the northern PRB terminus is to the maximum extent practicable.

The results of the Treatability Testing task will serve as a basis of PRB dimensions (width) and composition. There are no additional Site investigation data needs in order to complete the PRB remedial design to be presented in the EDR for Ecology approval before construction.

[9] The dissolved arsenic concentrations are up to 1,000 times lower at monitoring wells adjacent to Wapato Creek (MW-7, MW-9, and MW-12) than at perched groundwater monitoring wells approximately 200 feet upgradient.

The proposed PRB dimensions in this PRDI Technical Memo satisfy the requirements for the PRB cleanup action element in the CAP, and requirements of the Agreed Order. This PRDI Technical Memo requests Ecology concurrence with the proposed PRB alignment shown in Figure 6 and depths in Table 5 above. With Ecology's concurrence, the remedial design activities will be completed and the EDR prepared in accordance with the Agreed Order.

References

Aspect Consulting, LLC (Aspect), 2021, Final Remedial Design Work Plan, Parcel 15 (Portac) – Port of Tacoma, December 9, 2021.

GSI, 2018. Public Review Draft Remedial Investigation Report, Parcel 15 (Portac) Investigation, Ecology Facility Site No. 1215/Cleanup Site. 3642. GSI Water Solutions, Inc. February 2018.

GSI, 2019a. Event 5 Groundwater Data Report Technical Memorandum. GSI Water Solutions, Inc. May 9, 2019.

GSI, 2019b. Event 6 Groundwater Data Report Technical Memorandum. GSI Water Solutions, Inc. December 16, 2019.

GSI, 2018. Public Review Draft Remedial Investigation Report, Parcel 15 (Portac) Investigation, Ecology Facility Site No. 1215/Cleanup Site. 3642. GSI Water Solutions, Inc. February 2018.

Washington State Department of Ecology (Ecology), 2021, Cleanup Action Plan, Parcel 15 (Portac) – Port of Tacoma, July 6, 2021.

Limitations

Work for this project was performed for the Port of Tacoma (Client), and this memorandum 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 memorandum does not represent a legal opinion. No other warranty, expressed or implied, is made.

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Attachments:
Table 1 – Soil Analytical Results
Table 2 – Groundwater Analytical Results - Grab Samples
Table 3 – Groundwater Analytical Results - Monitoring Wells
Table 4 - December 2021 Groundwater Elevations
Table 5 – Proposed PRB Depth Control Points

Figure 1 – PRB Alignment Investigation Locations
Figure 2 – Cross-Section A-A'
Figure 3 – Cross-Section B-B'
Figure 4a – HPT - Electrical Conductivity Results

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TABLES

Table 1. Soil Analytical Results

DRAFT

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

Location	Date	Depth	Arsenic (mg/kg)	Moisture Content (%)
AB-01	11/17/2021	15 ft	68.1	15.1
AB-01	11/17/2021	21 ft	11.4	14.8
AB-02	11/17/2021	17 ft	1.42	21.3
AB-02	11/17/2021	22 ft	2.61	27.6
AB-03	11/17/2021	19 ft	2.31	25.6
AB-03	11/17/2021	23 ft	3.07	24.6
AB-03	11/17/2021	25 ft	5.57	29
AB-04	11/10/2021	20 ft	1.51	24
AB-04	11/10/2021	23 ft	17	30.5
AB-05	11/17/2021	17 ft	3.16	29
AB-05	11/17/2021	23 ft	5.19	35.8
AB-06	11/17/2021	17 ft	1.85	27
AB-06	11/17/2021	22 ft	5.71	35.7
AB-06	11/17/2021	25 ft	1.41	18.3

Notes: mg/kg = milligrams per kilograms

Table 2. Groundwater Analytical Results - Grab Samples

DRAFT

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

Analyte	Unit	Cleanup Level (ug/L)	AB-01			AB-02			AB-03		AB-04			AB-05			AB-06		
			14 - 17 ft	18 - 21 ft	22 - 25 ft	14 - 17 ft	18 - 21 ft	22 - 25 ft	18 - 21 ft	22 - 25 ft	14 - 17 ft	18 - 21 ft	22 - 25 ft	14 - 17 ft	18 - 21 ft	22 - 25 ft	14 - 17 ft	18 - 21 ft	22 - 25 ft
			11/19/2021	11/19/2021	11/19/2021	11/19/2021	11/19/2021	11/19/2021	11/18/2021	11/18/2021	11/17/2021	11/17/2021	11/18/2021	11/18/2021	11/18/2021	11/18/2021	11/18/2021	11/18/2021	11/18/2021
Dissolved Metals																			
Arsenic	ug/L	5	**3.07**	**1.99**	**14.2**	**5.13**	**3.91**	**20.1**	**16.1**	**4.38**	**27.9**	**39.3**	**55.9**	**19.5**	**12.6**	**1.36**	**31**	**6.31**	**56.9**
Total Metals																			
Arsenic	ug/L		**9.82**	**2.07 J**	**28.3**	**28.8**	**20.4**	**138**	**56.7**	**8.01**	**45.3**	**68.6**	**83.6**	**29.5**	**18.2**	**13.8**	**47**	**10.8**	**68.9**
Calcium	ug/L		**58,600**	< 20000 U	**36,900**	--	--	--	--	--	**105,000 J**	**136,000 J**	**142,000 J**	--	--	--	--	--	--
Iron	ug/L		**4,010**	**23,600**	**36,500**	--	--	--	--	--	**160,000 J**	**144,000 J**	**177,000**	--	--	--	--	--	--
Magnesium	ug/L		**168,000**	**25,000**	**26,700**	--	--	--	--	--	**58,400 J**	**120,000 J**	**121,000**	--	--	--	--	--	--
Manganese	ug/L		**124**	**595**	**3,490 J**	--	--	--	--	--	**3,790 J**	**7,220 J**	**4,920**	--	--	--	--	--	--
Potassium	ug/L		**97,000**	**13,500**	**13,500**	--	--	--	--	--	**35,900 J**	**43,200 J**	**42,500**	--	--	--	--	--	--
Sodium	ug/L		**2,420,000 J**	**287,000**	**73,900**	--	--	--	--	--	**150,000 J**	**307,000 J**	**236,000**	--	--	--	--	--	--
Conventionals																			
Alkalinity, Total (as CaCO3)	mg/L		**170**	**215**	**321**	--	--	--	--	--	**688**	**1,050**	**979**	--	--	--	--	--	--
Bromide	mg/L		< 80 U	< 8 U	< 0.4 U	--	--	--	--	--	< 1.6 U	< 4 U	< 4 U	--	--	--	--	--	--
Chloride	mg/L		**3,250**	**330**	**22.4**	--	--	--	--	--	**63.6**	**232**	**225 J**	--	--	--	--	--	--
Fluoride	mg/L		**0.7**	**0.51**	**0.665**	--	--	--	--	--	**1.14**	**1.18**	**1.22**	--	--	--	--	--	--
Iron, Ferrous, Fe+2	mg/L		**26**	**3.79**	**30.5**	--	--	--	--	--	**187**	**151**	**166 J**	--	--	--	--	--	--
Nitrate-Nitrite (as N)	mg/L		< 0.55 U	< 0.55 U	< 0.55 U	--	--	--	--	--	< 0.44 U	< 1.1 U	< 1.1 U	--	--	--	--	--	--
Phosphorus	mg/L		< 2.62 U	< 2.62 U	< 2.62 U	--	--	--	--	--	< 2.1 U	< 5.25 U	< 5.25 U	--	--	--	--	--	--
Sulfate	mg/L		**566**	**40.6**	**3.42**	--	--	--	--	--	< 2.4 U	< 6 U	< 6 U	--	--	--	--	--	--
Total Organic Carbon	mg/L		**2.77**	**11.5**	**20.9**	--	--	--	--	--	**66**	**87.7**	**93.2**	--	--	--	--	--	--
Field Parameters																			
Temperature	deg C		**14.8**	**14.9**	**14.2**	**13.7**	**15.1**	--	**14.1**	**10.7**	**15.8**	**14.6**	**12.6**	**14**	**15.1**	**13.3**	**15.4**	**14.2**	**14.4**
Specific Conductance	uS/cm		**10040**	**1486**	**621.5**	**1804**	**2057**	--	**1827**	**2734**	**1738**	**2794**	**2683**	**2515**	**3101**	**3214**	**2894**	**1931**	**4039**
Dissolved Oxygen	mg/L		**15.8**	**12.7**	**12.1**	**9.2**	**13.3**	--	**1.7**	**59.1**	**16.3**	**7.3**	**15.8**	**51**	**34.7**	**35.6**	**8.9**	**15.1**	**11.5**
pH	pH units		**6.34**	**6.49**	**6.66**	**6.68**	**6.78**	--	**6.33**	**6.96**	**6.58**	**6.98**	**6.25**	**6.92**	**6.77**	**6.75**	**6.7**	**6.59**	**6.55**
Oxidation Reduction Potential	mV		**-30.1**	**-44.3**	**-71.8**	**-99.2**	**-101.9**	--	**-32.7**	**-12.5**	**13**	**-104**	**144.8**	**69.7**	**36.3**	**36.5**	**-15.7**	**-30.8**	**-37.5**
Turbidity	NTU		**EX**	**79.2**	**EX**	**84.9**	**EX**	**EX**	**EX**	**99.5**	**53.5**	**50.2**	**24.6**	**85.8**	**90.8**	**EX**	**75.9**	**EX**	**EX**

Notes

Bold - Analyte Detected

Blue Shading - exceeds Groundwater Cleanup Level (as selected in Cleanup Action Plan)

EX - turbidity result exceeded detection range of instrument (1000 NTU)

J - Analyte was positively identified. The reported result is an estimate.

U - Analyte was not detected at or above the reported result.

Table 3. Groundwater Analytical Results - Monitoring Wells

DRAFT

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

Analyte	Unit	Cleanup Level (ug/L)	B-5R 11/22/2021	MW-2R 11/22/2021	MW-7 11/22/2021	MW-9 11/22/2021	MW-12 11/22/2021
Dissolved Metals							
Arsenic	ug/L	5	**3.05 J**	--	**31.1**	**88.4**	**40.1**
Calcium	ug/L		**45,600 J**	--	**77,200 J**	**82,500 J**	**100,000 J**
Iron	ug/L		**28,600**	--	**56,800**	**190,000**	**147,000**
Magnesium	ug/L		**37,100**	--	**49,000**	**61,600**	**50,600**
Manganese	ug/L		**1,130**	--	**2,500**	**3,230**	**7,190**
Nickel	ug/L		< 130 U	--	< 130 U	< 130 U	< 130 U
Potassium	ug/L		**21,900 J**	--	**29,800 J**	**33,000 J**	**47,900 J**
Total Metals							
Arsenic	ug/L		< 2.63 U	--	**16.2**	**80.4**	**23.6**
Calcium	ug/L		**38,200 J**	--	**66,400 J**	**71,600 J**	**92,400 J**
Iron	ug/L		**27,800**	--	**53,100**	**198,000**	**136,000**
Magnesium	ug/L		**26,300**	--	**31,100**	**45,100**	**38,100**
Manganese	ug/L		**862**	--	**1,720**	**2,500**	**5,480**
Nickel	ug/L		< 60 U	--	< 300 U	< 300 U	< 300 U
Potassium	ug/L		**13,500 J**	--	18,800 UJ	**22,400 J**	**36,000 J**
Sodium	ug/L		--	--	--	--	--
SVOCs							
Pentachlorophenol	ug/L	1	--	**14.6**	--	--	--
Conventionals							
Alkalinity, Total (as CaCO3)	mg/L		**195**	--	**294**	**573**	**662**
Phosphorus	mg/L		**1.18**	--	**1.24**	**1.81**	**1.66**
Total Organic Carbon	mg/L		**10.7**	--	**28.6**	**79.3**	**83**
Field Parameters							
Temperature	deg C		**15.6**	**12.7**	**15.6**	**14.1**	**14.2**
Specific Conductance	uS/cm		**1675**	**629.8**	**818**	**1604**	**1680**
Dissolved Oxygen	mg/L		**2.2**	**10.1**	**1.8**	**2**	**1.8**
pH	pH units		**6.47**	**11.86**	**6.42**	**6.72**	**6.85**
Oxidation Reduction Potential	mV		**88.3**	**27.4**	**81**	**71.2**	**70.8**
Turbidity	NTU		**NM**	**NM**	**NM**	**NM**	**NM**
Iron, Ferrous, Fe+2	mg/L		**45.6**	--	**76.4**	**267**	**196**

Notes

Bold - Analyte Detected

Blue Shading - exceeds Groundwater Cleanup Level (as selected in Cleanup Action Plan)

NM - Not measured. Turbidimeter not functioning.

J - Analyte was positively identified. The reported result is an estimate.

U - Analyte was not detected at or above the reported result.

Table 4. December 2021 Groundwater Elevations

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

Well ID	TOC Elevation (ft)	DTW (ft bTOC)	GW Elevation (ft)
B-1R	22.88	11.7	11.18
B-3R	22.44	8.36	14.08
B-5R	20.46	10.06	10.4
B-6R	23.74	11.22	12.52
HC-2[a]	23.37	7.26	16.11
MW-1	20.25	9.24	11.01
MW-2R	20.69	8.2	12.49
MW-3	20.33	9.22	11.11
MW-4[a]	20.66	NM	NM
MW-5R	19.63	9.05	10.58
MW-6R	20.96	10.13	10.83
MW-7	25.03	13.83	11.2
MW-8	23.62	8.25	15.37
MW-9	25.02	14.26	10.76
MW-10	25.23	8.07	17.16
MW-11	24.39	11.43	12.96
MW-12	25.32	14.7	10.62
MW-13	23.69	6.53	17.16
MW-14	25.05	13.89	11.16

Notes:

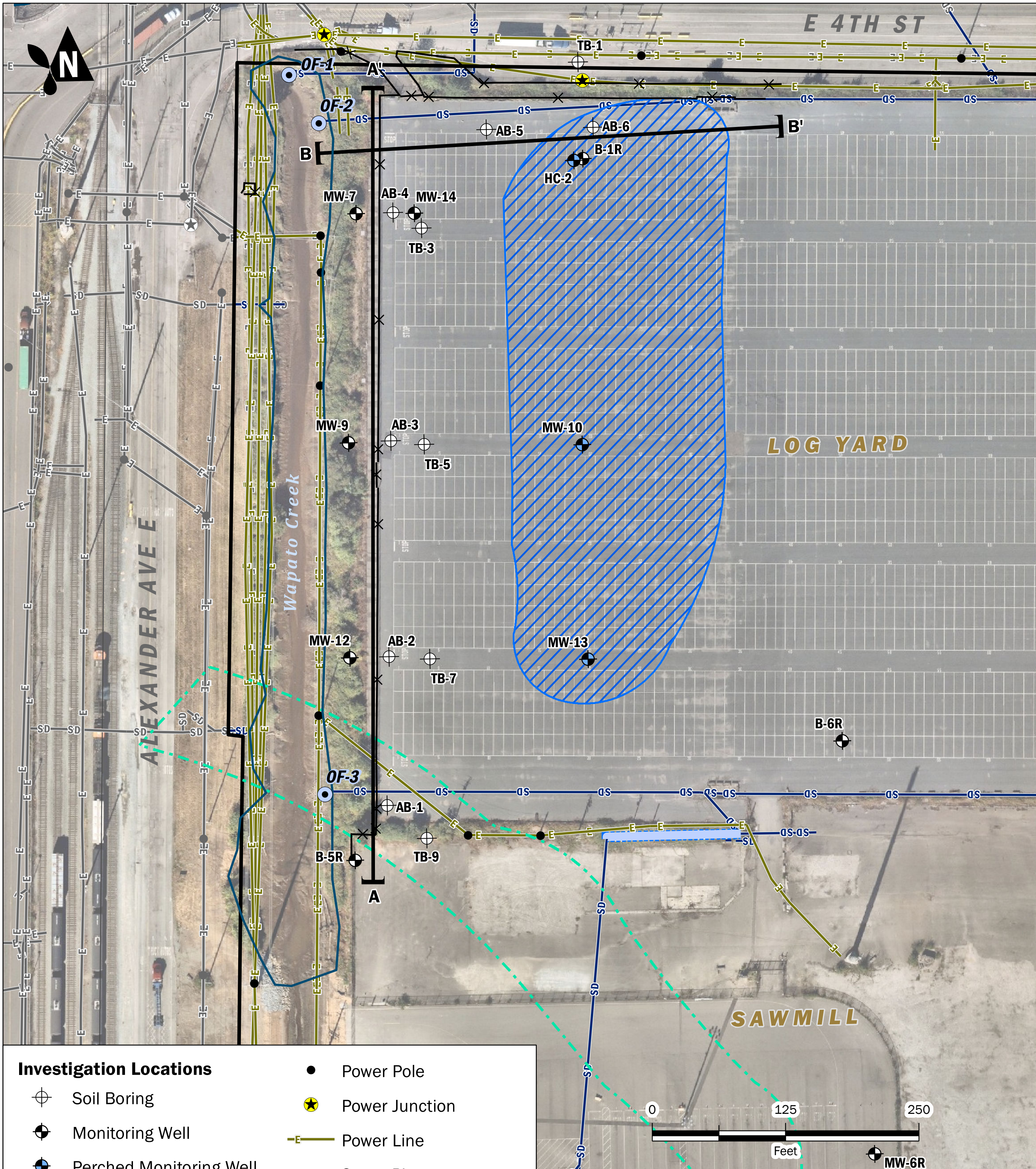
NM = not measured

Vertical datum: Mean Lower Low Water (MLLW) per Port of Tacoma Survey Control #2352 (Elevation 28.54)

a) MW-4 was not accessible

ft bTOC - feet below top of casing

FIGURES



Investigation Locations

- Soil Boring
- Monitoring Well
- Perched Monitoring Well
- Piezometer
- Ordinary High Water Mark
- Fence
- Cross Section Location

Site Features

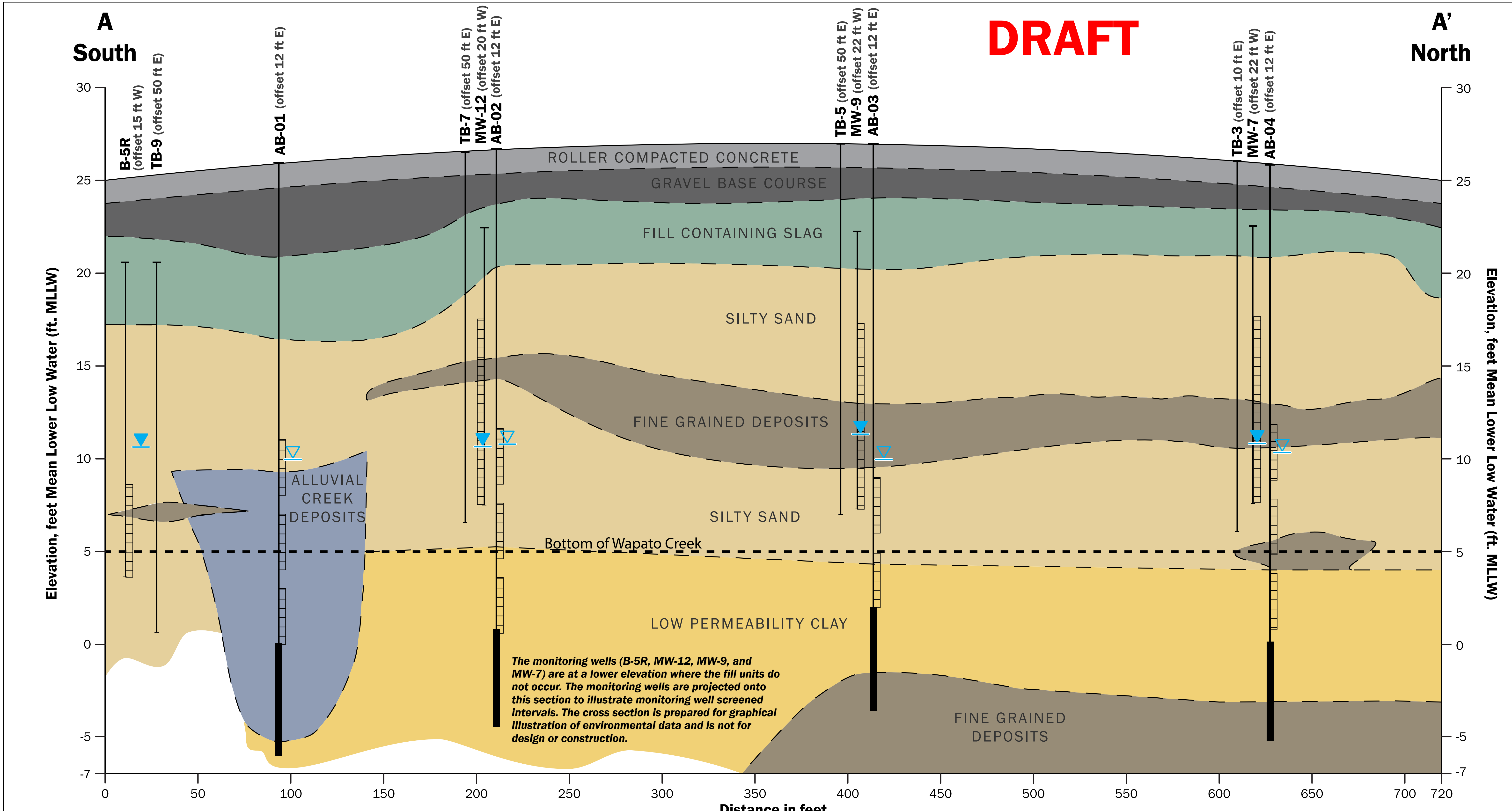
- Stormwater Outfall
- Power Pole
- Power Junction
- Power Line
- Storm Pipe
- Ditch
- Former Creek Channel
- Observed Perched Zone
- Port Parcel 15
- Pierce County Tax Parcel

PRB Alignment Investigation Locations

Pre-Remedial Design Investigation (PRDI) Technical Memorandum
Port of Tacoma - Parcel 15 (Portac)
Tacoma, Washington

Aspect CONSULTING	JAN-2022	BY: ACG / KB / WEG	FIGURE NO.
	PROJECT NO. 210158-4.1	REVISED BY: ACG / WEG	1

GIS Path: G:\projects\PortofTacoma\PortacParcel15_210158\Delivered\Pre-Remedial Design Investigation (PRDI) Technical Memorandum\01 PRB Alignment Investigation Locations.mxd || Coordinate System: NAD 1983 StatePlane Washington South FIPS 4602 Feet || Date Saved: 1/15/2022 || User: bgrimm || Print Date: 1/15/2022



LEGEND

- Roller Compacted Concrete
- Gravel Base Course
- Fill Containing Slag
- Silty Sand
- Fine Grained Deposits (Silt & Clay)
- Low Permeability Clay
- Alluvial Creek Deposits
- Inferred Geologic Contact

MW-7 — Boring Identification

Screened Interval

Maximum Water Level

Water Level at Time of Drilling

Groundwater Grab Sample Interval

HPT boring extended past direct push soil cores. Geologic information is interpreted from electrical conductivity and hydraulic profiling tool (HPT) data.

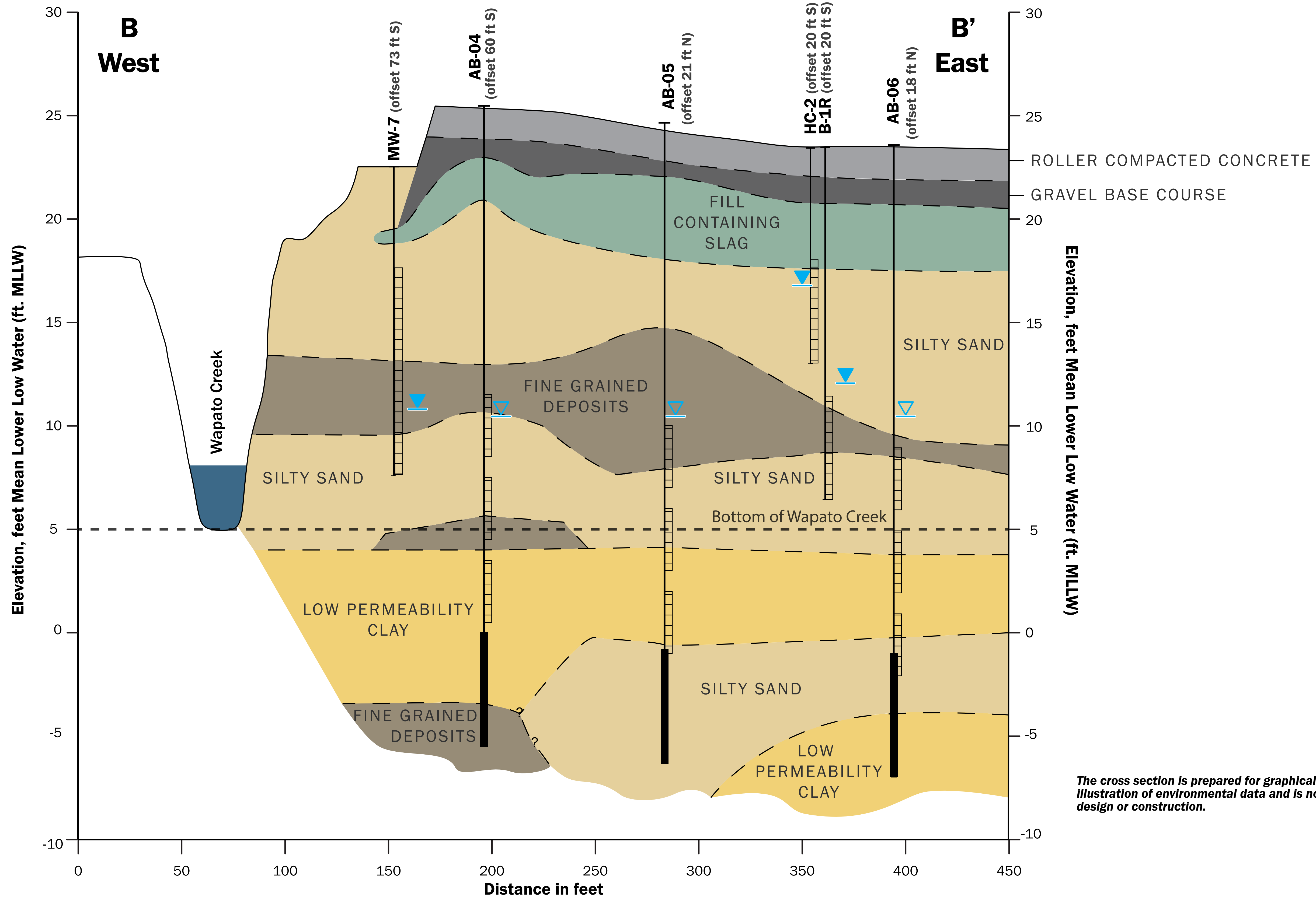
Notes:
- Maximum Water Level observed during Event 1 through Event 6 (2016-2019)
- Lithology for native, fill, and cap materials based on TB and AB boring logs

0 50 100
Feet
Vertical Exaggeration = x10

Cross Section A-A'

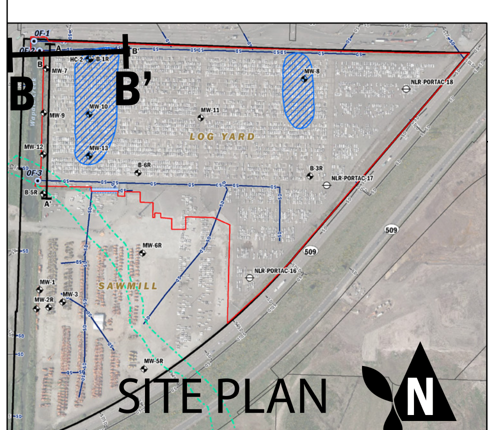
Pre-Remedial Design Investigation (PRDI) Technical Memorandum
Port of Tacoma - Parcel 15 (Portac)
Tacoma, Washington

Aspect CONSULTING	OCT-2021	BY: KB / RAC / AWP	FIGURE NO.
	PROJECT NO. 210158	REV BY: AG	2



The cross section is prepared for graphical illustration of environmental data and is not for design or construction.

DRAFT



LEGEND

- Roller Compacted Concrete
- Gravel Base Course
- Fill Containing Slag
- Silty Sand
- Fine Grained Deposits (Silt & Clay)
- Low Permeability Clay
- Alluvial Creek Deposits
- Inferred Geologic Contact
- MW-7 — Boring Identification
- Screened Interval
- Maximum Water Level
- Water Level at Time of Drilling
- Groundwater Grab Sample Interval
- *HPT boring extended past direct push soil cores. Geologic information is interpreted from electrical conductivity and hydraulic profiling tool (HPT) data.*

Notes:
- Maximum Water Level observed during Event 1 through Event 6 (2016-2019)
- Lithology for native, fill, and cap materials based on TB and AB boring logs

0 50 100
Feet
Vertical Exaggeration = x10

Cross Section B-B'

Pre-Remedial Design Investigation (PRDI) Technical Memorandum
Port of Tacoma - Parcel 15 (Portac)
Tacoma, Washington

Aspect CONSULTING	OCT-2021	BY: KB / RAC / AWP	FIGURE NO.
	PROJECT NO. 210158	REV BY: AG	3

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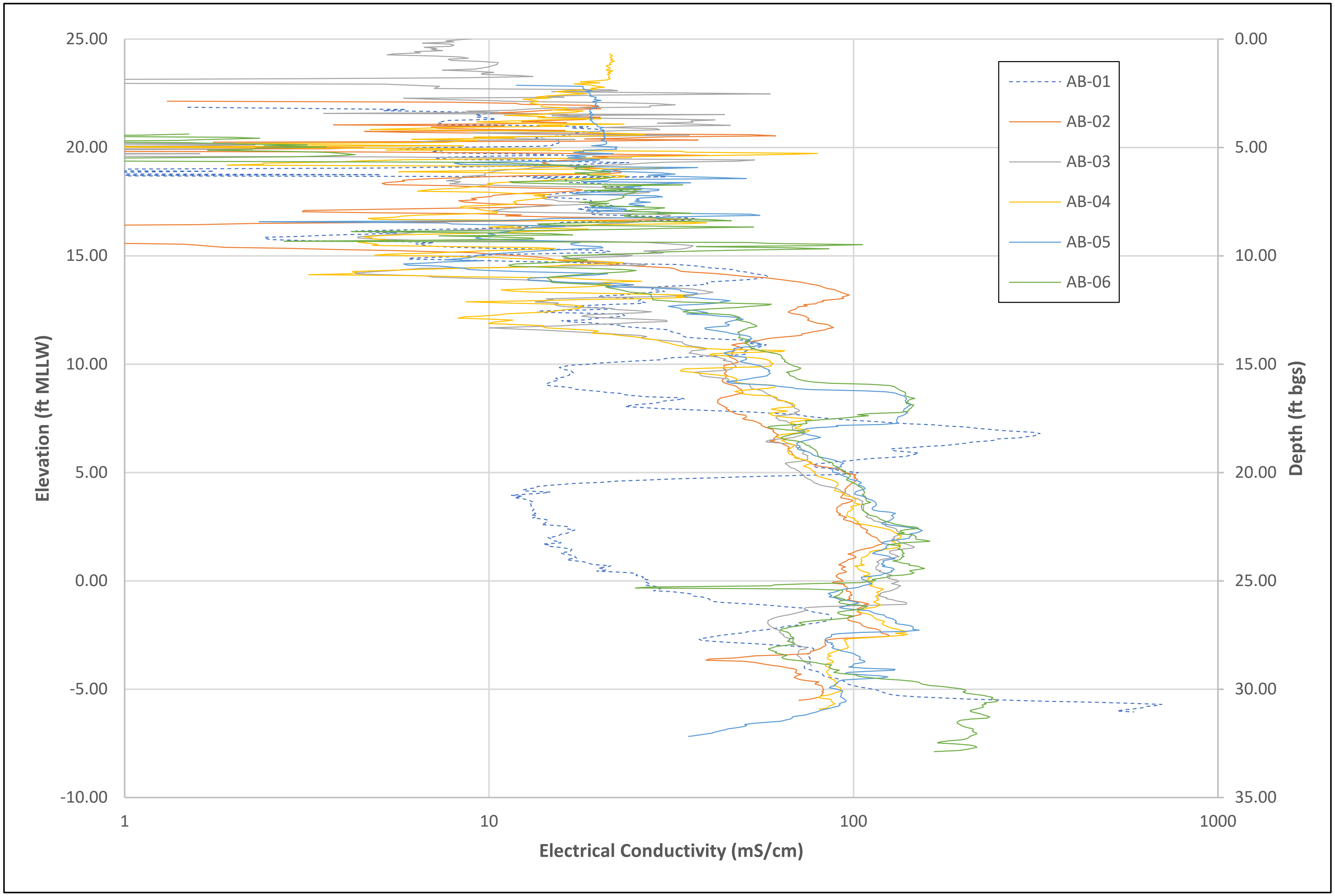
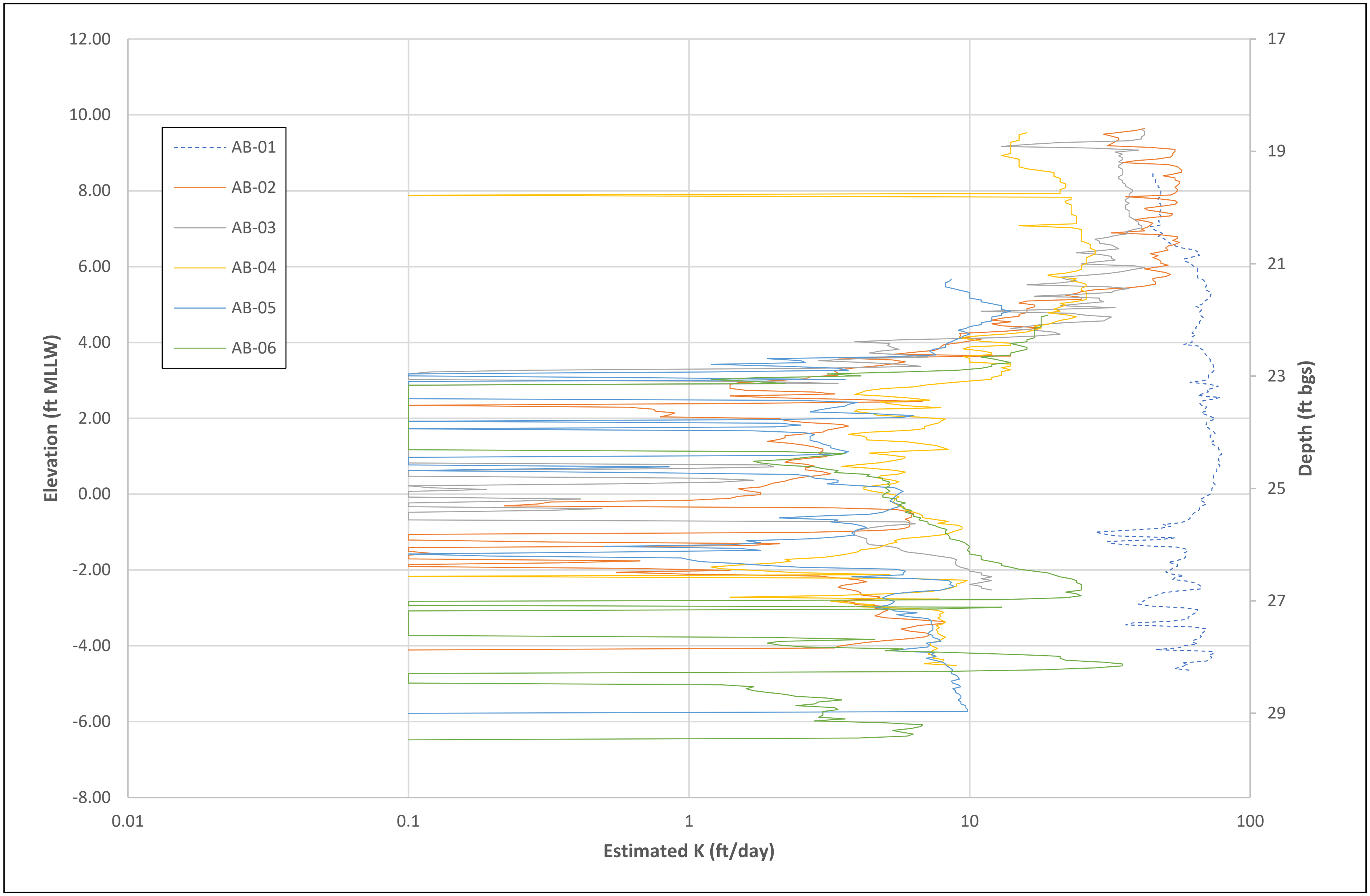


Figure 4a
HPT - Electrical Conductivity Results
PRDI Tech Memo
Parcel 15 Cleanup Phase 1, Tacoma, WA

Aspect Consulting
1/17/2022

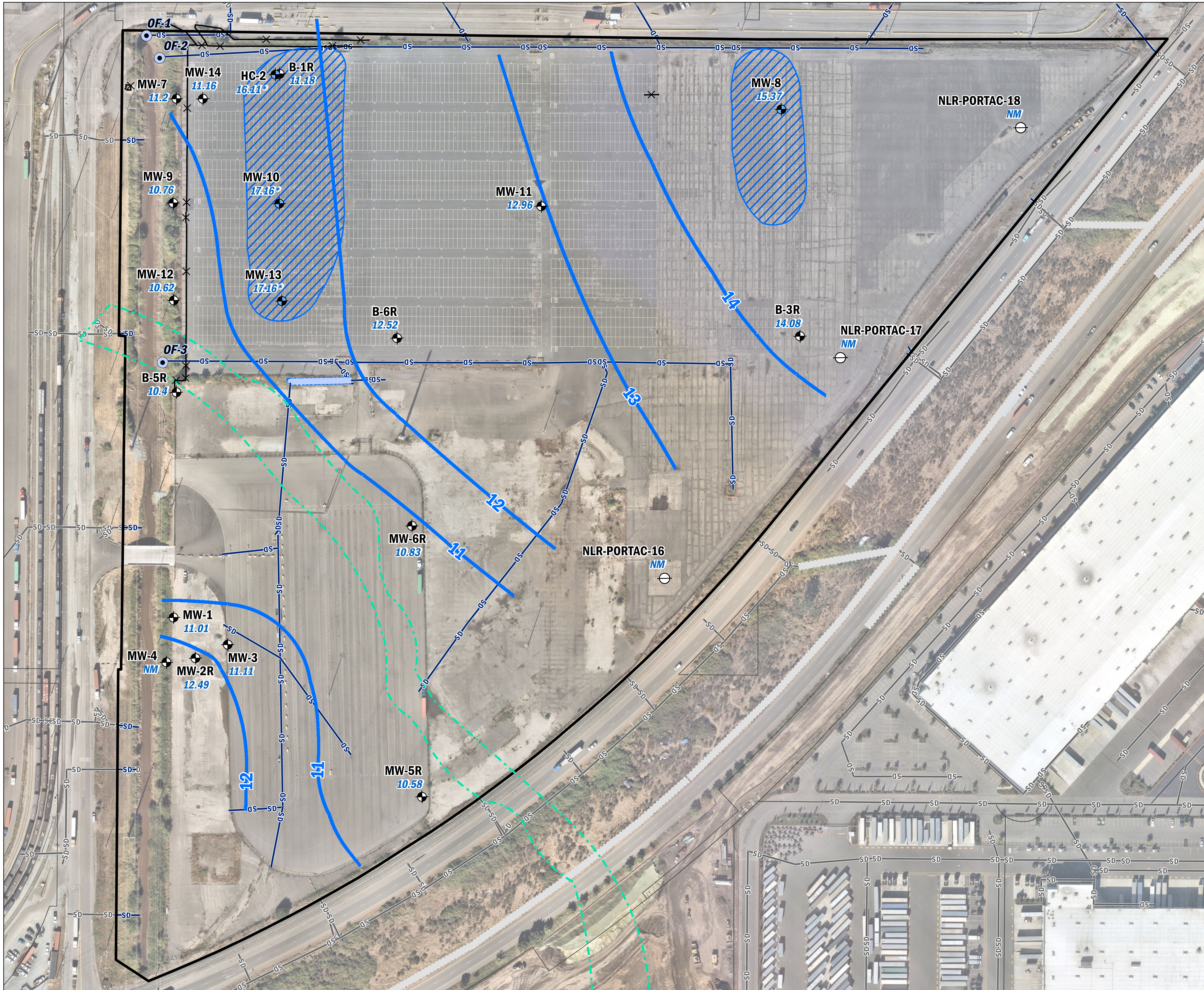
DRAFT



Aspect Consulting
1/17/2022

Figure 4b
HPT - Estimated K Results

PRDI Tech Memo
Parcel 15 Cleanup Phase 1, Tacoma, WA



Groundwater Elevation Contour (Feet Elevation, Mean Lower Low Water (MLLW))

Monitoring Well

Perched Monitoring Well

Piezometer

Fence

Stormwater Outfall

Storm Pipe

Ditch

Former Creek Channel

Observed Perched Zone

Port Parcel 15

Pierce County Tax Parcel

MW-11 ← Exploration Name

12.96 ← Groundwater Elevation (ft MLLW)

Notes:
* Not used in elevation contours
- NM = Not measured

0 200 400

Feet

DRAFT

December 2021 Groundwater Contour Map

Pre-Remedial Design Investigation (PRDI) Technical Memorandum

Port of Tacoma - Parcel 15 (Portac)

Tacoma, Washington

Aspect CONSULTING	JAN-2022	BY: DIM / SCC	FIGURE NO.
	PROJECT NO. 210158-4.1	REVISED BY: DIM / ACG / WEG	5

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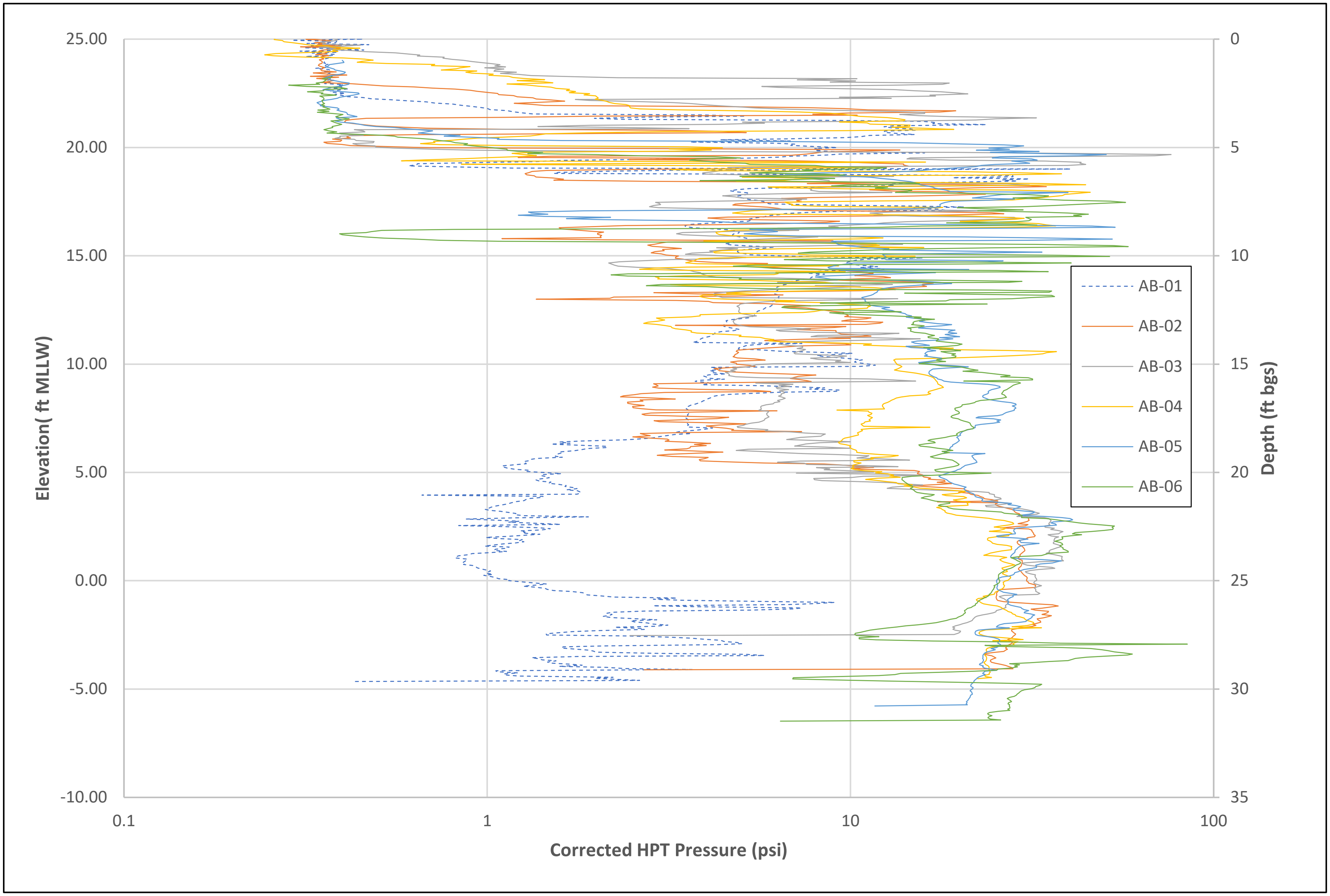
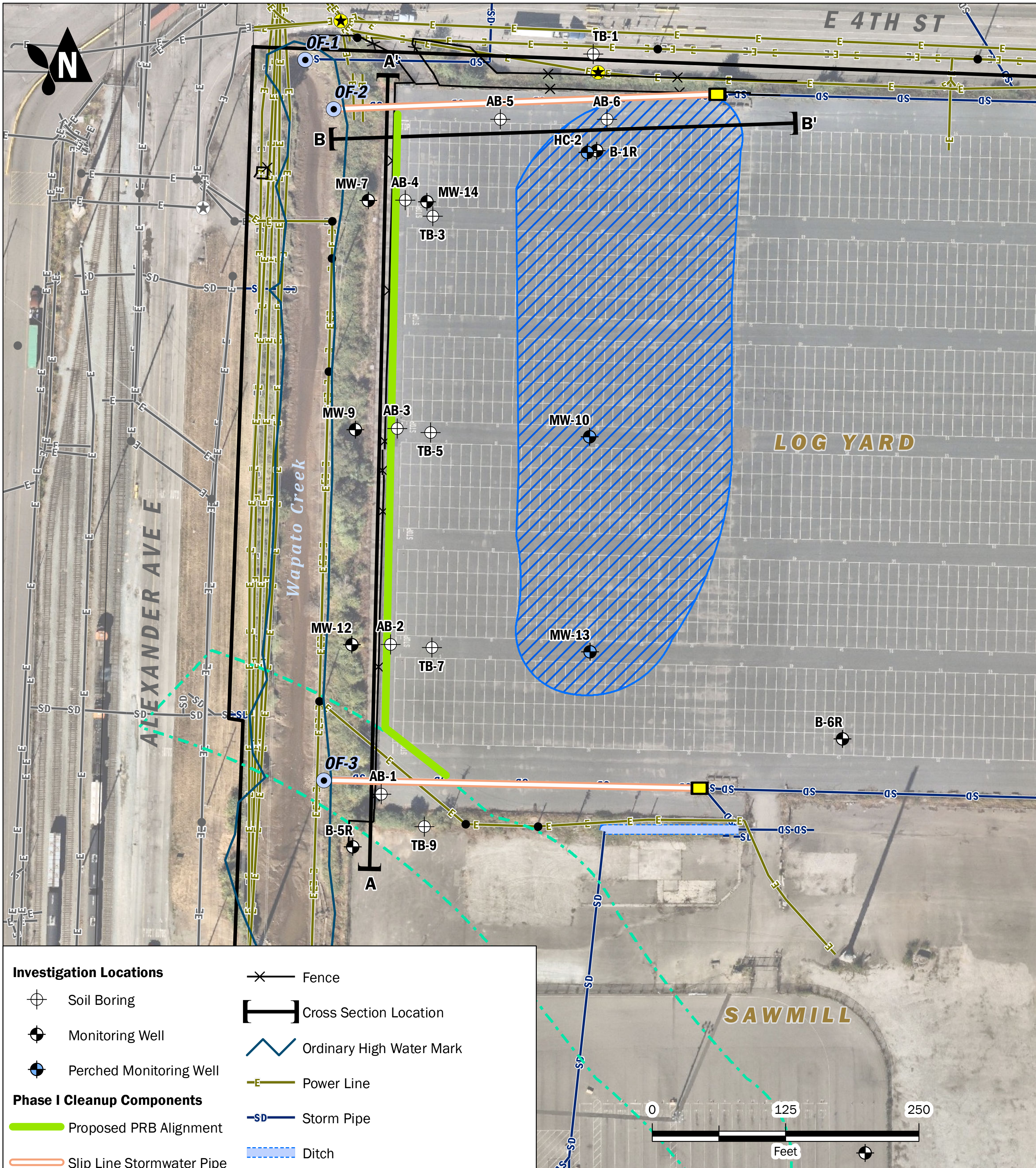


Figure 4c
HPT - Corrected HPT Pressure
PRDI Tech Memo
Parcel 15 Cleanup Phase 1, Tacoma, WA

Aspect Consulting
1/17/2022



Investigation Locations

- Soil Boring
- Monitoring Well
- Perched Monitoring Well

Phase I Cleanup Components

- Proposed PRB Alignment
- Slip Line Stormwater Pipe
- Replace Stormwater Vault

Site Features

- Stormwater Outfall
- Power Pole
- Power Junction
- Fence
- Cross Section Location
- Ordinary High Water Mark
- Power Line
- Storm Pipe
- Ditch
- Former Creek Channel
- Observed Perched Zone
- Port Parcel 15
- Pierce County Tax Parcel

Notes:
- PRB = Permeable Reactive Barrier
- Power poles, junctions, and lines, as well as storm pipes, have faded, grey symbology outside area of interest.

Proposed PRB Alignment

Pre-Remedial Design Investigation (PRDI) Technical Memorandum
Port of Tacoma - Parcel 15 (Portac)
Tacoma, Washington

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Aspect CONSULTING

JAN-2022	BY: ACG / WEG	FIGURE NO. 6
PROJECT NO. 210158-4.1	REVISED BY: DIM / WEG	

GIS Path: G:\projects\PortofTacoma\PortacParcel15_210158\Delivered\Pre-Remedial Design Investigation (PRDI) Technical Memorandum\06 Proposed PRB Alignment.mxd || Coordinate System: NAD 1983 StatePlane Washington South FIPS 4602 Feet || Date Saved: 1/17/2022 || User: nkochie || Print Date: 1/17/2022

APPENDIX A

Soil Boring Logs

Major Division	Subdivision	Fines	Symbol	Group Name
Coarse-Grained Soils - More than 50%1 Retained on No. 200 Sieve	Gravels - More than 50%[1] of Coarse Fraction Retained on No. 4 Sieve	≤5% Fines	GW	Well-graded GRAVEL Well-graded GRAVEL WITH SAND
			GP	Poorly-graded GRAVEL Poorly-graded GRAVEL WITH SAND
		≥15% Fines	GM	SILTY GRAVEL SILTY GRAVEL WITH SAND
			GC	CLAYEY GRAVEL CLAYEY GRAVEL WITH SAND
	Sands - 50%[1] or More of Coarse Fraction Passes No. 4 Sieve	≤5% Fines	SW	Well-graded SAND Well-graded SAND WITH GRAVEL
			SP	Poorly-graded SAND Poorly-graded SAND WITH GRAVEL
		≥15% Fines	SM	SILTY SAND SILTY SAND WITH GRAVEL
			SC	CLAYEY SAND CLAYEY SAND WITH GRAVEL
Fine-Grained Soils - 50%1 or More Passes No. 200 Sieve	Silts and Clays Liquid Limit Less than 50%		ML	SILT SANDY or GRAVELLY SILT SILT WITH SAND SILT WITH GRAVEL
			CL	LEAN CLAY SANDY or GRAVELLY LEAN CLAY LEAN CLAY WITH SAND LEAN CLAY WITH GRAVEL
			OL	ORGANIC SILT SANDY or GRAVELLY ORGANIC SILT ORGANIC SILT WITH SAND ORGANIC SILT WITH GRAVEL
	Silts and Clays Liquid Limit 50% or More		MH	ELASTIC SILT SANDY or GRAVELLY ELASTIC SILT ELASTIC SILT WITH SAND ELASTIC SILT WITH GRAVEL
			CH	FAT CLAY SANDY or GRAVELLY FAT CLAY FAT CLAY WITH SAND FAT CLAY WITH GRAVEL
			OH	ORGANIC CLAY SANDY or GRAVELLY ORGANIC CLAY ORGANIC CLAY WITH SAND ORGANIC CLAY WITH GRAVEL
Highly Organic Soils			PT	PEAT and other mostly organic soils

"WITH SILT" or "WITH CLAY" means 5 to 15% silt and clay, denoted by a "-" in the group name; e.g., SP-SM • "SILTY" or "CLAYEY" means >15% silt and clay • "WITH SAND" or "WITH GRAVEL" means 15 to 30% sand and gravel. • "SANDY" or "GRAVELLY" means >30% sand and gravel. • "Well-graded" means approximately equal amounts of fine to coarse grain sizes • "Poorly graded" means unequal amounts of grain sizes • Group names separated by "/" means soil contains layers of the two soil types; e.g., SM/ML.

Soils were described and identified in the field in general accordance with the methods described in ASTM D2488. Where indicated in the log, soils were classified using ASTM D2487 or other laboratory tests as appropriate. Refer to the report accompanying these exploration logs for details.

1. Estimated or measured percentage by dry weight
2. (SPT) Standard Penetration Test (ASTM D1586)
3. Determined by SPT, DCPT (ASTM STP399) or other field methods. See report text for details.

GEOTECHNICAL LAB TESTS

MC	=	Natural Moisture Content
PS	=	Particle Size Distribution
FC	=	Fines Content (% < 0.075 mm)
GH	=	Hydrometer Test
AL	=	Atterberg Limits
C	=	Consolidation Test
Str	=	Strength Test
OC	=	Organic Content (% Loss by Ignition)
Comp	=	Proctor Test
K	=	Hydraulic Conductivity Test
SG	=	Specific Gravity Test

CHEMICAL LAB TESTS

Organic Chemicals

BTEX	=	Benzene, Toluene, Ethylbenzene, Xylenes
TPH-Dx	=	Diesel and Oil-Range Petroleum Hydrocarbons
TPH-G	=	Gasoline-Range Petroleum Hydrocarbons
VOCs	=	Volatile Organic Compounds
SVOCs	=	Semi-Volatile Organic Compounds
PAHs	=	Polycyclic Aromatic Hydrocarbon Compounds
PCBs	=	Polychlorinated Biphenyls

Metals

RCRA8	=	As, Ba, Cd, Cr, Pb, Hg, Se, Ag, (d = dissolved, t = total)
MTCA5	=	As, Cd, Cr, Hg, Pb (d = dissolved, t = total)
PP-13	=	Ag, As, Be, Cd, Cr, Cu, Hg, Ni, Pb, Sb, Se, Tl, Zn (d=dissolved, t=total)

FIELD TESTS

PID	=	Photoionization Detector
Sheen	=	Oil Sheen Test
SPT[2]	=	Standard Penetration Test
NSPT	=	Non-Standard Penetration Test
DCPT	=	Dynamic Cone Penetration Test

COMPONENT DEFINITIONS

Descriptive Term		*Size Range and Sieve Number*
Boulders	=	Larger than 12 inches
Cobbles	=	3 inches to 12 inches
Coarse Gravel	=	3 inches to 3/4 inches
Fine Gravel	=	3/4 inches to No. 4 (4.75 mm)
Coarse Sand	=	No. 4 (4.75 mm) to No. 10 (2.00 mm)
Medium Sand	=	No. 10 (2.00 mm) to No. 40 (0.425 mm)
Fine Sand	=	No. 40 (0.425 mm) to No. 200 (0.075 mm)
Silt and Clay	=	Smaller than No. 200 (0.075 mm)

ESTIMATED[1] PERCENTAGE

% by Weight		*Modifier*	*% by Weight*		*Modifier*
<1	=	Subtrace	15 to 25	=	Little
1 to <5	=	Trace	30 to 45	=	Some
5 to 10	=	Few	>50	=	Mostly

MOISTURE CONTENT

Dry	=	Absence of moisture, dusty, dry to the touch
Slightly Moist	=	Perceptible moisture
Moist	=	Damp but no visible water
Very Moist	=	Water visible but not free draining
Wet	=	Visible free water, usually from below water table

RELATIVE DENSITY

Non-Cohesive or Coarse-Grained Soils

Density[3]		*SPT[2] Blows/Foot*	*Penetration with 1/2" Diameter Rod*
Very Loose	=	0 to 4	≥ 2'
Loose	=	5 to 10	1' to 2'
Medium Dense	=	11 to 30	3" to 1'
Dense	=	31 to 50	1" to 3"
Very Dense	=	> 50	< 1"

CONSISTENCY

Cohesive or Fine-Grained Soils

Consistency[3]		*SPT[2] Blows/Foot*	*Manual Test*
Very Soft	=	0 to 1	Penetrated >1" easily by thumb. Extrudes between thumb & fingers.
Soft	=	2 to 4	Penetrated 1/4" to 1" easily by thumb. Easily molded.
Medium Stiff	=	5 to 8	Penetrated >1/4" with effort by thumb. Molded with strong pressure.
Stiff	=	9 to 15	Indented ~1/4" with effort by thumb.
Very Stiff	=	16 to 30	Indented easily by thumbnail.
Hard	=	> 30	Indented with difficulty by thumbnail.

GEOLOGIC CONTACTS

Observed and Distinct | Observed and Gradual | Inferred

Aspect CONSULTING

Exploration Log Key

AI Path: Q:_ACAD Standards\FIELD REFERENCE\MASTERS\Exploration Log Key-2018.ai // user: jinman // last saved: 12/31/2018

Aspect Consulting	Portac - 210158		Environmental Exploration Log	
	Project Address & Site Specific Location		*Coordinates*	*Exploration Number*
	Port of Tacoma - Parcel 15 Tacoma, WA, SW corner of site		NA	**AB-01**
Contractor	*Equipment*	*Sampling Method*	*Ground Surface Elev.*	
Cascade	Geoprobe 7822	Percussion hammer	25' (est)	
Operator	*Exploration Method(s)*	*Work Start/Completion Dates*	*Top of Casing Elev.*	*Depth to Water (Below GS)*
Kyle	Direct push	11/17/2021	NA	15' (ATD)

Depth (feet)	Elev. (feet)	Exploration Notes and Completion Details	Sample Type/ID	Analytical Sample Number & Lab Test(s)	Field Tests	Material Type	Description	Depth (ft)
0	25	Surface restored with concrete					CONCRETE; roller compacted concrete.	
		Backfilled with 3/8" NSF60 bentonite chips.					**GRAVEL BASE COURSE** GRAVEL WITH SAND (GP); loose, wet, medium light gray, base course; fine to coarse angular gravel; dark yellowish orange, fine sand in bottom of sampler.	
5	20						**FILL CONTAINING SLAG** GRAVEL (GP); loose, moist, black; angular, fine to coarse slag fragments.	5
							SAND WITH SILT (SP-SM); moist, moderate brown; fine to medium sand; trace fine to coarse gravel; some oxide staining throughout; trace woody organics.	
10	15						**SILTY SAND** SILTY SAND (SM); moist, brownish black; fine sand; low plasticity fines.	10
							SAND WITH SILT (SP-SM); moist, very dusky purple; fine sand; non-plastic fines.	
15	10	∇ 11/17/2021					Becomes wet and coarser; fine to medium sand.	15
							ALLUVIAL CREEK DEPOSITS SAND (SW); loose, wet, black; medium sand; 10 to 15% red sand grains; trace to no silt; trace woody organics throughout.	
				AB-01-15				
20	5						Trace fine gravel.	20
				AB-01-21				
							Pocket of fine sand with silt, 2-3 inches thick.	
							Woody debris and trace fine to coarse gravel.	
25	0						Bottom of exploration at 25 ft. bgs.	25

DRAFT

Legend

Sample Type: No Soil Sample Recovery; Continuous core 1.85" ID

Water Level: ∇ Water Level ATD

See Exploration Log Key for explanation of symbols

Logged by: BCC/AWP
Approved by: AJY

Exploration Log AB-01

Sheet 1 of 1

Portac - 210158

Environmental Exploration Log

Project Address & Site Specific Location		Coordinates	Exploration Number
Port of Tacoma - Parcel 15 Tacoma, WA, SW area of the site		NA	AB-02

Contractor	Equipment	Sampling Method	Ground Surface Elev.
Cascade	Geoprobe 7822	Percussion hammer	25.75' (est)

Operator	Exploration Method(s)	Work Start/Completion Dates	Top of Casing Elev.	Depth to Water (Below GS)
Kyle	Direct push	11/17/2021	NA	15' (ATD)

Depth (feet)	Elev. (feet)	Exploration Notes and Completion Details	Sample Type/ID	Analytical Sample Number & Lab Test(s)	Field Tests	Description	Depth (ft)
	25	Surface restored with concrete				CONCRETE; roller compacted concrete	
						GRAVEL BASE COURSE GRAVEL WITH SAND (GP); loose, moist, medium light gray, base course; fine to coarse angular gravel.	
		Backfilled with 3/8" NSF60 bentonite chips.				**FILL CONTAINING SLAG** WOODY DEBRIS; black.	
5	20					GRAVEL WITH SAND (GP); moist, brownish black; fine to coarse angular slag fragments; coarse sand.	5
						SILTY SAND SAND (SP); loose, moist; fine to medium sand; trace silt; trace woody organics throughout.	
						Silt pocket, 2-3 inches thick.	
10	15					SAND WITH SILT (SP-SM); moist, olive black; very fine sand; low to non-plastic fines.	10
						FINE GRAINED DEPOSITS CLAY (CL); moist, olive black; medium plasticity; trace woody organics throughout.	
						SILTY SAND SAND WITH SILT (SP-SM); moist, olive black; fine sand; low to non-plastic fines.	
15	10	∇ 11/17/2021				Becomes wet with trace woody organics.	15
				AB-02-17			
20	5					**LOW PERMEABILITY CLAY** CLAY (CL); moist, olive black; low to medium plasticity; trace woody organics.	20
				AB-02-22			
						Increases to medium plasticity.	
25	0					Bottom of exploration at 25 ft. bgs.	25

DRAFT

Legend

Sample Type: No Soil Sample Recovery; Continuous core 1.85" ID

Water Level: ∇ Water Level ATD

See Exploration Log Key for explanation of symbols

Logged by: BCC/AWP
Approved by:

Exploration Log AB-02
Sheet 1 of 1

Aspect CONSULTING	Portac - 210158		Environmental Exploration Log	
	Project Address & Site Specific Location		*Coordinates*	*Exploration Number*
	Port of Tacoma - Parcel 15 Tacoma, WA, W side of the site		NA	**AB-03**

Contractor	*Equipment*	*Sampling Method*	*Ground Surface Elev.*
Cascade	Geoprobe 7822	Percussion hammer	27' (est)

Operator	*Exploration Method(s)*	*Work Start/Completion Dates*	*Top of Casing Elev.*	*Depth to Water (Below GS)*
Kyle	Direct push	11/17/2021	NA	17' (ATD)

Depth (feet)	Elev. (feet)	Exploration Notes and Completion Details	Analytical Sample Number & Lab Test(s)	Description	Depth (ft)
0	27	Surface restored with concrete		CONCRETE; roller compacted concrete	
1.5	25			**GRAVEL WITH BASE COURSE** GRAVEL WITH SAND (GP); loose, moist, medium light gray, base course; fine to coarse angular gravel.	
3		Backfilled with 3/8" NSF60 bentonite chips.		**FILL CONTAINING SLAG** GRAVEL (GP); loose, moist, brownish black; fine to coarse, angular slag fragments.	
5				GRAVEL WITH SAND (GP); moist; coarse gravel; fine sand; woody organics.	5
6				GRAVEL WITH SAND (GP); brownish black; medium slag fragments; fine sand.	
7	20			**SILTY SAND** SAND WITH SILT (SP-SM); moist, brownish black; fine to coarse sand; non-plastic fines.	
10					10
13	15			Becomes finer, low plasticity fines.	
13.5				**FINE GRAINED DEPOSITS** CLAY (CL); moist, olive black; medium plasticity.	
15				SAND (SW); wet, loose, black with red flecks; fine to medium sand; interfingers with clay inch 3 to 4 inch layers.	15
16				CLAY (CL); wet, olive black; medium plasticity; trace woody organics.	
17	10	∇ 11/17/2021		**SILTY SAND** SAND WITH SILT (SP-SM); wet, olive black; fine to coarse sand; non-plastic fines; interfingers with clay inch 3 to 4 inch layers.	
19			AB-03-19		
20				SILT (ML); medium dense, moist, brownish black; low plasticity fines; trace woody organics.	20
21				SAND (SP); moist, brownish gray; fine to coarse sand; trace to no silt. Interbed of clay, 1 to 2 inches thick.	
22	5			SILTY SAND (SM); wet, olive gray; fine sand; low plasticity fines.	
23			AB-03-23	**LOW PERMEABILITY CLAY** CLAY (CL); moist, olive gray; woody organics throughout.	
25			AB-03-25	Bottom of exploration at 25 ft. bgs.	25

DRAFT

Legend

Sample Type: No Soil Sample Recovery; Continuous core 1.85" ID

Water Level: ∇ Water Level ATD

See Exploration Log Key for explanation of symbols

Logged by: BCC/AWP
Approved by:

Exploration Log AB-03
Sheet 1 of 1

Aspect CONSULTING	Portac - 210158		Environmental Exploration Log	
	Project Address & Site Specific Location		*Coordinates*	*Exploration Number*
	Port of Tacoma - Parcel 15 Tacoma, WA, NW corner of the site		NA	**AB-04**
Contractor	*Equipment*	*Sampling Method*	*Ground Surface Elev.*	
Cascade	Geoprobe 7822	Percussion hammer	25.5' (est)	
Operator	*Exploration Method(s)*	*Work Start/Completion Dates*	*Top of Casing Elev.*	*Depth to Water (Below GS)*
Kyle	Direct push	11/16/2021	NA	15' (ATD)

Depth (feet)	Elev. (feet)	Exploration Notes and Completion Details	Sample Type/ID	Analytical Sample Number & Lab Test(s)	Field Tests	Material Type	Description	Depth (ft)
	25	Surface restored with concrete					CONCRETE; roller compacted concrete	
							GRAVEL BASE COURSE GRAVEL WITH SAND (GP); loose, moist, medium light gray, base course; fine to coarse angular gravel.	
		Backfilled with 3/8" NSF60 bentonite chips.					**FILL CONTAINING SLAG** GRAVEL (GP); loose, moist, brownish black; fine to coarse, angular slag fragments. Woody organic debris.	
5	20						**SILTY SAND** SAND WITH SILT (SP-SM); moist, olive black; fine sand with silt; some laminated bedding throughout.	5
10	15						Becomes fine to medium sand.	10
							Becomes fine sand.	
							Becomes fine to medium sand; 10 to 15% red sand grains.	
							FINE GRAINED DEPOSITS SILT (ML); moist, olive black; non-plastic fines; black, woody organics throughout.	
15	10	▽ 11/16/2021					**SILTY SAND** SILTY SAND (SM); wet, olive black; medium to fine sand; low plasticity fines.	15
							Silt lense, olive black, 2 to 3 inches thick.	
20	5						Becomes very dusky purple, fine sand; 10 to 15% red sand grains.	20
							LOW PERMEABILITY CLAY SILT (ML); wet, olive black; non-plastic fines.	
							CLAY (CL); moist, olive gray; medium plasticity; woody organics throughout.	
				AB-04-20 AB-04-23				
25	0						Bottom of exploration at 25 ft. bgs.	25

DRAFT

Legend

Sample Type: No Soil Sample Recovery; Continuous core 1.85" ID

Water Level: ▽ Water Level ATD

See Exploration Log Key for explanation of symbols

Logged by: BCC/AWP
Approved by:

Exploration Log AB-04
Sheet 1 of 1

Portac - 210158

Environmental Exploration Log

Project Address & Site Specific Location			Coordinates	Exploration Number
Port of Tacoma - Parcel 15 Tacoma, WA, NW area of the site			NA	**AB-05**
Contractor	**Equipment**	**Sampling Method**	**Ground Surface Elev.**	
Cascade	Geoprobe 7822	Percussion hammer	24' (est)	
Operator	**Exploration Method(s)**	**Work Start/Completion Dates**	**Top of Casing Elev.**	**Depth to Water (Below GS)**
Kyle	Direct push	11/17/2021	NA	15' (ATD)

Depth (feet)	Elev. (feet)	Exploration Notes and Completion Details	Sample Type/ID	Analytical Sample Number & Lab Test(s)	Field Tests	Material Type	Description	Depth (ft)
0	24	Surface restored with concrete					CONCRETE; roller compacted concrete	0
1.5							**GRAVEL BASE COURSE** GRAVEL WITH SAND (GP); loose, moist, medium light gray, base course; fine to coarse angular gravel.	
2.5		Backfilled with 3/8" NSF60 bentonite chips.					**FILL CONTAINING SLAG** GRAVEL (GP); loose, moist, black; fine to coarse, angular slag fragments; woody organics.	
	20						SAND WITH SILT (SP-SM); moist, black; fine to medium sand; 10 to 15% red sand grains; slag fragments in shoe of sampler.	
5							GRAVEL (GP); loose, moist, black; fine to coarse, angular slag fragments. Woody organics. No woody organics.	5
7							**SILTY SAND** SAND WITH SILT (SP-SM); moist, brownish black; fine to medium sand; 10 to 15% red sand grains.	
	15							
10							Becomes fine sand with woody organics throughout.	10
							Becomes brownish gray, fine sand.	
13.5	10						**FINE GRAINED DEPOSITS** CLAY (CL); moist, brownish black; medium plasticity fines; trace sand.	
15		▽ 11/17/2021					**SILTY SAND** SILTY SAND (SM); wet, brownish black; fine sand; non-plastic fines.	15
16				AB-05-17			SAND WITH SILT (SP-SM); very moist, brownish black; fine to medium sand; grades finer downward; trace woody organics.	
	5							
20							**LOW PERMEABILITY CLAY** CLAY (CL); moist, brownish black; woody organics throughout.	20
				AB-05-23				
	0							
24.5							**SILTY SAND** SAND WITH SILT (SP-SM); moist, grayish black; fine to medium sand.	
25								25

DRAFT

Legend

Sample Type
- ◯ No Soil Sample Recovery
- ◫ Continuous core 1.85" ID

Water Level
- ▽ Water Level ATD

Bottom of exploration at 25 ft. bgs.
See Exploration Log Key for explanation of symbols

Logged by: BCC/AWP
Approved by:

Exploration Log AB-05

Sheet 1 of 1

NEW STANDARD EXPLORATION LOG TEMPLATE P:\GINTW\PROJECTS\210158 - PORTAC.GPJ December 17, 2021

Review Stage:DRAFT Rev.0

Aspect CONSULTING	Portac - 210158		Environmental Exploration Log	
	Project Address & Site Specific Location		*Coordinates*	*Exploration Number*
	Port of Tacoma - Parcel 15 Tacoma, WA, N side of the site		NA	**AB-06**
Contractor	*Equipment*	*Sampling Method*	*Ground Surface Elev.*	
Cascade	Geoprobe 7822	Percussion hammer	23' (est)	
Operator	*Exploration Method(s)*	*Work Start/Completion Dates*	*Top of Casing Elev.*	*Depth to Water (Below GS)*
Kyle	Direct push	11/17/2021	NA	15' (ATD)

Depth (feet)	Elev. (feet)	Exploration Notes and Completion Details	Sample Type/ID	Analytical Sample Number & Lab Test(s)	Field Tests	Material Type	Description	Depth (ft)
		Surface restored with concrete					CONCRETE; roller compacted concrete	
							FILL CONTAINING SLAG GRAVEL WITH SAND (GP); loose, moist, medium light gray, base course; fine to coarse angular gravel.	
	20	Backfilled with 3/8" NSF60 bentonite chips.					GRAVEL (GP); loose, moist, black; fine to medium, angular slag fragments.	
							SAND WITH SILT (SP-SM); black; medium sand; medium angular sand fragments.	
5							GRAVEL (GP); loose, moist, black; fine to medium, angular slag fragments.	5
							SILTY SAND SAND WITH SILT (SP-SM); moist, brownish black; fine to coarse sand; some woody organics.	
	15							
10							Becomes fine sand.	10
	10							
							FINE GRAINED DEPOSITS CLAY (CL); wet, very dusky purple; medium plasticity.	
15		∇ 11/17/2021					**SILTY SAND** SAND WITH SILT (SP-SM); moist; fine to medium sand; non-plastic fines; woody organics throughout.	15
				AB-06-17				
	5						Becomes fine sand. Low plasticity fines.	
20							**LOW PERMEABILTY CLAY** CLAY (CL); moist, olive black; medium plasticity; woody organics throughout.	20
				AB-06-22				
	0							
							SILTY SAND SILTY SAND (SM); moist, brownish black; fine sand; low plasticity fines.	
25				AB-06-25			Bottom of exploration at 25 ft. bgs.	25

DRAFT

Legend

Sample Type: ◯ No Soil Sample Recovery; ◫ Continuous core 1.85" ID

Water Level: ∇ Water Level ATD

See Exploration Log Key for explanation of symbols

Logged by: BCC/AWP
Approved by:

Exploration Log AB-06

Sheet 1 of 1

APPENDIX B

Field XRF Results

Table B-1. AB-01 Field XRF Results

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

Elevation (ft)	Depth (ft)	Arsenic (mg/kg)	Arsenic 2σ	Iron (mg/kg)	Iron 2σ	Manganese (mg/kg)	Manganese 2σ
22.60	2.50	4	1	9168	108	150	30
20.10	5.00	2244	19	136006	285	286	34
18.10	7.00	3	1	18789	123	158	25
17.10	8.00	100	3	36787	139	406	27
15.10	10.00	14	2	16266	108	155	23
13.10	12.00	3	1	15006	117	113	25
10.10	15.00	3	1	15895	115	192	26
9.10	16.00	2	1	24258	133	192	25
7.10	18.00	2	1	14722	122	176	28
5.10	20.00	21	2	11934	128	93	30
2.10	23.00	3	1	13622	113	160	26

Notes

ft - feet

mg/kg - milligrams/kilogram

2σ - represents two standard deviations, or a confidence interval of 95%

Table B-2. AB-02 Field XRF Results

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

Elevation (ft)	Depth (ft)	Arsenic (mg/kg)	Arsenic 2σ	Iron (mg/kg)	Iron 2σ	Manganese (mg/kg)	Manganese 2σ
22.84	3.00	196	4	17157	108	135	22
20.84	5.00	1036	13	41683	192	96	27
18.34	7.50	236	4	18375	128	245	29
15.84	10.00	6	1	21678	124	283	27
14.34	11.50	< 2 U	1	19705	108	132	21
13.34	12.50	< 2 U	2	14518	112	157	25
10.84	15.00	6	1	23531	122	326	26
8.84	17.00	3	1	20399	117	264	25
6.84	19.00	< 2 U	2	17430	112	183	24
5.84	20.00	< 2 U	1	9013	95	< 13 U	37
1.84	24.00	3	1	20541	101	178	20

Notes

ft - feet

mg/kg - milligrams/kilogram

2σ - represents two standard deviations, or a confidence interval of 95%

Table B-3. AB-03 Field XRF Results

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

Elevation (ft)	Depth (ft)	Arsenic (mg/kg)	Arsenic 2σ	Iron (mg/kg)	Iron 2σ	Manganese (mg/kg)	Manganese 2σ
24.22	3.00	9	2	9952	107	< 13 U	34
23.72	3.50	1075	11	47609	169	214	25
22.22	5.00	379	5	28899	117	303	22
21.22	6.00	6153	34	223454	345	515	39
19.22	8.00	116	3	25257	120	333	25
17.22	10.00	4	1	28101	131	395	28
14.22	13.00	5	2	12258	130	116	31
13.22	14.00	3	1	18138	105	128	21
12.22	15.00	9	1	34377	124	427	24
10.22	17.00	< 2 U	2	16176	101	128	21
8.22	19.00	< 2 U	2	11225	114	88	27
6.22	21.00	6	1	16826	101	172	21
5.22	22.00	< 2 U	2	24625	120	393	27
4.22	23.00	3	1	20614	105	227	22
2.72	24.50	3	1	9654	97	35	22

Notes

ft - feet

mg/kg - milligrams/kilogram

2σ - represents two standard deviations, or a confidence interval of 95%

Table B-4. AB-04 Field XRF Results

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

Elevation (ft)	Depth (ft)	Arsenic (mg/kg)	Arsenic 2σ	Iron (mg/kg)	Iron 2σ	Manganese (mg/kg)	Manganese 2σ
21.98	3.50	455	9	30202	166	203	30
20.48	5.00	135	4	8490	123	64	31
17.48	8.00	40	3	6940	129	< 13 U	33
15.48	10.00	< 2 U	2	14515	129	119	28
13.48	12.00	4	2	12124	170	154	44
12.98	12.50	< 2 U	1	11195	99	44	21
9.48	16.00	< 2 U	2	10932	140	103	35
5.48	20.00	< 2 U	2	6735	138	53	40
2.48	23.00	3	1	9998	101	67	23

Notes

ft - feet

mg/kg - milligrams/kilogram

2σ - represents two standard deviations, or a confidence interval of 95%

Table B-5. AB-05 Field XRF Results

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

Elevation (ft)	Depth (ft)	Arsenic (mg/kg)	Arsenic 2σ	Iron (mg/kg)	Iron 2σ	Manganese (mg/kg)	Manganese 2σ
21.02	3.00	42	3	10223	120	51	28
17.52	6.50	4965	30	177526	334	478	38
16.02	8.00	57	2	17693	121	214	27
14.02	10.00	40	2	10061	103	< 13 U	34
12.02	12.00	3	2	8601	129	83	35
9.02	15.00	< 2 U	2	10299	117	91	29
8.02	16.00	2	1	15350	123	168	28
7.52	16.50	< 2 U	2	7364	110	< 13 U	40
3.02	21.00	7	2	8423	117	39	29
-0.98	25.00	< 2 U	1	16642	105	167	22

Notes

ft - feet

mg/kg - milligrams/kilogram

2σ - represents two standard deviations, or a confidence interval of 95%

Table B-6. AB-06 Field XRF Results

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

Elevation (ft)	Depth (ft)	Arsenic (mg/kg)	Arsenic 2σ	Iron (mg/kg)	Iron 2σ	Manganese (mg/kg)	Manganese 2σ
21.27	2.00	818	6	30237	117	227	20
20.77	2.50	13	1	15024	110	141	24
18.27	5.00	232	3	11277	67	< 13 U	11
16.77	6.50	121	3	24335	114	311	24
13.27	10.00	4656	27	180384	287	529	36
11.27	12.00	139	4	8738	103	44	25
8.27	15.00	4	1	9939	102	35	23
7.77	15.50	12	2	10432	118	68	27
5.27	18.00	2	1	18615	111	284	25
3.77	19.50	5	1	14138	99	158	22
3.27	20.00	10	1	5417	71	< 13 U	18
-0.73	24.00	< 2 U	3	9878	145	98	37

Notes

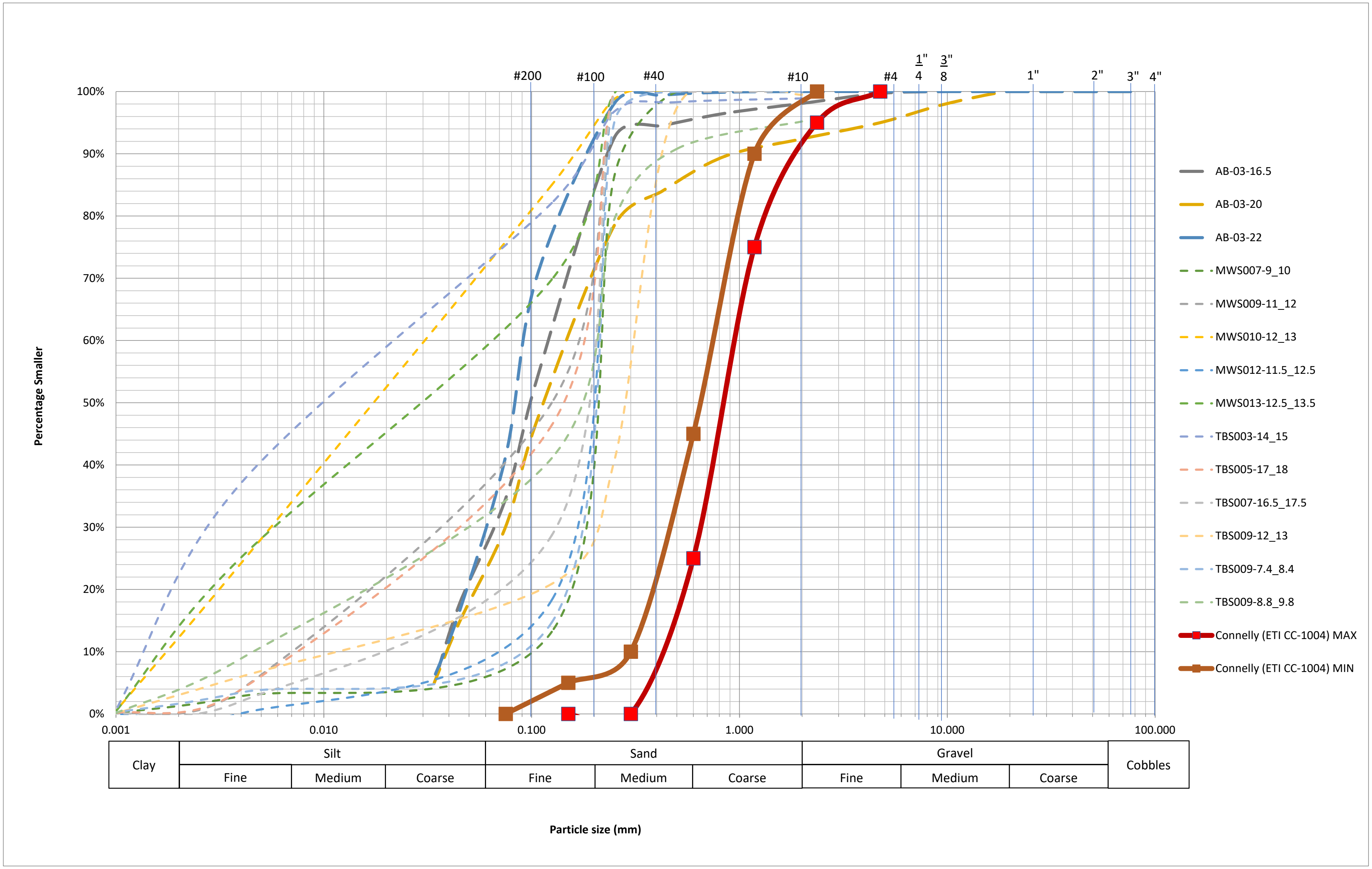
ft - feet

mg/kg - milligrams/kilogram

2σ - represents two standard deviations, or a confidence interval of 95%

APPENDIX C

Grain Size Analysis and Plots



Aspect Consulting
12/29/2021
S:\Port of Tacoma\Portac\Report Drafts\2021_12 PRDI Tech Memo\Appendices\App C - Grain Size Analysis\GSA.xlsx

Figure C.1
Grain Size Analysis
PRDI Technical Memorandum
Project No. 210158, Port of Tacoma Parcel 15, Tacoma, Washington

APPENDIX D

Cascade Final Data Report (HPT)

DRILLING | TECHNICAL SERVICES

11/30/2021

FINAL DATA REPORT

High Resolution Site Characterization

Hydraulic Profiling Tool (HPT)

Port of Tacoma

Tacoma, Washington

306211138

Prepared for:
Aspect Consulting LLC
Adam Griffin
710 2nd Ave, Suite 550
Seattle, Washington 98104

TABLE OF CONTENTS

PROGRAM NARRATIVE

Cascade Technical Services (Cascade) is pleased to present this data report to Aspect Consulting for the Hydraulic Profiling Tool (HPT) services provided between November 15th and 16th , 2021 at the Port of Tacoma in Tacoma, Washington.

Cascade advanced six HPT borings at the site achieving depths up to approximately 30 feet below ground surface. For each location, Cascade generated a continuous log of the electrical conductivity (EC) and HPT data from ground surface to termination.

Field work, including the operation of the HPT and EC probe, was conducted by trained professionals and quality assurance/quality control (QA/QC) measurements associated with these data were found to be within the tolerances set forth in the standard operating procedures (SOPs) with no exceptions.

Additional information regarding the HPT and EC systems is provided in the reference material included in this report.

I certify that the data package is in compliance with the terms and conditions of the contract and meets Cascade's data quality standards, with no exceptions. Release of the data contained in this package has been authorized by the data manager or his/her designee, as verified by the following signature.

Brad Carlson
Regional Manager, Site Characterization

QA/QC SUMMARY TABLE

Provided below is a summary of QA/QC information and any deviations from the SOPs that occurred during the field activities.

Location	Date	Time	Total Depth (ft bgs)	Response Test	Comments / Deviations
AB-01	November 16, 2021	10:55:54	30.00	Pass	None
AB-02	November 16, 2021	10:00:44	30.20	Pass	None
AB-03	November 16, 2021	09:11:31	30.00	Pass	None
AB-04	November 15, 2021	12:55:57	30.25	Pass	None
AB-05	November 15, 2021	14:32:17	30.05	Pass	None
AB-06	November 15, 2021	15:32:29	30.00	Pass	None

PROJECT DETAILS

This section provides information regarding the Cascade personnel present at the site during the field activities and the specific equipment used during field activities.

Cascade Personnel

The following personnel were present during field activities at the Site:

- Chuck Terry, HRSC Specialist
- Caleb Trusty, DPT Rig Operator

Cascade Equipment

The following HRSC equipment was utilized during field activities at the Site:

- Geoprobe 78 Series direct push drill rig
- 1.75-inch O.D. MH6534 HPT probe
- Geoprobe K6300 HPT Controller
- Geoprobe FI 6000 Computer
- 150-foot HPT trunkline
- 1.75-inch O.D. drive rods

INTERPRETATION AND RECOMMENDATIONS

This section provides a summary of the data collected during this investigation program, Cascade's recommendations for updating the conceptual site model, and suggestions for next steps in the site management process, including remediation, if appropriate.

Data Interpretation

A detailed, written interpretation of the data collected during this field event was not included in the contracted scope of work, however, Cascade was in contact with the project team throughout the field mobilization and submitted daily HRSC logs.

Recommendations

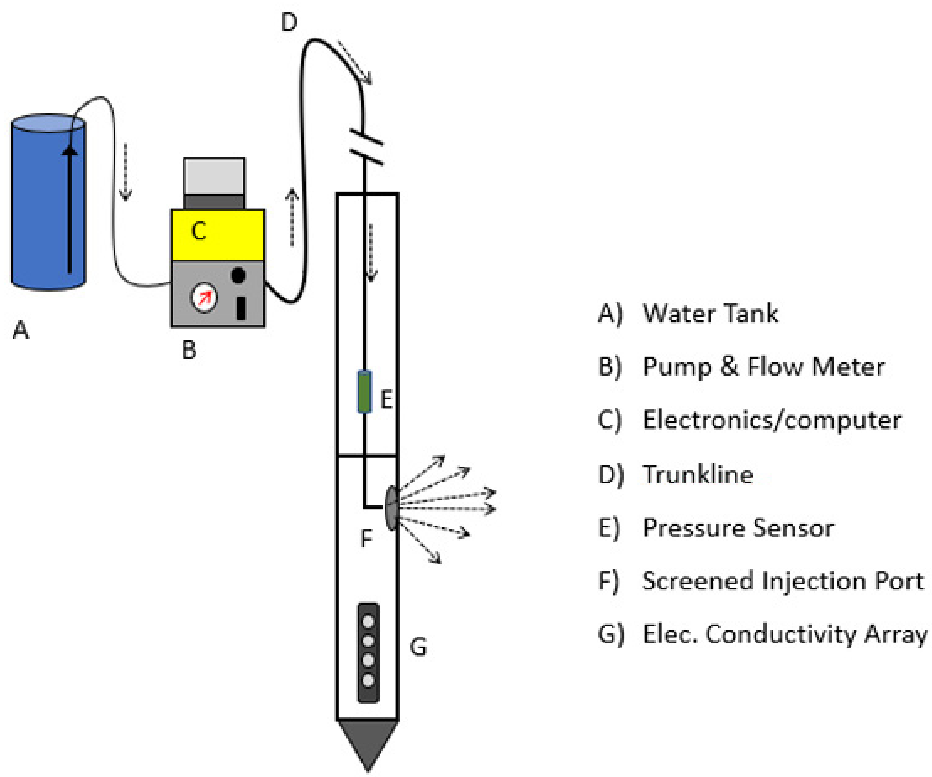
Additional recommendations were not included in this scope of work. Please contact the Cascade Project Manager if you would like to discuss further investigation or remediation alternatives. We would be excited to continue to learn about this site and assist you in meeting your site management goals.

REFERENCE MATERIAL

This section provides information useful in understanding and interpreting the data logs generated as part of this HRSC investigation.

HPT System Overview

The hydraulic profiling tool creates a log of the relative formation permeability versus depth in real time as the probe is advanced into the subsurface. It operates by injecting clean water at a constant flow rate from an aboveground reservoir through the direct push rods and out into the surrounding soil via an injection port on the side of the probe. Simultaneously, sensors record the flow rate, the back pressure required by the pump to maintain that flow rate, and the current depth of the probe. These measurements are collected by the onboard software and an estimated hydraulic conductivity (K) value is calculated and plotted alongside the other measurements in real time.



Generalized schematic of the HPT tool. Source: Geoprobe HPT Standard Operating Procedure

Reference Testing and Dissipation Tests

Reference testing is conducted to ensure that the HPT pressure transducer is working correctly and to evaluate the condition of the HPT injection screen. The HPT reference test also calculates atmospheric pressure which is required to obtain static water level readings and to determine the estimated K values for the log. The reference test utilizes an apparatus consisting of a tube with a valve located 6 inches above the HPT injection screen and the top of the tube located another 6 inches above the valve. When the tube is filled completely with water, the 12 inches of water will supply an additional 0.433 pounds per square inch (psi) of pressure on the injection screen (in addition to atmospheric pressure). When the valve is opened that additional pressure drops to 0.217 psi at the HPT injection screen. The accuracy of the pressure transducer can be assessed by comparing the pressure readings when the tube is filled and when the tube is filled only to the valve; this is done both with and without the pump running. A tolerance of plus or minus 10 percent is applied for a passing test.

Dissipation tests are conducted to determine the hydrostatic pressure of the water column above the transducer during logging. To conduct a dissipation test, advancement of the tooling is stopped, the HPT pump is stopped, and flow drops to zero. The pressure applied to the HPT pressure transducer by the injection of water into the formation begins to dissipate. This pressure should dissipate to a value equal to atmospheric pressure plus the hydrostatic pressure applied by water in the formation. In post-processing of the HPT log, the dissipation value and the atmospheric pressure determined during reference testing can be used to remove the influence of atmospheric and hydrostatic pressures from the values recorded by the transducer. These adjustments result in the corrected HPT pressure log which is a measure of the properties of the subsurface material.

HPT Data Interpretation

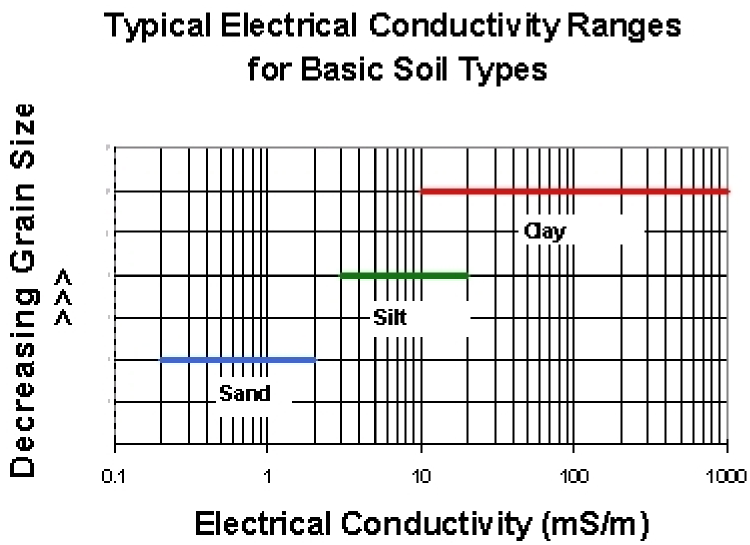
An HPT log typically includes several types of data, many of which are reduced by the software to generate the estimated K values. The dissipation testing results conducted by the operator during the advancement of the tool are used to adjust the HPT back pressure values to account for the hydrostatic pressure of the water column above the probe during advancement. This adjustment results in the corrected HPT pressure data set. Subsequently, the corrected HPT pressure and the HPT flow data sets are used to calculate the estimated K values.

The most useful measurement from the HPT is the estimated K log, which as noted above, is a measure of the relative permeability of the formation versus depth. Despite the fact that these data are presented in units typical of traditional hydraulic conductivity (feet per day), they are not traditional K values and should not be used in many of the applications where a traditional K value would be appropriate. The accuracy of the estimated K values is typically one to two orders of magnitude, which would clearly generate a significant amount of uncertainty if used for any seepage velocity or risk-based calculations. The estimated K values are, however, extremely useful for understanding what zones of the subsurface are exhibiting higher or lower relative permeability.

As a secondary data set from this tool, the HPT back pressure can be helpful in the design of injected remedies. The back pressure is a measure of the level of difficulty faced injecting the clean water from the HPT system into the formation; this is analogous to level of success an injection may achieve at the same depths.

EC Data Interpretation

In a general sense, the electrical conductivity of a soil varies with grain size. This correlation can be utilized to gather an understanding of the subsurface from the EC data. The EC measured in the subsurface can also vary based on changes in mineralogy, groundwater geochemistry, and contamination. It is important, then, to confirm the accuracy of the EC data for this use by collecting confirmatory soil borings from your site.



Relationship between electrical conductivity and grain size. Source: Geoprobe Electrical Conductivity System Standard Operating Procedure

CASCADE

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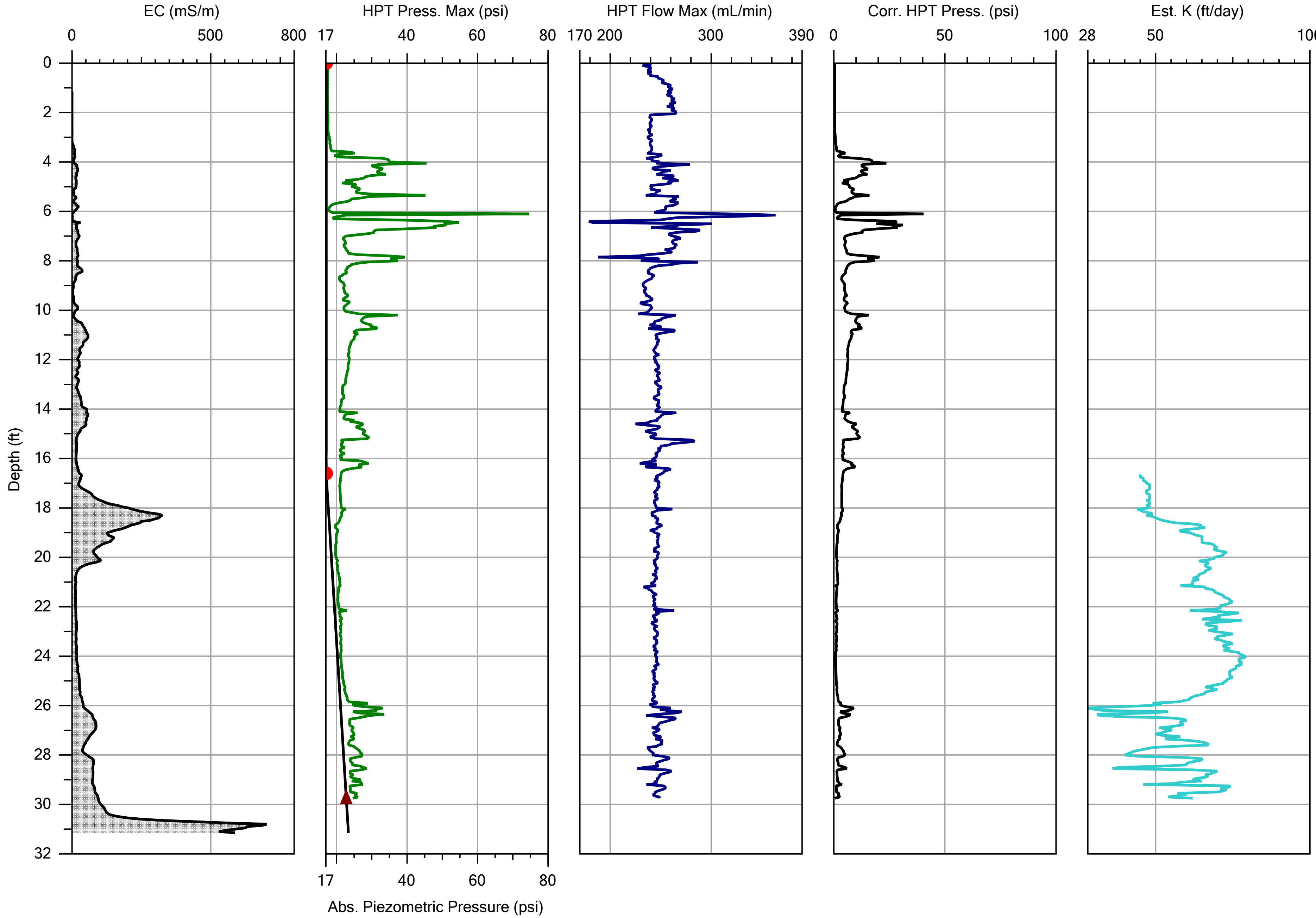
INVESTIGATION DATA PLOTS



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DRILLING | TECHNICAL SERVICES

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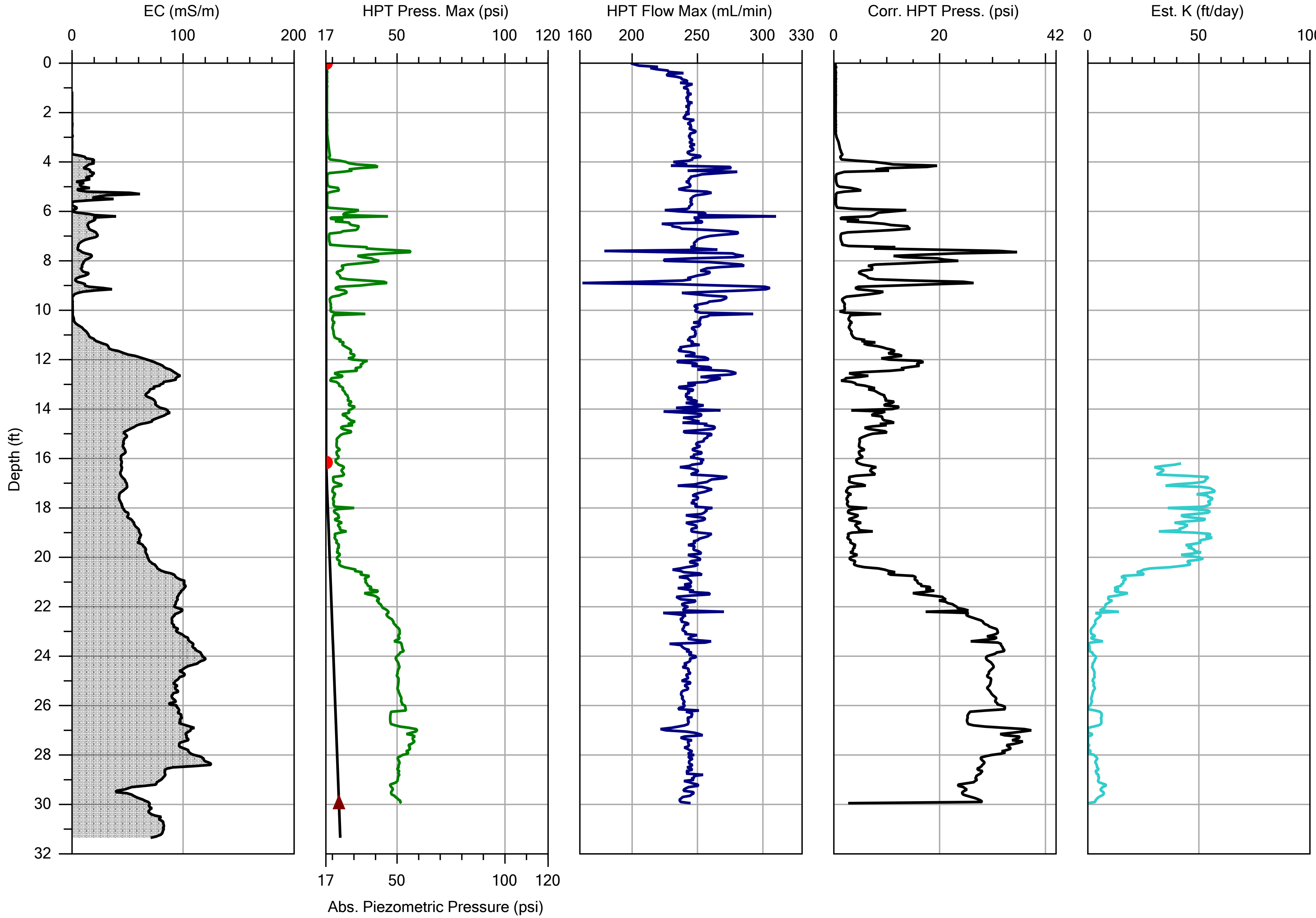
Project ID: Port of Tacoma Parcel 15	Client: Aspect Consulting	Location: Tacoma, WA



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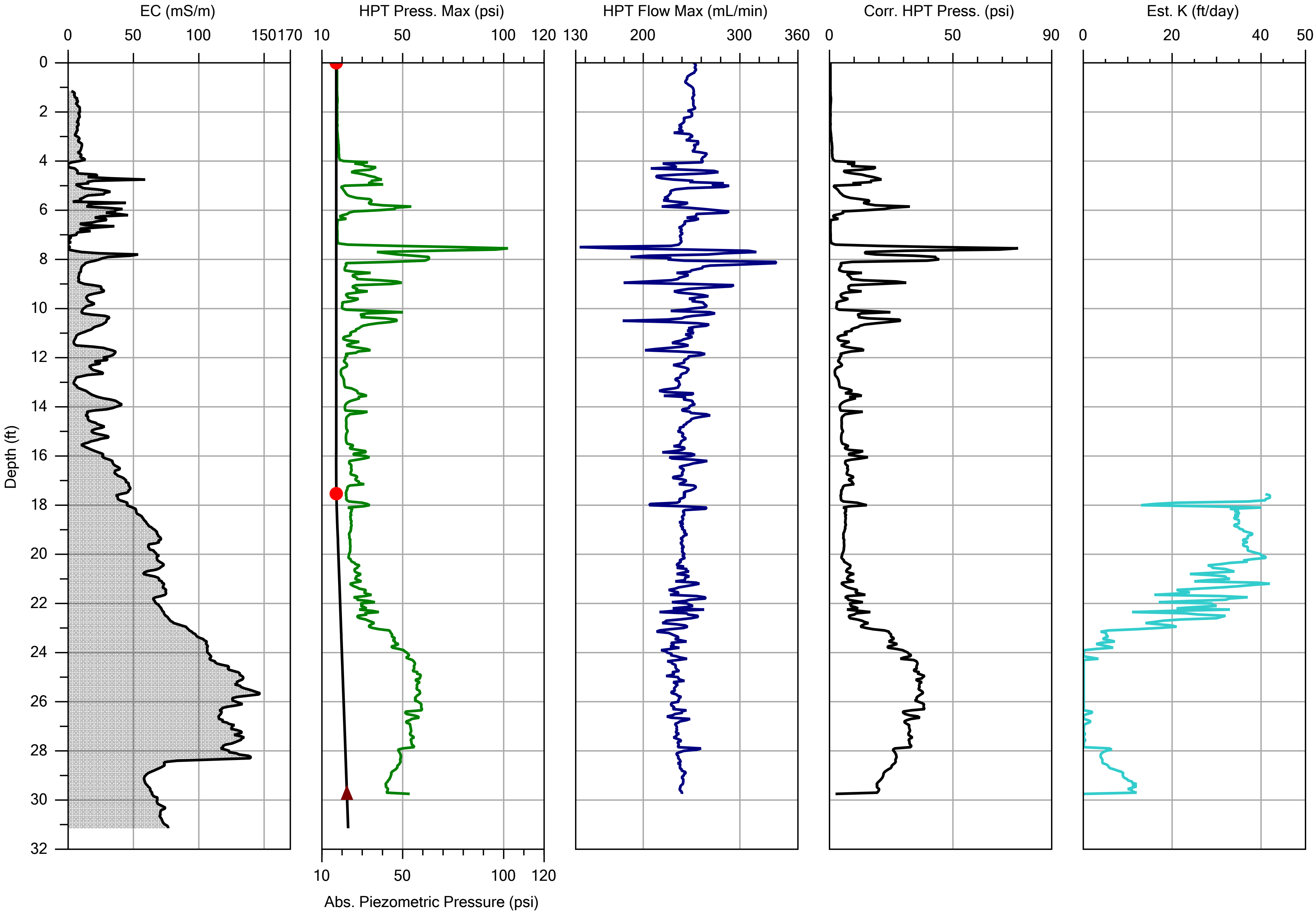
Project ID: Port of Tacoma Parcel 15	Client: Aspect Consulting	Location: Tacoma, WA



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DRILLING | TECHNICAL SERVICES

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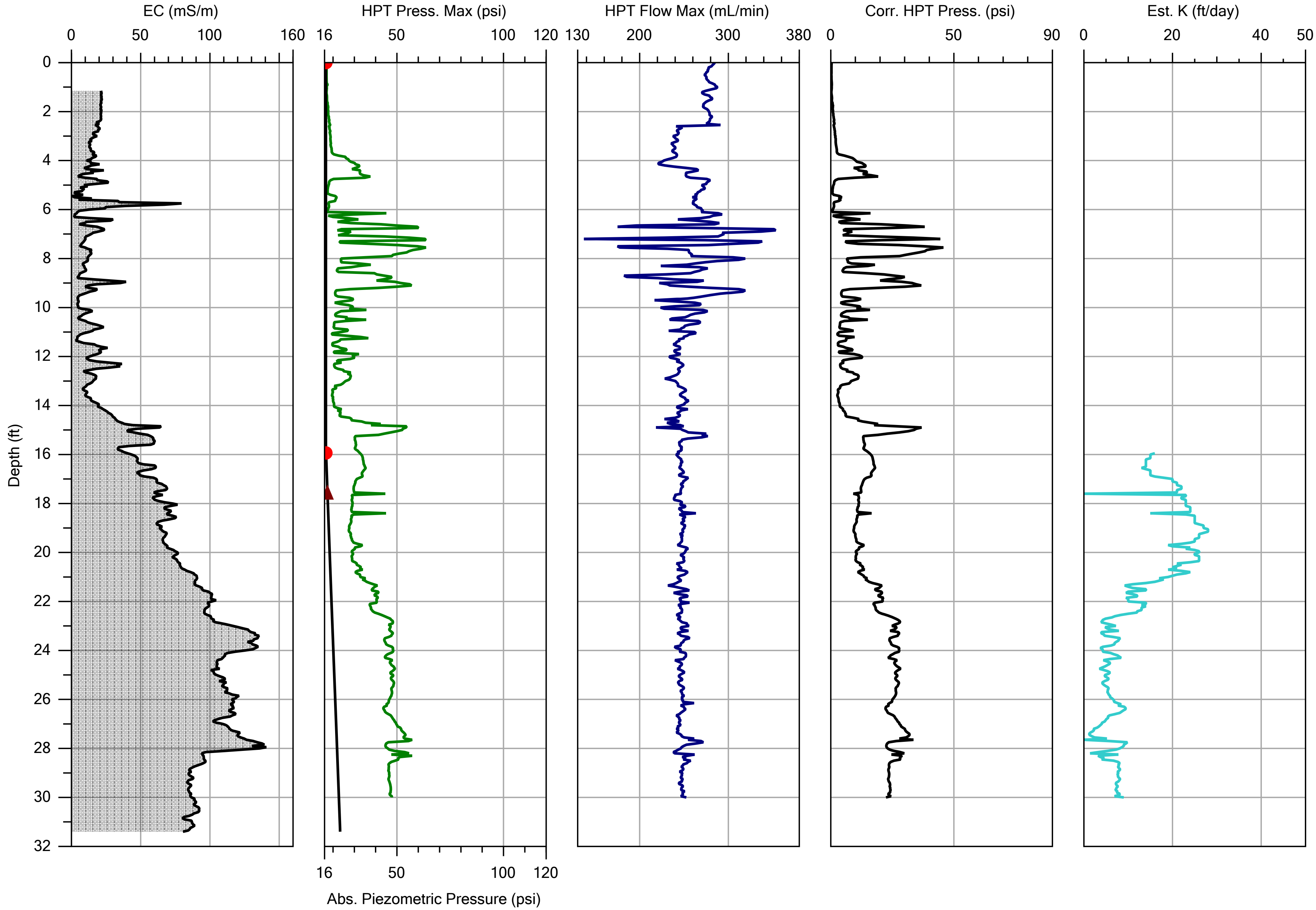

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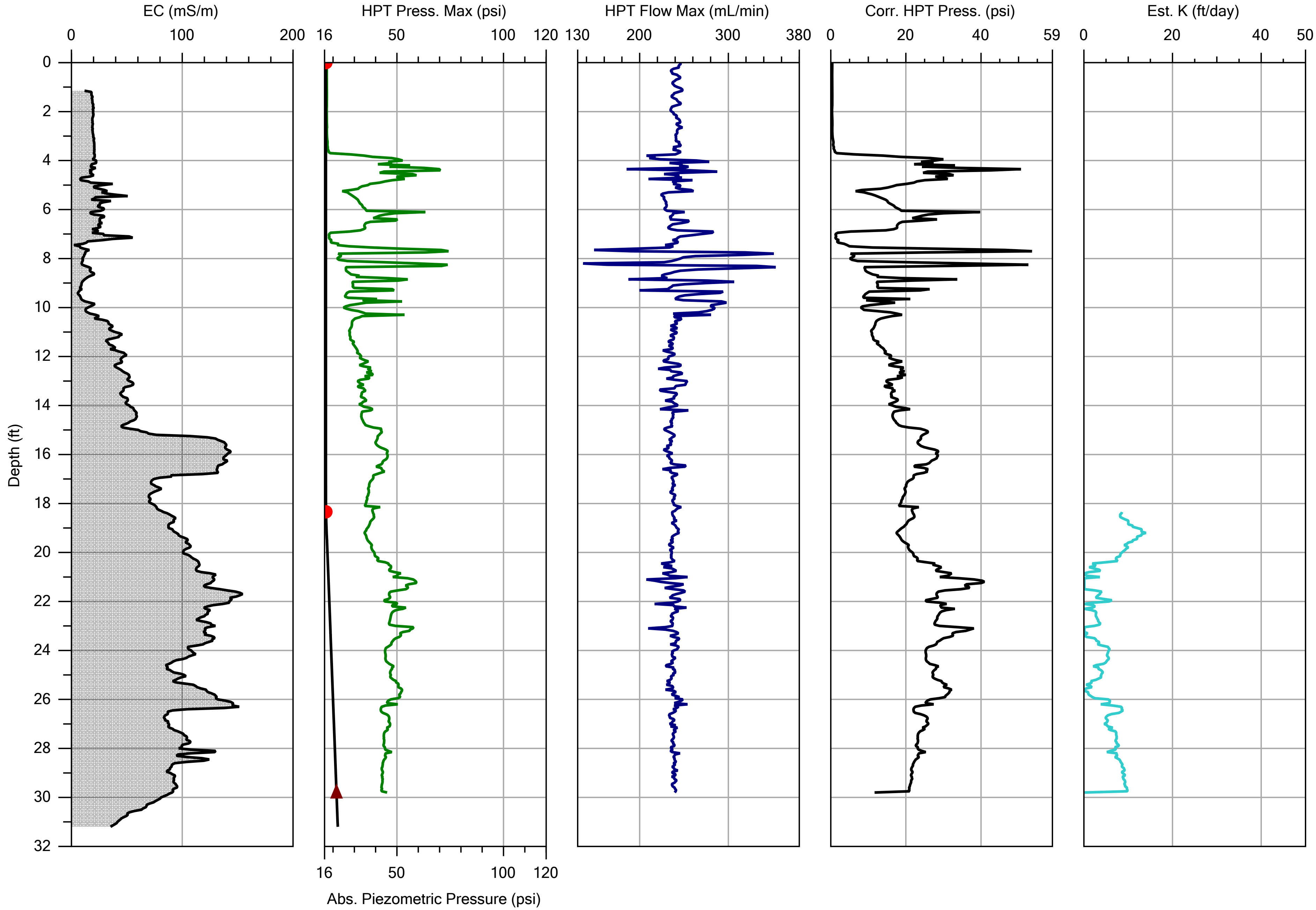

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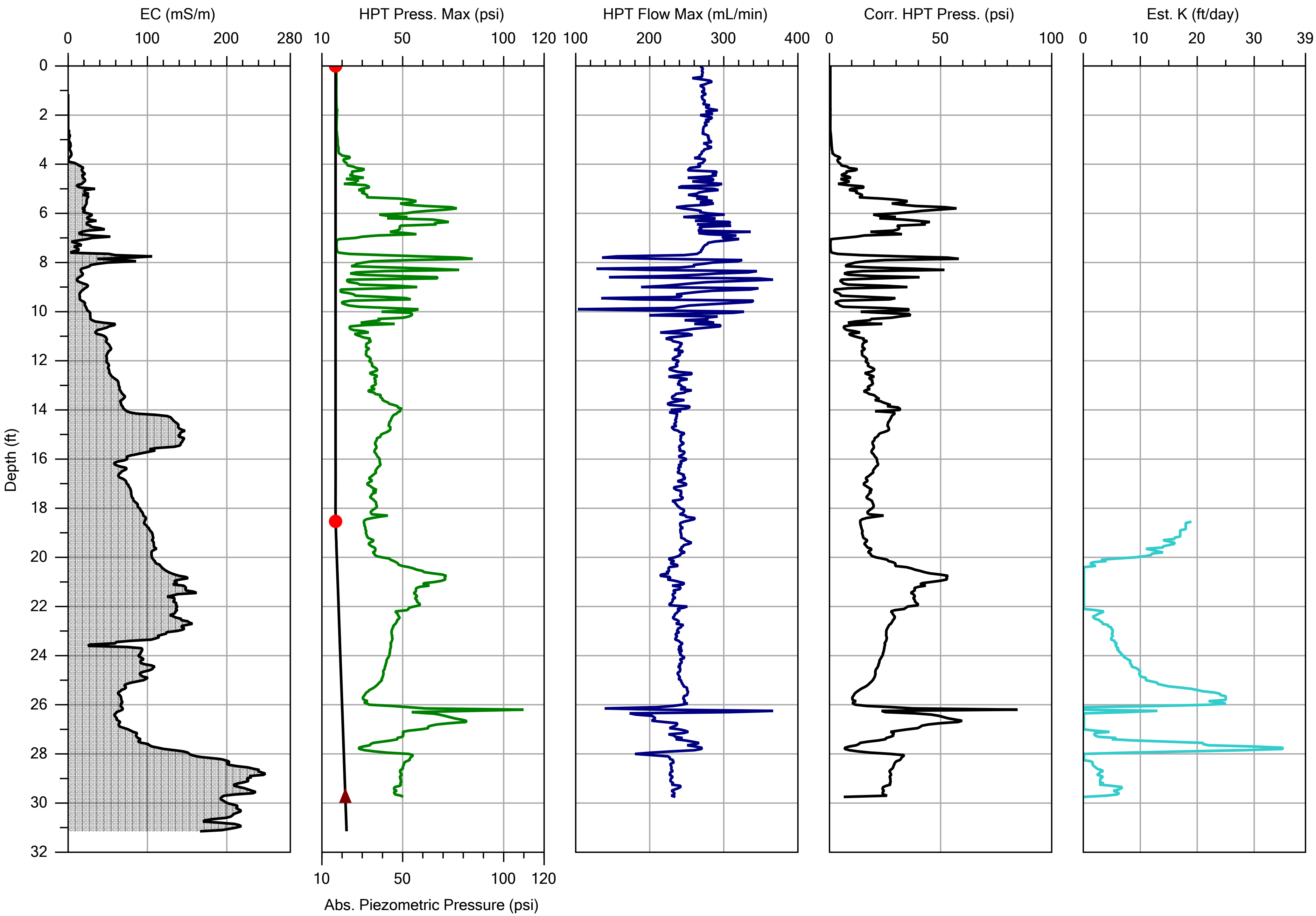
Company: Cascade	Operator: C Terry	Date: 11/15/21
Project ID: Port of Tacoma Parcel 15	Client: Aspect Consulting	Location: Tacoma, WA



CASCADE
DRILLING | TECHNICAL SERVICES

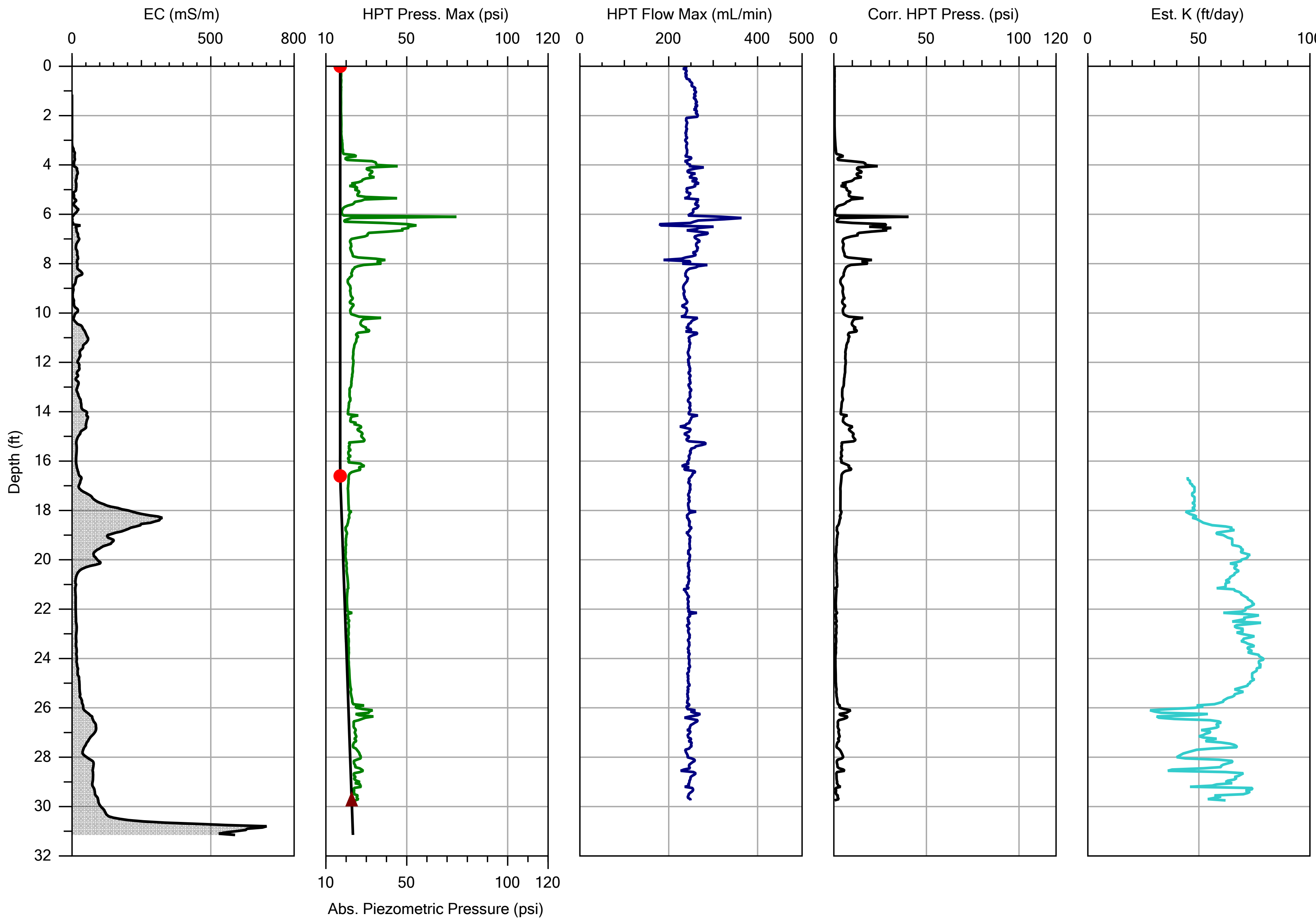
		File: AB-06.MHP
Company: Cascade	Operator: C Terry	Date: 11/15/21
Project ID: Port of Tacoma Parcel 15	Client: Aspect Consulting	Location: Tacoma, WA

CASCADE

DRILLING | TECHNICAL SERVICES

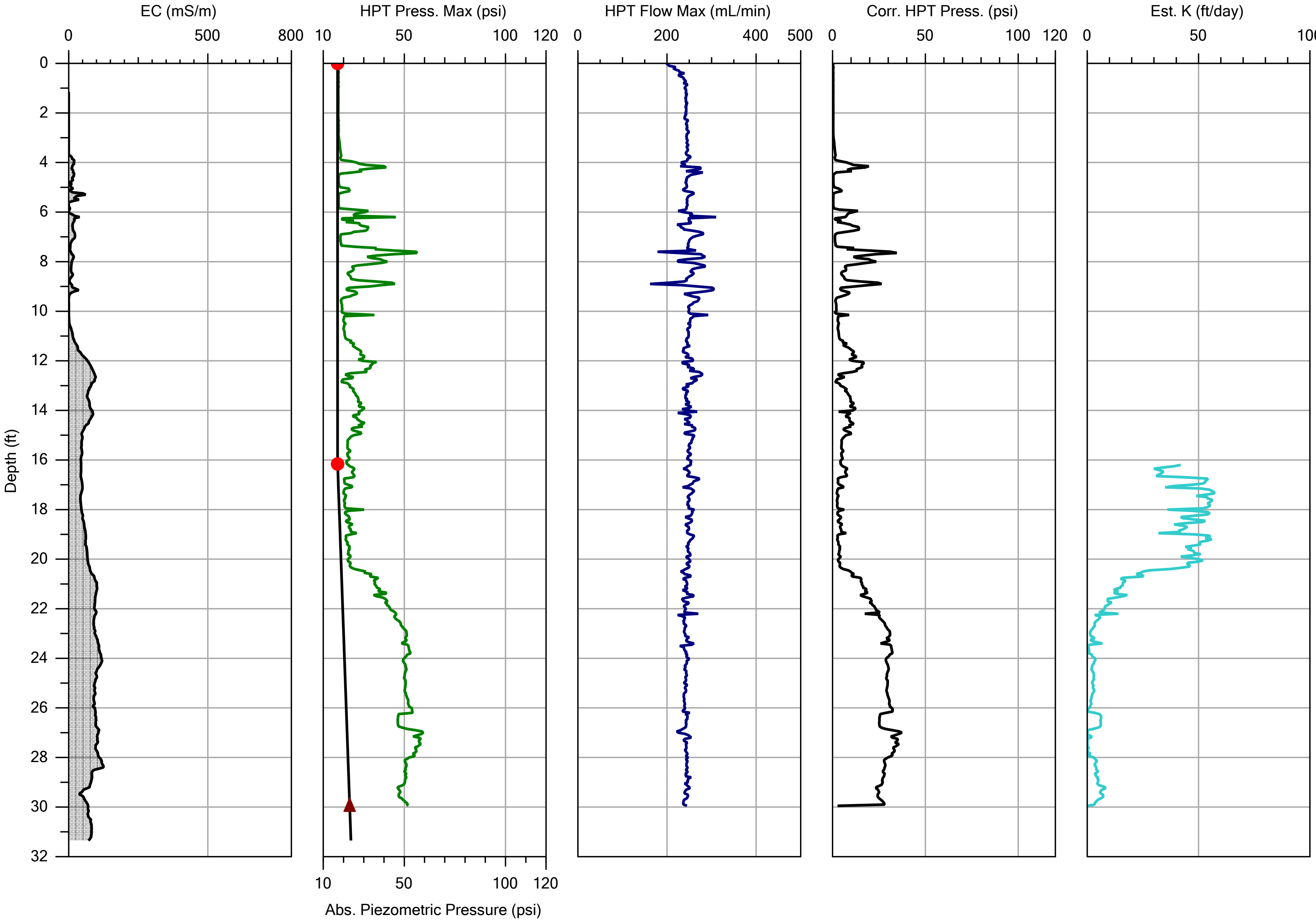
INVESTIGATION DATA PLOTS

COMMON SCALE



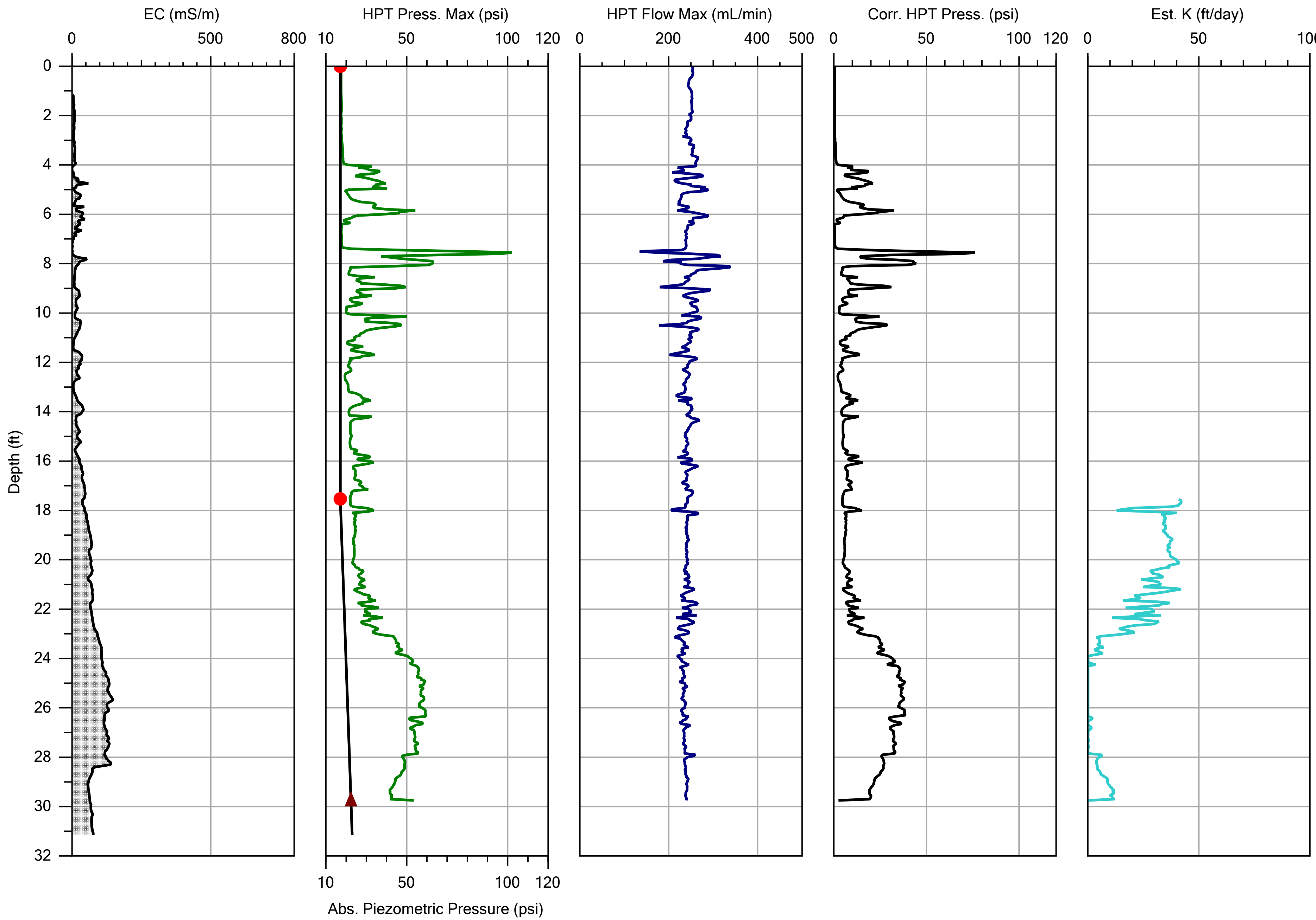
CASCADE
DRILLING | TECHNICAL SERVICES

		File: AB-01.MHP
Company: Cascade	Operator: C Terry	Date: 11/16/21
Project ID: Port of Tacoma Parcel 15	Client: Aspect Consulting	Location: Tacoma, WA



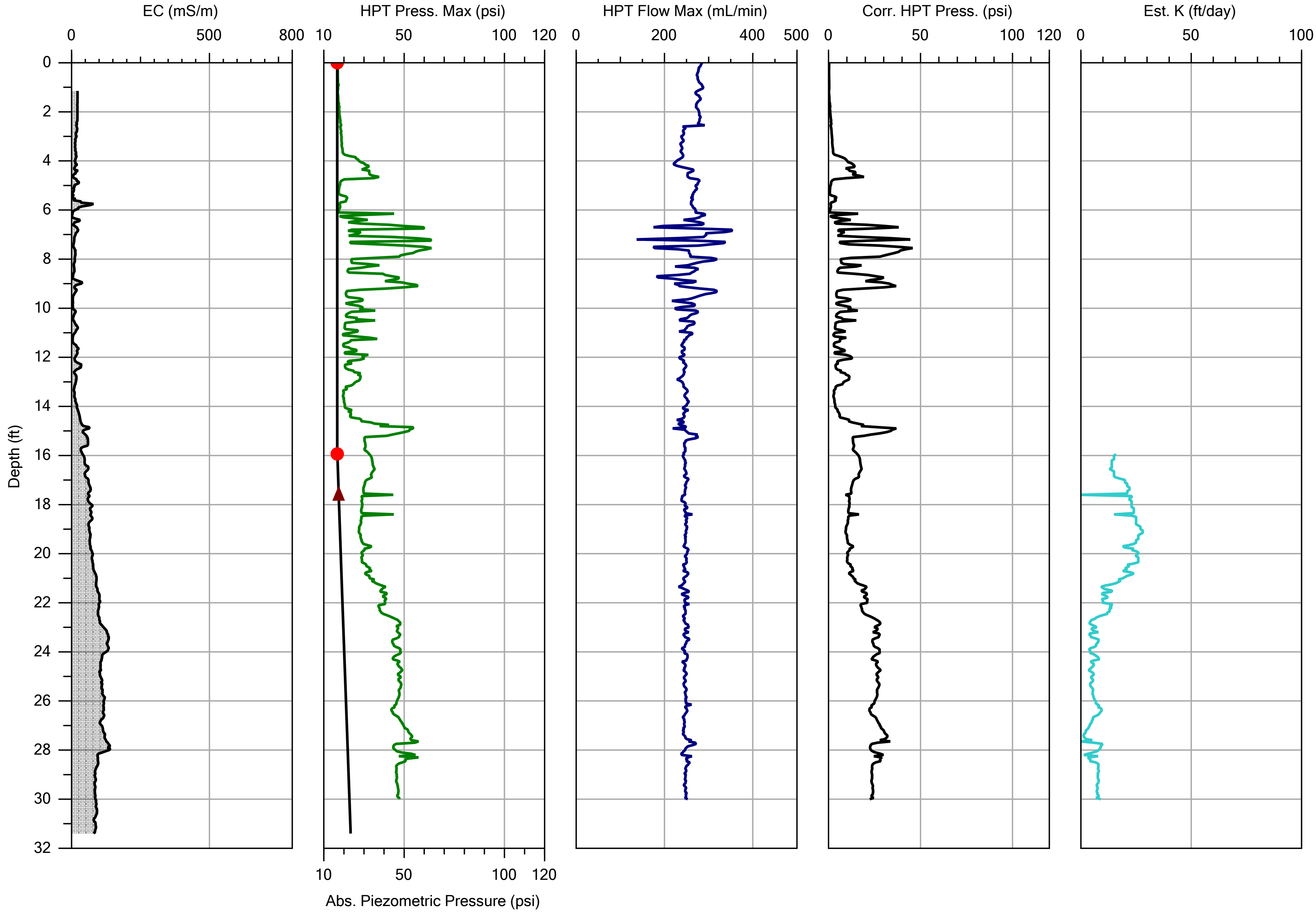
CASCADE
DRILLING | TECHNICAL SERVICES

		File: AB-02.MHP
Company: Cascade	Operator: C Terry	Date: 11/16/21
Project ID: Port of Tacoma Parcel 15	Client: Aspect Consulting	Location: Tacoma, WA



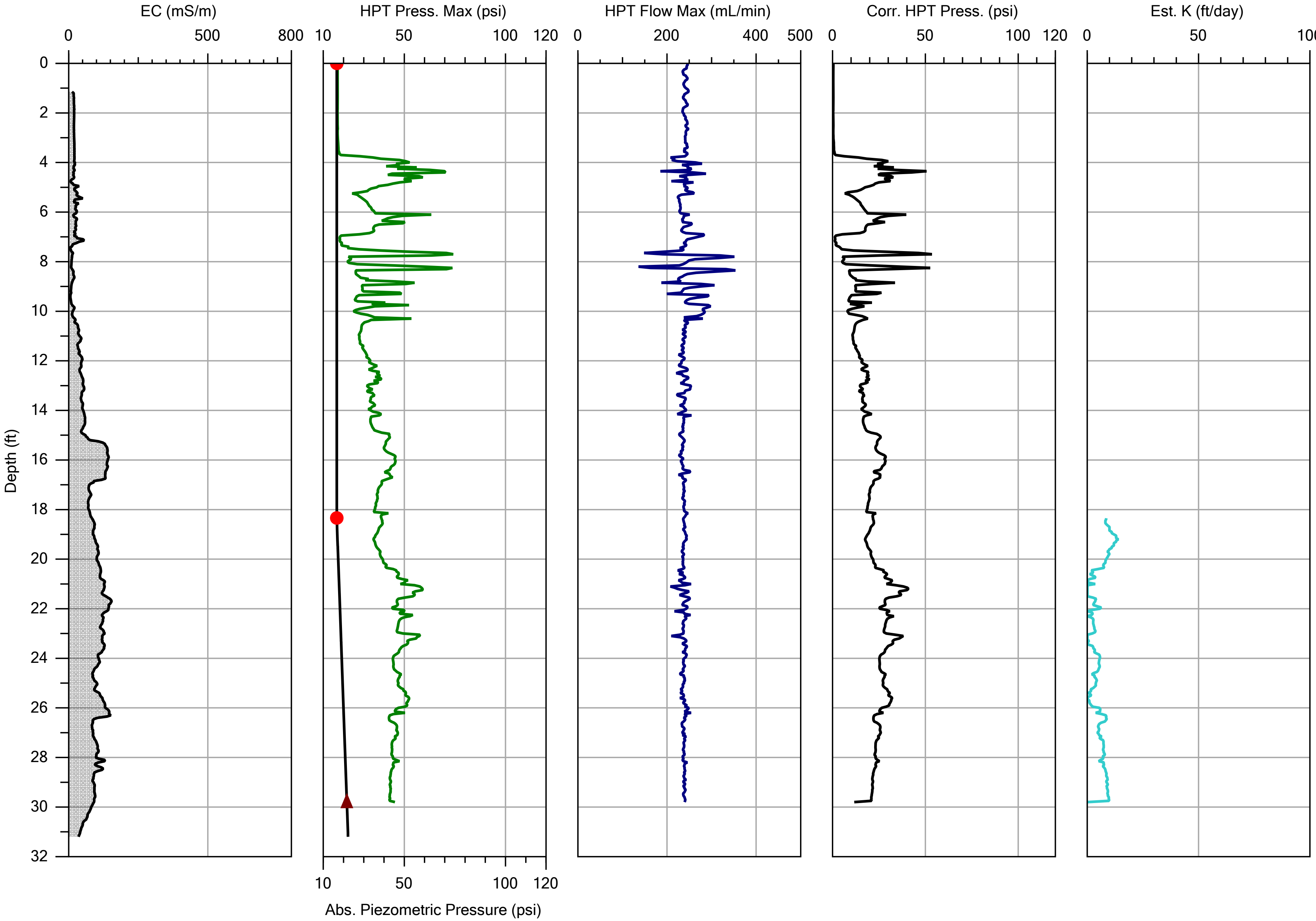
CASCADE
DRILLING | TECHNICAL SERVICES

		File: AB-03.MHP
Company: Cascade	Operator: C Terry	Date: 11/16/21
Project ID: Port of Tacoma Parcel 15	Client: Aspect Consulting	Location: Tacoma, WA



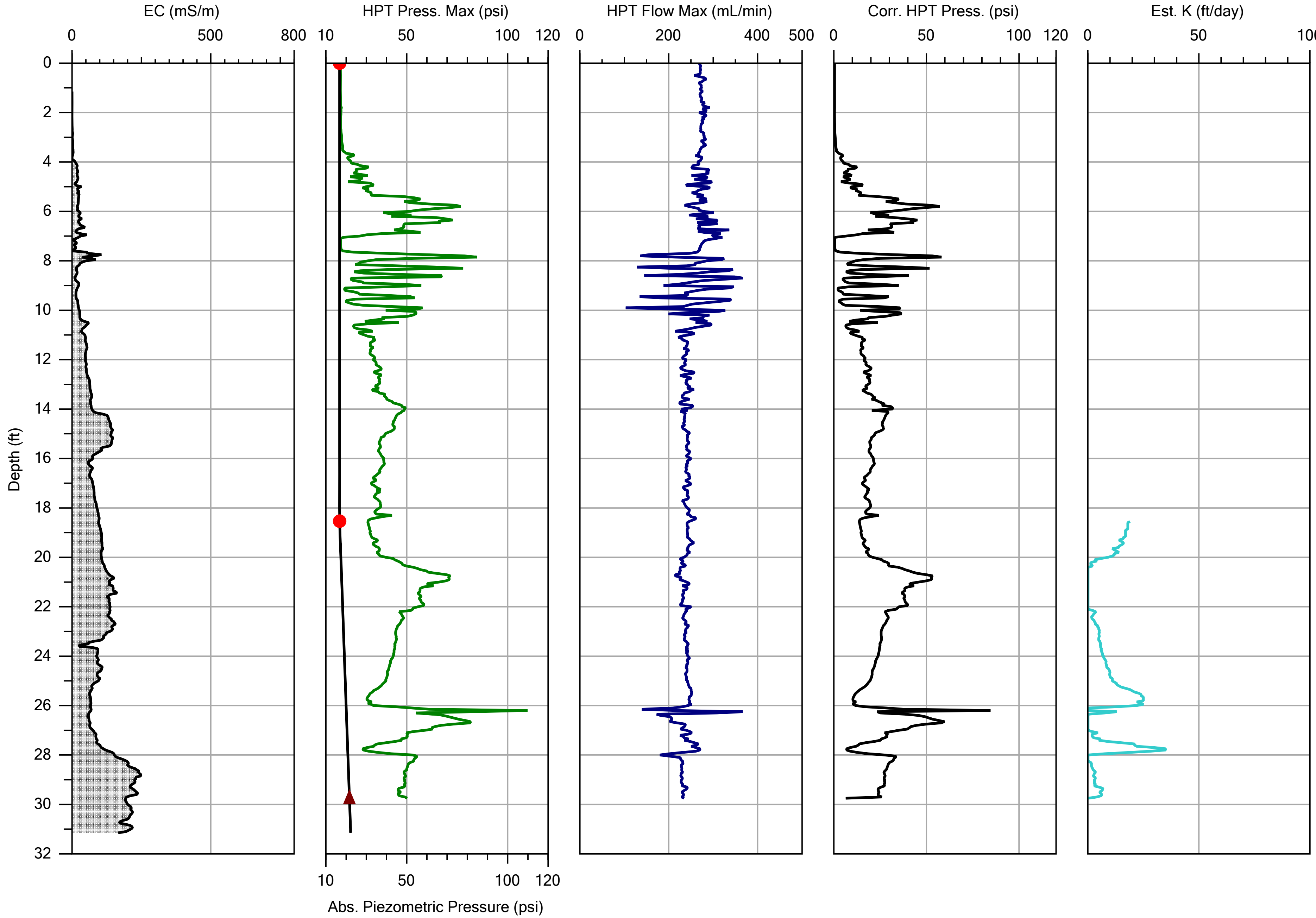
CASCADE DRILLING | TECHNICAL SERVICES

		File: AB-04.MHP
Company: Cascade	Operator: C Terry	Date: 11/15/21
Project ID: Port of Tacoma Parcel 15	Client: Aspect Consulting	Location: Tacoma, WA



CASCADE
DRILLING | TECHNICAL SERVICES

		File: AB-05.MHP
Company: Cascade	Operator: C Terry	Date: 11/15/21
Project ID: Port of Tacoma Parcel 15	Client: Aspect Consulting	Location: Tacoma, WA

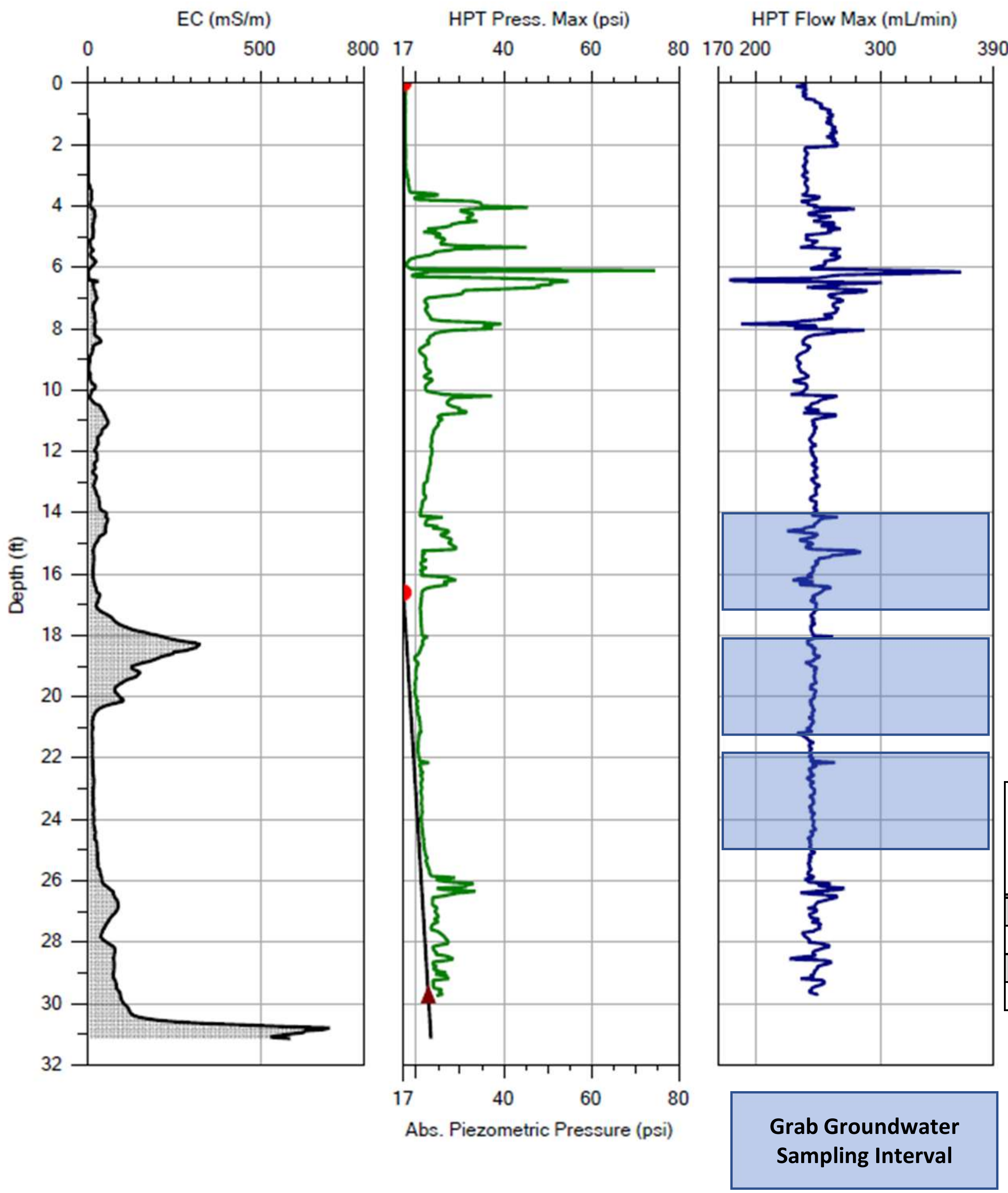


CASCADE DRILLING | TECHNICAL SERVICES

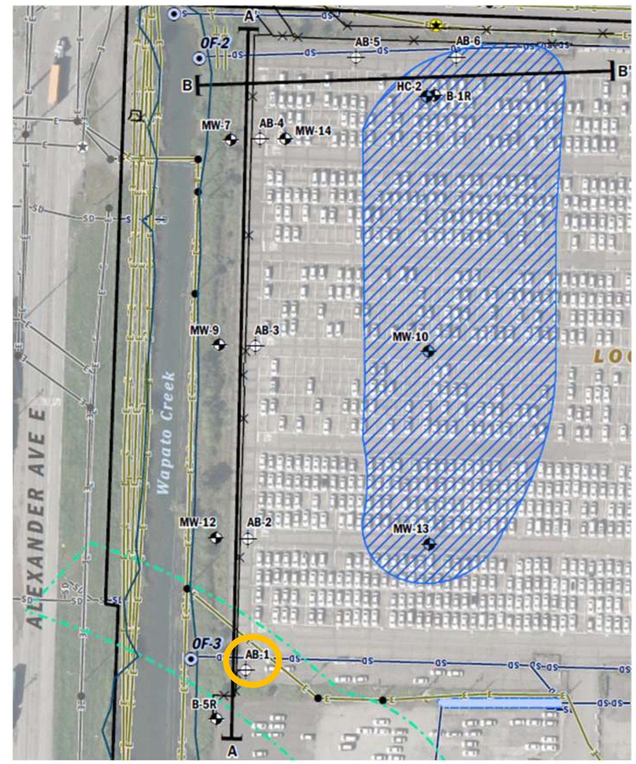
		File: AB-06.MHP
Company: Cascade	Operator: C Terry	Date: 11/15/21
Project ID: Port of Tacoma Parcel 15	Client: Aspect Consulting	Location: Tacoma, WA

APPENDIX E

Summary Profiles



DRAFT



Analyte	AB-01 14 - 17 ft 11/19/2021	AB-01 18 - 21 ft 11/19/2021	AB-01 22 - 25 ft 11/19/2021
Dissolved Metals			
Arsenic	**3.07**	**1.99**	**14.2**
Total Metals			
Arsenic	**9.82**	**2.07 J**	**28.3**

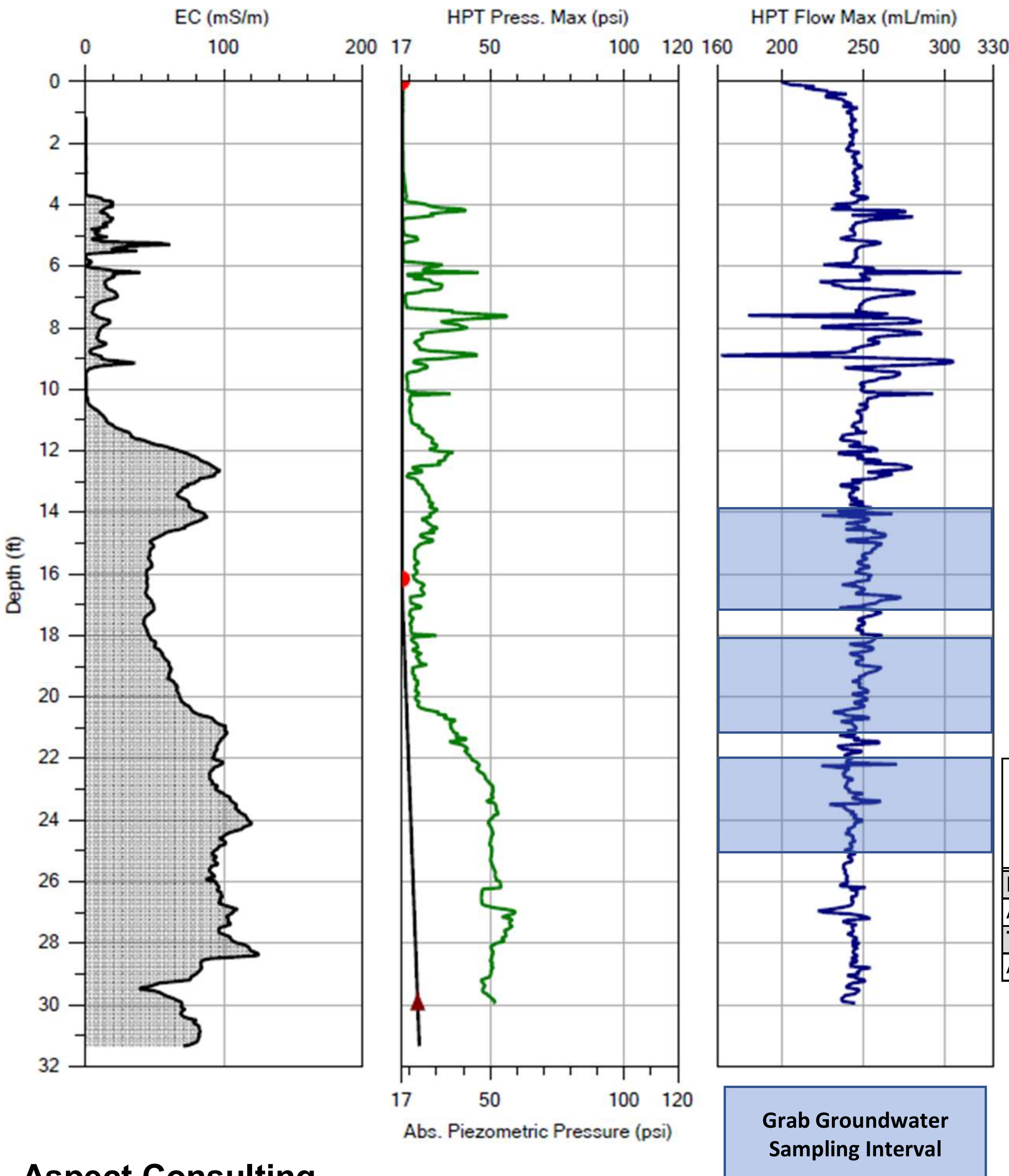
Notes:
J = estimated
U = non-detect
Results are in ug/L
Bold - detected
Shaded - exceeds cleanup level

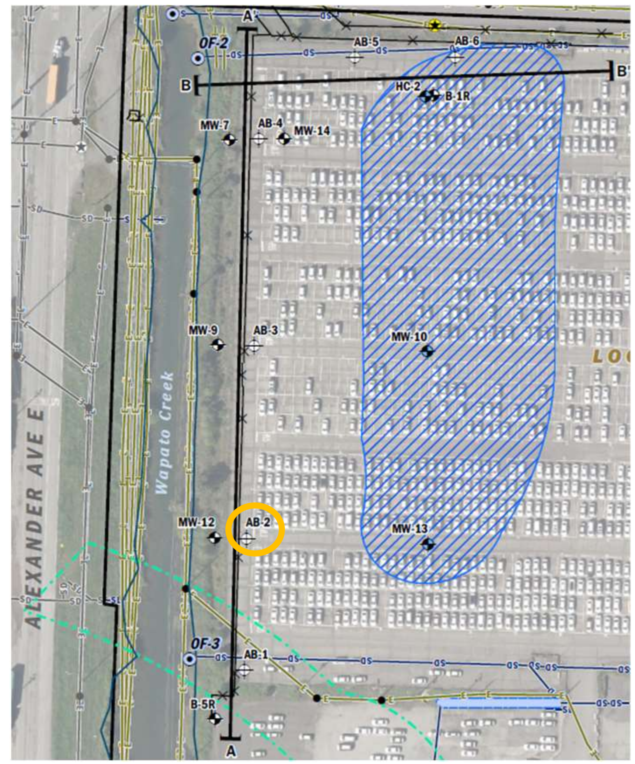
Figure E.1
AB-01 Summary

Pre-Remedial Design Investigation (PRDI) Technical Memorandum
Port of Tacoma - Parcel 15 (Portac)

Aspect Consulting
12/16/2021
S:\Port of Tacoma\Portac\Report Drafts\2021_12 PRDI Tech Memo\Figures

DRAFT





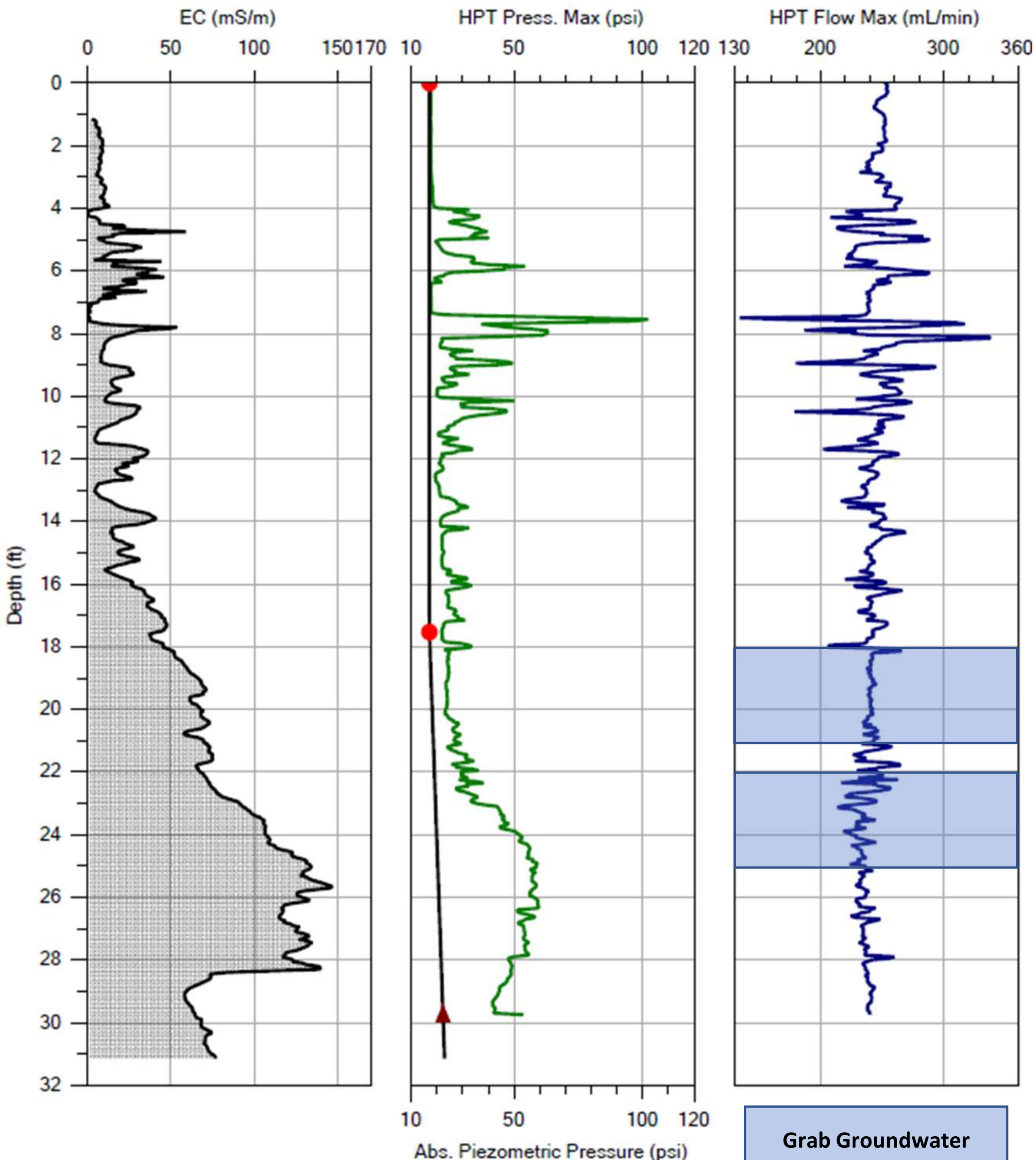
Analyte	AB-02 14 - 17 ft 11/19/2021	AB-02 18 - 21 ft 11/19/2021	AB-02 22 - 25 ft 11/19/2021
Dissolved Metals			
Arsenic	**5.13**	**3.91**	**20.1**
Total Metals			
Arsenic	**28.8**	**20.4**	**138**

Notes:
J = estimated
U = non-detect
Results are in ug/L
Bold - detected
Shaded - exceeds cleanup level

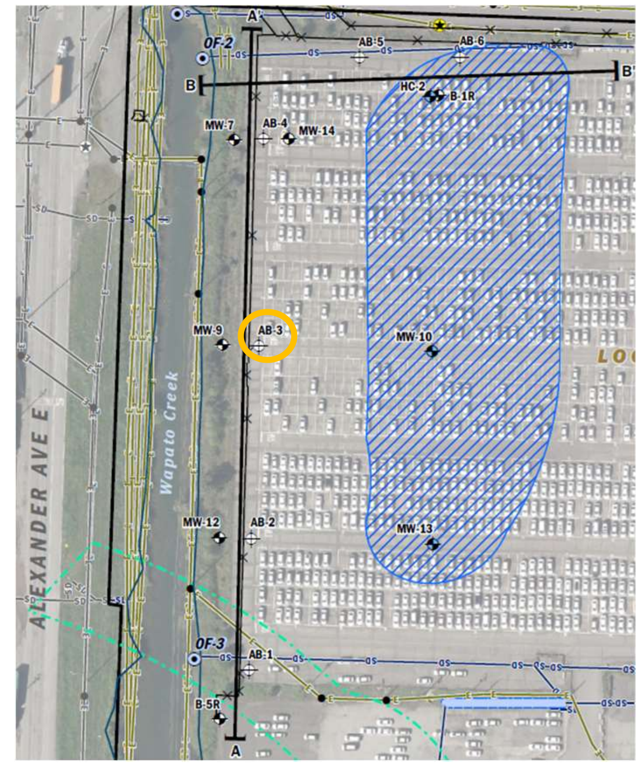
Figure E.2
AB-02 Summary
Pre-Remedial Design Investigation (PRDI) Technical Memorandum
Port of Tacoma - Parcel 15 (Portac)

Aspect Consulting
12/16/2021
S:\Port of Tacoma\Portac\Report Drafts\2021_12 PRDI Tech Memo\Figures

DRAFT



Grab Groundwater Sampling Interval



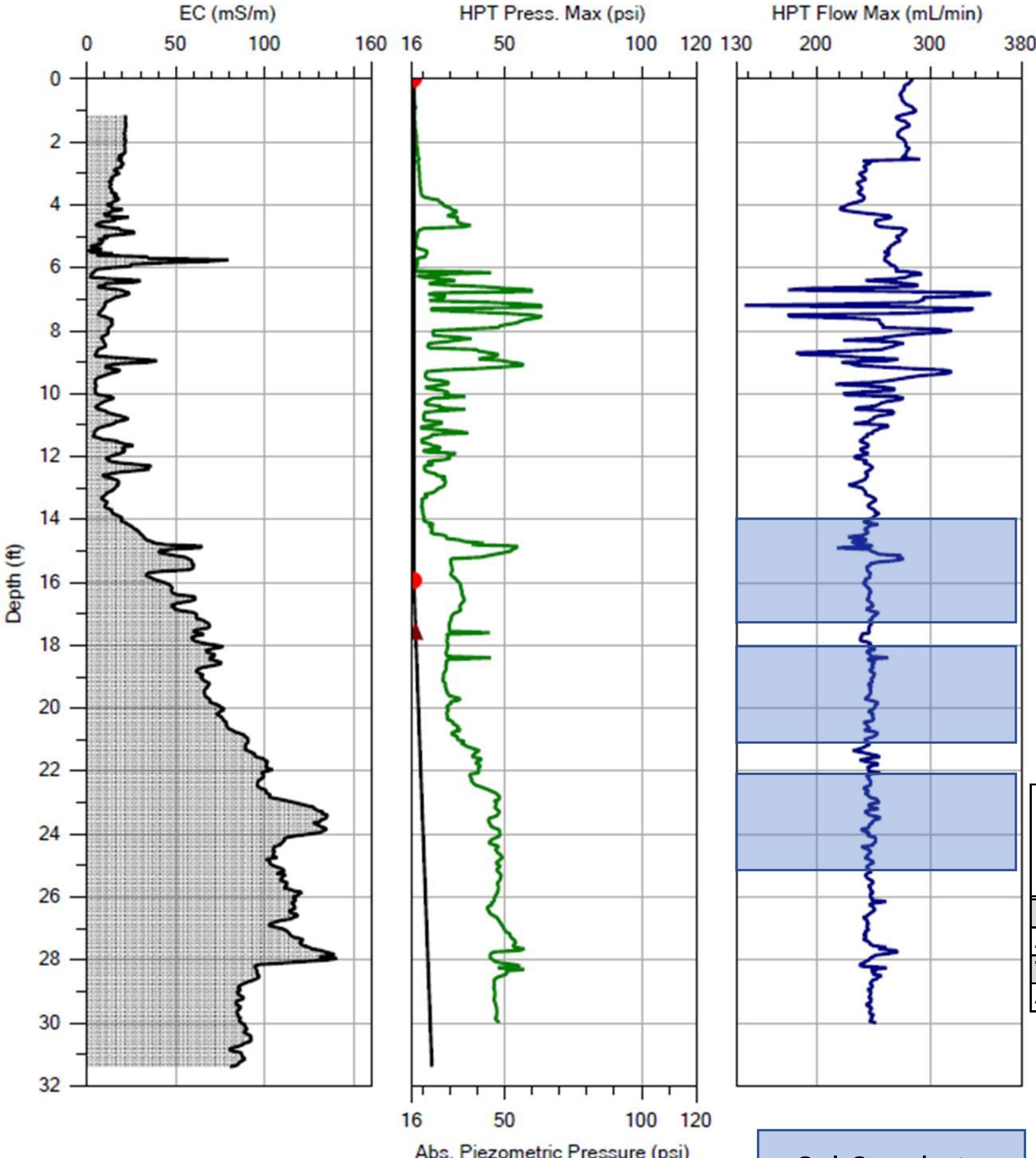
Analyte	AB-03	
	18 - 21 ft	22 - 25 ft
	11/18/2021	11/18/2021
Dissolved Metals		
Arsenic	**16.1**	**4.38**
Total Metals		
Arsenic	**56.7**	**8.01**

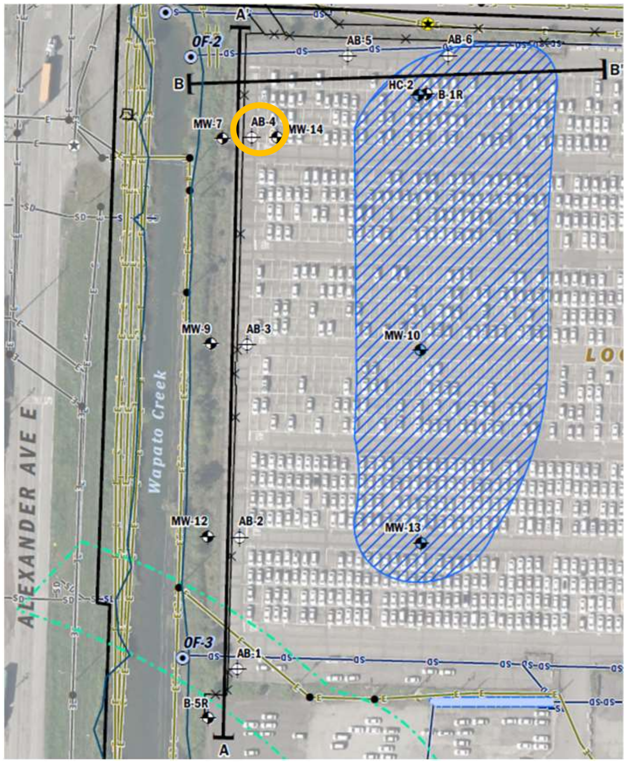
Notes:
J = estimated
U = non-detect
Results are in ug/L
Bold - detected
Shaded - exceeds cleanup level

Aspect Consulting
12/16/2021
S:\Port of Tacoma\Portac\Report Drafts\2021_12 PRDI Tech Memo\Figures

Figure E.3
AB-03 Summary
Pre-Remedial Design Investigation (PRDI) Technical Memorandum
Port of Tacoma - Parcel 15 (Portac)

DRAFT





Grab Groundwater Sampling Interval

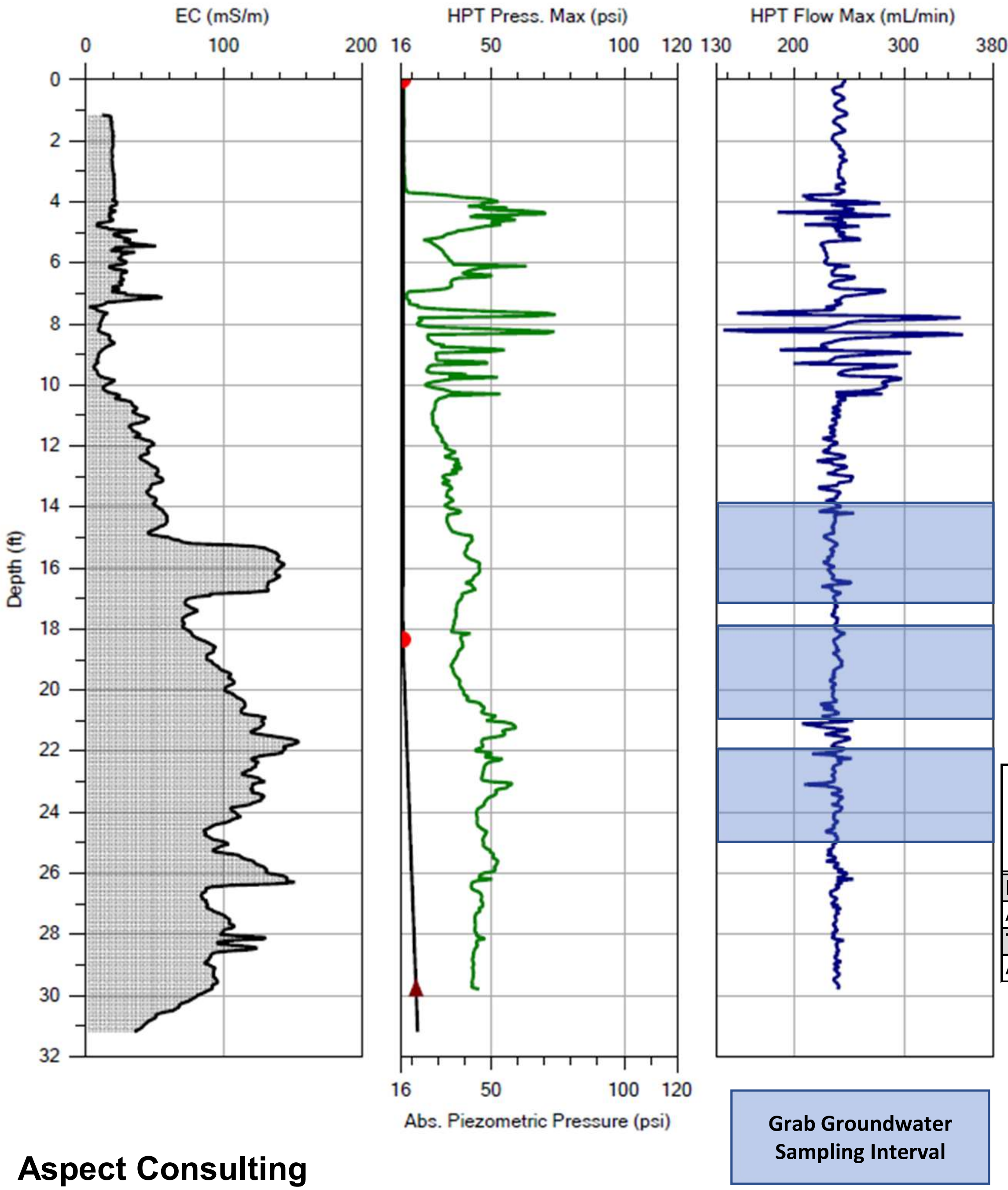
Analyte	AB-04 14 - 17 ft 11/17/2021	AB-04 18 - 21 ft 11/17/2021	AB-04 22 - 25 ft 11/18/2021
Dissolved Metals			
Arsenic	**27.9**	**39.3**	**55.9**
Total Metals			
Arsenic	**45.3**	**68.6**	**83.6**

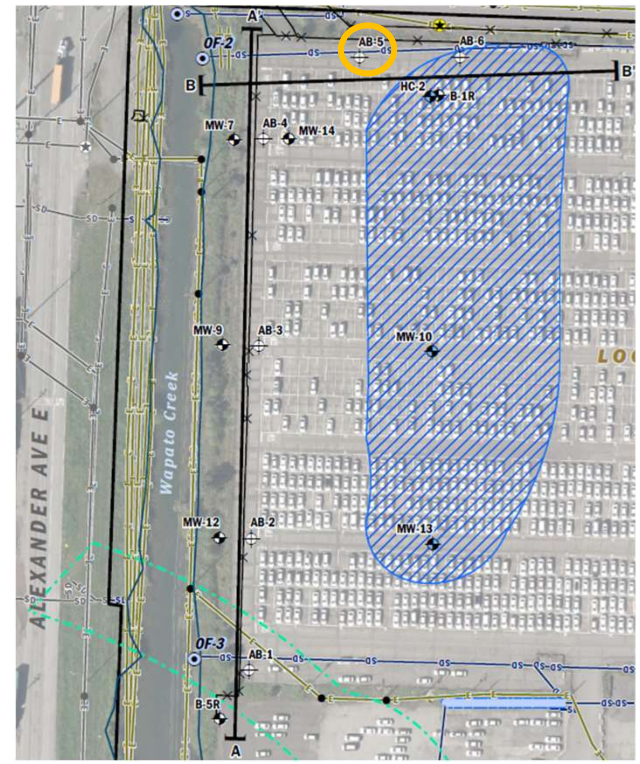
Notes:
J = estimated
U = non-detect
Results are in ug/L
Bold - detected
Shaded - exceeds cleanup level

Figure E.4
AB-04 Summary
Pre-Remedial Design Investigation (PRDI) Technical Memorandum
Port of Tacoma - Parcel 15 (Portac)

Aspect Consulting
12/16/2021
S:\Port of Tacoma\Portac\Report Drafts\2021_12 PRDI Tech Memo\Figures

DRAFT



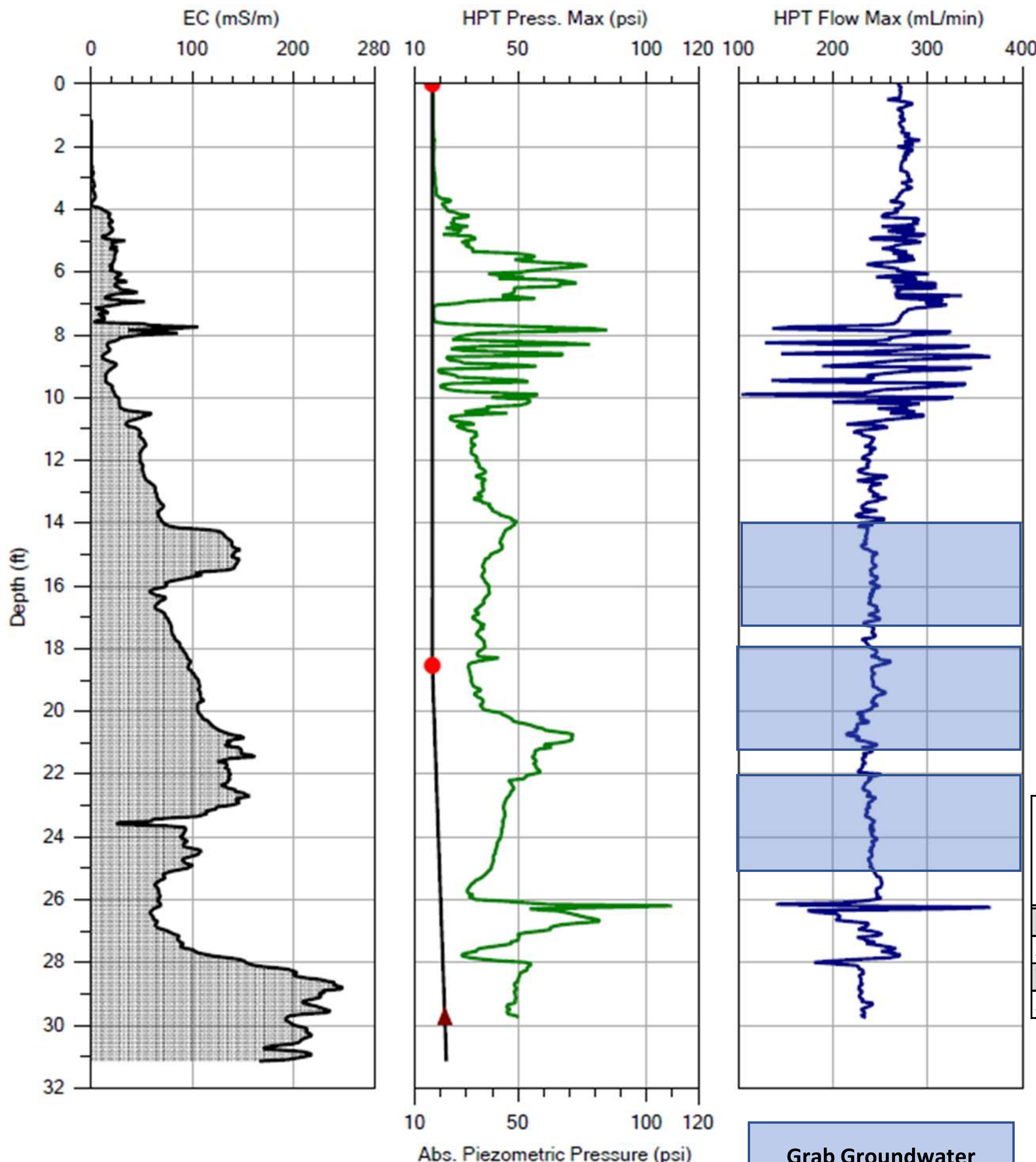


Analyte	AB-05		
	14 - 17 ft	18 - 21 ft	22 - 25 ft
	11/18/2021	11/18/2021	11/18/2021
Dissolved Metals			
Arsenic	**19.5**	**12.6**	**1.36**
Total Metals			
Arsenic	**29.5**	**18.2**	**13.8**

Notes:
J = estimated
U = non-detect
Results are in ug/L
Bold - detected
Shaded - exceeds cleanup level

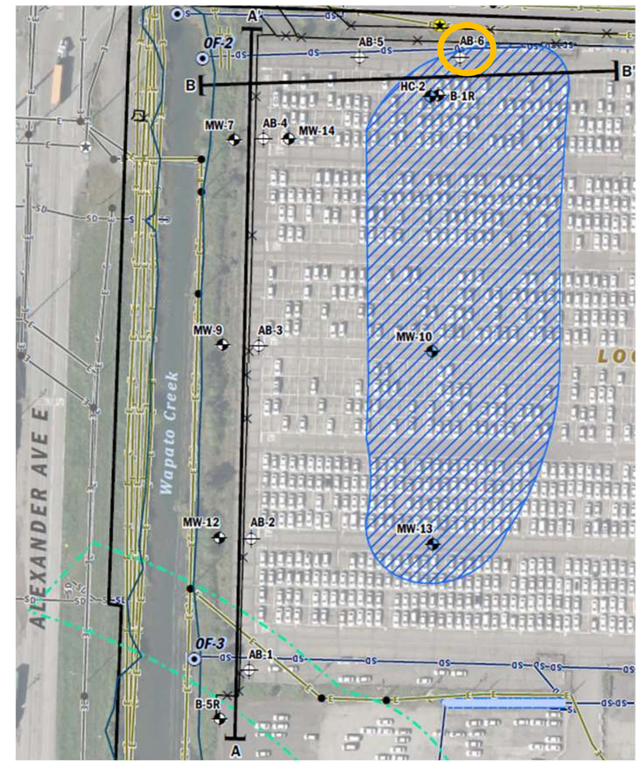
Aspect Consulting
12/16/2021
S:\Port of Tacoma\Portac\Report Drafts\2021_12 PRDI Tech Memo\Figures

Figure E.5
AB-05 Summary
Pre-Remedial Design Investigation (PRDI) Technical Memorandum
Port of Tacoma - Parcel 15 (Portac)



Grab Groundwater Sampling Interval

DRAFT



Analyte	AB-06		
	14 - 17 ft	18 - 21 ft	22 - 25 ft
	11/18/2021	11/18/2021	11/18/2021
Dissolved Metals			
Arsenic	**31**	**6.31**	**56.9**
Total Metals			
Arsenic	**47**	**10.8**	**68.9**

Notes:
J = estimated
U = non-detect
Results are in ug/L
Bold - detected
Shaded - exceeds cleanup level

Figure E.6
AB-06 Summary
Pre-Remedial Design Investigation (PRDI) Technical Memorandum
Port of Tacoma - Parcel 15 (Portac)

Aspect Consulting
12/16/2021
S:\Port of Tacoma\Portac\Report Drafts\2021_12 PRDI Tech Memo\Figures

APPENDIX F

Laboratory Analytical Reports

3600 Fremont Ave. N.
Seattle, WA 98103
T: (206) 352-3790
F: (206) 352-7178
info@fremontanalytical.com

Aspect Consulting
Adam Griffin
710 2nd Ave, Suite 550
Seattle, WA 98104

RE: Port of Tacoma Parcel 15
Work Order Number: 2111353

December 03, 2021

Attention Adam Griffin:

Fremont Analytical, Inc. received 2 sample(s) on 11/17/2021 for the analyses presented in the following report.

Sample Moisture (Percent Moisture)
Total Metals by EPA Method 6020B

This report consists of the following:

- Case Narrative
- Analytical Results
- Applicable Quality Control Summary Reports
- Chain of Custody

All analyses were performed consistent with the Quality Assurance program of Fremont Analytical, Inc. Please contact the laboratory if you should have any questions about the results.

Thank you for using Fremont Analytical.

Sincerely,

Brianna Barnes
Project Manager

DoD-ELAP Accreditation #79636 by PJLA, ISO/IEC 17025:2017 and QSM 5.3 for Environmental Testing
ORELAP Certification: WA 100009 (NELAP Recognized) for Environmental Testing
Washington State Department of Ecology Accredited for Environmental Testing, Lab ID C910

Original

Date: *12/03/2021*

CLIENT:	Aspect Consulting
Project:	Port of Tacoma Parcel 15
Work Order:	2111353

Work Order Sample Summary

Lab Sample ID	Client Sample ID	Date/Time Collected	Date/Time Received
2111353-001	AB-04-20	11/10/2021 3:40 PM	11/17/2021 8:06 AM
2111353-002	AB-04-23	11/10/2021 3:45 PM	11/17/2021 8:06 AM

Note: If no "Time Collected" is supplied, a default of 12:00AM is assigned

Case Narrative

WO#: **2111353**

Date: **12/3/2021**

CLIENT: Aspect Consulting

Project: Port of Tacoma Parcel 15

I. SAMPLE RECEIPT:

Samples receipt information is recorded on the attached Sample Receipt Checklist.

II. GENERAL REPORTING COMMENTS:

Results are reported on a wet weight basis unless dry-weight correction is denoted in the units field on the analytical report ("mg/kg-dry" or "ug/kg-dry").

Matrix Spike (MS) and MS Duplicate (MSD) samples are tested from an analytical batch of "like" matrix to check for possible matrix effect. The MS and MSD will provide site specific matrix data only for those samples which are spiked by the laboratory. The sample chosen for spike purposes may or may not have been a sample submitted in this sample delivery group. The validity of the analytical procedures for which data is reported in this analytical report is determined by the Laboratory Control Sample (LCS) and the Method Blank (MB). The LCS and the MB are processed with the samples and the MS/MSD to ensure method criteria are achieved throughout the entire analytical process.

III. ANALYSES AND EXCEPTIONS:

Exceptions associated with this report will be footnoted in the analytical results page(s) or the quality control summary page(s) and/or noted below.

Qualifiers:

* - Flagged value is not within established control limits
B - Analyte detected in the associated Method Blank
D - Dilution was required
E - Value above quantitation range
H - Holding times for preparation or analysis exceeded
I - Analyte with an internal standard that does not meet established acceptance criteria
J - Analyte detected below Reporting Limit
N - Tentatively Identified Compound (TIC)
Q - Analyte with an initial or continuing calibration that does not meet established acceptance criteria
S - Spike recovery outside accepted recovery limits
ND - Not detected at the Reporting Limit
R - High relative percent difference observed

Acronyms:

%Rec - Percent Recovery
CCB - Continued Calibration Blank
CCV - Continued Calibration Verification
DF - Dilution Factor
DUP - Sample Duplicate
HEM - Hexane Extractable Material
ICV - Initial Calibration Verification
LCS/LCSD - Laboratory Control Sample / Laboratory Control Sample Duplicate
MCL - Maximum Contaminant Level
MB or MBLANK - Method Blank
MDL - Method Detection Limit
MS/MSD - Matrix Spike / Matrix Spike Duplicate
PDS - Post Digestion Spike
Ref Val - Reference Value
REP - Sample Replicate
RL - Reporting Limit
RPD - Relative Percent Difference
SD - Serial Dilution
SGT - Silica Gel Treatment
SPK - Spike
Surr - Surrogate

Analytical Report

Work Order:	**2111353**
Date Reported:	**12/3/2021**

CLIENT: Aspect Consulting
Project: Port of Tacoma Parcel 15

Lab ID: 2111353-001 **Collection Date:** 11/10/2021 3:40:00 PM
Client Sample ID: **AB-04-20** **Matrix:** Soil

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Total Metals by EPA Method 6020B				Batch ID: 34584		Analyst: EH
Arsenic	1.51	0.110		mg/Kg-dry	1	12/2/2021 5:49:01 PM
Sample Moisture (Percent Moisture)				Batch ID: R71538		Analyst: ALB
Percent Moisture	24.0	0.500		wt%	1	11/24/2021 9:30:23 AM

Lab ID: 2111353-002 **Collection Date:** 11/10/2021 3:45:00 PM
Client Sample ID: **AB-04-23** **Matrix:** Soil

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Total Metals by EPA Method 6020B				Batch ID: 34584		Analyst: EH
Arsenic	17.0	0.127		mg/Kg-dry	1	12/2/2021 5:51:21 PM
Sample Moisture (Percent Moisture)				Batch ID: R71538		Analyst: ALB
Percent Moisture	30.5	0.500		wt%	1	11/24/2021 9:30:23 AM

Date: *12/3/2021*

Work Order: 2111353
CLIENT: Aspect Consulting
Project: Port of Tacoma Parcel 15

QC SUMMARY REPORT

Total Metals by EPA Method 6020B

Sample ID: **MB-34584** SampType: **MBLK** Units: **mg/Kg** Prep Date: **11/30/2021** RunNo: **71643**
Client ID: **MBLKS** Batch ID: **34584** Analysis Date: **12/1/2021** SeqNo: **1459648**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	ND	0.120									

Sample ID: **LCS-34584** SampType: **LCS** Units: **mg/Kg** Prep Date: **11/30/2021** RunNo: **71643**
Client ID: **LCSS** Batch ID: **34584** Analysis Date: **12/1/2021** SeqNo: **1459649**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	49.2	0.120	50.00	0	98.5	80	120				

Sample ID: **2111481-002AMS** SampType: **MS** Units: **mg/Kg-dry** Prep Date: **11/30/2021** RunNo: **71643**
Client ID: **BATCH** Batch ID: **34584** Analysis Date: **12/1/2021** SeqNo: **1459652**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	63.8	0.130	54.19	7.916	103	75	125				

Sample ID: **2111481-002AMSD** SampType: **MSD** Units: **mg/Kg-dry** Prep Date: **11/30/2021** RunNo: **71643**
Client ID: **BATCH** Batch ID: **34584** Analysis Date: **12/1/2021** SeqNo: **1459653**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	60.9	0.128	53.38	7.916	99.2	75	125	63.81	4.71	20	

Sample Log-In Check List

Client Name:	**AC**	Work Order Number:	**2111353**
Logged by:	**Gabrielle Coeuille**	Date Received:	**11/17/2021 8:06:00 AM**

Chain of Custody

1.	Is Chain of Custody complete?	Yes ☑	No ☐	Not Present ☐
2.	How was the sample delivered?	Client		

Log In

3.	Coolers are present?	Yes ☑	No ☐	NA ☐
4.	Shipping container/cooler in good condition?	Yes ☑	No ☐	
5.	Custody Seals present on shipping container/cooler? (Refer to comments for Custody Seals not intact)	Yes ☐	No ☐	Not Present ☑
6.	Was an attempt made to cool the samples?	Yes ☑	No ☐	NA ☐
7.	Were all items received at a temperature of >2°C to 6°C *	Yes ☑	No ☐	NA ☐
8.	Sample(s) in proper container(s)?	Yes ☑	No ☐	
9.	Sufficient sample volume for indicated test(s)?	Yes ☑	No ☐	
10.	Are samples properly preserved?	Yes ☑	No ☐	
11.	Was preservative added to bottles?	Yes ☐	No ☑	NA ☐
12.	Is there headspace in the VOA vials?	Yes ☐	No ☐	NA ☑
13.	Did all samples containers arrive in good condition(unbroken)?	Yes ☑	No ☐	
14.	Does paperwork match bottle labels?	Yes ☑	No ☐	
15.	Are matrices correctly identified on Chain of Custody?	Yes ☑	No ☐	
16.	Is it clear what analyses were requested?	Yes ☑	No ☐	
17.	Were all holding times able to be met?	Yes ☑	No ☐	

Special Handling (if applicable)

18.	Was client notified of all discrepancies with this order?	Yes ☐	No ☐	NA ☑

Person Notified: Date:

By Whom: Via: ☐ eMail ☐ Phone ☐ Fax ☐ In Person

Regarding:

Client Instructions:

19. Additional remarks:

Item Information

Item #	Temp ºC
Sample 1	3.9

* Note: DoD/ELAP and TNI require items to be received at 4°C +/- 2°C

Fremont Analytical

3600 Fremont Ave N.
Seattle, WA 98103
Tel: 206-352-3790
Fax: 206-352-7178

Chain of Custody Record & Laboratory Services Agreement

Date: 11/16/21 Page: 1 of: 1

Laboratory Project No (internal): 2111353

Project Name: Port of Tacoma Parcel 15

Special Remarks:

Client: Aspect Consulting

Project No: 210158

Address: 710 2nd Ave., Ste. 550

Collected by: Baxter Call

City, State, Zip: Seattle, WA, 98104

Location:

Telephone:

Report To (PM): Adam Griffin

Sample Disposal: ☐ Return to client ☐ Disposal by lab (after 30 days)

Fax:

PM Email: agriffin@aspectconsulting.com

	Sample Name	Sample Date	Sample Time	Sample Type (Matrix)*	# of Cont.	VOCs (EPA 8260 / 624)	BTEX	Gasoline Range Organics (GX)	Hydrocarbon Identification (HCID)	Diesel/Heavy Oil Range Organics (DX)	SVOCs (EPA 8270 / 625)	PAHs (EPA 8270 - SIM)	PCBs (EPA 8082 / 608)	Metals** (EPA 6020 / 200.8)	Total (T) | Dissolved (D)	Anions (IC)***	EDB (8011)	Arsenic				Comments
1	AB-04-20	11/16/21	1540	S	1													X				
2	AB-04-23	↓	1545	↓	↓													X				
3																						
4																						
5																						
6																						
7																						
8																						
9																						
10																						

*Matrix: A = Air, AQ = Aqueous, B = Bulk, O = Other, P = Product, S = Soil, SD = Sediment, SL = Solid, W = Water, DW = Drinking Water, GW = Ground Water, SW = Storm Water, WW = Waste Water

**Metals (Circle): MTCA-5 RCRA-8 Priority Pollutants TAL *Individual:* Ag Al As B Ba Be Ca Cd Co Cr Cu Fe Hg K Mg Mn Mo Na Ni Pb Sb Se Sr Sn Ti Tl V Zn

***Anions (Circle): Nitrate Nitrite Chloride Sulfate Bromide O-Phosphate Fluoride Nitrate+Nitrite

Turn-around Time:
☒ Standard ☐ Next Day
☐ 3 Day ☐ Same Day
☐ 2 Day ____ (specify)

I represent that I am authorized to enter into this Agreement with Fremont Analytical on behalf of the Client named above, that I have verified Client's agreement to each of the terms on the front and backside of this Agreement.

Relinquished (Signature)	Print Name	Date/Time	Received (Signature)	Print Name	Date/Time
x B Call	Baxter Call	11/16/21 1740	x Justine Mantz	Justine Mantz	11/17 8:06
x			x		

COC 1.3 - 11.06.20

www.fremontanalytical.com

3600 Fremont Ave. N.
Seattle, WA 98103
T: (206) 352-3790
F: (206) 352-7178
info@fremontanalytical.com

Aspect Consulting
Adam Griffin
710 2nd Ave, Suite 550
Seattle, WA 98104

RE: Port of Tacoma Parcel 15
Work Order Number: 2111398

December 07, 2021

Attention Adam Griffin:

Fremont Analytical, Inc. received 14 sample(s) on 11/17/2021 for the analyses presented in the following report.

Dissolved Metals by EPA Method 200.8
Ferrous Iron by SM3500-Fe B
Ion Chromatography by EPA Method 300.0
Sample Moisture (Percent Moisture)
Total Metals by EPA Method 200.8
Total Alkalinity by SM 2320B
Total Metals by EPA Method 6020B
Total Organic Carbon by SM 5310C

This report consists of the following:

- Case Narrative
- Analytical Results
- Applicable Quality Control Summary Reports
- Chain of Custody

All analyses were performed consistent with the Quality Assurance program of Fremont Analytical, Inc. Please contact the laboratory if you should have any questions about the results.

Thank you for using Fremont Analytical.

Sincerely,

DoD-ELAP Accreditation #79636 by PJLA, ISO/IEC 17025:2017 and QSM 5.3 for Environmental Testing
ORELAP Certification: WA 100009 (NELAP Recognized) for Environmental Testing
Washington State Department of Ecology Accredited for Environmental Testing, Lab ID C910

Brianna Barnes
Project Manager

Date: *12/07/2021*

CLIENT:	Aspect Consulting
Project:	Port of Tacoma Parcel 15
Work Order:	2111398

Work Order Sample Summary

Lab Sample ID	Client Sample ID	Date/Time Collected	Date/Time Received
2111398-001	AB-05-17	11/17/2021 8:40 AM	11/17/2021 5:41 PM
2111398-002	AB-05-23	11/17/2021 8:45 AM	11/17/2021 5:41 PM
2111398-003	AB-06-17	11/17/2021 10:07 AM	11/17/2021 5:41 PM
2111398-004	AB-06-22	11/17/2021 10:09 AM	11/17/2021 5:41 PM
2111398-005	AB-06-25	11/17/2021 10:10 AM	11/17/2021 5:41 PM
2111398-006	AB-03-19	11/17/2021 11:30 AM	11/17/2021 5:41 PM
2111398-007	AB-03-23	11/17/2021 11:35 AM	11/17/2021 5:41 PM
2111398-008	AB-03-25	11/17/2021 11:40 AM	11/17/2021 5:41 PM
2111398-009	AB-02-17	11/17/2021 12:40 PM	11/17/2021 5:41 PM
2111398-010	AB-02-22	11/17/2021 12:45 PM	11/17/2021 5:41 PM
2111398-011	AB-01-15	11/17/2021 2:05 PM	11/17/2021 5:41 PM
2111398-012	AB-01-21	11/17/2021 2:10 PM	11/17/2021 5:41 PM
2111398-013	AB4-14-111721	11/17/2021 3:15 PM	11/17/2021 5:41 PM
2111398-013	AB4-14-111721	11/17/2021 3:15 PM	11/17/2021 5:41 PM
2111398-014	AB4-18-111721	11/17/2021 3:45 PM	11/17/2021 5:41 PM
2111398-014	AB4-18-111721	11/17/2021 3:45 PM	11/17/2021 5:41 PM

Note: If no "Time Collected" is supplied, a default of 12:00AM is assigned

Case Narrative

WO#: **2111398**

Date: **12/7/2021**

CLIENT: Aspect Consulting
Project: Port of Tacoma Parcel 15

I. SAMPLE RECEIPT:
Samples receipt information is recorded on the attached Sample Receipt Checklist.

II. GENERAL REPORTING COMMENTS:
Results are reported on a wet weight basis unless dry-weight correction is denoted in the units field on the analytical report ("mg/kg-dry" or "ug/kg-dry").

Matrix Spike (MS) and MS Duplicate (MSD) samples are tested from an analytical batch of "like" matrix to check for possible matrix effect. The MS and MSD will provide site specific matrix data only for those samples which are spiked by the laboratory. The sample chosen for spike purposes may or may not have been a sample submitted in this sample delivery group. The validity of the analytical procedures for which data is reported in this analytical report is determined by the Laboratory Control Sample (LCS) and the Method Blank (MB). The LCS and the MB are processed with the samples and the MS/MSD to ensure method criteria are achieved throughout the entire analytical process.

III. ANALYSES AND EXCEPTIONS:
Exceptions associated with this report will be footnoted in the analytical results page(s) or the quality control summary page(s) and/or noted below.

Qualifiers:

* - Flagged value is not within established control limits
B - Analyte detected in the associated Method Blank
D - Dilution was required
E - Value above quantitation range
H - Holding times for preparation or analysis exceeded
I - Analyte with an internal standard that does not meet established acceptance criteria
J - Analyte detected below Reporting Limit
N - Tentatively Identified Compound (TIC)
Q - Analyte with an initial or continuing calibration that does not meet established acceptance criteria
S - Spike recovery outside accepted recovery limits
ND - Not detected at the Reporting Limit
R - High relative percent difference observed

Acronyms:

%Rec - Percent Recovery
CCB - Continued Calibration Blank
CCV - Continued Calibration Verification
DF - Dilution Factor
DUP - Sample Duplicate
HEM - Hexane Extractable Material
ICV - Initial Calibration Verification
LCS/LCSD - Laboratory Control Sample / Laboratory Control Sample Duplicate
MCL - Maximum Contaminant Level
MB or MBLANK - Method Blank
MDL - Method Detection Limit
MS/MSD - Matrix Spike / Matrix Spike Duplicate
PDS - Post Digestion Spike
Ref Val - Reference Value
REP - Sample Replicate
RL - Reporting Limit
RPD - Relative Percent Difference
SD - Serial Dilution
SGT - Silica Gel Treatment
SPK - Spike
Surr - Surrogate

Analytical Report

Work Order: **2111398**
Date Reported: **12/7/2021**

Client: Aspect Consulting
Collection Date: 11/17/2021 8:40:00 AM
Project: Port of Tacoma Parcel 15
Lab ID: 2111398-001
Matrix: Soil
Client Sample ID: AB-05-17

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Total Metals by EPA Method 6020B				Batch ID: 34611		Analyst: EH
Arsenic	3.16	0.129		mg/Kg-dry	1	12/6/2021 8:08:32 PM
Sample Moisture (Percent Moisture)				Batch ID: R71538		Analyst: ALB
Percent Moisture	29.0	0.500		wt%	1	11/24/2021 9:30:23 AM

Analytical Report

Work Order: **2111398**
Date Reported: **12/7/2021**

Client: Aspect Consulting
Project: Port of Tacoma Parcel 15
Lab ID: 2111398-002
Client Sample ID: **AB-05-23**
Collection Date: 11/17/2021 8:45:00 AM
Matrix: Soil

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Total Metals by EPA Method 6020B				Batch ID: 34611		Analyst: EH
Arsenic	5.19	0.148		mg/Kg-dry	1	12/6/2021 8:14:07 PM
Sample Moisture (Percent Moisture)				Batch ID: R71538		Analyst: ALB
Percent Moisture	35.8	0.500		wt%	1	11/24/2021 9:30:23 AM

Analytical Report

Work Order: **2111398**
Date Reported: **12/7/2021**

Client: Aspect Consulting
Project: Port of Tacoma Parcel 15
Lab ID: 2111398-003
Client Sample ID: **AB-06-17**

Collection Date: 11/17/2021 10:07:00 AM
Matrix: Soil

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Total Metals by EPA Method 6020B				Batch ID: 34611		Analyst: EH
Arsenic	1.85	0.128		mg/Kg-dry	1	12/6/2021 8:19:41 PM
Sample Moisture (Percent Moisture)				Batch ID: R71538		Analyst: ALB
Percent Moisture	27.0	0.500		wt%	1	11/24/2021 9:30:23 AM

Analytical Report

Work Order: **2111398**
Date Reported: **12/7/2021**

Client: Aspect Consulting
Project: Port of Tacoma Parcel 15
Lab ID: 2111398-004
Client Sample ID: **AB-06-22**
Collection Date: 11/17/2021 10:09:00 AM
Matrix: Soil

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Total Metals by EPA Method 6020B				Batch ID: 34611		Analyst: EH
Arsenic	5.71	0.141		mg/Kg-dry	1	12/6/2021 8:25:14 PM
Sample Moisture (Percent Moisture)				Batch ID: R71538		Analyst: ALB
Percent Moisture	35.7	0.500		wt%	1	11/24/2021 9:30:23 AM

Fremont Analytical

Analytical Report

Work Order: **2111398**
Date Reported: **12/7/2021**

Client: Aspect Consulting
Project: Port of Tacoma Parcel 15
Lab ID: 2111398-005
Client Sample ID: AB-06-25

Collection Date: 11/17/2021 10:10:00 AM
Matrix: Soil

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Total Metals by EPA Method 6020B				Batch ID: 34611		Analyst: EH
Arsenic	1.41	0.114		mg/Kg-dry	1	12/6/2021 8:30:48 PM
Sample Moisture (Percent Moisture)				Batch ID: R71540		Analyst: ALB
Percent Moisture	18.3	0.500		wt%	1	11/24/2021 10:08:03 AM

Analytical Report

Work Order: **2111398**
Date Reported: **12/7/2021**

Client: Aspect Consulting
Collection Date: 11/17/2021 11:30:00 AM
Project: Port of Tacoma Parcel 15
Lab ID: 2111398-006
Matrix: Soil
Client Sample ID: **AB-03-19**

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Total Metals by EPA Method 6020B				Batch ID: 34611		Analyst: EH
Arsenic	2.31	0.120		mg/Kg-dry	1	12/6/2021 8:47:33 PM
Sample Moisture (Percent Moisture)				Batch ID: R71540		Analyst: ALB
Percent Moisture	25.6	0.500		wt%	1	11/24/2021 10:08:03 AM

Analytical Report

Work Order: **2111398**
Date Reported: **12/7/2021**

Client: Aspect Consulting
Collection Date: 11/17/2021 11:35:00 AM
Project: Port of Tacoma Parcel 15
Lab ID: 2111398-007
Matrix: Soil
Client Sample ID: AB-03-23

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Total Metals by EPA Method 6020B				Batch ID: 34611		Analyst: EH
Arsenic	3.07	0.122		mg/Kg-dry	1	12/6/2021 8:53:07 PM
Sample Moisture (Percent Moisture)				Batch ID: R71540		Analyst: ALB
Percent Moisture	24.6	0.500		wt%	1	11/24/2021 10:08:03 AM

Analytical Report

Work Order: **2111398**
Date Reported: **12/7/2021**

Client: Aspect Consulting
Collection Date: 11/17/2021 11:40:00 AM
Project: Port of Tacoma Parcel 15
Lab ID: 2111398-008
Matrix: Soil
Client Sample ID: AB-03-25

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Total Metals by EPA Method 6020B				Batch ID: 34611		Analyst: EH
Arsenic	5.57	0.129		mg/Kg-dry	1	12/6/2021 8:58:41 PM
Sample Moisture (Percent Moisture)				Batch ID: R71540		Analyst: ALB
Percent Moisture	29.0	0.500		wt%	1	11/24/2021 10:08:03 AM

Analytical Report

Work Order: **2111398**
Date Reported: **12/7/2021**

Client: Aspect Consulting
Collection Date: 11/17/2021 12:40:00 PM
Project: Port of Tacoma Parcel 15
Lab ID: 2111398-009
Matrix: Soil
Client Sample ID: AB-02-17

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Total Metals by EPA Method 6020B				Batch ID: 34611		Analyst: EH
Arsenic	1.42	0.118		mg/Kg-dry	1	12/6/2021 9:04:14 PM
Sample Moisture (Percent Moisture)				Batch ID: R71540		Analyst: ALB
Percent Moisture	21.3	0.500		wt%	1	11/24/2021 10:08:03 AM

Analytical Report

Work Order: **2111398**
Date Reported: **12/7/2021**

Client: Aspect Consulting
Project: Port of Tacoma Parcel 15
Lab ID: 2111398-010
Client Sample ID: **AB-02-22**

Collection Date: 11/17/2021 12:45:00 PM
Matrix: Soil

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Total Metals by EPA Method 6020B				Batch ID: 34611		Analyst: EH
Arsenic	2.61	0.128		mg/Kg-dry	1	12/6/2021 9:09:48 PM
Sample Moisture (Percent Moisture)				Batch ID: R71540		Analyst: ALB
Percent Moisture	27.6	0.500		wt%	1	11/24/2021 10:08:03 AM

Analytical Report

Fremont Analytical

Work Order: **2111398**
Date Reported: **12/7/2021**

Client: Aspect Consulting
Collection Date: 11/17/2021 2:05:00 PM
Project: Port of Tacoma Parcel 15
Lab ID: 2111398-011
Matrix: Soil
Client Sample ID: **AB-01-15**

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Total Metals by EPA Method 6020B				Batch ID: 34611		Analyst: EH
Arsenic	68.1	0.111		mg/Kg-dry	1	12/6/2021 9:15:22 PM
Sample Moisture (Percent Moisture)				Batch ID: R71540		Analyst: ALB
Percent Moisture	15.1	0.500		wt%	1	11/24/2021 10:08:03 AM

Analytical Report

Work Order: **2111398**
Date Reported: **12/7/2021**

Client: Aspect Consulting
Project: Port of Tacoma Parcel 15
Lab ID: 2111398-012
Client Sample ID: **AB-01-21**

Collection Date: 11/17/2021 2:10:00 PM
Matrix: Soil

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Total Metals by EPA Method 6020B				Batch ID: 34611		Analyst: EH
Arsenic	11.4	0.112		mg/Kg-dry	1	12/6/2021 9:20:56 PM
Sample Moisture (Percent Moisture)				Batch ID: R71540		Analyst: ALB
Percent Moisture	14.8	0.500		wt%	1	11/24/2021 10:08:03 AM

Analytical Report

Fremont Analytical

Work Order: **2111398**
Date Reported: **12/7/2021**

Client: Aspect Consulting
Project: Port of Tacoma Parcel 15
Lab ID: 2111398-013
Client Sample ID: **AB4-14-111721**
Collection Date: 11/17/2021 3:15:00 PM
Matrix: Groundwater

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Ion Chromatography by EPA Method 300.0				Batch ID: 34514		Analyst: SS
Fluoride	1.14	0.320	D	mg/L	4	11/19/2021 1:13:00 PM
Chloride	63.6	5.00	D	mg/L	50	11/19/2021 1:36:00 PM
Bromide	ND	1.60	D	mg/L	4	11/19/2021 1:13:00 PM
Nitrate (as N)+Nitrite (as N)	ND	0.440	D	mg/L	4	11/19/2021 1:13:00 PM
Ortho-Phosphate (as P)	ND	2.10	D	mg/L	4	11/19/2021 1:13:00 PM
Sulfate	ND	2.40	D	mg/L	4	11/19/2021 1:13:00 PM
Dissolved Metals by EPA Method 200.8				Batch ID: 34564		Analyst: EH
Arsenic	27.9	1.00		µg/L	1	12/6/2021 1:24:58 PM
Total Metals by EPA Method 200.8				Batch ID: 34582		Analyst: EH
Arsenic	45.3	5.00	D	µg/L	5	12/1/2021 6:50:21 PM
Calcium	105,000	1,000	DE	µg/L	5	12/1/2021 6:50:21 PM
Iron	160,000	500	DE	µg/L	5	12/1/2021 6:50:21 PM
Magnesium	58,400	500	DE	µg/L	5	12/1/2021 6:50:21 PM
Manganese	3,790	25.0	DE	µg/L	5	12/1/2021 6:50:21 PM
Potassium	35,900	1,000	DE	µg/L	5	12/1/2021 6:50:21 PM
Sodium	150,000	1,000	DEQ	µg/L	5	12/1/2021 6:50:21 PM

NOTES:
Q - Associated calibration verification is above acceptance criteria (119%). Result may be high-biased.

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Total Organic Carbon by SM 5310C				Batch ID: R71554		Analyst: TN
Total Organic Carbon	66.0	2.00	D	mg/L	4	11/29/2021 12:50:00 PM
Total Alkalinity by SM 2320B				Batch ID: R71498		Analyst: CH
Alkalinity, Total (As CaCO3)	688	2.50		mg/L	1	11/23/2021 8:16:35 AM
Ferrous Iron by SM3500-Fe B				Batch ID: R71532		Analyst: SS
Ferrous Iron	187	50.0	D	mg/L	500	11/18/2021 1:55:00 PM

Analytical Report

Work Order: **2111398**
Date Reported: **12/7/2021**

Client: Aspect Consulting
Collection Date: 11/17/2021 3:45:00 PM
Project: Port of Tacoma Parcel 15
Lab ID: 2111398-014
Matrix: Groundwater
Client Sample ID: AB4-18-111721

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Ion Chromatography by EPA Method 300.0				Batch ID: 34514		Analyst: SS
Fluoride	1.18	0.800	D	mg/L	10	11/19/2021 12:27:00 PM
Chloride	232	20.0	D	mg/L	200	11/19/2021 3:08:00 PM
Bromide	ND	4.00	D	mg/L	10	11/19/2021 12:27:00 PM
Nitrate (as N)+Nitrite (as N)	ND	1.10	D	mg/L	10	11/19/2021 12:27:00 PM
Ortho-Phosphate (as P)	ND	5.25	D	mg/L	10	11/19/2021 12:27:00 PM
Sulfate	ND	6.00	D	mg/L	10	11/19/2021 12:27:00 PM
Dissolved Metals by EPA Method 200.8				Batch ID: 34564		Analyst: EH
Arsenic	39.3	1.00		µg/L	1	12/6/2021 1:27:18 PM
Total Metals by EPA Method 200.8				Batch ID: 34582		Analyst: EH
Arsenic	68.6	5.00	D	µg/L	5	12/1/2021 6:55:55 PM
Calcium	136,000	1,000	DE	µg/L	5	12/1/2021 6:55:55 PM
Iron	144,000	500	DE	µg/L	5	12/1/2021 6:55:55 PM
Magnesium	120,000	500	DE	µg/L	5	12/1/2021 6:55:55 PM
Manganese	7,220	25.0	DE	µg/L	5	12/1/2021 6:55:55 PM
Potassium	43,200	1,000	DE	µg/L	5	12/1/2021 6:55:55 PM
Sodium	307,000	1,000	DEQ	µg/L	5	12/1/2021 6:55:55 PM

NOTES:
Q - Associated calibration verification is above acceptance criteria (119%). Result may be high-biased.

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Total Organic Carbon by SM 5310C				Batch ID: R71554		Analyst: TN
Total Organic Carbon	87.7	2.00	D	mg/L	4	11/29/2021 1:13:00 PM
Total Alkalinity by SM 2320B				Batch ID: R71558		Analyst: CH
Alkalinity, Total (As CaCO3)	1,050	2.50		mg/L	1	11/29/2021 8:22:52 AM
Ferrous Iron by SM3500-Fe B				Batch ID: R71532		Analyst: SS
Ferrous Iron	151	12.5	D	mg/L	125	11/18/2021 1:55:00 PM

Work Order: 2111398
CLIENT: Aspect Consulting
Project: Port of Tacoma Parcel 15

QC SUMMARY REPORT

Total Alkalinity by SM 2320B

Sample ID: **MB-R71498** SampType: **MBLK** Units: **mg/L** Prep Date: **11/23/2021** RunNo: **71498**
Client ID: **MBLKW** Batch ID: **R71498** Analysis Date: **11/23/2021** SeqNo: **1456211**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Alkalinity, Total (As CaCO3)	ND	2.50									

Sample ID: **LCS-R71498** SampType: **LCS** Units: **mg/L** Prep Date: **11/23/2021** RunNo: **71498**
Client ID: **LCSW** Batch ID: **R71498** Analysis Date: **11/23/2021** SeqNo: **1456212**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Alkalinity, Total (As CaCO3)	110	2.50	100.0	0	110	88.3	113				

Sample ID: **2111395-001BDUP** SampType: **DUP** Units: **mg/L** Prep Date: **11/23/2021** RunNo: **71498**
Client ID: **BATCH** Batch ID: **R71498** Analysis Date: **11/23/2021** SeqNo: **1456214**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Alkalinity, Total (As CaCO3)	861	2.50						891.3	3.50	20	

Sample ID: **MB-R71558** SampType: **MBLK** Units: **mg/L** Prep Date: **11/29/2021** RunNo: **71558**
Client ID: **MBLKW** Batch ID: **R71558** Analysis Date: **11/29/2021** SeqNo: **1457543**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Alkalinity, Total (As CaCO3)	ND	2.50									

Sample ID: **LCS-R71558** SampType: **LCS** Units: **mg/L** Prep Date: **11/29/2021** RunNo: **71558**
Client ID: **LCSW** Batch ID: **R71558** Analysis Date: **11/29/2021** SeqNo: **1457544**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Alkalinity, Total (As CaCO3)	107	2.50	100.0	0	107	88.3	113				

Date: *12/7/2021*

Work Order: 2111398
CLIENT: Aspect Consulting
Project: Port of Tacoma Parcel 15

QC SUMMARY REPORT

Total Alkalinity by SM 2320B

Sample ID: **2111438-007CDUP** SampType: **DUP** Units: **mg/L** Prep Date: **11/29/2021** RunNo: **71558**
Client ID: **BATCH** Batch ID: **R71558** Analysis Date: **11/29/2021** SeqNo: **1457547**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Alkalinity, Total (As CaCO3)	590	2.50						607.8	2.90	20	

Date: *12/7/2021*

Work Order: 2111398
CLIENT: Aspect Consulting
Project: Port of Tacoma Parcel 15

QC SUMMARY REPORT

Ferrous Iron by SM3500-Fe B

Sample ID: **MB-R71532** SampType: **MBLK** Units: **mg/L** Prep Date: **11/18/2021** RunNo: **71532**
Client ID: **MBLKW** Batch ID: **R71532** Analysis Date: **11/18/2021** SeqNo: **1457098**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Ferrous Iron	ND	0.100									

Sample ID: **LCS-R71532** SampType: **LCS** Units: **mg/L** Prep Date: **11/18/2021** RunNo: **71532**
Client ID: **LCSW** Batch ID: **R71532** Analysis Date: **11/18/2021** SeqNo: **1457099**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Ferrous Iron	0.427	0.100	0.4000	0	107	85	115				

Sample ID: **2111398-013DDUP** SampType: **DUP** Units: **mg/L** Prep Date: **11/18/2021** RunNo: **71532**
Client ID: **AB4-14-111721** Batch ID: **R71532** Analysis Date: **11/18/2021** SeqNo: **1457101**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Ferrous Iron	189	50.0						187.5	0.871	20	D

Sample ID: **2111398-013DMS** SampType: **MS** Units: **mg/L** Prep Date: **11/18/2021** RunNo: **71532**
Client ID: **AB4-14-111721** Batch ID: **R71532** Analysis Date: **11/18/2021** SeqNo: **1457102**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Ferrous Iron	392	50.0	200.0	187.5	102	70	130				D

Sample ID: **2111398-013DMSD** SampType: **MSD** Units: **mg/L** Prep Date: **11/18/2021** RunNo: **71532**
Client ID: **AB4-14-111721** Batch ID: **R71532** Analysis Date: **11/18/2021** SeqNo: **1457103**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Ferrous Iron	379	50.0	200.0	187.5	95.9	70	130	392.4	3.40	20	D

Date: *12/7/2021*

Work Order: 2111398
CLIENT: Aspect Consulting
Project: Port of Tacoma Parcel 15

QC SUMMARY REPORT

Ion Chromatography by EPA Method 300.0

Sample ID: **MB-34514** SampType: **MBLK** Units: **mg/L** Prep Date: **11/19/2021** RunNo: **71484**
Client ID: **MBLKW** Batch ID: **34514** Analysis Date: **11/19/2021** SeqNo: **1455700**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Fluoride	ND	0.0800									
Chloride	ND	0.100									
Bromide	ND	0.400									
Nitrate (as N)+Nitrite (as N)	ND	0.110									
Ortho-Phosphate (as P)	ND	0.525									
Sulfate	ND	0.600									

Sample ID: **LCS-34514** SampType: **LCS** Units: **mg/L** Prep Date: **11/19/2021** RunNo: **71484**
Client ID: **LCSW** Batch ID: **34514** Analysis Date: **11/19/2021** SeqNo: **1455703**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Fluoride	0.476	0.0800	0.5000	0	95.2	90	110				
Chloride	0.715	0.100	0.7500	0	95.3	90	110				
Bromide	2.33	0.400	2.500	0	93.3	90	110				
Nitrate (as N)+Nitrite (as N)	1.41	0.110	1.500	0	94.1	90	110				
Ortho-Phosphate (as P)	1.37	0.525	1.250	0	110	90	110				
Sulfate	3.97	0.600	3.750	0	106	90	110				

Sample ID: **2111398-013CDUP** SampType: **DUP** Units: **mg/L** Prep Date: **11/19/2021** RunNo: **71484**
Client ID: **AB4-14-111721** Batch ID: **34514** Analysis Date: **11/19/2021** SeqNo: **1455706**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Fluoride	ND	4.00						0		20	D
Chloride	63.3	5.00						63.65	0.630	20	D
Bromide	ND	20.0						0		20	D
Nitrate (as N)+Nitrite (as N)	ND	5.50						0		20	D
Ortho-Phosphate (as P)	ND	26.2						0		20	D
Sulfate	ND	30.0						0		20	D

Date: *12/7/2021*

Work Order: 2111398
CLIENT: Aspect Consulting
Project: Port of Tacoma Parcel 15

QC SUMMARY REPORT

Ion Chromatography by EPA Method 300.0

Sample ID: **2111398-013CMS** SampType: **MS** Units: **mg/L** Prep Date: **11/19/2021** RunNo: **71484**
Client ID: **AB4-14-111721** Batch ID: **34514** Analysis Date: **11/19/2021** SeqNo: **1455707**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Fluoride	25.4	4.00	25.00	2.000	93.4	80	120				D
Chloride	102	5.00	37.50	63.65	102	80	120				D
Bromide	118	20.0	125.0	0	94.1	80	120				D
Nitrate (as N)+Nitrite (as N)	71.2	5.50	75.00	0	95.0	80	120				D
Ortho-Phosphate (as P)	63.8	26.2	62.50	0	102	80	120				D
Sulfate	202	30.0	187.5	0	108	80	120				D

Sample ID: **2111398-013CMSD** SampType: **MSD** Units: **mg/L** Prep Date: **11/19/2021** RunNo: **71484**
Client ID: **AB4-14-111721** Batch ID: **34514** Analysis Date: **11/19/2021** SeqNo: **1455708**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Fluoride	25.5	4.00	25.00	2.000	94.0	80	120	25.35	0.590	20	D
Chloride	103	5.00	37.50	63.65	104	80	120	102.0	0.733	20	D
Bromide	118	20.0	125.0	0	94.7	80	120	117.6	0.635	20	D
Nitrate (as N)+Nitrite (as N)	70.6	5.50	75.00	0	94.1	80	120	71.25	0.987	20	D
Ortho-Phosphate (as P)	77.6	26.2	62.50	0	124	80	120	63.75	19.6	20	DS
Sulfate	210	30.0	187.5	0	112	80	120	202.4	3.50	20	D

NOTES:
S - Outlying spike recovery(ies) observed. A duplicate analysis was performed and recovered within range.

Work Order: 2111398
CLIENT: Aspect Consulting
Project: Port of Tacoma Parcel 15

QC SUMMARY REPORT

Total Organic Carbon by SM 5310C

Sample ID: **MB-R71554** SampType: **MBLK** Units: **mg/L** Prep Date: **11/23/2021** RunNo: **71554**
Client ID: **MBLKW** Batch ID: **R71554** Analysis Date: **11/23/2021** SeqNo: **1457466**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Total Organic Carbon	ND	0.500									

Sample ID: **LCS-R71554** SampType: **LCS** Units: **mg/L** Prep Date: **11/23/2021** RunNo: **71554**
Client ID: **LCSW** Batch ID: **R71554** Analysis Date: **11/23/2021** SeqNo: **1457467**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Total Organic Carbon	5.07	0.500	5.000	0	101	93.1	106				

Sample ID: **2111389-001ADUP** SampType: **DUP** Units: **mg/L** Prep Date: **11/23/2021** RunNo: **71554**
Client ID: **BATCH** Batch ID: **R71554** Analysis Date: **11/23/2021** SeqNo: **1457475**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Total Organic Carbon	1.40	0.500						1.383	1.51	20	

Sample ID: **2111389-002AMS** SampType: **MS** Units: **mg/L** Prep Date: **11/24/2021** RunNo: **71554**
Client ID: **BATCH** Batch ID: **R71554** Analysis Date: **11/24/2021** SeqNo: **1457479**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Total Organic Carbon	8.61	0.500	5.000	3.606	100	69.1	124				

Sample ID: **2111389-002AMSD** SampType: **MSD** Units: **mg/L** Prep Date: **11/24/2021** RunNo: **71554**
Client ID: **BATCH** Batch ID: **R71554** Analysis Date: **11/24/2021** SeqNo: **1457480**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Total Organic Carbon	8.64	0.500	5.000	3.606	101	69.1	124	8.614	0.255	30	

Date: *12/7/2021*

Work Order: 2111398
CLIENT: Aspect Consulting
Project: Port of Tacoma Parcel 15

QC SUMMARY REPORT

Total Organic Carbon by SM 5310C

Sample ID: **2111438-006DDUP**	SampType: **DUP**			Units: **mg/L**		Prep Date: **11/24/2021**			RunNo: **71554**		
Client ID: **BATCH**	Batch ID: **R71554**					Analysis Date: **11/24/2021**			SeqNo: **1457492**		
Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Total Organic Carbon	20.5	0.500						20.94	1.98	20	

Sample ID: **2111438-006DMS**	SampType: **MS**			Units: **mg/L**		Prep Date: **11/24/2021**			RunNo: **71554**		
Client ID: **BATCH**	Batch ID: **R71554**					Analysis Date: **11/24/2021**			SeqNo: **1457493**		
Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Total Organic Carbon	25.4	0.500	5.000	20.94	88.7	69.1	124				

Date: *12/7/2021*

Work Order: 2111398
CLIENT: Aspect Consulting
Project: Port of Tacoma Parcel 15

QC SUMMARY REPORT

Dissolved Metals by EPA Method 200.8

Sample ID: **MB-34564** SampType: **MBLK** Units: **µg/L** Prep Date: **11/29/2021** RunNo: **71713**
Client ID: **MBLKW** Batch ID: **34564** Analysis Date: **12/3/2021** SeqNo: **1461811**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	ND	1.00									Q

NOTES:
Q - Initial calibration verification for this analyte exceeds acceptance criteria.

Sample ID: **LCS-34564** SampType: **LCS** Units: **µg/L** Prep Date: **11/29/2021** RunNo: **71713**
Client ID: **LCSW** Batch ID: **34564** Analysis Date: **12/3/2021** SeqNo: **1461812**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	112	1.00	100.0	0	112	85	115				

Sample ID: **2111296-002BDUP** SampType: **DUP** Units: **µg/L** Prep Date: **11/29/2021** RunNo: **71713**
Client ID: **BATCH** Batch ID: **34564** Analysis Date: **12/3/2021** SeqNo: **1461814**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	ND	1.00						0		30	Q

NOTES:
Q - Initial calibration verification for this analyte exceeds acceptance criteria.

Sample ID: **2111296-002BMS** SampType: **MS** Units: **µg/L** Prep Date: **11/29/2021** RunNo: **71713**
Client ID: **BATCH** Batch ID: **34564** Analysis Date: **12/3/2021** SeqNo: **1461815**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	556	1.00	500.0	0	111	70	130				

Sample ID: **2111296-002BMSD** SampType: **MSD** Units: **µg/L** Prep Date: **11/29/2021** RunNo: **71713**
Client ID: **BATCH** Batch ID: **34564** Analysis Date: **12/3/2021** SeqNo: **1461816**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	543	1.00	500.0	0	109	70	130	556.0	2.45	30	

Date: *12/7/2021*

Work Order: 2111398
CLIENT: Aspect Consulting
Project: Port of Tacoma Parcel 15

QC SUMMARY REPORT

Dissolved Metals by EPA Method 200.8

Sample ID: **MB-34563FB**	SampType: **MBLK**		Units: **µg/L**		Prep Date: **11/29/2021**			RunNo: **71713**			
Client ID: **MBLKW**	Batch ID: **34564**				Analysis Date: **12/3/2021**			SeqNo: **1461922**			
Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	ND	1.00									Q

NOTES:
Q - Initial calibration verification for this analyte exceeds acceptance criteria.

Work Order: 2111398
CLIENT: Aspect Consulting
Project: Port of Tacoma Parcel 15

QC SUMMARY REPORT

Total Metals by EPA Method 200.8

Sample ID: **MB-34582** SampType: **MBLK** Units: **µg/L** Prep Date: **11/30/2021** RunNo: **71642**
Client ID: **MBLKW** Batch ID: **34582** Analysis Date: **12/1/2021** SeqNo: **1459600**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	ND	1.00									
Iron	ND	100									
Magnesium	ND	100									
Manganese	ND	5.00									
Potassium	ND	200									
Sodium	ND	200									

Sample ID: **LCS-34582** SampType: **LCS** Units: **µg/L** Prep Date: **11/30/2021** RunNo: **71642**
Client ID: **LCSW** Batch ID: **34582** Analysis Date: **12/1/2021** SeqNo: **1459601**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	115	1.00	100.0	0	115	85	115				
Iron	1,060	100	1,000	0	106	85	115				
Magnesium	1,030	100	1,000	0	103	85	115				
Manganese	113	5.00	100.0	0	113	85	115				
Potassium	1,030	200	1,000	0	103	85	115				
Sodium	1,020	200	1,000	0	102	85	115				

Sample ID: **2111488-005ADUP** SampType: **DUP** Units: **µg/L** Prep Date: **11/30/2021** RunNo: **71642**
Client ID: **BATCH** Batch ID: **34582** Analysis Date: **12/1/2021** SeqNo: **1459605**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	ND	1.00						0		30	
Iron	619	100						620.2	0.262	30	
Magnesium	1,010	100						1,024	1.45	30	
Manganese	117	5.00						117.7	0.247	30	
Potassium	1,970	200						1,989	1.02	30	
Sodium	7,770	200						7,740	0.326	30	E

Work Order: 2111398
CLIENT: Aspect Consulting
Project: Port of Tacoma Parcel 15

QC SUMMARY REPORT

Total Metals by EPA Method 200.8

Sample ID: **2111488-005AMS** SampType: **MS** Units: **µg/L** Prep Date: **11/30/2021** RunNo: **71642**
Client ID: **BATCH** Batch ID: **34582** Analysis Date: **12/1/2021** SeqNo: **1459606**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	96.6	1.00	100.0	0.5304	96.1	70	130				
Iron	1,480	100	1,000	620.2	85.9	50	150				
Magnesium	2,010	100	1,000	1,024	99.0	70	130				
Manganese	210	5.00	100.0	117.7	92.6	70	130				
Potassium	2,810	200	1,000	1,989	81.6	50	150				
Sodium	8,730	200	1,000	7,740	98.6	50	150				E

Sample ID: **MB-34582** SampType: **MBLK** Units: **µg/L** Prep Date: **11/30/2021** RunNo: **71642**
Client ID: **MBLKW** Batch ID: **34582** Analysis Date: **12/1/2021** SeqNo: **1460322**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Calcium	ND	200									

Sample ID: **LCS-34582** SampType: **LCS** Units: **µg/L** Prep Date: **11/30/2021** RunNo: **71642**
Client ID: **LCSW** Batch ID: **34582** Analysis Date: **12/1/2021** SeqNo: **1460323**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Calcium	1,060	200	1,000	0	106	85	115				

Sample ID: **2111488-005ADUP** SampType: **DUP** Units: **µg/L** Prep Date: **11/30/2021** RunNo: **71642**
Client ID: **BATCH** Batch ID: **34582** Analysis Date: **12/1/2021** SeqNo: **1460324**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Calcium	17,500	200						17,600	0.290	30	EQ

Fremont Analytical

Date: *12/7/2021*

Work Order: 2111398
CLIENT: Aspect Consulting
Project: Port of Tacoma Parcel 15

QC SUMMARY REPORT

Total Metals by EPA Method 200.8

Sample ID: **2111488-005AMS** SampType: **MS** Units: **µg/L** Prep Date: **11/30/2021** RunNo: **71642**
Client ID: **BATCH** Batch ID: **34582** Analysis Date: **12/1/2021** SeqNo: **1460325**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Calcium	18,700	200	1,000	17,600	112	50	150				E

Fremont Analytical

Date: *12/7/2021*

Work Order: 2111398
CLIENT: Aspect Consulting
Project: Port of Tacoma Parcel 15

QC SUMMARY REPORT

Total Metals by EPA Method 6020B

Sample ID: **MB-34611** | SampType: **MBLK** | Units: **mg/Kg** | Prep Date: **12/2/2021** | RunNo: **71758**
Client ID: **MBLKS** | Batch ID: **34611** | Analysis Date: **12/6/2021** | SeqNo: **1462968**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	ND	0.0916									

Sample ID: **LCS-34611** | SampType: **LCS** | Units: **mg/Kg** | Prep Date: **12/2/2021** | RunNo: **71758**
Client ID: **LCSS** | Batch ID: **34611** | Analysis Date: **12/6/2021** | SeqNo: **1462969**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	39.2	0.0909	37.88	0	103	80	120				

Sample ID: **2111392-016AMS** | SampType: **MS** | Units: **mg/Kg-dry** | Prep Date: **12/2/2021** | RunNo: **71758**
Client ID: **BATCH** | Batch ID: **34611** | Analysis Date: **12/6/2021** | SeqNo: **1462976**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	48.9	0.107	44.41	1.775	106	75	125				

Sample ID: **2111392-016AMSD** | SampType: **MSD** | Units: **mg/Kg-dry** | Prep Date: **12/2/2021** | RunNo: **71758**
Client ID: **BATCH** | Batch ID: **34611** | Analysis Date: **12/6/2021** | SeqNo: **1462979**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	45.3	0.0994	41.40	1.775	105	75	125	48.87	7.68	20	

Sample Log-In Check List

Client Name:	**AC**	Work Order Number:	**2111398**
Logged by:	**Gabrielle Coeuille**	Date Received:	**11/17/2021 5:41:00 PM**

Chain of Custody

		Yes	No	
1.	Is Chain of Custody complete?	☑	☐	Not Present ☐
2.	How was the sample delivered?	Client		

Log In

		Yes	No	
3.	Coolers are present?	☑	☐	NA ☐
4.	Shipping container/cooler in good condition?	☑	☐	
5.	Custody Seals present on shipping container/cooler? (Refer to comments for Custody Seals not intact)	☐	☐	Not Present ☑
6.	Was an attempt made to cool the samples?	☑	☐	NA ☐
7.	Were all items received at a temperature of >2°C to 6°C *	☑	☐	NA ☐
8.	Sample(s) in proper container(s)?	☑	☐	
9.	Sufficient sample volume for indicated test(s)?	☑	☐	
10.	Are samples properly preserved?	☑	☐	
11.	Was preservative added to bottles?	☐	☑	NA ☐
12.	Is there headspace in the VOA vials?	☐	☐	NA ☑
13.	Did all samples containers arrive in good condition(unbroken)?	☑	☐	
14.	Does paperwork match bottle labels?	☑	☐	
15.	Are matrices correctly identified on Chain of Custody?	☑	☐	
16.	Is it clear what analyses were requested?	☑	☐	
17.	Were all holding times able to be met?	☑	☐	

Special Handling (if applicable)

		Yes	No	
18.	Was client notified of all discrepancies with this order?	☐	☐	NA ☑

Person Notified:		Date:	
By Whom:		Via:	☐ eMail ☐ Phone ☐ Fax ☐ In Person
Regarding:			
Client Instructions:			

19. Additional remarks:

Item Information

Item #	Temp ºC
Sample 1	4.7

* Note: DoD/ELAP and TNI require items to be received at 4°C +/- 2°C

Fremont Analytical	3600 Fremont Ave N. Seattle, WA 98103 Tel: 206-352-3790 Fax: 206-352-7178	

Chain of Custody Record & Laboratory Services Agreement

Date: 11/17/21 Page: 1 of: 2

Laboratory Project No (internal): 2111398

Project Name: Port of Tacoma Parcel 15

Special Remarks:

Client: Aspect Consulting

Project No: 210158

Address: 710 2nd Ave. Ste. 550

Collected by: Baxter Call

City, State, Zip: Seattle, WA, 98104

Location:

Telephone:

Report To (PM): Adam Griffin

Sample Disposal: ☐ Return to client ☐ Disposal by lab (after 30 days)

Fax:

PM Email: agriffin@aspectconsulting.com

	Sample Name	Sample Date	Sample Time	Sample Type (Matrix)*	# of Cont.	VOCs (EPA 8260 / 624)	BTEX	Gasoline Range Organics (GX)	Hydrocarbon Identification (HCID)	Diesel/Heavy Oil Range Organics (DX)	SVOCs (EPA 8270 / 625)	PAHs (EPA 8270 - SIM)	PCBs (EPA 8082 / 608)	Metals** (EPA 6020 / 200.8)	Total (T) / Dissolved (D)	Anions (IC)***	EDB (8011)	Arsenic				Comments
1	AB-05-17	11/17/21	0840	S	1													X				
2	AB-05-23		0845																			
3	AB-06-17		1007																			
4	AB-06-22		1009																			
5	AB-06-25		1010																			
6	AB-03-19		1130																			
7	AB-03-23		1135																			
8	AB-03-25		1140																			
9	AB-02-17		1240																			
10	AB-02-22		1245																			

*Matrix: A = Air, AQ = Aqueous, B = Bulk, O = Other, P = Product, S = Soil, SD = Sediment, SL = Solid, W = Water, DW = Drinking Water, GW = Ground Water, SW = Storm Water, WW = Waste Water

**Metals (Circle): MTCA-5 RCRA-8 Priority Pollutants TAL *Individual:* Ag Al As B Ba Be Ca Cd Co Cr Cu Fe Hg K Mg Mn Mo Na Ni Pb Sb Se Sr Sn Ti Tl V Zn

***Anions (Circle): Nitrate Nitrite Chloride Sulfate Bromide O-Phosphate Fluoride Nitrate+Nitrite

Turn-around Time:

☒ Standard ☐ Next Day

☐ 3 Day ☐ Same Day

☐ 2 Day ______ (specify)

I represent that I am authorized to enter into this Agreement with Fremont Analytical on behalf of the Client named above, that I have verified Client's agreement to each of the terms on the front and backside of this Agreement.

Relinquished (Signature)	Print Name	Date/Time	Received (Signature)	Print Name	Date/Time
x B Call	Baxter Call	11/17/21 1730	x Justine Martz	Justine Martz	11/17 17:41
Relinquished (Signature) x	Print Name	Date/Time	Received (Signature) x	Print Name	Date/Time

Fremont Analytical

3600 Fremont Ave N.
Seattle, WA 98103
Tel: 206-352-3790
Fax: 206-352-7178

Chain of Custody Record & Laboratory Services Agreement

Date: 11/17/21 Page: 2 of: 2

Laboratory Project No (internal): 2111398

Special Remarks:

Client: Aspect Consulting

Address:

City, State, Zip:

Telephone:

Fax:

Project Name:

Project No: 210158

Collected by: Baxter Call

Location:

Report To (PM):

PM Email:

Sample Disposal: ☐ Return to client ☐ Disposal by lab (after 30 days)

	Sample Name	Sample Date	Sample Time	Sample Type (Matrix)*	# of Cont.	VOCs (EPA 8260 / 624)	BTEX	Gasoline Range Organics (GX)	Hydrocarbon Identification (HCID)	Diesel/Heavy Oil Range Organics (DX)	SVOCs (EPA 8270 / 625)	PAHs (EPA 8270 - SIM)	PCBs (EPA 8082 / 608)	Metals** (EPA 6020 / 200.8) Total (T)	Dissolved (D)	Anions (IC)***	EDB (8011)	Arsenic	Alkalinity, TOC	Ferrous Fe		Comments
1	AB-01-15	11/17/21	1405	S	1													X				
2	AB-01-21	↓	1410	↓	↓									~~X~~ BC				↓				
3	ABY-14-111721	↓	1515	GW	5									X		X			X	X		Only dissolved analysis is As.
4	ABY-18-111721	↓	1545	↓	↓									X		X			X	X		" . Marked field filtered.
5																						
6																						
7																						
8																						
9																						
10																						

*Matrix: A = Air, AQ = Aqueous, B = Bulk, O = Other, P = Product, S = Soil, SD = Sediment, SL = Solid, W = Water, DW = Drinking Water, GW = Ground Water, SW = Storm Water, WW = Waste Water

**Metals (Circle): MTCA-5 RCRA-8 Priority Pollutants TAL *Individual:* Ag Al As B Ba Be Ca Cd Co Cr Cu Fe Hg K Mg Mn Mo Na Ni Pb Sb Se Sr Sn Ti Tl V Zn

***Anions (Circle): Nitrate Nitrite Chloride Sulfate Bromide O-Phosphate Fluoride Nitrate+Nitrite as N, and as P (ortho)

Turn-around Time: ☒ Standard ☐ Next Day ☐ 3 Day ☐ Same Day ☐ 2 Day ______ (specify)

I represent that I am authorized to enter into this Agreement with Fremont Analytical on behalf of the Client named above, that I have verified Client's agreement to each of the terms on the front and backside of this Agreement.

Relinquished (Signature)	Print Name	Date/Time	Received (Signature)	Print Name	Date/Time
x B Call	Baxter Call	11/17/21 1730	x Justine Mantz	Justine Mantz	11/17 17:41
x			x		

COC 1.3 - 11.06.20

www.fremontanalytical.com

3600 Fremont Ave. N.
Seattle, WA 98103
T: (206) 352-3790
F: (206) 352-7178
info@fremontanalytical.com

Aspect Consulting
Adam Griffin
710 2nd Ave, Suite 550
Seattle, WA 98104

RE: Port of Tacoma Parcel 15
Work Order Number: 2111422

December 07, 2021

Attention Adam Griffin:

Fremont Analytical, Inc. received 9 sample(s) on 11/19/2021 for the analyses presented in the following report.

Dissolved Metals by EPA Method 200.8
Ferrous Iron by SM3500-Fe B
Ion Chromatography by EPA Method 300.0
Total Metals by EPA Method 200.8
Total Alkalinity by SM 2320B
Total Organic Carbon by SM 5310C

This report consists of the following:

- Case Narrative
- Analytical Results
- Applicable Quality Control Summary Reports
- Chain of Custody

All analyses were performed consistent with the Quality Assurance program of Fremont Analytical, Inc. Please contact the laboratory if you should have any questions about the results.

Thank you for using Fremont Analytical.

Sincerely,

Brianna Barnes
Project Manager

DoD-ELAP Accreditation #79636 by PJLA, ISO/IEC 17025:2017 and QSM 5.3 for Environmental Testing
ORELAP Certification: WA 100009 (NELAP Recognized) for Environmental Testing
Washington State Department of Ecology Accredited for Environmental Testing, Lab ID C910

CLIENT:	Aspect Consulting
Project:	Port of Tacoma Parcel 15
Work Order:	2111422

Work Order Sample Summary

Lab Sample ID	Client Sample ID	Date/Time Collected	Date/Time Received
2111422-001	AB4-22-111821	11/18/2021 9:00 AM	11/19/2021 8:40 AM
2111422-001	AB4-22-111821	11/18/2021 9:00 AM	11/19/2021 8:40 AM
2111422-002	AB-5-14-111821	11/18/2021 10:45 AM	11/19/2021 8:40 AM
2111422-002	AB-5-14-111821	11/18/2021 10:45 AM	11/19/2021 8:40 AM
2111422-003	AB5-18-111821	11/18/2021 11:40 AM	11/19/2021 8:40 AM
2111422-003	AB5-18-111821	11/18/2021 11:40 AM	11/19/2021 8:40 AM
2111422-004	AB5-22-111821	11/18/2021 12:40 PM	11/19/2021 8:40 AM
2111422-004	AB5-22-111821	11/18/2021 12:40 PM	11/19/2021 8:40 AM
2111422-005	AB6-14-111821	11/18/2021 1:26 PM	11/19/2021 8:40 AM
2111422-005	AB6-14-111821	11/18/2021 1:26 PM	11/19/2021 8:40 AM
2111422-006	AB6-18-111821	11/18/2021 1:35 PM	11/19/2021 8:40 AM
2111422-006	AB6-18-111821	11/18/2021 1:35 PM	11/19/2021 8:40 AM
2111422-007	AB6-22-111821	11/18/2021 2:15 PM	11/19/2021 8:40 AM
2111422-007	AB6-22-111821	11/18/2021 2:15 PM	11/19/2021 8:40 AM
2111422-008	AB3-22-111821	11/18/2021 3:30 PM	11/19/2021 8:40 AM
2111422-008	AB3-22-111821	11/18/2021 3:30 PM	11/19/2021 8:40 AM
2111422-009	AB3-18-111821	11/18/2021 4:00 PM	11/19/2021 8:40 AM
2111422-009	AB3-18-111821	11/18/2021 4:00 PM	11/19/2021 8:40 AM

Note: If no "Time Collected" is supplied, a default of 12:00AM is assigned

CLIENT: Aspect Consulting

Project: Port of Tacoma Parcel 15

I. SAMPLE RECEIPT:
Samples receipt information is recorded on the attached Sample Receipt Checklist.

II. GENERAL REPORTING COMMENTS:
Results are reported on a wet weight basis unless dry-weight correction is denoted in the units field on the analytical report ("mg/kg-dry" or "ug/kg-dry").

Matrix Spike (MS) and MS Duplicate (MSD) samples are tested from an analytical batch of "like" matrix to check for possible matrix effect. The MS and MSD will provide site specific matrix data only for those samples which are spiked by the laboratory. The sample chosen for spike purposes may or may not have been a sample submitted in this sample delivery group. The validity of the analytical procedures for which data is reported in this analytical report is determined by the Laboratory Control Sample (LCS) and the Method Blank (MB). The LCS and the MB are processed with the samples and the MS/MSD to ensure method criteria are achieved throughout the entire analytical process.

III. ANALYSES AND EXCEPTIONS:
Exceptions associated with this report will be footnoted in the analytical results page(s) or the quality control summary page(s) and/or noted below.

Qualifiers:

* - Flagged value is not within established control limits
B - Analyte detected in the associated Method Blank
D - Dilution was required
E - Value above quantitation range
H - Holding times for preparation or analysis exceeded
I - Analyte with an internal standard that does not meet established acceptance criteria
J - Analyte detected below Reporting Limit
N - Tentatively Identified Compound (TIC)
Q - Analyte with an initial or continuing calibration that does not meet established acceptance criteria
S - Spike recovery outside accepted recovery limits
ND - Not detected at the Reporting Limit
R - High relative percent difference observed

Acronyms:

%Rec - Percent Recovery
CCB - Continued Calibration Blank
CCV - Continued Calibration Verification
DF - Dilution Factor
DUP - Sample Duplicate
HEM - Hexane Extractable Material
ICV - Initial Calibration Verification
LCS/LCSD - Laboratory Control Sample / Laboratory Control Sample Duplicate
MCL - Maximum Contaminant Level
MB or MBLANK - Method Blank
MDL - Method Detection Limit
MS/MSD - Matrix Spike / Matrix Spike Duplicate
PDS - Post Digestion Spike
Ref Val - Reference Value
REP - Sample Replicate
RL - Reporting Limit
RPD - Relative Percent Difference
SD - Serial Dilution
SGT - Silica Gel Treatment
SPK - Spike
Surr - Surrogate

Analytical Report

Fremont Analytical

Work Order: **2111422**
Date Reported: **12/7/2021**

CLIENT: Aspect Consulting
Project: Port of Tacoma Parcel 15

Lab ID: 2111422-001 **Collection Date:** 11/18/2021 9:00:00 AM
Client Sample ID: **AB4-22-111821** **Matrix:** Groundwater

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Ion Chromatography by EPA Method 300.0				Batch ID: 34518		Analyst: SS
Fluoride	1.22	0.800	D	mg/L	10	11/20/2021 2:42:00 AM
Chloride	225	1.00	ED	mg/L	10	11/20/2021 2:42:00 AM
Bromide	ND	4.00	DQ*	mg/L	10	11/20/2021 2:42:00 AM
Nitrate (as N)+Nitrite (as N)	ND	1.10	D	mg/L	10	11/20/2021 2:42:00 AM
Ortho-Phosphate (as P)	ND	5.25	D	mg/L	10	11/20/2021 2:42:00 AM
Sulfate	ND	6.00	D	mg/L	10	11/20/2021 2:42:00 AM

NOTES:
* - Associated LCS does not meet acceptance criteria; refer to QC summary.
Q - Associated calibration verification is below acceptance criteria. Result may be low-biased.

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Dissolved Metals by EPA Method 200.8				Batch ID: 34645		Analyst: EH
Arsenic	55.9	1.00		µg/L	1	12/7/2021 2:27:44 PM
Total Metals by EPA Method 200.8				Batch ID: 34560		Analyst: EH
Arsenic	83.6	2.00	D	µg/L	2	12/1/2021 11:09:06 AM
Calcium	142,000	10,000	DQ*	µg/L	50	12/3/2021 4:07:55 PM
Iron	177,000	5,000	D	µg/L	50	12/3/2021 4:07:55 PM
Magnesium	121,000	5,000	D	µg/L	50	12/3/2021 4:07:55 PM
Manganese	4,920	250	D	µg/L	50	12/3/2021 4:07:55 PM
Potassium	42,500	10,000	D	µg/L	50	12/3/2021 4:07:55 PM
Sodium	236,000	10,000	D	µg/L	50	12/3/2021 4:07:55 PM

NOTES:
* - Associated LCS does not meet acceptance criteria; refer to QC summary.
Q - Associated calibration verification is above acceptance criteria. Result may be high-biased.

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Total Organic Carbon by SM 5310C				Batch ID: R71660		Analyst: SS
Total Organic Carbon	93.2	2.00	D	mg/L	4	12/1/2021 10:16:00 AM
Total Alkalinity by SM 2320B				Batch ID: R71631		Analyst: CH
Alkalinity, Total (As CaCO3)	979	2.50		mg/L	1	12/1/2021 8:37:29 AM
Ferrous Iron by SM3500-Fe B				Batch ID: R71552		Analyst: SS
Ferrous Iron	166	12.5	DH	mg/L	125	11/19/2021 9:05:00 AM

Analytical Report

Work Order: **2111422**
Date Reported: **12/7/2021**

CLIENT: Aspect Consulting
Project: Port of Tacoma Parcel 15

Lab ID: 2111422-001 **Collection Date:** 11/18/2021 9:00:00 AM
Client Sample ID: **AB4-22-111821** **Matrix:** Groundwater

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Ion Chromatography by EPA Method 300.0				Batch ID: 34518		Analyst: SS
Fluoride	1.22	0.800	D	mg/L	10	11/20/2021 2:42:00 AM
Chloride	225	1.00	ED	mg/L	10	11/20/2021 2:42:00 AM
Bromide	ND	4.00	DQ*	mg/L	10	11/20/2021 2:42:00 AM
Nitrate (as N)+Nitrite (as N)	ND	1.10	D	mg/L	10	11/20/2021 2:42:00 AM
Ortho-Phosphate (as P)	ND	5.25	D	mg/L	10	11/20/2021 2:42:00 AM
Sulfate	ND	6.00	D	mg/L	10	11/20/2021 2:42:00 AM

NOTES:
* - Associated LCS does not meet acceptance criteria; refer to QC summary.
Q - Associated calibration verification is below acceptance criteria. Result may be low-biased.

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Dissolved Metals by EPA Method 200.8				Batch ID: 34645		Analyst: EH
Arsenic	55.9	1.00		µg/L	1	12/7/2021 2:27:44 PM
Total Metals by EPA Method 200.8				Batch ID: 34560		Analyst: EH
Arsenic	83.6	2.00	D	µg/L	2	12/1/2021 11:09:06 AM
Calcium	142,000	10,000	DQ*	µg/L	50	12/3/2021 4:07:55 PM
Iron	177,000	5,000	D	µg/L	50	12/3/2021 4:07:55 PM
Magnesium	121,000	5,000	D	µg/L	50	12/3/2021 4:07:55 PM
Manganese	4,920	250	D	µg/L	50	12/3/2021 4:07:55 PM
Potassium	42,500	10,000	D	µg/L	50	12/3/2021 4:07:55 PM
Sodium	236,000	10,000	D	µg/L	50	12/3/2021 4:07:55 PM

NOTES:
* - Associated LCS does not meet acceptance criteria; refer to QC summary.
Q - Associated calibration verification is above acceptance criteria. Result may be high-biased.

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Total Organic Carbon by SM 5310C				Batch ID: R71660		Analyst: SS
Total Organic Carbon	93.2	2.00	D	mg/L	4	12/1/2021 10:16:00 AM
Total Alkalinity by SM 2320B				Batch ID: R71631		Analyst: CH
Alkalinity, Total (As CaCO3)	979	2.50		mg/L	1	12/1/2021 8:37:29 AM
Ferrous Iron by SM3500-Fe B				Batch ID: R71552		Analyst: SS
Ferrous Iron	166	12.5	DH	mg/L	125	11/19/2021 9:05:00 AM

Analytical Report

Work Order: **2111422**
Date Reported: **12/7/2021**

CLIENT: Aspect Consulting
Project: Port of Tacoma Parcel 15

Lab ID: 2111422-002 | **Collection Date:** 11/18/2021 10:45:00 AM
Client Sample ID: **AB-5-14-111821** | **Matrix:** Groundwater

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Dissolved Metals by EPA Method 200.8				Batch ID: 34645		Analyst: EH
Arsenic	19.5	1.00		µg/L	1	12/7/2021 2:30:04 PM
Total Metals by EPA Method 200.8				Batch ID: 34560		Analyst: EH
Arsenic	29.5	2.00	D	µg/L	2	12/1/2021 11:11:27 AM

Lab ID: 2111422-002 | **Collection Date:** 11/18/2021 10:45:00 AM
Client Sample ID: **AB-5-14-111821** | **Matrix:** Groundwater

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Dissolved Metals by EPA Method 200.8				Batch ID: 34645		Analyst: EH
Arsenic	19.5	1.00		µg/L	1	12/7/2021 2:30:04 PM
Total Metals by EPA Method 200.8				Batch ID: 34560		Analyst: EH
Arsenic	29.5	2.00	D	µg/L	2	12/1/2021 11:11:27 AM

Lab ID: 2111422-003 | **Collection Date:** 11/18/2021 11:40:00 AM
Client Sample ID: **AB5-18-111821** | **Matrix:** Groundwater

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Dissolved Metals by EPA Method 200.8				Batch ID: 34645		Analyst: EH
Arsenic	12.6	1.00		µg/L	1	12/7/2021 2:51:38 PM
Total Metals by EPA Method 200.8				Batch ID: 34560		Analyst: EH
Arsenic	18.2	2.00	D	µg/L	2	12/1/2021 11:13:47 AM

Analytical Report

Work Order:	**2111422**
Date Reported:	**12/7/2021**

CLIENT: Aspect Consulting
Project: Port of Tacoma Parcel 15

Lab ID: 2111422-003 **Collection Date:** 11/18/2021 11:40:00 AM
Client Sample ID: **AB5-18-111821** **Matrix:** Groundwater

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Dissolved Metals by EPA Method 200.8				Batch ID: 34645		Analyst: EH
Arsenic	12.6	1.00		µg/L	1	12/7/2021 2:51:38 PM
Total Metals by EPA Method 200.8				Batch ID: 34560		Analyst: EH
Arsenic	18.2	2.00	D	µg/L	2	12/1/2021 11:13:47 AM

Lab ID: 2111422-004 **Collection Date:** 11/18/2021 12:40:00 PM
Client Sample ID: **AB5-22-111821** **Matrix:** Groundwater

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Dissolved Metals by EPA Method 200.8				Batch ID: 34645		Analyst: EH
Arsenic	1.36	1.00		µg/L	1	12/7/2021 2:53:59 PM
Total Metals by EPA Method 200.8				Batch ID: 34560		Analyst: EH
Arsenic	13.8	2.00	D	µg/L	2	12/1/2021 11:16:08 AM

Lab ID: 2111422-004 **Collection Date:** 11/18/2021 12:40:00 PM
Client Sample ID: **AB5-22-111821** **Matrix:** Groundwater

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Dissolved Metals by EPA Method 200.8				Batch ID: 34645		Analyst: EH
Arsenic	1.36	1.00		µg/L	1	12/7/2021 2:53:59 PM
Total Metals by EPA Method 200.8				Batch ID: 34560		Analyst: EH
Arsenic	13.8	2.00	D	µg/L	2	12/1/2021 11:16:08 AM

CLIENT: Aspect Consulting
Project: Port of Tacoma Parcel 15

Lab ID: 2111422-005 **Collection Date:** 11/18/2021 1:26:00 PM
Client Sample ID: **AB6-14-111821** **Matrix:** Groundwater

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Dissolved Metals by EPA Method 200.8				Batch ID: 34645		Analyst: EH
Arsenic	31.0	1.00		µg/L	1	12/7/2021 2:56:19 PM
Total Metals by EPA Method 200.8				Batch ID: 34560		Analyst: EH
Arsenic	47.0	2.00	D	µg/L	2	12/1/2021 11:18:28 AM

Lab ID: 2111422-005 **Collection Date:** 11/18/2021 1:26:00 PM
Client Sample ID: **AB6-14-111821** **Matrix:** Groundwater

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Dissolved Metals by EPA Method 200.8				Batch ID: 34645		Analyst: EH
Arsenic	31.0	1.00		µg/L	1	12/7/2021 2:56:19 PM
Total Metals by EPA Method 200.8				Batch ID: 34560		Analyst: EH
Arsenic	47.0	2.00	D	µg/L	2	12/1/2021 11:18:28 AM

Lab ID: 2111422-006 **Collection Date:** 11/18/2021 1:35:00 PM
Client Sample ID: **AB6-18-111821** **Matrix:** Groundwater

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Dissolved Metals by EPA Method 200.8				Batch ID: 34645		Analyst: EH
Arsenic	6.31	1.00		µg/L	1	12/7/2021 2:58:40 PM
Total Metals by EPA Method 200.8				Batch ID: 34560		Analyst: EH
Arsenic	10.8	2.00	D	µg/L	2	12/1/2021 11:20:49 AM

Analytical Report

Work Order: **2111422**
Date Reported: **12/7/2021**

CLIENT: Aspect Consulting
Project: Port of Tacoma Parcel 15

Lab ID: 2111422-006 **Collection Date:** 11/18/2021 1:35:00 PM
Client Sample ID: **AB6-18-111821** **Matrix:** Groundwater

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Dissolved Metals by EPA Method 200.8				Batch ID: 34645		Analyst: EH
Arsenic	6.31	1.00		µg/L	1	12/7/2021 2:58:40 PM
Total Metals by EPA Method 200.8				Batch ID: 34560		Analyst: EH
Arsenic	10.8	2.00	D	µg/L	2	12/1/2021 11:20:49 AM

Lab ID: 2111422-007 **Collection Date:** 11/18/2021 2:15:00 PM
Client Sample ID: **AB6-22-111821** **Matrix:** Groundwater

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Dissolved Metals by EPA Method 200.8				Batch ID: 34645		Analyst: EH
Arsenic	56.9	1.00		µg/L	1	12/7/2021 3:01:01 PM
Total Metals by EPA Method 200.8				Batch ID: 34560		Analyst: EH
Arsenic	68.9	2.00	D	µg/L	2	12/1/2021 11:23:09 AM

Lab ID: 2111422-007 **Collection Date:** 11/18/2021 2:15:00 PM
Client Sample ID: **AB6-22-111821** **Matrix:** Groundwater

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Dissolved Metals by EPA Method 200.8				Batch ID: 34645		Analyst: EH
Arsenic	56.9	1.00		µg/L	1	12/7/2021 3:01:01 PM
Total Metals by EPA Method 200.8				Batch ID: 34560		Analyst: EH
Arsenic	68.9	2.00	D	µg/L	2	12/1/2021 11:23:09 AM

CLIENT: Aspect Consulting
Project: Port of Tacoma Parcel 15

Lab ID: 2111422-008 **Collection Date:** 11/18/2021 3:30:00 PM
Client Sample ID: **AB3-22-111821** **Matrix:** Groundwater

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Dissolved Metals by EPA Method 200.8				Batch ID: 34645		Analyst: EH
Arsenic	4.38	1.00		µg/L	1	12/7/2021 3:03:21 PM
Total Metals by EPA Method 200.8				Batch ID: 34560		Analyst: EH
Arsenic	8.01	2.00	D	µg/L	2	12/1/2021 11:25:30 AM

Lab ID: 2111422-008 **Collection Date:** 11/18/2021 3:30:00 PM
Client Sample ID: **AB3-22-111821** **Matrix:** Groundwater

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Dissolved Metals by EPA Method 200.8				Batch ID: 34645		Analyst: EH
Arsenic	4.38	1.00		µg/L	1	12/7/2021 3:03:21 PM
Total Metals by EPA Method 200.8				Batch ID: 34560		Analyst: EH
Arsenic	8.01	2.00	D	µg/L	2	12/1/2021 11:25:30 AM

Lab ID: 2111422-009 **Collection Date:** 11/18/2021 4:00:00 PM
Client Sample ID: **AB3-18-111821** **Matrix:** Groundwater

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Dissolved Metals by EPA Method 200.8				Batch ID: 34645		Analyst: EH
Arsenic	16.1	1.00		µg/L	1	12/7/2021 3:05:42 PM
Total Metals by EPA Method 200.8				Batch ID: 34560		Analyst: EH
Arsenic	56.7	2.00	D	µg/L	2	12/1/2021 11:44:55 AM

Analytical Report

Fremont Analytical

Work Order: **2111422**
Date Reported: **12/7/2021**

CLIENT: Aspect Consulting
Project: Port of Tacoma Parcel 15

Lab ID: 2111422-009
Client Sample ID: **AB3-18-111821**

Collection Date: 11/18/2021 4:00:00 PM
Matrix: Groundwater

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Dissolved Metals by EPA Method 200.8				Batch ID: 34645		Analyst: EH
Arsenic	16.1	1.00		µg/L	1	12/7/2021 3:05:42 PM
Total Metals by EPA Method 200.8				Batch ID: 34560		Analyst: EH
Arsenic	56.7	2.00	D	µg/L	2	12/1/2021 11:44:55 AM

Date: *12/7/2021*

Work Order: 2111422
CLIENT: Aspect Consulting
Project: Port of Tacoma Parcel 15

QC SUMMARY REPORT
Total Alkalinity by SM 2320B

Sample ID: **MB-R71631** SampType: **MBLK** Units: **mg/L** Prep Date: **12/1/2021** RunNo: **71631**
Client ID: **MBLKW** Batch ID: **R71631** Analysis Date: **12/1/2021** SeqNo: **1459394**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Alkalinity, Total (As CaCO3)	ND	2.50									

Sample ID: **LCS-R71631** SampType: **LCS** Units: **mg/L** Prep Date: **12/1/2021** RunNo: **71631**
Client ID: **LCSW** Batch ID: **R71631** Analysis Date: **12/1/2021** SeqNo: **1459395**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Alkalinity, Total (As CaCO3)	108	2.50	100.0	0	108	88.3	113				

Sample ID: **2111438-004CDUP** SampType: **DUP** Units: **mg/L** Prep Date: **12/1/2021** RunNo: **71631**
Client ID: **BATCH** Batch ID: **R71631** Analysis Date: **12/1/2021** SeqNo: **1459742**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Alkalinity, Total (As CaCO3)	217	2.50						214.6	1.31	20	

Date: *12/7/2021*

Work Order: 2111422
CLIENT: Aspect Consulting
Project: Port of Tacoma Parcel 15

QC SUMMARY REPORT
Ferrous Iron by SM3500-Fe B

Sample ID: **MB-R71552** SampType: **MBLK** Units: **mg/L** Prep Date: **11/19/2021** RunNo: **71552**
Client ID: **MBLKW** Batch ID: **R71552** Analysis Date: **11/19/2021** SeqNo: **1457409**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Ferrous Iron	ND	0.100									

Sample ID: **LCS-R71552** SampType: **LCS** Units: **mg/L** Prep Date: **11/19/2021** RunNo: **71552**
Client ID: **LCSW** Batch ID: **R71552** Analysis Date: **11/19/2021** SeqNo: **1457410**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Ferrous Iron	0.424	0.100	0.4000	0	106	85	115				

Sample ID: **2111422-001EDUP** SampType: **DUP** Units: **mg/L** Prep Date: **11/19/2021** RunNo: **71552**
Client ID: **AB4-22-111821** Batch ID: **R71552** Analysis Date: **11/19/2021** SeqNo: **1457412**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Ferrous Iron	172	12.5						166.1	3.40	20	DH

Sample ID: **2111422-001EMS** SampType: **MS** Units: **mg/L** Prep Date: **11/19/2021** RunNo: **71552**
Client ID: **AB4-22-111821** Batch ID: **R71552** Analysis Date: **11/19/2021** SeqNo: **1457413**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Ferrous Iron	226	12.5	50.00	166.1	121	70	130				DH

Sample ID: **2111422-001EMSD** SampType: **MSD** Units: **mg/L** Prep Date: **11/19/2021** RunNo: **71552**
Client ID: **AB4-22-111821** Batch ID: **R71552** Analysis Date: **11/19/2021** SeqNo: **1457414**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Ferrous Iron	223	12.5	50.00	166.1	114	70	130	226.4	1.46	20	DH

Date: *12/7/2021*

Work Order: 2111422
CLIENT: Aspect Consulting
Project: Port of Tacoma Parcel 15

QC SUMMARY REPORT

Ion Chromatography by EPA Method 300.0

Sample ID: **LCS-34518** SampType: **LCS** Units: **mg/L** Prep Date: **11/19/2021** RunNo: **71553**
Client ID: **LCSW** Batch ID: **34518** Analysis Date: **11/19/2021** SeqNo: **1457428**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Fluoride	0.467	0.0800	0.5000	0	93.4	90	110				
Chloride	0.703	0.100	0.7500	0	93.7	90	110				
Bromide	2.16	0.400	2.500	0	86.3	90	110				S
Nitrate (as N)+Nitrite (as N)	1.32	0.110	1.375	0	96.4	90	110				
Ortho-Phosphate (as P)	1.42	0.525	1.250	0	114	90	110				S
Sulfate	3.85	0.600	3.750	0	103	90	110				

NOTES:
S - Outlying spike recovery observed (high bias) for Phosphorus, Total Orthophosphate (As PO4). Detections will be qualified with a *.
S - Outlying spike recovery observed (low bias) for Bromide. Samples will be qualified with a *.

Sample ID: **MB-34518** SampType: **MBLK** Units: **mg/L** Prep Date: **11/19/2021** RunNo: **71553**
Client ID: **MBLKW** Batch ID: **34518** Analysis Date: **11/20/2021** SeqNo: **1457429**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Fluoride	ND	0.0800									
Chloride	ND	0.100									
Bromide	ND	0.400									Q*
Nitrate (as N)+Nitrite (as N)	ND	0.110									
Ortho-Phosphate (as P)	ND	0.525									
Sulfate	ND	0.600									

NOTES:
* - Associated LCS does not meet acceptance criteria; refer to QC summary.
Q - Associated calibration verification is below acceptance criteria. Result may be low-biased.

Sample ID: **2111224-001EDUP** SampType: **DUP** Units: **mg/L** Prep Date: **11/19/2021** RunNo: **71553**
Client ID: **BATCH** Batch ID: **34518** Analysis Date: **11/20/2021** SeqNo: **1457432**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Fluoride	ND	0.800						0		20	D
Chloride	19.0	1.00						19.06	0.315	20	D
Bromide	ND	4.00						0		20	DQ*

Date: *12/7/2021*

Work Order: 2111422
CLIENT: Aspect Consulting
Project: Port of Tacoma Parcel 15

QC SUMMARY REPORT

Ion Chromatography by EPA Method 300.0

Sample ID: **2111224-001EDUP** SampType: **DUP** Units: **mg/L** Prep Date: **11/19/2021** RunNo: **71553**
Client ID: **BATCH** Batch ID: **34518** Analysis Date: **11/20/2021** SeqNo: **1457432**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Nitrate (as N)+Nitrite (as N)	ND	1.10						0		20	D
Ortho-Phosphate (as P)	ND	5.25						0		20	DH
Sulfate	ND	6.00						0		20	D

NOTES:
* - Associated LCS does not meet acceptance criteria; refer to QC summary.
Q - Associated calibration verification is below acceptance criteria. Result may be low-biased.

Sample ID: **2111224-001EMS** SampType: **MS** Units: **mg/L** Prep Date: **11/19/2021** RunNo: **71553**
Client ID: **BATCH** Batch ID: **34518** Analysis Date: **11/20/2021** SeqNo: **1457433**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Fluoride	4.81	0.800	5.000	0.3200	89.8	80	120				D
Chloride	26.8	1.00	7.500	19.06	103	80	120				D
Bromide	21.6	4.00	25.00	0	86.6	80	120				D
Nitrate (as N)+Nitrite (as N)	14.2	1.10	15.00	0	94.9	80	120				D
Ortho-Phosphate (as P)	13.4	5.25	12.50	0	107	80	120				DH
Sulfate	38.7	6.00	37.50	0	103	80	120				D

Sample ID: **2111224-001EMSD** SampType: **MSD** Units: **mg/L** Prep Date: **11/19/2021** RunNo: **71553**
Client ID: **BATCH** Batch ID: **34518** Analysis Date: **11/20/2021** SeqNo: **1457434**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Fluoride	4.81	0.800	5.000	0.3200	89.8	80	120	4.810	0	20	D
Chloride	26.9	1.00	7.500	19.06	104	80	120	26.77	0.336	20	D
Bromide	21.7	4.00	25.00	0	86.9	80	120	21.65	0.323	20	D
Nitrate (as N)+Nitrite (as N)	14.4	1.10	15.00	0	95.8	80	120	14.24	0.909	20	D
Ortho-Phosphate (as P)	14.8	5.25	12.50	0	119	80	120	13.38	10.4	20	DH
Sulfate	38.7	6.00	37.50	0	103	80	120	38.69	0.103	20	D

Fremont Analytical

Date: *12/7/2021*

Work Order: 2111422
CLIENT: Aspect Consulting
Project: Port of Tacoma Parcel 15

QC SUMMARY REPORT

Ion Chromatography by EPA Method 300.0

Sample ID: **2111426-012ADUP** SampType: **DUP** Units: **mg/L** Prep Date: **11/19/2021** RunNo: **71553**
Client ID: **BATCH** Batch ID: **34518** Analysis Date: **11/20/2021** SeqNo: **1457459**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Fluoride	ND	0.400						0		20	D
Chloride	26.9	0.500						27.15	0.776	20	EDQ
Bromide	ND	2.00						0		20	DQ*
Nitrate (as N)+Nitrite (as N)	ND	0.550						0		20	D
Ortho-Phosphate (as P)	ND	2.62						0		20	D
Sulfate	79.4	3.00						79.81	0.547	20	ED

NOTES:
* - Associated LCS does not meet acceptance criteria; refer to QC summary.
Q - Associated calibration verification is below acceptance criteria. Result may be low-biased.

Sample ID: **2111426-012AMS** SampType: **MS** Units: **mg/L** Prep Date: **11/19/2021** RunNo: **71553**
Client ID: **BATCH** Batch ID: **34518** Analysis Date: **11/20/2021** SeqNo: **1457435**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Fluoride	2.38	0.400	2.500	0.1500	89.2	80	120				D
Chloride	30.9	0.500	3.750	27.15	101	80	120				DE
Bromide	11.0	2.00	12.50	0	88.0	80	120				D
Nitrate (as N)+Nitrite (as N)	7.30	0.550	7.500	0	97.4	80	120				D
Ortho-Phosphate (as P)	5.96	2.62	6.250	0	95.4	80	120				D
Sulfate	103	3.00	18.75	79.81	126	80	120				DES

NOTES:
S - Analyte concentration was too high for accurate spike recovery(ies).

Fremont Analytical

Date: *12/7/2021*

Work Order: 2111422
CLIENT: Aspect Consulting
Project: Port of Tacoma Parcel 15

QC SUMMARY REPORT

Total Organic Carbon by SM 5310C

Sample ID: **MB-R71660** SampType: **MBLK** Units: **mg/L** Prep Date: **11/30/2021** RunNo: **71660**
Client ID: **MBLKW** Batch ID: **R71660** Analysis Date: **11/30/2021** SeqNo: **1460088**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Total Organic Carbon	ND	0.500									

Sample ID: **LCS-R71660** SampType: **LCS** Units: **mg/L** Prep Date: **11/30/2021** RunNo: **71660**
Client ID: **LCSW** Batch ID: **R71660** Analysis Date: **11/30/2021** SeqNo: **1460070**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Total Organic Carbon	5.16	0.500	5.000	0	103	93.1	106				

Sample ID: **2111422-001DDUP** SampType: **DUP** Units: **mg/L** Prep Date: **11/30/2021** RunNo: **71660**
Client ID: **AB4-22-111821** Batch ID: **R71660** Analysis Date: **11/30/2021** SeqNo: **1460072**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Total Organic Carbon	99.5	0.500						99.81	0.333	20	E

Sample ID: **2111422-001DMS** SampType: **MS** Units: **mg/L** Prep Date: **11/30/2021** RunNo: **71660**
Client ID: **AB4-22-111821** Batch ID: **R71660** Analysis Date: **11/30/2021** SeqNo: **1460073**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Total Organic Carbon	103	0.500	5.000	99.81	59.7	69.1	124				ES

NOTES:
S - Analyte concentration was too high for accurate spike recovery(ies).

Sample ID: **2111422-001DMSD** SampType: **MSD** Units: **mg/L** Prep Date: **11/30/2021** RunNo: **71660**
Client ID: **AB4-22-111821** Batch ID: **R71660** Analysis Date: **11/30/2021** SeqNo: **1460074**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Total Organic Carbon	103	0.500	5.000	99.81	67.6	69.1	124	102.8	0.386	30	ES

NOTES:
S - Analyte concentration was too high for accurate spike recovery(ies).

Date: *12/7/2021*

Work Order: 2111422
CLIENT: Aspect Consulting
Project: Port of Tacoma Parcel 15

QC SUMMARY REPORT

Dissolved Metals by EPA Method 200.8

Sample ID: **MB-34645** SampType: **MBLK** Units: **µg/L** Prep Date: **12/6/2021** RunNo: **71782**
Client ID: **MBLKW** Batch ID: **34645** Analysis Date: **12/7/2021** SeqNo: **1463529**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	ND	1.00									

Sample ID: **LCS-34645** SampType: **LCS** Units: **µg/L** Prep Date: **12/6/2021** RunNo: **71782**
Client ID: **LCSW** Batch ID: **34645** Analysis Date: **12/7/2021** SeqNo: **1463530**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	489	1.00	500.0	0	97.9	85	115				

Sample ID: **2111399-009DDUP** SampType: **DUP** Units: **µg/L** Prep Date: **12/6/2021** RunNo: **71782**
Client ID: **BATCH** Batch ID: **34645** Analysis Date: **12/7/2021** SeqNo: **1463532**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	2.22	1.00						1.974	11.7	30	

Sample ID: **2111399-009DMS** SampType: **MS** Units: **µg/L** Prep Date: **12/6/2021** RunNo: **71782**
Client ID: **BATCH** Batch ID: **34645** Analysis Date: **12/7/2021** SeqNo: **1463535**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	487	1.00	500.0	1.974	96.9	70	130				

Sample ID: **MB-34645FB** SampType: **MBLK** Units: **µg/L** Prep Date: **12/6/2021** RunNo: **71782**
Client ID: **MBLKW** Batch ID: **34645** Analysis Date: **12/7/2021** SeqNo: **1463555**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	ND	1.00									

NOTES:
Filter Blank

Fremont Analytical

Date: *12/7/2021*

Work Order: 2111422
CLIENT: Aspect Consulting
Project: Port of Tacoma Parcel 15

QC SUMMARY REPORT

Total Metals by EPA Method 200.8

Sample ID: **MB-34560** SampType: **MBLK** Units: **µg/L** Prep Date: **11/29/2021** RunNo: **71597**
Client ID: **MBLKW** Batch ID: **34560** Analysis Date: **11/30/2021** SeqNo: **1458454**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	ND	1.00									

Sample ID: **LCS-34560** SampType: **LCS** Units: **µg/L** Prep Date: **11/29/2021** RunNo: **71597**
Client ID: **LCSW** Batch ID: **34560** Analysis Date: **11/30/2021** SeqNo: **1458455**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	103	1.00	100.0	0	103	85	115				

Sample ID: **2111402-003BDUP** SampType: **DUP** Units: **µg/L** Prep Date: **11/29/2021** RunNo: **71597**
Client ID: **BATCH** Batch ID: **34560** Analysis Date: **11/30/2021** SeqNo: **1458457**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	ND	1.00						0		30	

Sample ID: **2111402-003BMS** SampType: **MS** Units: **µg/L** Prep Date: **11/29/2021** RunNo: **71597**
Client ID: **BATCH** Batch ID: **34560** Analysis Date: **11/30/2021** SeqNo: **1458462**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	109	5.00	100.0	0.5514	108	70	130				D

Sample ID: **MB-34560** SampType: **MBLK** Units: **µg/L** Prep Date: **11/29/2021** RunNo: **71597**
Client ID: **MBLKW** Batch ID: **34560** Analysis Date: **12/3/2021** SeqNo: **1462189**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Calcium	ND	200									
Iron	ND	100									
Magnesium	ND	100									
Manganese	ND	5.00									

Fremont Analytical

Date: *12/7/2021*

Work Order: 2111422
CLIENT: Aspect Consulting
Project: Port of Tacoma Parcel 15

QC SUMMARY REPORT

Total Metals by EPA Method 200.8

Sample ID: **MB-34560** SampType: **MBLK** Units: **µg/L** Prep Date: **11/29/2021** RunNo: **71597**
Client ID: **MBLKW** Batch ID: **34560** Analysis Date: **12/3/2021** SeqNo: **1462189**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Potassium	ND	200									
Sodium	ND	200									

Sample ID: **LCS-34560** SampType: **LCS** Units: **µg/L** Prep Date: **11/29/2021** RunNo: **71597**
Client ID: **LCSW** Batch ID: **34560** Analysis Date: **12/3/2021** SeqNo: **1462190**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Calcium	1,170	200	1,000	0	117	85	115				S
Iron	1,050	100	1,000	0	105	85	115				
Magnesium	1,010	100	1,000	0	101	85	115				
Manganese	106	5.00	100.0	0	106	85	115				
Potassium	1,040	200	1,000	0	104	85	115				
Sodium	1,010	200	1,000	0	101	85	115				

NOTES:
S - Outlying spike recovery observed (high bias). Detections will be qualified with a *.

Sample Log-In Check List

Client Name:	**AC**	Work Order Number:	**2111422**
Logged by:	**Gabrielle Coeuille**	Date Received:	**11/19/2021 8:40:00 AM**

Chain of Custody

1.	Is Chain of Custody complete?	Yes ☑	No ☐	Not Present ☐
2.	How was the sample delivered?	Client		

Log In

3.	Coolers are present?	Yes ☑	No ☐	NA ☐
4.	Shipping container/cooler in good condition?	Yes ☑	No ☐	
5.	Custody Seals present on shipping container/cooler? (Refer to comments for Custody Seals not intact)	Yes ☐	No ☐	Not Present ☑
6.	Was an attempt made to cool the samples?	Yes ☑	No ☐	NA ☐
7.	Were all items received at a temperature of >2°C to 6°C *	Yes ☑	No ☐	NA ☐
8.	Sample(s) in proper container(s)?	Yes ☑	No ☐	
9.	Sufficient sample volume for indicated test(s)?	Yes ☑	No ☐	
10.	Are samples properly preserved?	Yes ☑	No ☐	
11.	Was preservative added to bottles?	Yes ☑	No ☐	NA ☐ HNO3
12.	Is there headspace in the VOA vials?	Yes ☐	No ☐	NA ☑
13.	Did all samples containers arrive in good condition(unbroken)?	Yes ☑	No ☐	
14.	Does paperwork match bottle labels?	Yes ☑	No ☐	
15.	Are matrices correctly identified on Chain of Custody?	Yes ☑	No ☐	
16.	Is it clear what analyses were requested?	Yes ☑	No ☐	
17.	Were all holding times able to be met?	Yes ☐	No ☑	

Special Handling (if applicable)

18.	Was client notified of all discrepancies with this order?	Yes ☐	No ☐	NA ☑

Person Notified:		Date:	
By Whom:		Via:	☐ eMail ☐ Phone ☐ Fax ☐ In Person
Regarding:			
Client Instructions:			

19. Additional remarks:

Ferrous Iron - 24 hr Hold Time.

Item Information

Item #	Temp ºC
Sample 1	1.3

* Note: DoD/ELAP and TNI require items to be received at 4°C +/- 2°C

Original

Fremont Analytical

3600 Fremont Ave N.
Seattle, WA 98103
Tel: 206-352-3790
Fax: 206-352-7178

Chain of Custody Record & Laboratory Services Agreement

Date: 11/18/21 Page: 1 of: 1

Laboratory Project No (internal): 2111422

Project Name: Port of Tacoma Parcel 15

Special Remarks:

Client: Aspect Consulting

Project No: 210158

Address: 710 2nd Ave, Ste. 550

Collected by: Baxter Call

City, State, Zip: Seattle, WA, 98104

Location:

Telephone:

Report To (PM): Adam Griffin

Sample Disposal: ☐ Return to client ☐ Disposal by lab (after 30 days)

Fax:

PM Email: agriffin@aspectconsulting.com

	Sample Name	Sample Date	Sample Time	Sample Type (Matrix)*	# of Cont.	VOCs (EPA 8260 / 624)	BTEX	Gasoline Range Organics (GX)	Hydrocarbon Identification (HCID)	Diesel/Heavy Oil Range Organics (DX)	SVOCs (EPA 8270 / 625)	PAHs (EPA 8270 - SIM)	PCBs (EPA 8082 / 608)	Metals** (EPA 6020 / 200.8) Total (T) Dissolved (D)	Anions (IC)***	EDB (8011)	Alkalinity	TOC	Ferrous Fe	Total & Dissolved As	Comments
1	AB4-22-111821	11/18/21	0900	GW	5									X	X		X	X	X		Only dissolved analysis is As
2	AB-5-14-111821		1045		2															X	Marked Field Filtered
3	AB5-18-111821		1140																		
4	AB5-22-111821		1240																		
5	AB6-14-111821		1320																		
6	AB6-18-111821		1335																		
7	AB6-22-111821		1415																		
8	AB3-22-111821		1530																		Min volume sampled.
9	AB3-18-111821		1600																		
10																					

*Matrix: A = Air, AQ = Aqueous, B = Bulk, O = Other, P = Product, S = Soil, SD = Sediment, SL = Solid, W = Water, DW = Drinking Water, GW = Ground Water, SW = Storm Water, WW = Waste Water

**Metals (Circle): MTCA-5 RCRA-8 Priority Pollutants TAL Individual: Ag Al As B Ba Be Ca Cd Co Cr Cu Fe Hg K Mg Mn Mo Na Ni Pb Sb Se Sr Sn Ti Tl V Zn

***Anions (Circle): Nitrate Nitrite Chloride Sulfate Bromide O-Phosphate Fluoride Nitrate+Nitrite ***as P ***as N

Turn-around Time: ☒ Standard ☐ Next Day ☐ 3 Day ☐ Same Day ☐ 2 Day ____ (specify)

I represent that I am authorized to enter into this Agreement with Fremont Analytical on behalf of the Client named above, that I have verified Client's agreement to each of the terms on the front and backside of this Agreement.

Relinquished (Signature)	Print Name	Date/Time	Received (Signature)	Print Name	Date/Time
x B Call	Baxter Call	11/18/21 2000	x Justine Martz	Justine Martz	11/19 8:40
Relinquished (Signature) x	Print Name	Date/Time	Received (Signature) x	Print Name	Date/Time

COC 1.3 - 11.06.20

www.fremontanalytical.com

Fremont Analytical

3600 Fremont Ave. N.
Seattle, WA 98103
T: (206) 352-3790
F: (206) 352-7178
info@fremontanalytical.com

Aspect Consulting
Adam Griffin
710 2nd Ave, Suite 550
Seattle, WA 98104

RE: Port of Tacoma Parcel 15
Work Order Number: 2111428

Attention Adam Griffin:

Fremont Analytical, Inc. received 3 sample(s) on 11/19/2021 for the analyses presented in the following report.

Grain Size by ASTM D422

This report consists of the following:

- Case Narrative
- Analytical Results
- Applicable Quality Control Summary Reports
- Chain of Custody

All analyses were performed consistent with the Quality Assurance program of Fremont Analytical, Inc. Please contact the laboratory if you should have any questions about the results.

Thank you for using Fremont Analytical.

Sincerely,

Brianna Barnes
Project Manager

DoD-ELAP Accreditation #79636 by PJLA, ISO/IEC 17025:2017 and QSM 5.3 for Environmental Testing
ORELAP Certification: WA 100009 (NELAP Recognized) for Environmental Testing
Washington State Department of Ecology Accredited for Environmental Testing, Lab ID C910

Date: *11/30/2021*

CLIENT:	Aspect Consulting
Project:	Port of Tacoma Parcel 15
Work Order:	2111428

Work Order Sample Summary

Lab Sample ID	Client Sample ID	Date/Time Collected	Date/Time Received
2111428-001	AB-03-16.5	11/18/2021 4:00 PM	11/19/2021 8:40 AM
2111428-002	AB-03-20	11/18/2021 4:05 PM	11/19/2021 8:40 AM
2111428-003	AB-03-22	11/18/2021 4:10 PM	11/19/2021 8:40 AM

Note: If no "Time Collected" is supplied, a default of 12:00AM is assigned

CLIENT: Aspect Consulting
Project: Port of Tacoma Parcel 15

I. SAMPLE RECEIPT:
Samples receipt information is recorded on the attached Sample Receipt Checklist.

II. GENERAL REPORTING COMMENTS:
Results are reported on a wet weight basis unless dry-weight correction is denoted in the units field on the analytical report ("mg/kg-dry" or "ug/kg-dry"). Grain Size is report as Percent Finer and Percent Retained.

III. ANALYSES AND EXCEPTIONS:
Exceptions associated with this report will be footnoted in the analytical results page(s) or the quality control summary page(s) and/or noted below.

Qualifiers:

* - Flagged value is not within established control limits
B - Analyte detected in the associated Method Blank
D - Dilution was required
E - Value above quantitation range
H - Holding times for preparation or analysis exceeded
I - Analyte with an internal standard that does not meet established acceptance criteria
J - Analyte detected below Reporting Limit
N - Tentatively Identified Compound (TIC)
Q - Analyte with an initial or continuing calibration that does not meet established acceptance criteria
S - Spike recovery outside accepted recovery limits
ND - Not detected at the Reporting Limit
R - High relative percent difference observed

Acronyms:

%Rec - Percent Recovery
CCB - Continued Calibration Blank
CCV - Continued Calibration Verification
DF - Dilution Factor
DUP - Sample Duplicate
HEM - Hexane Extractable Material
ICV - Initial Calibration Verification
LCS/LCSD - Laboratory Control Sample / Laboratory Control Sample Duplicate
MCL - Maximum Contaminant Level
MB or MBLANK - Method Blank
MDL - Method Detection Limit
MS/MSD - Matrix Spike / Matrix Spike Duplicate
PDS - Post Digestion Spike
Ref Val - Reference Value
REP - Sample Replicate
RL - Reporting Limit
RPD - Relative Percent Difference
SD - Serial Dilution
SGT - Silica Gel Treatment
SPK - Spike
Surr - Surrogate

3600 Fremont Ave. N
Seattle, WA 98103
Tel: 206-352-3790
Fax: 206-352-7178
Email: info@fremontanalytical.com

Grain Size by ASTM D422

Project:	**Port of Tacoma Parcel 15**
Client:	**Aspect Consulting**
Lab Project #:	**2111428**

Percent Finer (Passing) than the Indicated Size

UOM = Percent

Grain Size Classification	*Gravel*						*Coarse Sand*	*Medium Sand*		*Fine Sand*			*Silt*		
Sieve Size	**3"**	**2"**	**1 1/2"**	**1"**	**3/4"**	**3/8"**	**#4**	**#10**	**#20**	**#40**	**#60**	**#140**	**#200**	**#325**	**#450**
Particle Size (Microns)	**76200**	**50800**	**38100**	**25400**	**19050**	**9525**	**4750**	**2000**	**850**	**425**	**250**	**106**	**75**	**45**	**34**
Sample ID															
AB-03-16.5	100%	100%	100%	100%	100%	100%	99.7%	98.1%	96.5%	94.5%	92.6%	53.8%	34.6%	17.7%	4.89%
AB-03-20	100%	100%	100%	100%	100%	97.9%	95.0%	92.4%	89.6%	84.0%	78.5%	47.1%	30.1%	14.8%	5.01%
AB-03-22	100%	100%	100%	100%	100%	100%	100%	100.0%	99.9%	99.4%	98.1%	70.3%	41.4%	16.5%	5.93%

Fremont Analytical
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Grain Size by ASTM D422

Project:	Port of Tacoma Parcel 15
Client:	Aspect Consulting
Lab Project #:	2111428

Percent Retained in Each Size Fraction

UOM = Percent

Grain Size Classification	*Gravel*							*Coarse Sand*	*Medium Sand*		*Fine Sand*			*Silt*		
Sieves Size	3"	2"	1 1/2"	1"	3/4"	3/8"	#4	#10	#20	#40	#60	#140	#200	#325	#450	
Particle Size (Microns)	>76200	76200-50800	50800-38100	38100-25400	25400-19000	19050-9525	9525-4750	4750-2000	2000-850	850-425	425-250	250-106	106-75	75-45	45-34	<34
Sample ID																
AB-03-16.5	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.341%	1.60%	1.59%	1.93%	1.89%	38.9%	19.1%	16.9%	12.9%	4.89%
AB-03-20	0.00%	0.00%	0.00%	0.00%	0.00%	2.11%	2.88%	2.63%	2.76%	5.59%	5.55%	31.4%	17.1%	15.3%	9.80%	5.01%
AB-03-22	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.0474%	0.0719%	0.510%	1.24%	27.8%	29.0%	24.9%	10.6%	5.93%

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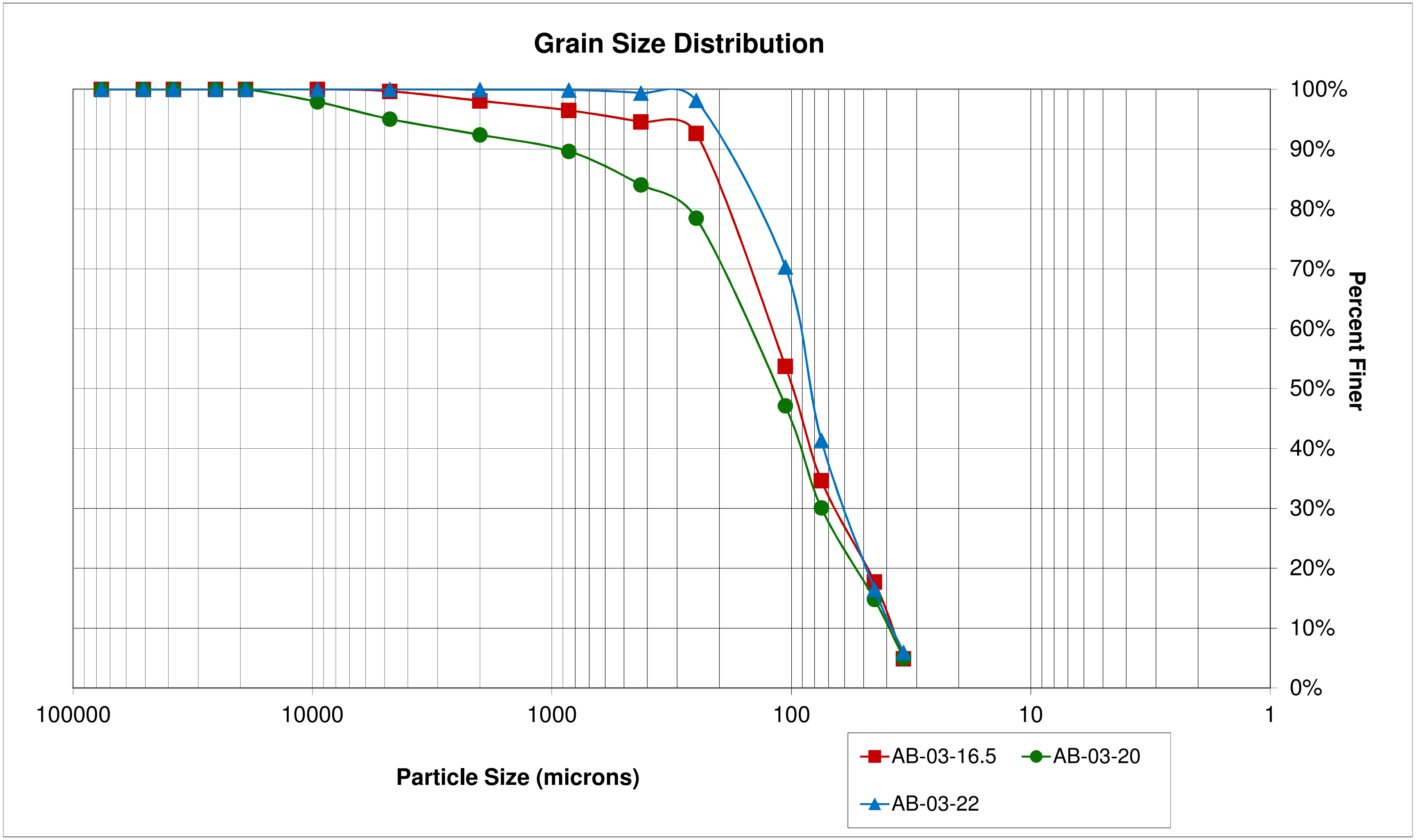
Grain Size by ASTM D422

Project: Port of Tacoma Parcel 15
Client: Aspect Consulting
Lab Project #: 2111428



Fremont Analytical

Sample Log-In Check List

Client Name:	**AC**	Work Order Number:	**2111428**
Logged by:	**Gabrielle Coeuille**	Date Received:	**11/19/2021 8:40:00 AM**

Chain of Custody

1.	Is Chain of Custody complete?	Yes ☑	No ☐	Not Present ☐
2.	How was the sample delivered?	Client		

Log In

3.	Coolers are present?	Yes ☑	No ☐	NA ☐
4.	Shipping container/cooler in good condition?	Yes ☑	No ☐	
5.	Custody Seals present on shipping container/cooler? (Refer to comments for Custody Seals not intact)	Yes ☐	No ☐	Not Present ☑
6.	Was an attempt made to cool the samples?	Yes ☑	No ☐	NA ☐
7.	Were all items received at a temperature of >2°C to 6°C *	Yes ☑	No ☐	NA ☐
8.	Sample(s) in proper container(s)?	Yes ☑	No ☐	
9.	Sufficient sample volume for indicated test(s)?	Yes ☑	No ☐	
10.	Are samples properly preserved?	Yes ☑	No ☐	
11.	Was preservative added to bottles?	Yes ☐	No ☑	NA ☐
12.	Is there headspace in the VOA vials?	Yes ☐	No ☐	NA ☑
13.	Did all samples containers arrive in good condition(unbroken)?	Yes ☑	No ☐	
14.	Does paperwork match bottle labels?	Yes ☑	No ☐	
15.	Are matrices correctly identified on Chain of Custody?	Yes ☑	No ☐	
16.	Is it clear what analyses were requested?	Yes ☑	No ☐	
17.	Were all holding times able to be met?	Yes ☑	No ☐	

Special Handling (if applicable)

18.	Was client notified of all discrepancies with this order?	Yes ☐	No ☐	NA ☑

Person Notified:		Date:	
By Whom:		Via:	☐ eMail ☐ Phone ☐ Fax ☐ In Person
Regarding:			
Client Instructions:			

19. Additional remarks:

Item Information

Item #	Temp ºC
Sample 1	1.3

* Note: DoD/ELAP and TNI require items to be received at 4°C +/- 2°C

Fremont Analytical

3600 Fremont Ave N.
Seattle, WA 98103
Tel: 206-352-3790
Fax: 206-352-7178

Chain of Custody Record & Laboratory Services Agreement

Date: 11/18/21 Page: 1 of: 1

Laboratory Project No (internal): 2111424

Project Name: Port of Tacoma Parcel 15

Special Remarks:

Client: Aspect Consulting

Project No: 210158

Address: 710 2nd Ave Ste. 550

Collected by: Baxter Call

City, State, Zip: Seattle, WA, 98104

Location:

Telephone:

Report To (PM): Adam Griffin

Sample Disposal: ☐ Return to client ☐ Disposal by lab (after 30 days)

Fax:

PM Email: agriffin@aspectconsulting.com

	Sample Name	Sample Date	Sample Time	Sample Type (Matrix)*	# of Cont.	VOCs (EPA 8260 / 624)	BTEX	Gasoline Range Organics (GX)	Hydrocarbon Identification (HCID)	Diesel/Heavy Oil Range Organics (DX)	SVOCs (EPA 8270 / 625)	PAHs (EPA 8270 - SIM)	PCBs (EPA 8082 / 608)	Metals** (EPA 6020 / 200.8)	Total (T) / Dissolved (D)	Anions (IC)***	EDB (8011)	Grain Size				Comments
1	AB-03-16.5	11/18/21	1600	S	1													X				By ASTM D422
2	AB-03-20	↓	1605	↓	↓													↓				↓
3	AB-03-22		1610																			
4																						
5																						
6																						
7																						
8																						
9																						
10																						

*Matrix: A = Air, AQ = Aqueous, B = Bulk, O = Other, P = Product, S = Soil, SD = Sediment, SL = Solid, W = Water, DW = Drinking Water, GW = Ground Water, SW = Storm Water, WW = Waste Water

**Metals (Circle): MTCA-5 RCRA-8 Priority Pollutants TAL *Individual:* Ag Al As B Ba Be Ca Cd Co Cr Cu Fe Hg K Mg Mn Mo Na Ni Pb Sb Se Sr Sn Ti Tl V Zn

***Anions (Circle): Nitrate Nitrite Chloride Sulfate Bromide O-Phosphate Fluoride Nitrate+Nitrite

Turn-around Time:
☒ Standard ☐ Next Day
☐ 3 Day ☐ Same Day
☐ 2 Day ______ (specify)

I represent that I am authorized to enter into this Agreement with Fremont Analytical on behalf of the Client named above, that I have verified Client's agreement to each of the terms on the front and backside of this Agreement.

Relinquished (Signature)	Print Name	Date/Time	Received (Signature)	Print Name	Date/Time
x B Call	Baxter Call	11/18/21 2000	x Justine Mantz	Justine Mantz	11/19 8:40
x			x		

www.fremontanalytical.com

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Aspect Consulting
Adam Griffin
710 2nd Ave, Suite 550
Seattle, WA 98104

RE: Port of Tacoma Parcel 15
Work Order Number: 2111438

December 14, 2021

Attention Adam Griffin:

Fremont Analytical, Inc. received 7 sample(s) on 11/19/2021 for the analyses presented in the following report.

Dissolved Metals by EPA Method 200.8
Ferrous Iron by SM3500-Fe B
Ion Chromatography by EPA Method 300.0
Total Metals by EPA Method 200.8
Total Alkalinity by SM 2320B
Total Organic Carbon by SM 5310C

This report consists of the following:

- Case Narrative
- Analytical Results
- Applicable Quality Control Summary Reports
- Chain of Custody

All analyses were performed consistent with the Quality Assurance program of Fremont Analytical, Inc. Please contact the laboratory if you should have any questions about the results.

Thank you for using Fremont Analytical.

Sincerely,

Brianna Barnes
Project Manager

DoD-ELAP Accreditation #79636 by PJLA, ISO/IEC 17025:2017 and QSM 5.3 for Environmental Testing
ORELAP Certification: WA 100009 (NELAP Recognized) for Environmental Testing
Washington State Department of Ecology Accredited for Environmental Testing, Lab ID C910

CLIENT:	Aspect Consulting
Project:	Port of Tacoma Parcel 15
Work Order:	2111438

Work Order Sample Summary

Lab Sample ID	Client Sample ID	Date/Time Collected	Date/Time Received
2111438-001	AB2-18-111921	11/19/2021 8:40 AM	11/19/2021 3:42 PM
2111438-001	AB2-18-111921	11/19/2021 8:40 AM	11/19/2021 3:42 PM
2111438-002	AB2-22-111921	11/19/2021 8:50 AM	11/19/2021 3:42 PM
2111438-003	AB2-14-111921	11/19/2021 9:25 AM	11/19/2021 3:42 PM
2111438-003	AB2-14-111921	11/19/2021 9:25 AM	11/19/2021 3:42 PM
2111438-004	AB1-18-111921	11/19/2021 10:55 AM	11/19/2021 3:42 PM
2111438-004	AB1-18-111921	11/19/2021 10:55 AM	11/19/2021 3:42 PM
2111438-005	AB1-14-111921	11/19/2021 11:50 AM	11/19/2021 3:42 PM
2111438-005	AB1-14-111921	11/19/2021 11:50 AM	11/19/2021 3:42 PM
2111438-006	AB1-22-111921	11/19/2021 11:20 AM	11/19/2021 3:42 PM
2111438-006	AB1-22-111921	11/19/2021 11:20 AM	11/19/2021 3:42 PM
2111438-007	MW-14-111921	11/19/2021 1:10 PM	11/19/2021 3:42 PM
2111438-007	MW-14-111921	11/19/2021 1:10 PM	11/19/2021 3:42 PM

Note: If no "Time Collected" is supplied, a default of 12:00AM is assigned

Case Narrative

WO#: **2111438**
Date: **12/14/2021**

CLIENT: Aspect Consulting
Project: Port of Tacoma Parcel 15

I. SAMPLE RECEIPT:
Samples receipt information is recorded on the attached Sample Receipt Checklist.

II. GENERAL REPORTING COMMENTS:
Results are reported on a wet weight basis unless dry-weight correction is denoted in the units field on the analytical report ("mg/kg-dry" or "ug/kg-dry").

Matrix Spike (MS) and MS Duplicate (MSD) samples are tested from an analytical batch of "like" matrix to check for possible matrix effect. The MS and MSD will provide site specific matrix data only for those samples which are spiked by the laboratory. The sample chosen for spike purposes may or may not have been a sample submitted in this sample delivery group. The validity of the analytical procedures for which data is reported in this analytical report is determined by the Laboratory Control Sample (LCS) and the Method Blank (MB). The LCS and the MB are processed with the samples and the MS/MSD to ensure method criteria are achieved throughout the entire analytical process.

III. ANALYSES AND EXCEPTIONS:
Exceptions associated with this report will be footnoted in the analytical results page(s) or the quality control summary page(s) and/or noted below.

2111438-007B
M-200.8-D has been Sub Contracted.
2111438-007F
TEST_SUB has been Sub Contracted.

12/14/2021: Revision 1 reports Arsenic detections below the reporting limit for AB1-18-111921.

Qualifiers:

* - Flagged value is not within established control limits
B - Analyte detected in the associated Method Blank
D - Dilution was required
E - Value above quantitation range
H - Holding times for preparation or analysis exceeded
I - Analyte with an internal standard that does not meet established acceptance criteria
J - Analyte detected below Reporting Limit
N - Tentatively Identified Compound (TIC)
Q - Analyte with an initial or continuing calibration that does not meet established acceptance criteria
S - Spike recovery outside accepted recovery limits
ND - Not detected at the Reporting Limit
R - High relative percent difference observed

Acronyms:

%Rec - Percent Recovery
CCB - Continued Calibration Blank
CCV - Continued Calibration Verification
DF - Dilution Factor
DUP - Sample Duplicate
HEM - Hexane Extractable Material
ICV - Initial Calibration Verification
LCS/LCSD - Laboratory Control Sample / Laboratory Control Sample Duplicate
MCL - Maximum Contaminant Level
MB or MBLANK - Method Blank
MDL - Method Detection Limit
MS/MSD - Matrix Spike / Matrix Spike Duplicate
PDS - Post Digestion Spike
Ref Val - Reference Value
REP - Sample Replicate
RL - Reporting Limit
RPD - Relative Percent Difference
SD - Serial Dilution
SGT - Silica Gel Treatment
SPK - Spike
Surr - Surrogate

Analytical Report

Work Order: **2111438**
Date Reported: **12/14/2021**

Client: Aspect Consulting
Project: Port of Tacoma Parcel 15
Lab ID: 2111438-001
Client Sample ID: **AB2-18-111921**
Collection Date: 11/19/2021 8:40:00 AM
Matrix: Groundwater

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Dissolved Metals by EPA Method 200.8				Batch ID: 34657		Analyst: EH
Arsenic	3.91	1.00		µg/L	1	12/8/2021 12:17:04 PM
Total Metals by EPA Method 200.8				Batch ID: 34525		Analyst: EH
Arsenic	20.4	5.00	D	µg/L	5	11/30/2021 4:33:10 PM

Analytical Report

Work Order: **2111438**
Date Reported: **12/14/2021**

Client: Aspect Consulting
Project: Port of Tacoma Parcel 15
Lab ID: 2111438-002
Client Sample ID: **AB2-22-111921**

Collection Date: 11/19/2021 8:50:00 AM
Matrix: Groundwater

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Dissolved Metals by EPA Method 200.8				Batch ID: 34657		Analyst: EH
Arsenic	20.1	1.00		µg/L	1	12/8/2021 12:19:25 PM
Total Metals by EPA Method 200.8				Batch ID: 34525		Analyst: EH
Arsenic	138	5.00	D	µg/L	5	11/30/2021 4:35:30 PM

Fremont Analytical

Analytical Report

Work Order: **2111438**
Date Reported: **12/14/2021**

Client: Aspect Consulting
Collection Date: 11/19/2021 9:25:00 AM
Project: Port of Tacoma Parcel 15
Lab ID: 2111438-003
Matrix: Groundwater
Client Sample ID: AB2-14-111921

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Dissolved Metals by EPA Method 200.8				Batch ID: 34657		Analyst: EH
Arsenic	5.13	1.00		µg/L	1	12/8/2021 12:21:46 PM
Total Metals by EPA Method 200.8				Batch ID: 34525		Analyst: EH
Arsenic	28.8	5.00	D	µg/L	5	11/30/2021 4:37:51 PM

Analytical Report

Work Order: **2111438**
Date Reported: **12/14/2021**

Client: Aspect Consulting
Project: Port of Tacoma Parcel 15
Lab ID: 2111438-004
Client Sample ID: **AB1-18-111921**

Collection Date: 11/19/2021 10:55:00 AM
Matrix: Groundwater

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Ion Chromatography by EPA Method 300.0				Batch ID: 34519		Analyst: SS
Fluoride	0.510	0.400	D	mg/L	5	11/20/2021 5:20:00 PM
Chloride	330	20.0	D	mg/L	200	12/13/2021 4:45:00 PM
Bromide	ND	8.00	D	mg/L	20	12/13/2021 4:22:00 PM
Nitrate (as N)+Nitrite (as N)	ND	0.550	D	mg/L	5	11/20/2021 5:20:00 PM
Ortho-Phosphate (as P)	ND	2.62	D	mg/L	5	11/20/2021 5:20:00 PM
Sulfate	40.6	12.0	D	mg/L	20	12/13/2021 4:22:00 PM
Dissolved Metals by EPA Method 200.8				Batch ID: 34657		Analyst: EH
Arsenic	1.99	1.00		µg/L	1	12/8/2021 12:24:06 PM
Total Metals by EPA Method 200.8				Batch ID: 34525		Analyst: EH
Arsenic	2.07	5.00	JD	µg/L	5	11/30/2021 4:40:12 PM
Calcium	ND	20,000	D	µg/L	100	12/1/2021 5:15:36 PM
Iron	23,600	500	D	µg/L	5	11/30/2021 4:40:12 PM
Magnesium	25,000	10,000	D	µg/L	100	12/1/2021 5:15:36 PM
Manganese	595	25.0	D	µg/L	5	11/30/2021 4:40:12 PM
Potassium	13,500	1,000	D	µg/L	5	11/30/2021 4:40:12 PM
Sodium	287,000	20,000	D	µg/L	100	12/1/2021 5:15:36 PM
Total Organic Carbon by SM 5310C				Batch ID: R71554		Analyst: TN
Total Organic Carbon	11.5	0.500		mg/L	1	11/24/2021 5:14:00 AM
Total Alkalinity by SM 2320B				Batch ID: R71631		Analyst: CH
Alkalinity, Total (As CaCO3)	215	2.50		mg/L	1	12/1/2021 8:37:29 AM
Ferrous Iron by SM3500-Fe B				Batch ID: R71552		Analyst: SS
Ferrous Iron	3.79	0.500	D	mg/L	5	11/19/2021 5:30:00 PM

Analytical Report

Work Order: **2111438**
Date Reported: **12/14/2021**

Client: Aspect Consulting
Project: Port of Tacoma Parcel 15
Lab ID: 2111438-005
Client Sample ID: AB1-14-111921

Collection Date: 11/19/2021 11:50:00 AM
Matrix: Groundwater

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Ion Chromatography by EPA Method 300.0				Batch ID: 34519		Analyst: SS
Fluoride	0.700	0.400	D	mg/L	5	11/20/2021 5:43:00 PM
Chloride	3,250	200	D	mg/L	2000	12/13/2021 5:31:00 PM
Bromide	ND	80.0	D	mg/L	200	12/13/2021 5:08:00 PM
Nitrate (as N)+Nitrite (as N)	ND	0.550	D	mg/L	5	11/20/2021 5:43:00 PM
Ortho-Phosphate (as P)	ND	2.62	D	mg/L	5	11/20/2021 5:43:00 PM
Sulfate	566	120	D	mg/L	200	12/13/2021 5:08:00 PM
Dissolved Metals by EPA Method 200.8				Batch ID: 34657		Analyst: EH
Arsenic	3.07	1.00		µg/L	1	12/8/2021 12:35:03 PM
Total Metals by EPA Method 200.8				Batch ID: 34525		Analyst: EH
Arsenic	9.82	5.00	D	µg/L	5	11/30/2021 4:42:32 PM
Calcium	58,600	20,000	D	µg/L	100	12/1/2021 5:21:10 PM
Iron	4,010	500	D	µg/L	5	11/30/2021 4:42:32 PM
Magnesium	168,000	10,000	D	µg/L	100	12/1/2021 5:21:10 PM
Manganese	124	25.0	D	µg/L	5	11/30/2021 4:42:32 PM
Potassium	97,000	20,000	D	µg/L	100	12/1/2021 5:21:10 PM
Sodium	2,420,000	20,000	DE	µg/L	100	12/1/2021 5:21:10 PM
Total Organic Carbon by SM 5310C				Batch ID: R71554		Analyst: TN
Total Organic Carbon	2.77	0.500		mg/L	1	11/24/2021 5:38:00 AM
Total Alkalinity by SM 2320B				Batch ID: R71631		Analyst: CH
Alkalinity, Total (As CaCO3)	170	2.50		mg/L	1	12/1/2021 8:37:29 AM
Ferrous Iron by SM3500-Fe B				Batch ID: R71552		Analyst: SS
Ferrous Iron	26.0	12.5	D	mg/L	125	11/19/2021 5:30:00 PM

Analytical Report

Fremont Analytical

Work Order: **2111438**
Date Reported: **12/14/2021**

Client: Aspect Consulting
Collection Date: 11/19/2021 11:20:00 AM
Project: Port of Tacoma Parcel 15
Lab ID: 2111438-006
Matrix: Groundwater
Client Sample ID: **AB1-22-111921**

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Ion Chromatography by EPA Method 300.0				Batch ID: 34519		Analyst: SS
Fluoride	0.665	0.400	D	mg/L	5	11/20/2021 6:06:00 PM
Chloride	22.4	1.00	D	mg/L	10	12/13/2021 6:17:00 PM
Bromide	ND	0.400		mg/L	1	12/13/2021 5:54:00 PM
Nitrate (as N)+Nitrite (as N)	ND	0.550	D	mg/L	5	11/20/2021 6:06:00 PM
Ortho-Phosphate (as P)	ND	2.62	D	mg/L	5	11/20/2021 6:06:00 PM
Sulfate	3.42	0.600		mg/L	1	12/13/2021 5:54:00 PM
Dissolved Metals by EPA Method 200.8				Batch ID: 34657		Analyst: EH
Arsenic	14.2	1.00		µg/L	1	12/8/2021 12:37:24 PM
Total Metals by EPA Method 200.8				Batch ID: 34525		Analyst: EH
Arsenic	28.3	5.00	D	µg/L	5	11/30/2021 4:49:36 PM
Calcium	36,900	20,000	D	µg/L	100	12/1/2021 5:26:44 PM
Iron	36,500	10,000	D	µg/L	100	12/1/2021 5:26:44 PM
Magnesium	26,700	10,000	D	µg/L	100	12/1/2021 5:26:44 PM
Manganese	3,490	500	DQ	µg/L	100	12/1/2021 5:26:44 PM
Potassium	13,500	1,000	D	µg/L	5	11/30/2021 4:49:36 PM
Sodium	73,900	20,000	D	µg/L	100	12/1/2021 5:26:44 PM

NOTES:
Q - Associated calibration verification is above acceptance criteria (116%). Result may be high-biased.

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Total Organic Carbon by SM 5310C				Batch ID: R71554		Analyst: TN
Total Organic Carbon	20.9	0.500		mg/L	1	11/24/2021 6:01:00 AM
Total Alkalinity by SM 2320B				Batch ID: R71631		Analyst: CH
Alkalinity, Total (As CaCO3)	321	2.50		mg/L	1	12/1/2021 8:37:29 AM
Ferrous Iron by SM3500-Fe B				Batch ID: R71552		Analyst: SS
Ferrous Iron	30.5	12.5	D	mg/L	125	11/19/2021 5:30:00 PM

Analytical Report

Work Order: **2111438**
Date Reported: **12/14/2021**

Client: Aspect Consulting
Project: Port of Tacoma Parcel 15
Lab ID: 2111438-007
Client Sample ID: **MW-14-111921**
Collection Date: 11/19/2021 1:10:00 PM
Matrix: Groundwater

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Ion Chromatography by EPA Method 300.0				Batch ID: 34519		Analyst: SS
Fluoride	1.44	0.400	D	mg/L	5	11/20/2021 11:56:00 AM
Chloride	36.2	2.00	D	mg/L	20	12/13/2021 7:03:00 PM
Bromide	0.986	0.800	D	mg/L	2	12/13/2021 6:40:00 PM
Nitrate (as N)+Nitrite (as N)	ND	0.550	D	mg/L	5	11/20/2021 11:56:00 AM
Ortho-Phosphate (as P)	ND	2.62	D	mg/L	5	11/20/2021 11:56:00 AM
Sulfate	15.9	1.20	D	mg/L	2	12/13/2021 6:40:00 PM
Total Metals by EPA Method 200.8				Batch ID: 34525		Analyst: EH
Calcium	76,700	20,000	DQ	µg/L	100	12/1/2021 5:43:28 PM
Iron	105,000	10,000	D	µg/L	100	12/1/2021 5:43:28 PM
Magnesium	32,000	10,000	D	µg/L	100	12/1/2021 5:43:28 PM
Manganese	2,070	25.0	D	µg/L	5	11/30/2021 4:51:57 PM
Potassium	29,400	20,000	D	µg/L	100	12/1/2021 5:43:28 PM
Sodium	186,000	20,000	D	µg/L	100	12/1/2021 5:43:28 PM

NOTES:
Q - Associated calibration verification is above acceptance criteria (111%). Result may be high-biased.

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Total Organic Carbon by SM 5310C				Batch ID: R71542		Analyst: SS
Total Organic Carbon	59.0	2.00	D	mg/L	4	11/23/2021 7:19:00 PM
Total Alkalinity by SM 2320B				Batch ID: R71558		Analyst: CH
Alkalinity, Total (As CaCO3)	608	2.50		mg/L	1	11/29/2021 8:22:52 AM
Ferrous Iron by SM3500-Fe B				Batch ID: R71552		Analyst: SS
Ferrous Iron	157	12.5	D	mg/L	125	11/19/2021 5:30:00 PM

Fremont Analytical

Date: *12/14/2021*

Work Order: 2111438
CLIENT: Aspect Consulting
Project: Port of Tacoma Parcel 15

QC SUMMARY REPORT

Total Alkalinity by SM 2320B

Sample ID: **MB-R71558** SampType: **MBLK** Units: **mg/L** Prep Date: **11/29/2021** RunNo: **71558**
Client ID: **MBLKW** Batch ID: **R71558** Analysis Date: **11/29/2021** SeqNo: **1457543**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Alkalinity, Total (As CaCO3)	ND	2.50									

Sample ID: **LCS-R71558** SampType: **LCS** Units: **mg/L** Prep Date: **11/29/2021** RunNo: **71558**
Client ID: **LCSW** Batch ID: **R71558** Analysis Date: **11/29/2021** SeqNo: **1457544**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Alkalinity, Total (As CaCO3)	107	2.50	100.0	0	107	88.3	113				

Sample ID: **2111438-007CDUP** SampType: **DUP** Units: **mg/L** Prep Date: **11/29/2021** RunNo: **71558**
Client ID: **MW-14-111921** Batch ID: **R71558** Analysis Date: **11/29/2021** SeqNo: **1457547**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Alkalinity, Total (As CaCO3)	590	2.50						607.8	2.90	20	

Sample ID: **MB-R71631** SampType: **MBLK** Units: **mg/L** Prep Date: **12/1/2021** RunNo: **71631**
Client ID: **MBLKW** Batch ID: **R71631** Analysis Date: **12/1/2021** SeqNo: **1459394**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Alkalinity, Total (As CaCO3)	ND	2.50									

Sample ID: **LCS-R71631** SampType: **LCS** Units: **mg/L** Prep Date: **12/1/2021** RunNo: **71631**
Client ID: **LCSW** Batch ID: **R71631** Analysis Date: **12/1/2021** SeqNo: **1459395**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Alkalinity, Total (As CaCO3)	108	2.50	100.0	0	108	88.3	113				

Date: *12/14/2021*

Work Order: 2111438
CLIENT: Aspect Consulting
Project: Port of Tacoma Parcel 15

QC SUMMARY REPORT

Total Alkalinity by SM 2320B

Sample ID: **2111438-004CDUP** SampType: **DUP** Units: **mg/L** Prep Date: **12/1/2021** RunNo: **71631**
Client ID: **AB1-18-111921** Batch ID: **R71631** Analysis Date: **12/1/2021** SeqNo: **1459742**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Alkalinity, Total (As CaCO3)	217	2.50						214.6	1.31	20	

Date: *12/14/2021*

Work Order: 2111438
CLIENT: Aspect Consulting
Project: Port of Tacoma Parcel 15

QC SUMMARY REPORT

Ferrous Iron by SM3500-Fe B

Sample ID: **MB-R71552** SampType: **MBLK** Units: **mg/L** Prep Date: **11/19/2021** RunNo: **71552**
Client ID: **MBLKW** Batch ID: **R71552** Analysis Date: **11/19/2021** SeqNo: **1457409**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Ferrous Iron	ND	0.100									

Sample ID: **LCS-R71552** SampType: **LCS** Units: **mg/L** Prep Date: **11/19/2021** RunNo: **71552**
Client ID: **LCSW** Batch ID: **R71552** Analysis Date: **11/19/2021** SeqNo: **1457410**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Ferrous Iron	0.424	0.100	0.4000	0	106	85	115				

Sample ID: **2111422-001EDUP** SampType: **DUP** Units: **mg/L** Prep Date: **11/19/2021** RunNo: **71552**
Client ID: **BATCH** Batch ID: **R71552** Analysis Date: **11/19/2021** SeqNo: **1457412**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Ferrous Iron	172	12.5						166.1	3.40	20	DH

Sample ID: **2111422-001EMS** SampType: **MS** Units: **mg/L** Prep Date: **11/19/2021** RunNo: **71552**
Client ID: **BATCH** Batch ID: **R71552** Analysis Date: **11/19/2021** SeqNo: **1457413**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Ferrous Iron	226	12.5	50.00	166.1	121	70	130				DH

Sample ID: **2111422-001EMSD** SampType: **MSD** Units: **mg/L** Prep Date: **11/19/2021** RunNo: **71552**
Client ID: **BATCH** Batch ID: **R71552** Analysis Date: **11/19/2021** SeqNo: **1457414**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Ferrous Iron	223	12.5	50.00	166.1	114	70	130	226.4	1.46	20	DH

Fremont Analytical

Date: *12/14/2021*

Work Order: 2111438
CLIENT: Aspect Consulting
Project: Port of Tacoma Parcel 15

QC SUMMARY REPORT

Ion Chromatography by EPA Method 300.0

Sample ID: **2111444-001ADUP** SampType: **DUP** Units: **mg/L** Prep Date: **11/19/2021** RunNo: **71557**
Client ID: **BATCH** Batch ID: **34519** Analysis Date: **11/20/2021** SeqNo: **1457513**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Fluoride	ND	0.400						0		20	D
Nitrate (as N)+Nitrite (as N)	ND	0.550						0		20	D
Ortho-Phosphate (as P)	ND	2.62						0		20	D

Sample ID: **2111444-001AMS** SampType: **MS** Units: **mg/L** Prep Date: **11/19/2021** RunNo: **71557**
Client ID: **BATCH** Batch ID: **34519** Analysis Date: **11/20/2021** SeqNo: **1457514**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Fluoride	2.37	0.400	2.500	0.1650	88.2	80	120				D
Nitrate (as N)+Nitrite (as N)	7.17	0.550	7.500	0	95.5	80	120				D
Ortho-Phosphate (as P)	6.50	2.62	6.250	0	104	80	120				D

Sample ID: **MB-34519** SampType: **MBLK** Units: **mg/L** Prep Date: **11/19/2021** RunNo: **71557**
Client ID: **MBLKW** Batch ID: **34519** Analysis Date: **11/20/2021** SeqNo: **1457529**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Fluoride	ND	0.0800									
Nitrate (as N)+Nitrite (as N)	ND	0.110									
Ortho-Phosphate (as P)	ND	0.525									

Sample ID: **LCS-34519** SampType: **LCS** Units: **mg/L** Prep Date: **11/19/2021** RunNo: **71557**
Client ID: **LCSW** Batch ID: **34519** Analysis Date: **11/20/2021** SeqNo: **1457530**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Fluoride	0.481	0.0800	0.5000	0	96.2	90	110				
Nitrate (as N)+Nitrite (as N)	1.46	0.110	1.500	0	97.0	90	110				
Ortho-Phosphate (as P)	1.69	0.525	1.250	0	135	90	110				S

NOTES:
S - Outlying spike recovery observed. Detections will be qualified with a *.

Date: *12/14/2021*

Work Order: 2111438
CLIENT: Aspect Consulting
Project: Port of Tacoma Parcel 15

QC SUMMARY REPORT

Ion Chromatography by EPA Method 300.0

Sample ID: **2111430-001EDUP** SampType: **DUP** Units: **mg/L** Prep Date: **11/19/2021** RunNo: **71557**
Client ID: **BATCH** Batch ID: **34519** Analysis Date: **11/20/2021** SeqNo: **1457532**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Fluoride	ND	0.400						0		20	D
Nitrate (as N)+Nitrite (as N)	1.10	0.550						1.110	0.905	20	D
Ortho-Phosphate (as P)	ND	2.62						0		20	DH

Sample ID: **2111430-001EMS** SampType: **MS** Units: **mg/L** Prep Date: **11/19/2021** RunNo: **71557**
Client ID: **BATCH** Batch ID: **34519** Analysis Date: **11/20/2021** SeqNo: **1457533**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Fluoride	2.35	0.400	2.500	0.1550	87.8	80	120				D
Nitrate (as N)+Nitrite (as N)	8.32	0.550	7.500	1.110	96.1	80	120				D
Ortho-Phosphate (as P)	7.59	2.62	6.250	0	121	80	120				DSH

NOTES:
S - Outlying spike recovery(ies) observed.

Sample ID: **2111430-001EMSD** SampType: **MSD** Units: **mg/L** Prep Date: **11/19/2021** RunNo: **71557**
Client ID: **BATCH** Batch ID: **34519** Analysis Date: **11/20/2021** SeqNo: **1457534**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Fluoride	2.34	0.400	2.500	0.1550	87.4	80	120	2.350	0.426	20	D
Nitrate (as N)+Nitrite (as N)	8.15	0.550	7.500	1.110	93.9	80	120	8.315	2.00	20	D
Ortho-Phosphate (as P)	8.06	2.62	6.250	0	129	80	120	7.585	6.13	20	DSH

NOTES:
S - Outlying spike recovery(ies) observed.

Sample ID: **MB-34734** SampType: **MBLK** Units: **mg/L** Prep Date: **12/13/2021** RunNo: **71918**
Client ID: **MBLKW** Batch ID: **34734** Analysis Date: **12/13/2021** SeqNo: **1467227**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	ND	0.100									
Bromide	ND	0.400									
Sulfate	ND	0.600									

Fremont Analytical

Date: 12/14/2021

Work Order: 2111438
CLIENT: Aspect Consulting
Project: Port of Tacoma Parcel 15

QC SUMMARY REPORT

Ion Chromatography by EPA Method 300.0

Sample ID: **MB-34734** SampType: **MBLK** Units: **mg/L** Prep Date: **12/13/2021** RunNo: **71918**
Client ID: **MBLKW** Batch ID: **34734** Analysis Date: **12/13/2021** SeqNo: **1467227**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual

Sample ID: **LCS-34734** SampType: **LCS** Units: **mg/L** Prep Date: **12/13/2021** RunNo: **71918**
Client ID: **LCSW** Batch ID: **34734** Analysis Date: **12/13/2021** SeqNo: **1467228**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	0.718	0.100	0.7500	0	95.7	90	110				
Bromide	2.39	0.400	2.500	0	95.7	90	110				
Sulfate	3.65	0.600	3.750	0	97.4	90	110				

Sample ID: **2112182-003ADUP** SampType: **DUP** Units: **mg/L** Prep Date: **12/13/2021** RunNo: **71918**
Client ID: **BATCH** Batch ID: **34734** Analysis Date: **12/13/2021** SeqNo: **1467242**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	6.22	0.100						6.231	0.209	20	E
Bromide	ND	0.400						0		20	
Sulfate	6.64	0.600						6.638	0	20	

Sample ID: **2112182-004AMS** SampType: **MS** Units: **mg/L** Prep Date: **12/13/2021** RunNo: **71918**
Client ID: **BATCH** Batch ID: **34734** Analysis Date: **12/13/2021** SeqNo: **1467244**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	7.06	0.100	0.7500	6.251	108	80	120				E
Bromide	2.33	0.400	2.500	0	93.4	80	120				
Sulfate	10.5	0.600	3.750	6.499	107	80	120				

Date: *12/14/2021*

Work Order: 2111438
CLIENT: Aspect Consulting
Project: Port of Tacoma Parcel 15

QC SUMMARY REPORT

Ion Chromatography by EPA Method 300.0

Sample ID: **2112182-004AMSD** SampType: **MSD** Units: **mg/L** Prep Date: **12/13/2021** RunNo: **71918**
Client ID: **BATCH** Batch ID: **34734** Analysis Date: **12/13/2021** SeqNo: **1467245**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	7.07	0.100	0.7500	6.251	109	80	120	7.061	0.127	20	E
Bromide	2.34	0.400	2.500	0	93.6	80	120	2.334	0.257	20	
Sulfate	10.5	0.600	3.750	6.499	108	80	120	10.50	0.314	20	

Work Order: 2111438
CLIENT: Aspect Consulting
Project: Port of Tacoma Parcel 15

QC SUMMARY REPORT
Total Organic Carbon by SM 5310C

Sample ID: **MB-R71542** SampType: **MBLK** Units: **mg/L** Prep Date: **11/19/2021** RunNo: **71542**
Client ID: **MBLKW** Batch ID: **R71542** Analysis Date: **11/19/2021** SeqNo: **1457264**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Total Organic Carbon	ND	0.500									

Sample ID: **LCS-R71542** SampType: **LCS** Units: **mg/L** Prep Date: **11/19/2021** RunNo: **71542**
Client ID: **LCSW** Batch ID: **R71542** Analysis Date: **11/19/2021** SeqNo: **1457265**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Total Organic Carbon	5.13	0.500	5.000	0	103	93.1	106				

Sample ID: **2111378-001ADUP** SampType: **DUP** Units: **mg/L** Prep Date: **11/19/2021** RunNo: **71542**
Client ID: **BATCH** Batch ID: **R71542** Analysis Date: **11/19/2021** SeqNo: **1457267**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Total Organic Carbon	3.34	0.500						3.320	0.511	20	

Sample ID: **2111378-002AMS** SampType: **MS** Units: **mg/L** Prep Date: **11/19/2021** RunNo: **71542**
Client ID: **BATCH** Batch ID: **R71542** Analysis Date: **11/19/2021** SeqNo: **1457269**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Total Organic Carbon	6.27	0.500	5.000	1.140	103	69.1	124				

Sample ID: **2111378-002AMSD** SampType: **MSD** Units: **mg/L** Prep Date: **11/19/2021** RunNo: **71542**
Client ID: **BATCH** Batch ID: **R71542** Analysis Date: **11/19/2021** SeqNo: **1457270**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Total Organic Carbon	6.15	0.500	5.000	1.140	100	69.1	124	6.270	1.88	30	

Work Order: 2111438
CLIENT: Aspect Consulting
Project: Port of Tacoma Parcel 15

QC SUMMARY REPORT

Total Organic Carbon by SM 5310C

Sample ID: **2111383-001ADUP** SampType: **DUP** Units: **mg/L** Prep Date: **11/20/2021** RunNo: **71542**
Client ID: **BATCH** Batch ID: **R71542** Analysis Date: **11/20/2021** SeqNo: **1457281**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Total Organic Carbon	6.86	0.500						7.173	4.48	20	

Sample ID: **2111383-002AMS** SampType: **MS** Units: **mg/L** Prep Date: **11/20/2021** RunNo: **71542**
Client ID: **BATCH** Batch ID: **R71542** Analysis Date: **11/20/2021** SeqNo: **1457283**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Total Organic Carbon	10.0	0.500	5.000	5.042	99.5	69.1	124				

Sample ID: **MB-R71554** SampType: **MBLK** Units: **mg/L** Prep Date: **11/23/2021** RunNo: **71554**
Client ID: **MBLKW** Batch ID: **R71554** Analysis Date: **11/23/2021** SeqNo: **1457466**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Total Organic Carbon	ND	0.500									

Sample ID: **LCS-R71554** SampType: **LCS** Units: **mg/L** Prep Date: **11/23/2021** RunNo: **71554**
Client ID: **LCSW** Batch ID: **R71554** Analysis Date: **11/23/2021** SeqNo: **1457467**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Total Organic Carbon	5.07	0.500	5.000	0	101	93.1	106				

Sample ID: **2111389-001ADUP** SampType: **DUP** Units: **mg/L** Prep Date: **11/23/2021** RunNo: **71554**
Client ID: **BATCH** Batch ID: **R71554** Analysis Date: **11/23/2021** SeqNo: **1457475**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Total Organic Carbon	1.40	0.500						1.383	1.51	20	

Work Order: 2111438
CLIENT: Aspect Consulting
Project: Port of Tacoma Parcel 15

QC SUMMARY REPORT

Total Organic Carbon by SM 5310C

Sample ID: **2111389-002AMS** SampType: **MS** Units: **mg/L** Prep Date: **11/24/2021** RunNo: **71554**
Client ID: **BATCH** Batch ID: **R71554** Analysis Date: **11/24/2021** SeqNo: **1457479**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Total Organic Carbon	8.61	0.500	5.000	3.606	100	69.1	124				

Sample ID: **2111389-002AMSD** SampType: **MSD** Units: **mg/L** Prep Date: **11/24/2021** RunNo: **71554**
Client ID: **BATCH** Batch ID: **R71554** Analysis Date: **11/24/2021** SeqNo: **1457480**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Total Organic Carbon	8.64	0.500	5.000	3.606	101	69.1	124	8.614	0.255	30	

Sample ID: **2111438-006DDUP** SampType: **DUP** Units: **mg/L** Prep Date: **11/24/2021** RunNo: **71554**
Client ID: **AB1-22-111921** Batch ID: **R71554** Analysis Date: **11/24/2021** SeqNo: **1457492**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Total Organic Carbon	20.5	0.500						20.94	1.98	20	

Sample ID: **2111438-006DMS** SampType: **MS** Units: **mg/L** Prep Date: **11/24/2021** RunNo: **71554**
Client ID: **AB1-22-111921** Batch ID: **R71554** Analysis Date: **11/24/2021** SeqNo: **1457493**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Total Organic Carbon	25.4	0.500	5.000	20.94	88.7	69.1	124				

Date: *12/14/2021*

Work Order: 2111438
CLIENT: Aspect Consulting
Project: Port of Tacoma Parcel 15

QC SUMMARY REPORT

Dissolved Metals by EPA Method 200.8

Sample ID: **MB-34658FB** SampType: **MBLK** Units: **µg/L** Prep Date: **12/7/2021** RunNo: **71811**
Client ID: **MBLKW** Batch ID: **34657** Analysis Date: **12/8/2021** SeqNo: **1464193**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	ND	1.00									

Sample ID: **MB-34657** SampType: **MBLK** Units: **µg/L** Prep Date: **12/7/2021** RunNo: **71811**
Client ID: **MBLKW** Batch ID: **34657** Analysis Date: **12/8/2021** SeqNo: **1464194**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	ND	1.00									

Sample ID: **LCS-34657** SampType: **LCS** Units: **µg/L** Prep Date: **12/7/2021** RunNo: **71811**
Client ID: **LCSW** Batch ID: **34657** Analysis Date: **12/8/2021** SeqNo: **1464195**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	525	1.00	500.0	0	105	85	115				

Sample ID: **2111363-003BDUP** SampType: **DUP** Units: **µg/L** Prep Date: **12/7/2021** RunNo: **71811**
Client ID: **BATCH** Batch ID: **34657** Analysis Date: **12/8/2021** SeqNo: **1464199**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	2.31	1.00						1.361	51.8	30	

Sample ID: **2111363-003BMS** SampType: **MS** Units: **µg/L** Prep Date: **12/7/2021** RunNo: **71811**
Client ID: **BATCH** Batch ID: **34657** Analysis Date: **12/8/2021** SeqNo: **1464200**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	528	1.00	500.0	1.361	105	70	130				

Fremont Analytical

Date: *12/14/2021*

Work Order: 2111438
CLIENT: Aspect Consulting
Project: Port of Tacoma Parcel 15

QC SUMMARY REPORT

Total Metals by EPA Method 200.8

Sample ID: **MB-34525** SampType: **MBLK** Units: **µg/L** Prep Date: **11/22/2021** RunNo: **71594**
Client ID: **MBLKW** Batch ID: **34525** Analysis Date: **11/30/2021** SeqNo: **1458302**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	ND	1.00									
Calcium	ND	200									
Magnesium	ND	100									
Manganese	ND	5.00									
Potassium	ND	200									
Sodium	ND	200									

Sample ID: **LCS-34525** SampType: **LCS** Units: **µg/L** Prep Date: **11/22/2021** RunNo: **71594**
Client ID: **LCSW** Batch ID: **34525** Analysis Date: **11/30/2021** SeqNo: **1458303**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	106	1.00	100.0	0	106	85	115				
Calcium	2,440	200	1,000	0	244	85	115				S
Magnesium	1,010	100	1,000	0	101	85	115				
Manganese	109	5.00	100.0	0	109	85	115				
Potassium	997	200	1,000	0	99.7	85	115				
Sodium	1,010	200	1,000	0	101	85	115				

NOTES:
S - Outlying spike recovery observed (high bias). Detections will be qualified with a *.

Sample ID: **2111302-001ADUP** SampType: **DUP** Units: **µg/L** Prep Date: **11/22/2021** RunNo: **71594**
Client ID: **BATCH** Batch ID: **34525** Analysis Date: **11/30/2021** SeqNo: **1458305**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	ND	1.00						0		30	
Calcium	437	200						384.5	12.9	30	
Magnesium	ND	100						0		30	
Manganese	ND	5.00						0		30	
Potassium	253	200						252.0	0.544	30	
Sodium	360	200						457.0	23.8	30	

Date: *12/14/2021*

Work Order:	2111438
CLIENT:	Aspect Consulting
Project:	Port of Tacoma Parcel 15

QC SUMMARY REPORT

Total Metals by EPA Method 200.8

Sample ID: **2111302-001ADUP** SampType: **DUP** Units: **µg/L** Prep Date: **11/22/2021** RunNo: **71594**
Client ID: **BATCH** Batch ID: **34525** Analysis Date: **11/30/2021** SeqNo: **1458305**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual

Sample ID: **2111302-001AMS** SampType: **MS** Units: **µg/L** Prep Date: **11/22/2021** RunNo: **71594**
Client ID: **BATCH** Batch ID: **34525** Analysis Date: **11/30/2021** SeqNo: **1458306**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	93.5	1.00	100.0	0	93.5	70	130				
Calcium	2,690	200	1,000	384.5	231	50	150				S
Magnesium	1,150	100	1,000	74.31	108	70	130				
Manganese	114	5.00	100.0	4.434	110	70	130				
Potassium	1,250	200	1,000	252.0	99.7	50	150				
Sodium	1,390	200	1,000	457.0	93.6	50	150				

NOTES:

S - Outlying spike recovery(ies) observed.

Fremont Analytical

Sample Log-In Check List

Client Name:	**AC**	Work Order Number:	**2111438**
Logged by:	**Gabrielle Coeuille**	Date Received:	**11/19/2021 3:42:02 PM**

Chain of Custody

1.	Is Chain of Custody complete?	Yes ☑	No ☐	Not Present ☐
2.	How was the sample delivered?	Client		

Log In

3.	Coolers are present?	Yes ☑	No ☐	NA ☐
4.	Shipping container/cooler in good condition?	Yes ☑	No ☐	
5.	Custody Seals present on shipping container/cooler? (Refer to comments for Custody Seals not intact)	Yes ☐	No ☐	Not Present ☑
6.	Was an attempt made to cool the samples?	Yes ☑	No ☐	NA ☐
7.	Were all items received at a temperature of >2°C to 6°C *	Yes ☑	No ☐	NA ☐
8.	Sample(s) in proper container(s)?	Yes ☑	No ☐	
9.	Sufficient sample volume for indicated test(s)?	Yes ☑	No ☐	
10.	Are samples properly preserved?	Yes ☑	No ☐	
11.	Was preservative added to bottles?	Yes ☐	No ☑	NA ☐
12.	Is there headspace in the VOA vials?	Yes ☐	No ☐	NA ☑
13.	Did all samples containers arrive in good condition(unbroken)?	Yes ☑	No ☐	
14.	Does paperwork match bottle labels?	Yes ☑	No ☐	
15.	Are matrices correctly identified on Chain of Custody?	Yes ☑	No ☐	
16.	Is it clear what analyses were requested?	Yes ☑	No ☐	
17.	Were all holding times able to be met?	Yes ☑	No ☐	

Special Handling (if applicable)

18.	Was client notified of all discrepancies with this order?	Yes ☐	No ☐	NA ☑

Person Notified:		Date:	
By Whom:		Via:	☐ eMail ☐ Phone ☐ Fax ☐ In Person
Regarding:			
Client Instructions:			

19. Additional remarks:

Item Information

Item #	Temp ºC
Sample 1	5.6

* Note: DoD/ELAP and TNI require items to be received at 4°C +/- 2°C

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

James E. Bruya, Ph.D.
Yelena Aravkina, M.S.
Michael Erdahl, B.S.
Arina Podnozova, B.S.
Eric Young, B.S.

3012 16th Avenue West
Seattle, WA 98119-2029
(206) 285-8282
fbi@isomedia.com
www.friedmanandbruya.com

November 29, 2021

Mike Ridgeway, Project Manager
Fremont Analytical
3600 Fremont Ave N.
Seattle, WA 98103

Dear Mr Ridgeway:

Included are the results from the testing of material submitted on November 22, 2021 from the COCID 1192, F&BI 111425 project. There are 8 pages included in this report. Any samples that may remain are currently scheduled for disposal in 30 days, or as directed by the Chain of Custody document. If you would like us to return your samples or arrange for long term storage at our offices, please contact us as soon as possible.

We appreciate this opportunity to be of service to you and hope you will call if you should have any questions.

Sincerely,

FRIEDMAN & BRUYA, INC.

Michael Erdahl
Project Manager

Enclosures
c: Brianna Barnes, Matt Langston
FRE1129R.DOC

CASE NARRATIVE

This case narrative encompasses samples received on November 22, 2021 by Friedman & Bruya, Inc. from the Fremont Analytical COCID 1192, F&BI 111425 project. Samples were logged in under the laboratory ID's listed below.

Laboratory ID	Fremont Analytical
111425 -01	MW-14-111921
111425 -02	MW-14-111921

All quality control requirements were acceptable.

Analysis For Dissolved Metals By EPA Method 200.8

Client ID:	MW-14-111921	Client:	Fremont Analytical
Date Received:	11/22/21	Project:	COCID 1192, F&BI 111425
Date Extracted:	11/23/21	Lab ID:	111425-01 x5
Date Analyzed:	11/23/21	Data File:	111425-01 x5.057
Matrix:	Water	Instrument:	ICPMS2
Units:	ug/L (ppb)	Operator:	SP

Analyte:	Concentration ug/L (ppb)
Arsenic	21.2

Analysis For Dissolved Metals By EPA Method 200.8

Client ID:	Method Blank	Client:	Fremont Analytical
Date Received:	Not Applicable	Project:	COCID 1192, F&BI 111425
Date Extracted:	11/23/21	Lab ID:	I1-773 mb
Date Analyzed:	11/23/21	Data File:	I1-773 mb.047
Matrix:	Water	Instrument:	ICPMS2
Units:	ug/L (ppb)	Operator:	SP

Analyte:	Concentration ug/L (ppb)
Arsenic	<1

Analysis For Total Metals By EPA Method 200.8

Client ID:	MW-14-111921	Client:	Fremont Analytical
Date Received:	11/22/21	Project:	COCID 1192, F&BI 111425
Date Extracted:	11/23/21	Lab ID:	111425-02 x5
Date Analyzed:	11/23/21	Data File:	111425-02 x5.058
Matrix:	Water	Instrument:	ICPMS2
Units:	ug/L (ppb)	Operator:	SP

Analyte:	Concentration ug/L (ppb)
Arsenic	22.9

Analysis For Total Metals By EPA Method 200.8

Client ID:	Method Blank	Client:	Fremont Analytical
Date Received:	Not Applicable	Project:	COCID 1192, F&BI 111425
Date Extracted:	11/23/21	Lab ID:	I1-773 mb
Date Analyzed:	11/23/21	Data File:	I1-773 mb.047
Matrix:	Water	Instrument:	ICPMS2
Units:	ug/L (ppb)	Operator:	SP

Analyte:	Concentration ug/L (ppb)
Arsenic	<1

Date of Report: 11/29/21
Date Received: 11/22/21
Project: COCID 1192, F&BI 111425

QUALITY ASSURANCE RESULTS FOR THE ANALYSIS OF WATER SAMPLES FOR DISSOLVED METALS USING EPA METHOD 200.8

Laboratory Code: 111432-01 (Matrix Spike)

Analyte	Reporting Units	Spike Level	Sample Result	Percent Recovery MS	Percent Recovery MSD	Acceptance Criteria	RPD (Limit 20)
Arsenic	ug/L (ppb)	10	37.1	95	89	70-130	7

Laboratory Code: Laboratory Control Sample

Analyte	Reporting Units	Spike Level	Percent Recovery LCS	Acceptance Criteria
Arsenic	ug/L (ppb)	10	90	85-115

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Date of Report: 11/29/21
Date Received: 11/22/21
Project: COCID 1192, F&BI 111425

QUALITY ASSURANCE RESULTS
FOR THE ANALYSIS OF WATER SAMPLES
FOR TOTAL METALS USING EPA METHOD 200.8

Laboratory Code: 111432-01 (Matrix Spike)

Analyte	Reporting Units	Spike Level	Sample Result	Percent Recovery MS	Percent Recovery MSD	Acceptance Criteria	RPD (Limit 20)
Arsenic	ug/L (ppb)	10	37.1	95	89	70-130	7

Laboratory Code: Laboratory Control Sample

Analyte	Reporting Units	Spike Level	Percent Recovery LCS	Acceptance Criteria
Arsenic	ug/L (ppb)	10	90	85-115

Data Qualifiers & Definitions

a - The analyte was detected at a level less than five times the reporting limit. The RPD results may not provide reliable information on the variability of the analysis.

b - The analyte was spiked at a level that was less than five times that present in the sample. Matrix spike recoveries may not be meaningful.

ca - The calibration results for the analyte were outside of acceptance criteria. The value reported is an estimate.

c - The presence of the analyte may be due to carryover from previous sample injections.

cf - The sample was centrifuged prior to analysis.

d - The sample was diluted. Detection limits were raised and surrogate recoveries may not be meaningful.

dv - Insufficient sample volume was available to achieve normal reporting limits.

f - The sample was laboratory filtered prior to analysis.

fb - The analyte was detected in the method blank.

fc - The analyte is a common laboratory and field contaminant.

hr - The sample and duplicate were reextracted and reanalyzed. RPD results were still outside of control limits. Variability is attributed to sample inhomogeneity.

hs - Headspace was present in the container used for analysis.

ht – The analysis was performed outside the method or client-specified holding time requirement.

ip - Recovery fell outside of control limits due to sample matrix effects.

j - The analyte concentration is reported below the lowest calibration standard. The value reported is an estimate.

J - The internal standard associated with the analyte is out of control limits. The reported concentration is an estimate.

jl - The laboratory control sample(s) percent recovery and/or RPD were out of control limits. The reported concentration should be considered an estimate.

js - The surrogate associated with the analyte is out of control limits. The reported concentration should be considered an estimate.

lc - The presence of the analyte is likely due to laboratory contamination.

L - The reported concentration was generated from a library search.

nm - The analyte was not detected in one or more of the duplicate analyses. Therefore, calculation of the RPD is not applicable.

pc - The sample was received with incorrect preservation or in a container not approved by the method. The value reported should be considered an estimate.

ve - The analyte response exceeded the valid instrument calibration range. The value reported is an estimate.

vo - The value reported fell outside the control limits established for this analyte.

x - The sample chromatographic pattern does not resemble the fuel standard used for quantitation.

Fremont Analytical

CHAIN OF CUSTODY RECORD

Omega COCID 1192 | PAGE: 1 | OF: 1

Fremont Analytical, Inc.
3600 Fremont Ave. N.
Seattle, WA 98103
TEL: 206-352-3790
FAX: 206-352-7178
Website: www.fremontanalytical.com

111425

ME 11-22-21 AI3

SUB CONTRATOR: Friedman & Bruya	COMPANY: Friedman & Bruya
ADDRESS: 3012 16th Avenue West	
CITY, STATE, ZIP: Seattle, WA 98119	
PHONE: (206) 285-8282 FAX:	EMAIL:
ACCOUNT #:	

SPECIAL INSTRUCTIONS / COMMENTS:
ASAP TAT. Please email results to Brianna Barnes at bbarnes@fremontanalytical.com and Matt Langston at mlangston@fremontanalytical.com.

ITEM #	SAMPLE ID	CLIENT SAMPLE ID	BOTTLE TYPE	MATRIX	DATE COLLECTED	NUMBER OF CONTAINERS	COMMENTS: Methanol Preserved Weights HOT Sample Notation, Additional Sample Description.	Lab ID
1	2111438-007B M-200.8-D (E200.8D)	MW-14-111921	250 HDPE NON	Groundwater	11/19/2021 1:10:00 PM	1	Dissolved As- Field Filtered	-01
2	2111438-007F TEST_SUB	MW-14-111921	250ML POLY	Groundwater	11/19/2021 1:10:00 PM	1	Total As- 200.8	-02

Samples received at 2 °C

Relinquished By:	Date:	Time:	Received By:	Date:	Time:
[signature]	11/22/21	1234	[signature]	11/22/21	1350

TAT: Standard ☐ RUSH Next BD ☐ 2nd BD ☐ 3rd BD ☐

Note: RUSH requests will incur surcharges!

REPORT TRANSMITTAL DESIRED:
☐ HARDCOPY (extra cost) ☐ FAX ☐ EMAIL ☐ ONLINE

FOR LAB USE ONLY
Temp of samples ______ °C Attempt to Cool ? ______
Comments: ______

Fremont Analytical

3600 Fremont Ave N.
Seattle, WA 98103
Tel: 206-352-3790
Fax: 206-352-7178

Chain of Custody Record & Laboratory Services Agreement

Date: 11/19/21 Page: 1 of: 1

Laboratory Project No (internal): 2111438

Project Name: Port of Tacoma Parcel 15

Project No: 21015-8

Collected by: Baxter Call

Location:

Report To (PM): Adam Griffin

PM Email: agriffin@aspectconsulting.com

Special Remarks:

Sample Disposal: ☐ Return to client ☐ Disposal by lab (after 30 days)

Client: Aspect Consulting

Address: 710 2nd Ave Ste. 550

City, State, Zip: Seattle, WA, 98104

Telephone:

Fax:

Sample Name	Sample Date	Sample Time	Sample Type (Matrix)*	# of Cont.	VOCs (EPA 8260 / 624)	BTEX	Gasoline Range Organics (GX)	Hydrocarbon Identification (HCID)	Diesel/Heavy Oil Range Organics (DX)	SVOCs (EPA 8270 / 625)	PAHs (EPA 8270 - SIM)	PCBs (EPA 8082 / 608)	Metals** (EPA 6020 / 200.8)	Total (T) / Dissolved (D)	Anions (IC)***	EDB (8011)	Total & Dissolved As	Alkalinity, TOC	Ferrous Fe		Comments
1 AB2-18-111921	11/19/21	0840	GW	2													X				Marked field filtered.
2 AB2-22-111921	↓	0850	↓	3													X				Min vol. sampled. One bottle to be lab filtered.
3 AB2-14-111921	↓	0925	↓	2													X				Marked field filtered.
4 AB1-18-111921	↓	1055	↓	5									X				X	X	X		↓
5 AB1-14-111921	↓	1150	↓	↓									↓				↓	↓	↓		↓
6 AB1-22-111921	↓	1120	↓	↓									↓				↓	↓	↓		↓
7 MW-14-111921	↓	1310	↓	↓									X				↓	↓	↓		Total + Dissolved metals; same day turn around
8																					
9																					
10																					

*Matrix: A = Air, AQ = Aqueous, B = Bulk, O = Other, P = Product, S = Soil, SD = Sediment, SL = Solid, W = Water, DW = Drinking Water, GW = Ground Water, SW = Storm Water, WW = Waste Water

**Metals (Circle): MTCA-5 RCRA-8 Priority Pollutants TAL Individual: Ag Al As B Ba Be Ca Cd Co Cr Cu Fe Hg K Mg Mn Mo Na Ni Pb Sb Se Sr Sn Ti Tl V Zn

***Anions (Circle): Nitrate Nitrite Chloride Sulfate Bromide O-Phosphate * Fluoride Nitrate+Nitrite ** * as P ** as N

Turn-around Time: ☒ Standard ☐ Next Day ☐ 3 Day ☐ Same Day ☐ 2 Day ______ (specify)

I represent that I am authorized to enter into this Agreement with Fremont Analytical on behalf of the Client named above, that I have verified Client's agreement to each of the terms on the front and backside of this Agreement.

Relinquished (Signature)	Print Name	Date/Time	Received (Signature)	Print Name	Date/Time
x B Call	Baxter Call	11/19/21 1620	x Justine Mantz	Justine Mantz	11/19 16:30
x			x		

COC 1.3 - 11.06.20

3600 Fremont Ave. N.
Seattle, WA 98103
T: (206) 352-3790
F: (206) 352-7178
info@fremontanalytical.com

Aspect Consulting
Adam Griffin
710 2nd Ave, Suite 550
Seattle, WA 98104

RE: Port of Tacoma Parcel 15
Work Order Number: 2111472

December 14, 2021

Attention Adam Griffin:

Fremont Analytical, Inc. received 5 sample(s) on 11/22/2021 for the analyses presented in the following report.

Dissolved Metals by EPA Method 200.8
Ferrous Iron by SM3500-Fe B
Pentachlorophenol by EPA Method 8270 (SIM)
Total Metals by EPA Method 200.8
Total Alkalinity by SM 2320B
Total Organic Carbon by SM 5310C
Total Phosphorous by EPA Method 365.3

This report consists of the following:

- Case Narrative
- Analytical Results
- Applicable Quality Control Summary Reports
- Chain of Custody

All analyses were performed consistent with the Quality Assurance program of Fremont Analytical, Inc. Please contact the laboratory if you should have any questions about the results.

Thank you for using Fremont Analytical.

Sincerely,

Brianna Barnes
Project Manager

DoD-ELAP Accreditation #79636 by PJLA, ISO/IEC 17025:2017 and QSM 5.3 for Environmental Testing
ORELAP Certification: WA 100009 (NELAP Recognized) for Environmental Testing
Washington State Department of Ecology Accredited for Environmental Testing, Lab ID C910

CLIENT:	Aspect Consulting
Project:	Port of Tacoma Parcel 15
Work Order:	2111472

Work Order Sample Summary

Lab Sample ID	Client Sample ID	Date/Time Collected	Date/Time Received
2111472-001	MW2R112221	11/22/2021 11:55 AM	11/22/2021 5:53 PM
2111472-002	B5R-112221	11/22/2021 10:20 AM	11/22/2021 5:53 PM
2111472-002	B5R-112221	11/22/2021 10:20 AM	11/22/2021 5:53 PM
2111472-003	MW12-112221	11/22/2021 1:15 PM	11/22/2021 5:53 PM
2111472-003	MW12-112221	11/22/2021 1:15 PM	11/22/2021 5:53 PM
2111472-004	MW9-112221	11/22/2021 1:55 PM	11/22/2021 5:53 PM
2111472-004	MW9-112221	11/22/2021 1:55 PM	11/22/2021 5:53 PM
2111472-005	MW7-112221	11/22/2021 3:00 PM	11/22/2021 5:53 PM
2111472-005	MW7-112221	11/22/2021 3:00 PM	11/22/2021 5:53 PM

Note: If no "Time Collected" is supplied, a default of 12:00AM is assigned

Case Narrative

WO#: **2111472**

Date: **12/14/2021**

CLIENT: Aspect Consulting

Project: Port of Tacoma Parcel 15

I. SAMPLE RECEIPT:
Samples receipt information is recorded on the attached Sample Receipt Checklist.

II. GENERAL REPORTING COMMENTS:
Results are reported on a wet weight basis unless dry-weight correction is denoted in the units field on the analytical report ("mg/kg-dry" or "ug/kg-dry").

Matrix Spike (MS) and MS Duplicate (MSD) samples are tested from an analytical batch of "like" matrix to check for possible matrix effect. The MS and MSD will provide site specific matrix data only for those samples which are spiked by the laboratory. The sample chosen for spike purposes may or may not have been a sample submitted in this sample delivery group. The validity of the analytical procedures for which data is reported in this analytical report is determined by the Laboratory Control Sample (LCS) and the Method Blank (MB). The LCS and the MB are processed with the samples and the MS/MSD to ensure method criteria are achieved throughout the entire analytical process.

III. ANALYSES AND EXCEPTIONS:
Exceptions associated with this report will be footnoted in the analytical results page(s) or the quality control summary page(s) and/or noted below.

Anions have been sub contracted.

12/14/21: Revision 1 includes correction to sample IDs and reports Arsenic detections below the Reporting Limit.

Qualifiers:

* - Flagged value is not within established control limits
B - Analyte detected in the associated Method Blank
D - Dilution was required
E - Value above quantitation range
H - Holding times for preparation or analysis exceeded
I - Analyte with an internal standard that does not meet established acceptance criteria
J - Analyte detected below Reporting Limit
N - Tentatively Identified Compound (TIC)
Q - Analyte with an initial or continuing calibration that does not meet established acceptance criteria
S - Spike recovery outside accepted recovery limits
ND - Not detected at the Reporting Limit
R - High relative percent difference observed

Acronyms:

%Rec - Percent Recovery
CCB - Continued Calibration Blank
CCV - Continued Calibration Verification
DF - Dilution Factor
DUP - Sample Duplicate
HEM - Hexane Extractable Material
ICV - Initial Calibration Verification
LCS/LCSD - Laboratory Control Sample / Laboratory Control Sample Duplicate
MCL - Maximum Contaminant Level
MB or MBLANK - Method Blank
MDL - Method Detection Limit
MS/MSD - Matrix Spike / Matrix Spike Duplicate
PDS - Post Digestion Spike
Ref Val - Reference Value
REP - Sample Replicate
RL - Reporting Limit
RPD - Relative Percent Difference
SD - Serial Dilution
SGT - Silica Gel Treatment
SPK - Spike
Surr - Surrogate

Analytical Report

Work Order: **2111472**
Date Reported: **12/14/2021**

Client: Aspect Consulting
Project: Port of Tacoma Parcel 15
Lab ID: 2111472-001
Client Sample ID: **MW2R112221**

Collection Date: 11/22/2021 11:55:00 AM
Matrix: Groundwater

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Pentachlorophenol by EPA Method 8270 (SIM)				Batch ID: 34550		Analyst: SB
Pentachlorophenol	14.6	4.96	D	µg/L	10	11/29/2021 3:55:44 PM
Surr: 2,4,6-Tribromophenol	87.5	50.7 - 144	D	%Rec	10	11/29/2021 3:55:44 PM

Client: Aspect Consulting
Project: Port of Tacoma Parcel 15
Lab ID: 2111472-002
Client Sample ID: B5R-112221
Collection Date: 11/22/2021 10:20:00 AM
Matrix: Groundwater

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Dissolved Metals by EPA Method 200.8				Batch ID: 34623		Analyst: EH
Arsenic	3.05	5.00	JD	µg/L	5	12/6/2021 6:50:32 PM
Calcium	45,600	2,620	DQ	µg/L	5	12/6/2021 6:50:32 PM
Iron	28,600	500	D	µg/L	5	12/6/2021 6:50:32 PM
Magnesium	37,100	10,000	D	µg/L	100	12/3/2021 8:29:46 PM
Manganese	1,130	180	D	µg/L	100	12/3/2021 8:29:46 PM
Nickel	ND	130	D	µg/L	100	12/3/2021 8:29:46 PM
Potassium	21,900	20,000	DQ*	µg/L	100	12/3/2021 8:29:46 PM

NOTES:
* - Associated LCS does not meet acceptance criteria; refer to QC summary.
Q - Associated calibration verification is above acceptance criteria. Result may be high-biased.

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Total Metals by EPA Method 200.8				Batch ID: 34596		Analyst: EH
Arsenic	ND	2.63	DMDL	µg/L	20	12/7/2021 10:24:51 AM
Calcium	38,200	20,000	DQ	µg/L	100	12/7/2021 6:02:52 PM
Iron	27,800	2,000	D	µg/L	20	12/7/2021 10:24:51 AM
Magnesium	26,300	2,000	D	µg/L	20	12/7/2021 10:24:51 AM
Manganese	862	100	D	µg/L	20	12/7/2021 10:24:51 AM
Nickel	ND	60.0	D	µg/L	20	12/7/2021 10:24:51 AM
Potassium	13,500	4,000	DQ	µg/L	20	12/7/2021 10:24:51 AM

NOTES:
MDL - Analyte reported to Method Detection Limit (MDL)
Q - Initial and continuing calibration verification for Calcium exceeds acceptance criteria. CCVs are high-biased for the analyte
Q - Associated calibration verification is below acceptance criteria. Result may be low-biased.

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Total Organic Carbon by SM 5310C				Batch ID: R71660		Analyst: SS
Total Organic Carbon	10.7	0.500		mg/L	1	11/30/2021 1:14:00 PM
Total Alkalinity by SM 2320B				Batch ID: R71631		Analyst: CH
Alkalinity, Total (As CaCO3)	195	2.50		mg/L	1	12/1/2021 8:37:29 AM
Ferrous Iron by SM3500-Fe B				Batch ID: R71647		Analyst: SS
Ferrous Iron	45.6	12.5	D	mg/L	125	11/23/2021 8:30:00 AM

Client: Aspect Consulting

Project: Port of Tacoma Parcel 15

Lab ID: 2111472-002

Client Sample ID: **B5R-112221**

Collection Date: 11/22/2021 10:20:00 AM

Matrix: Groundwater

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Total Phosphorous by EPA Method 365.3				Batch ID: 34654		Analyst: SLL
Phosphorus, Total (As P)	1.18	0.250		mg/L	1	12/7/2021 5:03:10 PM

Analytical Report

Work Order: **2111472**
Date Reported: **12/14/2021**

Client: Aspect Consulting
Project: Port of Tacoma Parcel 15
Lab ID: 2111472-003
Client Sample ID: **MW12-112221**
Collection Date: 11/22/2021 1:15:00 PM
Matrix: Groundwater

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Dissolved Metals by EPA Method 200.8				Batch ID: 34623		Analyst: EH
Arsenic	40.1	20.0	D	µg/L	20	12/6/2021 6:56:07 PM
Calcium	100,000	10,500	DQ	µg/L	20	12/6/2021 6:56:07 PM
Iron	147,000	2,000	D	µg/L	20	12/6/2021 6:56:07 PM
Magnesium	50,600	10,000	D	µg/L	100	12/3/2021 8:35:20 PM
Manganese	7,190	180	D	µg/L	100	12/3/2021 8:35:20 PM
Nickel	ND	130	D	µg/L	100	12/3/2021 8:35:20 PM
Potassium	47,900	20,000	DQ	µg/L	100	12/3/2021 8:35:20 PM

NOTES:
* - Associated LCS does not meet acceptance criteria; refer to QC summary.
Q - Associated calibration verification is above acceptance criteria. Result may be high-biased.

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Total Metals by EPA Method 200.8				Batch ID: 34596		Analyst: EH
Arsenic	23.6	100	JD	µg/L	100	12/7/2021 10:27:11 AM
Calcium	92,400	20,000	DQ	µg/L	100	12/7/2021 6:08:27 PM
Iron	136,000	10,000	D	µg/L	100	12/7/2021 10:27:11 AM
Magnesium	38,100	10,000	D	µg/L	100	12/7/2021 10:27:11 AM
Manganese	5,480	500	D	µg/L	100	12/7/2021 10:27:11 AM
Nickel	ND	300	D	µg/L	100	12/7/2021 10:27:11 AM
Potassium	36,000	20,000	DQ	µg/L	100	12/7/2021 10:27:11 AM

NOTES:
Q - Initial and continuing calibration verification for Calcium exceeds acceptance criteria. CCVs are high-biased for the analyte
Q - Associated calibration verification is below acceptance criteria. Result may be low-biased.

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Total Organic Carbon by SM 5310C				Batch ID: R71660		Analyst: SS
Total Organic Carbon	83.0	2.00	D	mg/L	4	12/1/2021 10:38:00 AM
Total Alkalinity by SM 2320B				Batch ID: R71663		Analyst: CH
Alkalinity, Total (As CaCO3)	662	2.50		mg/L	1	12/2/2021 8:32:24 AM
Ferrous Iron by SM3500-Fe B				Batch ID: R71647		Analyst: SS
Ferrous Iron	196	12.5	D	mg/L	125	11/23/2021 8:30:00 AM
Total Phosphorous by EPA Method 365.3				Batch ID: 34654		Analyst: SLL
Phosphorus, Total (As P)	1.66	0.250		mg/L	1	12/7/2021 5:03:10 PM

Client: Aspect Consulting
Project: Port of Tacoma Parcel 15
Lab ID: 2111472-004
Client Sample ID: **MW9-112221**
Collection Date: 11/22/2021 1:55:00 PM
Matrix: Groundwater

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Dissolved Metals by EPA Method 200.8				Batch ID: 34623		Analyst: EH
Arsenic	88.4	20.0	D	µg/L	20	12/6/2021 7:01:41 PM
Calcium	82,500	10,500	DQ	µg/L	20	12/6/2021 7:01:41 PM
Iron	190,000	2,000	D	µg/L	20	12/6/2021 7:01:41 PM
Magnesium	61,600	10,000	D	µg/L	100	12/3/2021 8:40:54 PM
Manganese	3,230	180	D	µg/L	100	12/3/2021 8:40:54 PM
Nickel	ND	130	D	µg/L	100	12/3/2021 8:40:54 PM
Potassium	33,000	20,000	DQ*	µg/L	100	12/3/2021 8:40:54 PM

NOTES:
* - Associated LCS does not meet acceptance criteria; refer to QC summary.
Q - Associated calibration verification is above acceptance criteria. Result may be high-biased.

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Total Metals by EPA Method 200.8				Batch ID: 34596		Analyst: EH
Arsenic	80.4	100	JD	µg/L	100	12/7/2021 10:29:32 AM
Calcium	71,600	20,000	DQ	µg/L	100	12/7/2021 6:25:12 PM
Iron	198,000	10,000	D	µg/L	100	12/7/2021 10:29:32 AM
Magnesium	45,100	10,000	D	µg/L	100	12/7/2021 10:29:32 AM
Manganese	2,500	500	D	µg/L	100	12/7/2021 10:29:32 AM
Nickel	ND	300	D	µg/L	100	12/7/2021 10:29:32 AM
Potassium	22,400	20,000	DQ	µg/L	100	12/7/2021 10:29:32 AM

NOTES:
Q - Initial and continuing calibration verification for Calcium exceeds acceptance criteria. CCVs are high-biased for the analyte
Q - Associated calibration verification is below acceptance criteria. Result may be low-biased.

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Total Organic Carbon by SM 5310C				Batch ID: R71660		Analyst: SS
Total Organic Carbon	79.3	2.00	D	mg/L	4	12/1/2021 11:01:00 AM
Total Alkalinity by SM 2320B				Batch ID: R71663		Analyst: CH
Alkalinity, Total (As CaCO3)	573	2.50		mg/L	1	12/2/2021 8:32:24 AM
Ferrous Iron by SM3500-Fe B				Batch ID: R71647		Analyst: SS
Ferrous Iron	267	25.0	D	mg/L	250	11/23/2021 8:30:00 AM
Total Phosphorous by EPA Method 365.3				Batch ID: 34654		Analyst: SLL
Phosphorus, Total (As P)	1.81	0.250		mg/L	1	12/7/2021 5:03:10 PM

Analytical Report

Work Order: **2111472**
Date Reported: **12/14/2021**

Client: Aspect Consulting
Collection Date: 11/22/2021 3:00:00 PM
Project: Port of Tacoma Parcel 15
Lab ID: 2111472-005
Matrix: Groundwater
Client Sample ID: MW7-112221

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Dissolved Metals by EPA Method 200.8				Batch ID: 34623		Analyst: EH
Arsenic	31.1	20.0	D	µg/L	20	12/6/2021 7:07:16 PM
Calcium	77,200	10,500	DQ	µg/L	20	12/6/2021 7:07:16 PM
Iron	56,800	2,000	D	µg/L	20	12/6/2021 7:07:16 PM
Magnesium	49,000	10,000	D	µg/L	100	12/3/2021 8:46:28 PM
Manganese	2,500	180	D	µg/L	100	12/3/2021 8:46:28 PM
Nickel	ND	130	D	µg/L	100	12/3/2021 8:46:28 PM
Potassium	29,800	20,000	DQ*	µg/L	100	12/3/2021 8:46:28 PM

NOTES:
* - Associated LCS does not meet acceptance criteria; refer to QC summary.
Q - Associated calibration verification is above acceptance criteria. Result may be high-biased.

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Total Metals by EPA Method 200.8				Batch ID: 34596		Analyst: EH
Arsenic	16.2	100	JD	µg/L	100	12/7/2021 10:31:52 AM
Calcium	66,400	20,000	DQ	µg/L	100	12/7/2021 6:30:47 PM
Iron	53,100	10,000	D	µg/L	100	12/7/2021 10:31:52 AM
Magnesium	31,100	10,000	D	µg/L	100	12/7/2021 10:31:52 AM
Manganese	1,720	500	D	µg/L	100	12/7/2021 10:31:52 AM
Nickel	ND	300	D	µg/L	100	12/7/2021 10:31:52 AM
Potassium	18,800	20,000	JDQ	µg/L	100	12/7/2021 10:31:52 AM

NOTES:
Q - Initial and continuing calibration verification for Calcium exceeds acceptance criteria. CCVs are high-biased for the analyte
Q - Associated calibration verification is below acceptance criteria. Result may be low-biased.

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Total Organic Carbon by SM 5310C				Batch ID: R71660		Analyst: SS
Total Organic Carbon	28.6	0.500		mg/L	1	11/30/2021 2:32:00 PM
Total Alkalinity by SM 2320B				Batch ID: R71663		Analyst: CH
Alkalinity, Total (As CaCO3)	294	2.50		mg/L	1	12/2/2021 8:32:24 AM
Ferrous Iron by SM3500-Fe B				Batch ID: R71647		Analyst: SS
Ferrous Iron	76.4	12.5	D	mg/L	125	11/23/2021 8:30:00 AM
Total Phosphorous by EPA Method 365.3				Batch ID: 34654		Analyst: SLL
Phosphorus, Total (As P)	1.24	0.250		mg/L	1	12/7/2021 5:03:10 PM

Work Order: 2111472
CLIENT: Aspect Consulting
Project: Port of Tacoma Parcel 15

QC SUMMARY REPORT

Total Alkalinity by SM 2320B

Sample ID: **MB-R71631**	SampType: **MBLK**		Units: **mg/L**			Prep Date: **12/1/2021**			RunNo: **71631**		
Client ID: **MBLKW**	Batch ID: **R71631**					Analysis Date: **12/1/2021**			SeqNo: **1459394**		
Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Alkalinity, Total (As CaCO3)	ND	2.50									

Sample ID: **LCS-R71631**	SampType: **LCS**		Units: **mg/L**			Prep Date: **12/1/2021**			RunNo: **71631**		
Client ID: **LCSW**	Batch ID: **R71631**					Analysis Date: **12/1/2021**			SeqNo: **1459395**		
Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Alkalinity, Total (As CaCO3)	108	2.50	100.0	0	108	88.3	113				

Sample ID: **2111438-004CDUP**	SampType: **DUP**		Units: **mg/L**			Prep Date: **12/1/2021**			RunNo: **71631**		
Client ID: **BATCH**	Batch ID: **R71631**					Analysis Date: **12/1/2021**			SeqNo: **1459742**		
Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Alkalinity, Total (As CaCO3)	217	2.50						214.6	1.31	20	

Sample ID: **MB-R71663**	SampType: **MBLK**		Units: **mg/L**			Prep Date: **12/2/2021**			RunNo: **71663**		
Client ID: **MBLKW**	Batch ID: **R71663**					Analysis Date: **12/2/2021**			SeqNo: **1460161**		
Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Alkalinity, Total (As CaCO3)	ND	2.50									

Sample ID: **LCS-R71663**	SampType: **LCS**		Units: **mg/L**			Prep Date: **12/2/2021**			RunNo: **71663**		
Client ID: **LCSW**	Batch ID: **R71663**					Analysis Date: **12/2/2021**			SeqNo: **1460162**		
Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Alkalinity, Total (As CaCO3)	107	2.50	100.0	0	107	88.3	113				

Date: *12/14/2021*

Work Order: 2111472
CLIENT: Aspect Consulting
Project: Port of Tacoma Parcel 15

QC SUMMARY REPORT

Total Alkalinity by SM 2320B

Sample ID: **2111548-003CDUP** SampType: **DUP** Units: **mg/L** Prep Date: **12/2/2021** RunNo: **71663**

Client ID: **BATCH** Batch ID: **R71663** Analysis Date: **12/2/2021** SeqNo: **1460430**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Alkalinity, Total (As CaCO3)	956	2.50						973.8	1.85	20	

Date: *12/14/2021*

Work Order: 2111472
CLIENT: Aspect Consulting
Project: Port of Tacoma Parcel 15

QC SUMMARY REPORT

Ferrous Iron by SM3500-Fe B

Sample ID: **MB-R71647** SampType: **MBLK** Units: **mg/L** Prep Date: **11/23/2021** RunNo: **71647**
Client ID: **MBLKW** Batch ID: **R71647** Analysis Date: **11/23/2021** SeqNo: **1459910**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Ferrous Iron	ND	0.100									

Sample ID: **LCS-R71647** SampType: **LCS** Units: **mg/L** Prep Date: **11/23/2021** RunNo: **71647**
Client ID: **LCSW** Batch ID: **R71647** Analysis Date: **11/23/2021** SeqNo: **1459911**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Ferrous Iron	0.398	0.100	0.4000	0	99.5	85	115				

Sample ID: **2111472-004EDUP** SampType: **DUP** Units: **mg/L** Prep Date: **11/23/2021** RunNo: **71647**
Client ID: **MW9-112221** Batch ID: **R71647** Analysis Date: **11/23/2021** SeqNo: **1459915**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Ferrous Iron	261	25.0						266.7	2.17	20	D

Sample ID: **2111472-004EMS** SampType: **MS** Units: **mg/L** Prep Date: **11/23/2021** RunNo: **71647**
Client ID: **MW9-112221** Batch ID: **R71647** Analysis Date: **11/23/2021** SeqNo: **1459916**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Ferrous Iron	374	25.0	100.0	266.7	107	70	130				D

Sample ID: **2111472-004EMSD** SampType: **MSD** Units: **mg/L** Prep Date: **11/23/2021** RunNo: **71647**
Client ID: **MW9-112221** Batch ID: **R71647** Analysis Date: **11/23/2021** SeqNo: **1459917**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Ferrous Iron	349	25.0	100.0	266.7	82.0	70	130	374.1	7.03	20	D

Work Order: 2111472
CLIENT: Aspect Consulting
Project: Port of Tacoma Parcel 15

QC SUMMARY REPORT

Total Phosphorous by EPA Method 365.3

Sample ID: **MB-34654** SampType: **MBLK** Units: **mg/L** Prep Date: **12/6/2021** RunNo: **71785**
Client ID: **MBLKW** Batch ID: **34654** Analysis Date: **12/7/2021** SeqNo: **1463575**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Phosphorus, Total (As P)	ND	0.250									

Sample ID: **LCS-34654** SampType: **LCS** Units: **mg/L** Prep Date: **12/6/2021** RunNo: **71785**
Client ID: **LCSW** Batch ID: **34654** Analysis Date: **12/7/2021** SeqNo: **1463576**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Phosphorus, Total (As P)	0.596	0.250	0.5000	0	119	65	135				

Sample ID: **2111472-002DDUP** SampType: **DUP** Units: **mg/L** Prep Date: **12/6/2021** RunNo: **71785**
Client ID: **B5R-112221** Batch ID: **34654** Analysis Date: **12/7/2021** SeqNo: **1463578**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Phosphorus, Total (As P)	1.16	0.250						1.180	1.74	30	

Sample ID: **2111472-002DMS** SampType: **MS** Units: **mg/L** Prep Date: **12/6/2021** RunNo: **71785**
Client ID: **B5R-112221** Batch ID: **34654** Analysis Date: **12/7/2021** SeqNo: **1463579**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Phosphorus, Total (As P)	1.70	0.250	0.5000	1.180	104	65	135				

Sample ID: **2111472-002DMSD** SampType: **MSD** Units: **mg/L** Prep Date: **12/6/2021** RunNo: **71785**
Client ID: **B5R-112221** Batch ID: **34654** Analysis Date: **12/7/2021** SeqNo: **1463580**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Phosphorus, Total (As P)	1.64	0.250	0.5000	1.180	92.7	65	135	1.702	3.50	30	

Date: *12/14/2021*

Work Order: 2111472
CLIENT: Aspect Consulting
Project: Port of Tacoma Parcel 15

QC SUMMARY REPORT

Total Phosphorous by EPA Method 365.3

Sample ID: **2111533-001DDUP**	SampType: **DUP**	Units: **mg/L**	Prep Date: **12/6/2021**	RunNo: **71785**
Client ID: **BATCH**	Batch ID: **34654**		Analysis Date: **12/7/2021**	SeqNo: **1463601**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Phosphorus, Total (As P)	ND	0.250						0		30	

Sample ID: **2111533-001DMS**	SampType: **MS**	Units: **mg/L**	Prep Date: **12/6/2021**	RunNo: **71785**
Client ID: **BATCH**	Batch ID: **34654**		Analysis Date: **12/7/2021**	SeqNo: **1463602**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Phosphorus, Total (As P)	0.561	0.250	0.5000	0	112	65	135				

Work Order: 2111472
CLIENT: Aspect Consulting
Project: Port of Tacoma Parcel 15

QC SUMMARY REPORT

Total Organic Carbon by SM 5310C

Sample ID: **MB-R71660**	SampType: **MBLK**			Units: **mg/L**		Prep Date: **11/30/2021**		RunNo: **71660**			
Client ID: **MBLKW**	Batch ID: **R71660**					Analysis Date: **11/30/2021**		SeqNo: **1460088**			
Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Total Organic Carbon	ND	0.500									

Sample ID: **LCS-R71660**	SampType: **LCS**			Units: **mg/L**		Prep Date: **11/30/2021**		RunNo: **71660**			
Client ID: **LCSW**	Batch ID: **R71660**					Analysis Date: **11/30/2021**		SeqNo: **1460070**			
Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Total Organic Carbon	5.16	0.500	5.000	0	103	93.1	106				

Sample ID: **2111422-001DDUP**	SampType: **DUP**			Units: **mg/L**		Prep Date: **11/30/2021**		RunNo: **71660**			
Client ID: **BATCH**	Batch ID: **R71660**					Analysis Date: **11/30/2021**		SeqNo: **1460072**			
Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Total Organic Carbon	99.5	0.500						99.81	0.333	20	E

Sample ID: **2111422-001DMS**	SampType: **MS**			Units: **mg/L**		Prep Date: **11/30/2021**		RunNo: **71660**			
Client ID: **BATCH**	Batch ID: **R71660**					Analysis Date: **11/30/2021**		SeqNo: **1460073**			
Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Total Organic Carbon	103	0.500	5.000	99.81	59.7	69.1	124				ES

NOTES:
S - Analyte concentration was too high for accurate spike recovery(ies).

Sample ID: **2111422-001DMSD**	SampType: **MSD**			Units: **mg/L**		Prep Date: **11/30/2021**		RunNo: **71660**			
Client ID: **BATCH**	Batch ID: **R71660**					Analysis Date: **11/30/2021**		SeqNo: **1460074**			
Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Total Organic Carbon	103	0.500	5.000	99.81	67.6	69.1	124	102.8	0.386	30	ES

NOTES:
S - Analyte concentration was too high for accurate spike recovery(ies).

Work Order: 2111472
CLIENT: Aspect Consulting
Project: Port of Tacoma Parcel 15

QC SUMMARY REPORT
Dissolved Metals by EPA Method 200.8

Sample ID: **MB-34623** SampType: **MBLK** Units: **µg/L** Prep Date: **12/2/2021** RunNo: **71741**
Client ID: **MBLKW** Batch ID: **34623** Analysis Date: **12/3/2021** SeqNo: **1462357**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	ND	1.00									
Calcium	ND	525									
Iron	ND	100									
Magnesium	ND	100									
Manganese	ND	1.80									
Nickel	ND	1.30									
Potassium	ND	200									

Sample ID: **2112026-004DDUP** SampType: **DUP** Units: **µg/L** Prep Date: **12/2/2021** RunNo: **71741**
Client ID: **BATCH** Batch ID: **34623** Analysis Date: **12/3/2021** SeqNo: **1462365**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	ND	100						0		30	D
Calcium	158,000	52,500						139,800	12.3	30	DQ
Iron	30,800	10,000						28,900	6.36	30	D
Magnesium	92,800	10,000						85,320	8.36	30	D
Manganese	7,660	180						7,030	8.55	30	D
Nickel	ND	130						0		30	D
Potassium	45,700	20,000						40,880	11.2	30	D*

NOTES:
* - Associated LCS does not meet acceptance criteria; refer to QC summary.
Q - Associated calibration verification is above acceptance criteria. Result may be high-biased.

Sample ID: **2112026-004DMS** SampType: **MS** Units: **µg/L** Prep Date: **12/2/2021** RunNo: **71741**
Client ID: **BATCH** Batch ID: **34623** Analysis Date: **12/3/2021** SeqNo: **1462366**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	62,600	100	50,000	0	125	70	130				D
Calcium	765,000	52,500	500,000	139,800	125	50	150				D
Iron	655,000	10,000	500,000	28,900	125	50	150				D

Work Order: 2111472
CLIENT: Aspect Consulting
Project: Port of Tacoma Parcel 15

QC SUMMARY REPORT

Dissolved Metals by EPA Method 200.8

Sample ID: **2112026-004DMS** SampType: **MS** Units: **µg/L** Prep Date: **12/2/2021** RunNo: **71741**
Client ID: **BATCH** Batch ID: **34623** Analysis Date: **12/3/2021** SeqNo: **1462366**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Magnesium	673,000	10,000	500,000	85,320	117	70	130				D
Manganese	68,400	180	50,000	7,030	123	70	130				D
Nickel	62,500	130	50,000	0	125	70	130				D
Potassium	662,000	20,000	500,000	40,880	124	50	150				D

Sample ID: **LCS-34623** SampType: **LCS** Units: **µg/L** Prep Date: **12/2/2021** RunNo: **71741**
Client ID: **LCSW** Batch ID: **34623** Analysis Date: **12/6/2021** SeqNo: **1463054**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	541	1.00	500.0	0	108	85	115				
Calcium	5,750	525	5,000	0	115	85	115				
Iron	5,100	100	5,000	0	102	85	115				
Magnesium	4,800	100	5,000	0	96.1	85	115				
Manganese	522	1.80	500.0	0	104	85	115				
Nickel	534	1.30	500.0	0	107	85	115				
Potassium	3,860	200	5,000	0	77.1	85	115				S

NOTES:
S - Outlying spike recovery observed (low bias). Samples will be qualified with a *.

Date: *12/14/2021*

Work Order: 2111472
CLIENT: Aspect Consulting
Project: Port of Tacoma Parcel 15

QC SUMMARY REPORT

Total Metals by EPA Method 200.8

Sample ID: **MB-34596** SampType: **MBLK** Units: **µg/L** Prep Date: **12/1/2021** RunNo: **71727**
Client ID: **MBLKW** Batch ID: **34596** Analysis Date: **12/3/2021** SeqNo: **1462060**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	ND	1.00									
Calcium	ND	200									Q
Magnesium	ND	100									
Manganese	ND	5.00									
Nickel	ND	3.00									
Potassium	ND	200									Q

NOTES:
Q - Initial calibration verification for this analyte exceeds acceptance criteria.
Q - Associated calibration verification is below acceptance criteria. Result may be low-biased for K.

Sample ID: **LCS-34596** SampType: **LCS** Units: **µg/L** Prep Date: **12/1/2021** RunNo: **71727**
Client ID: **LCSW** Batch ID: **34596** Analysis Date: **12/3/2021** SeqNo: **1462061**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	109	1.00	100.0	0	109	85	115				
Calcium	1,180	200	1,000	0	118	85	115				S
Magnesium	986	100	1,000	0	98.6	85	115				
Manganese	107	5.00	100.0	0	107	85	115				
Nickel	113	3.00	100.0	0	113	85	115				
Potassium	1,020	200	1,000	0	102	85	115				

NOTES:
S - Outlying spike recovery observed (high bias). Detections will be qualified with a *.

Sample ID: **2111427-003CDUP** SampType: **DUP** Units: **µg/L** Prep Date: **12/1/2021** RunNo: **71727**
Client ID: **BATCH** Batch ID: **34596** Analysis Date: **12/7/2021** SeqNo: **1463330**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	26.0	1.00						28.41	8.88	30	
Magnesium	17,500	100						19,580	11.0	30	E
Manganese	2,710	5.00						3,005	10.2	30	E
Nickel	ND	3.00						0		30	

Work Order: 2111472
CLIENT: Aspect Consulting
Project: Port of Tacoma Parcel 15

QC SUMMARY REPORT

Total Metals by EPA Method 200.8

Sample ID: **2111427-003CDUP** SampType: **DUP** Units: **µg/L** Prep Date: **12/1/2021** RunNo: **71727**
Client ID: **BATCH** Batch ID: **34596** Analysis Date: **12/7/2021** SeqNo: **1463330**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Potassium	5,530	200						6,126	10.3	30	EQ

NOTES:
Q - Associated calibration verification is below acceptance criteria. Result may be low-biased.

Sample ID: **2111427-003CMS** SampType: **MS** Units: **µg/L** Prep Date: **12/1/2021** RunNo: **71727**
Client ID: **BATCH** Batch ID: **34596** Analysis Date: **12/7/2021** SeqNo: **1463331**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	131	1.00	100.0	28.41	103	70	130				
Magnesium	19,300	100	1,000	19,580	-25.9	70	130				ES
Manganese	2,980	5.00	100.0	3,005	-24.3	70	130				ES
Nickel	95.4	3.00	100.0	2.253	93.2	70	130				
Potassium	6,770	200	1,000	6,126	64.0	50	150				E

NOTES:
S - Analyte concentration was too high for accurate spike recovery(ies).

Fremont Analytical

Date: *12/14/2021*

Work Order: 2111472
CLIENT: Aspect Consulting
Project: Port of Tacoma Parcel 15

QC SUMMARY REPORT

Pentachlorophenol by EPA Method 8270 (SIM)

Sample ID: **MB-34550** SampType: **MBLK** Units: **µg/L** Prep Date: **11/23/2021** RunNo: **71608**
Client ID: **MBLKW** Batch ID: **34550** Analysis Date: **11/29/2021** SeqNo: **1458567**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Pentachlorophenol	ND	0.494									
Surr: 2,4,6-Tribromophenol	3.39		3.948		85.9	50.7	144				

Sample ID: **LCS-34550** SampType: **LCS** Units: **µg/L** Prep Date: **11/23/2021** RunNo: **71608**
Client ID: **LCSW** Batch ID: **34550** Analysis Date: **11/29/2021** SeqNo: **1458568**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Pentachlorophenol	3.07	0.497	3.979	0	77.1	54.5	140				
Surr: 2,4,6-Tribromophenol	3.26		3.979		81.9	50.7	144				

Sample ID: **LCSD-34550** SampType: **LCSD** Units: **µg/L** Prep Date: **11/23/2021** RunNo: **71608**
Client ID: **LCSW02** Batch ID: **34550** Analysis Date: **11/29/2021** SeqNo: **1458569**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Pentachlorophenol	2.73	0.493	3.946	0	69.1	54.5	140	3.069	11.8	30	
Surr: 2,4,6-Tribromophenol	3.50		3.946		88.6	50.7	144		0		

Sample ID: **2111463-001DMS** SampType: **MS** Units: **µg/L** Prep Date: **11/23/2021** RunNo: **71608**
Client ID: **BATCH** Batch ID: **34550** Analysis Date: **11/29/2021** SeqNo: **1458571**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Pentachlorophenol	2.69	0.497	3.979	0	67.6	46.5	120				
Surr: 2,4,6-Tribromophenol	3.57		3.979		89.8	50.7	144				

Sample Log-In Check List

Client Name:	**AC**	Work Order Number:	**2111472**
Logged by:	**Gabrielle Coeuille**	Date Received:	**11/22/2021 5:53:00 PM**

Chain of Custody

1.	Is Chain of Custody complete?	Yes ☑	No ☐	Not Present ☐
2.	How was the sample delivered?	Client		

Log In

3.	Coolers are present?	Yes ☑	No ☐	NA ☐
4.	Shipping container/cooler in good condition?	Yes ☑	No ☐	
5.	Custody Seals present on shipping container/cooler? (Refer to comments for Custody Seals not intact)	Yes ☐	No ☐	Not Present ☑
6.	Was an attempt made to cool the samples?	Yes ☑	No ☐	NA ☐
7.	Were all items received at a temperature of >2°C to 6°C *	Yes ☑	No ☐	NA ☐
8.	Sample(s) in proper container(s)?	Yes ☑	No ☐	
9.	Sufficient sample volume for indicated test(s)?	Yes ☑	No ☐	
10.	Are samples properly preserved?	Yes ☑	No ☐	
11.	Was preservative added to bottles?	Yes ☐	No ☑	NA ☐
12.	Is there headspace in the VOA vials?	Yes ☐	No ☐	NA ☑
13.	Did all samples containers arrive in good condition(unbroken)?	Yes ☑	No ☐	
14.	Does paperwork match bottle labels?	Yes ☑	No ☐	
15.	Are matrices correctly identified on Chain of Custody?	Yes ☑	No ☐	
16.	Is it clear what analyses were requested?	Yes ☑	No ☐	
17.	Were all holding times able to be met?	Yes ☑	No ☐	

Special Handling (if applicable)

18.	Was client notified of all discrepancies with this order?	Yes ☑	No ☐	NA ☐

Person Notified:	Adam Griffin	Date:	
By Whom:	Brianna Barnes	Via:	☑ eMail ☐ Phone ☐ Fax ☐ In Person
Regarding:	Refer to Additional Remarks.		
Client Instructions:	Proceed with total Phosphorus and Nitrate+Nitrite analysis.		

19. Additional remarks:

Laboratory was unable to meet nitrate and ortho-phosphate hold times due to instrument malfunction.

Item Information

Item #	Temp ºC
Sample 1	0.9

* Note: DoD/ELAP and TNI require items to be received at 4°C +/- 2°C

Fremont Analytical

3600 Fremont Ave N.
Seattle, WA 98103
Tel: 206-352-3790
Fax: 206-352-7178

Chain of Custody Record & Laboratory Services Agreement

Client: Aspect Consulting
Address: 710 2nd Ave. Ste. 550
City, State, Zip: Seattle, WA, 98104
Telephone:
Fax:

Date: 11/22/21 **Page:** 1 **of:** 1
Project Name: Port of Tacoma Parcel 15
Project No: 210158
Collected by: Baxter Call
Location:
Report To (PM): Adam Griffin
PM Email: agriffin@aspectconsulting.com

Laboratory Project No (internal): 2111472
Special Remarks:
Sample Disposal: ☐ Return to client ☐ Disposal by lab (after 30 days)

	Sample Name	Sample Date	Sample Time	Sample Type (Matrix)*	# of Cont.	VOCs (EPA 8260 / 624)	BTEX	Gasoline Range Organics (GX)	Hydrocarbon Identification (HCID)	Diesel/Heavy Oil Range Organics (DX)	SVOCs (EPA 8270 / 625)	PAHs (EPA 8270 - SIM)	PCBs (EPA 8082 / 608)	Metals** (EPA 6020 / 200.8) Total (T)	Metals** Dissolved (D)	Anions (IC)***	EDB (8011)	Pentachlorophenol	Alkalinity	TOC	Ferrous Fe	Comments
1	MW2R-112221	11/22/21	1155	GW	1													X				
2	BSR-112221	↓	1020	↓	5									X		X			X	X	X	Marked field filtered
3	MW12-112221	↓	1315	↓	↓									↓		↓			↓	↓	↓	↓
4	MW9-112221	↓	1355	↓	↓									↓		↓			↓	↓	↓	↓
5	MW7-112221	↓	1500	↓	↓									↓		↓			↓	↓	↓	↓
6																						
7																						
8																						
9																						
10																						

*Matrix: A = Air, AQ = Aqueous, B = Bulk, O = Other, P = Product, S = Soil, SD = Sediment, SL = Solid, W = Water, DW = Drinking Water, GW = Ground Water, SW = Storm Water, WW = Waste Water

**Metals (Circle): MTCA-5 RCRA-8 Priority Pollutants TAL *Individual:* Ag Al As B Ba Be Ca Cd Co Cr Cu Fe Hg K Mg Mn Mo Na Ni Pb Sb Se Sr Sn Ti Tl V Zn

***Anions (Circle): Nitrate Nitrite Chloride Sulfate Bromide O-Phosphate* Fluoride Nitrate+Nitrite** *as P **as N

Turn-around Time: ☒ Standard ☐ Next Day ☐ 3 Day ☐ Same Day ☐ 2 Day ____ (specify)

I represent that I am authorized to enter into this Agreement with Fremont Analytical on behalf of the Client named above, that I have verified Client's agreement to each of the terms on the front and backside of this Agreement.

Relinquished (Signature)	Print Name	Date/Time	Received (Signature)	Print Name	Date/Time
x B Call	Baxter Call	11/22/21 1750	x CBaker	CAITLIN BAKER	11/22/21 1753
x			x		

www.fremontanalytical.com

COC 1.3 - 11.06.20

Analytical Resources, LLC
Analytical Chemists and Consultants

14 December 2021

Brianna Barnes
Fremont Analytical
3600 Fremont Avenue N.
Seattle, WA 98103

RE: Anions

Please find enclosed sample receipt documentation and analytical results for samples from the project referenced above.

Sample analyses were performed according to ARI's Quality Assurance Plan and any provided project specific Quality Assurance Plan. Each analytical section of this report has been approved and reviewed by an analytical peer, the appropriate Laboratory Supervisor or qualified substitute, and a technical reviewer.

Should you have any questions or problems, please feel free to contact us at your convenience.

Associated Work Order(s)	Associated SDG ID(s)
21L0034	N/A

I certify that this data package is in compliance with the terms and conditions of the contract, both technically and for completeness, for other than the conditions detailed in the enclose Narrative. ARI, an accredited laboratory, certifies that the report results for which ARI is accredited meets all the requirements of the accrediting body. A list of certified analyses, accreditations, and expiration dates is included in this report.

Release of the data contained in this hardcopy data package has been authorized by the Laboratory Manager or his/her designee, as verified by the following signature.

Analytical Resources, LLC

The results in this report apply to the samples analyzed in accordance with the chain of custody document. This analytical report must be reproduced in its entirety.

Shelly Fishel, Project Manager

ACCREDITED IN ACCORDANCE WITH nelac
Cert# 100006-012

4611 S. 134th Place, Suite 100 • Tukwila, WA 98168 • Ph: (206) 695-6200 • Fax: (206) 695-6202

Fremont Analytical

ARI Work Order: 21L0034

CHAIN OF CUSTODY RECORD

Omega COCID 1226 | PAGE: 1 | OF: 1

ADDRESS
Fremont Analytical, Inc.
3600 Fremont Ave. N.
Seattle, WA 98103
TEL: 206-352-3790
FAX: 206-352-7178
Website: www.fremontanalytical.com

SUB CONTRATOR: **ARI** COMPANY: **Analytical Resources Inc.**
ADDRESS: **4611 South 134th Place, Suite 100**
CITY, STATE, ZIP: **Tukwila, WA 98168**
PHONE: **(206) 695-6200** FAX: EMAIL:
ACCOUNT #:

SPECIAL INSTRUCTIONS / COMMENTS:
Please email results to Brianna Barnes at bbarnes@fremontanalytical.com and Matt Langston at mlangston@fremontanalytical.com.

5 Day TAT requested

ITEM #	SAMPLE ID	CLIENT SAMPLE ID	BOTTLE TYPE	MATRIX	DATE COLLECTED	NUMBER OF CONTAINERS	COMMENTS: Methanol Preserved Weights HOT Sample Notation, Additional Sample Description.
1	2111472-002F TEST_SUB	BSR-112221	250 HDPE NON	Groundwater	11/22/2021 10:20:00 AM	1	Chloride, Sufate, Bromide, fluoride by 300.0.
2	2111472-002G TEST_SUB	BSR-112221	250 ML HDPE H	Groundwater	11/22/2021 10:20:00 AM	1	N+N by 353.2
3	2111472-003F TEST_SUB	MW12-112221	250 HDPE NON	Groundwater	11/22/2021 1:15:00 PM	1	Chloride, Sufate, Bromide, fluoride by 300.0.
4	2111472-003G TEST_SUB	MW12-112221	250 ML HDPE H	Groundwater	11/22/2021 1:15:00 PM	1	N+N by 353.2
5	2111472-004F TEST_SUB	MW9-112221	250 HDPE NON	Groundwater	11/22/2021 1:55:00 PM	1	Chloride, Sufate, Bromide, fluoride by 300.0.
6	2111472-004G TEST_SUB	MW9-112221	250 ML HDPE H	Groundwater	11/22/2021 1:55:00 PM	1	N+N by 353.2
7	2111472-005F TEST_SUB	MW7-112221	500 ml HDPE N	Groundwater	11/22/2021 3:00:00 PM	1	Chloride, Sufate, Bromide, fluoride by 300.0.
8	2111472-005G TEST_SUB	MW7-112221	250 ML HDPE H	Groundwater	11/22/2021 3:00:00 PM	1	N+N by 353.2

Relinquished By:	Date:	Time:	Received By:	Date:	Time:
Relinquished By: Alexis Ireas	Date: 12/2/21	Time: 13:21	Received By: APaist	Date: 12/02/21	Time: 1553
Relinquished By:	Date:	Time:	Received By:	Date:	Time:
Relinquished By:	Date:	Time:	Received By:	Date:	Time:

TAT: Standard ☐ RUSH Next BD ☐ 2nd BD ☐ 3rd BD ☐

Note: RUSH requests will incur surcharges!

REPORT TRANSMITTAL DESIRED:
☐ HARDCOPY (extra cost) ☐ FAX ☐ EMAIL ☐ ONLINE

FOR LAB USE ONLY
Temp of samples ______ °C Attempt to Cool ? ______
Comments:

Fremont Analytical

CHAIN OF CUSTODY RECORD

Omega COCID 1226 | PAGE: 1 | OF: 1

ADDRESS
Fremont Analytical, Inc.
3600 Fremont Ave. N.
Seattle, WA 98103
TEL: 206-352-3790
FAX: 206-352-7178
Website: www.fremontanalytical.com

SUB CONTRATOR: ARI
COMPANY: Analytical Resources Inc.
ADDRESS: 4611 South 134th Place, Suite 100
CITY, STATE, ZIP: Tukwila, WA 98168
PHONE: (206) 695-6200 FAX: EMAIL:
ACCOUNT #:

SPECIAL INSTRUCTIONS / COMMENTS:
Please email results to Brianna Barnes at bbarnes@fremontanalytical.com and Matt Langston at mlangston@fremontanalytical.com.
Sample ID edits per BB 12/14/21

5 Day TAT requested

ITEM #	SAMPLE ID	CLIENT SAMPLE ID	BOTTLE TYPE	MATRIX	DATE COLLECTED	NUMBER OF CONTAINERS	COMMENTS: Methanol Preserved Weights HOT Sample Notation, Additional Sample Description.
1	2111472-002F TEST_SUB	~~BSR-112221~~ B5R-11221	250 HDPE NON	Groundwater	11/22/2021 10:20:00 AM	1	Chloride, Sufate, Bromide, fluoride by 300.0.
2	2111472-002G TEST_SUB	~~BSR-112221~~ B5R-11221	250 ML HDPE H	Groundwater	11/22/2021 10:20:00 AM	1	N+N by 353.2
3	2111472-003F TEST_SUB	MW12-112221	250 HDPE NON	Groundwater	11/22/2021 1:15:00 PM	1	Chloride, Sufate, Bromide, fluoride by 300.0.
4	2111472-003G TEST_SUB	MW12-112221	250 ML HDPE H	Groundwater	11/22/2021 1:15:00 PM	1	N+N by 353.2
5	2111472-004F TEST_SUB	MW9-112221	250 HDPE NON	Groundwater	11/22/2021 1:55:00 PM	1	Chloride, Sufate, Bromide, fluoride by 300.0.
6	2111472-004G TEST_SUB	MW9-112221	250 ML HDPE H	Groundwater	11/22/2021 1:55:00 PM	1	N+N by 353.2
7	2111472-005F TEST_SUB	MW7-112221	500 ml HDPE N	Groundwater	11/22/2021 3:00:00 PM	1	Chloride, Sufate, Bromide, fluoride by 300.0.
8	2111472-005G TEST_SUB	MW7-112221	250 ML HDPE H	Groundwater	11/22/2021 3:00:00 PM	1	N+N by 353.2

outgoing 4.9°

Relinquished By:	Date:	Time:	Received By:	Date:	Time:
Alex Jreas	12/2/21	13:21			

TAT: Standard ☐ RUSH Next BD ☐ 2nd BD ☐ 3rd BD ☐

Note: RUSH requests will incur surcharges!

REPORT TRANSMITTAL DESIRED:
☐ HARDCOPY (extra cost) ☐ FAX ☐ EMAIL ☐ ONLINE

FOR LAB USE ONLY
Temp of samples ______ °C Attempt to Cool ? ______
Comments: ______

Fremont Analytical	Project: Anions	
3600 Fremont Avenue N.	Project Number: 2111472	**Reported:**
Seattle WA, 98103	Project Manager: Brianna Barnes	14-Dec-2021 12:51

ANALYTICAL REPORT FOR SAMPLES

Sample ID	Laboratory ID	Matrix	Date Sampled	Date Received
B5R-112221	21L0034-01	Water	22-Nov-2021 10:20	02-Dec-2021 15:53
B5R-112221	21L0034-02	Water	22-Nov-2021 10:20	02-Dec-2021 15:53
MW12-112221	21L0034-03	Water	22-Nov-2021 13:15	02-Dec-2021 15:53
MW12-112221	21L0034-04	Water	22-Nov-2021 13:15	02-Dec-2021 15:53
MW9-112221	21L0034-05	Water	22-Nov-2021 13:55	02-Dec-2021 15:53
MW9-112221	21L0034-06	Water	22-Nov-2021 13:55	02-Dec-2021 15:53
MW7-112221	21L0034-07	Water	22-Nov-2021 15:00	02-Dec-2021 15:53
MW7-112221	21L0034-08	Water	22-Nov-2021 15:00	02-Dec-2021 15:53

Fremont Analytical	Project: Anions	
3600 Fremont Avenue N.	Project Number: 2111472	**Reported:**
Seattle WA, 98103	Project Manager: Brianna Barnes	14-Dec-2021 12:51

Work Order Case Narrative

Client: Fremont Analytical
Project: Anions
Work Order: 21L0034

Revised Report - December 14, 2021

This report was revised to correct sample IDs as supplied in the corrected COC.

Sample receipt

Samples as listed on the preceding page were received 02-Dec-2021 15:53 under ARI work order 21L0034. For details regarding sample receipt, please refer to the Cooler Receipt Form.

Wet Chemistry

The sample(s) were prepared and analyzed within the recommended holding times.

Initial and continuing calibrations were within method requirements.

The method blank(s) were clean at the reporting limits.

The blank spike (BS/LCS) percent recoveries were within control limits.

Analytical Resources, LLC
Analytical Chemists and Consultants

Printed: 12/2/2021 4:30:27PM

WORK ORDER

21L0034

Samples will be discarded 90 days after submission of a final report unless other instructions are received.

Client: Fremont Analytical | **Project Manager: Shelly Fishel**

Project: Anions | **Project Number: 2111472**

Preservation Confirmation

Container ID	Container Type	pH	
21L0034-01 A	HDPE NM, 250mL		
21L0034-02 A	HDPE NM, 250mL H2SO4	<2	Pass
21L0034-03 A	HDPE NM, 250mL		
21L0034-04 A	HDPE NM, 250mL H2SO4	<2	Pass
21L0034-05 A	HDPE NM, 250mL		
21L0034-06 A	HDPE NM, 250mL H2SO4	<2	Pass
21L0034-07 A	HDPE NM, 250mL		
21L0034-08 A	HDPE NM, 250mL H2SO4	<2	Pass

Preservation Confirmed By: [signature] Date: 12/2/21

Reviewed By ______ Date ______

Analytical Resources, Incorporated
Analytical Chemists and Consultants

Cooler Receipt Form

ARI Client: Fremont Analytical

Project Name: 211472 Anions

COC No(s): ______ NA

Delivered by: Fed-Ex UPS Courier Hand Delivered Other:______

Assigned ARI Job No: 21L0034

Tracking No: ______ NA

Preliminary Examination Phase:

Were intact, properly signed and dated custody seals attached to the outside of the cooler?	YES	NO
Were custody papers included with the cooler?	YES	NO
Were custody papers properly filled out (ink, signed, etc.)	YES	NO

Temperature of Cooler(s) (°C) (recommended 2.0-6.0 °C for chemistry)

Time 1553 4.3

If cooler temperature is out of compliance fill out form 00070F

Temp Gun ID#: D002565

Cooler Accepted by: AP Date: 12/02/21 Time: 1553

Complete custody forms and attach all shipping documents

Log-In Phase:

Was a temperature blank included in the cooler?		YES	NO
What kind of packing material was used? ... Bubble Wrap Wet Ice Gel Packs Baggies Foam Block Paper Other: ______			
Was sufficient ice used (if appropriate)?	NA	YES	NO
How were bottles sealed in plastic bags?	Individually	Grouped	Not
Did all bottles arrive in good condition (unbroken)?		YES	NO
Were all bottle labels complete and legible?		YES	NO
Did the number of containers listed on COC match with the number of containers received?		YES	NO
Did all bottle labels and tags agree with custody papers?		YES	NO
Were all bottles used correct for the requested analyses?		YES	NO
Do any of the analyses (bottles) require preservation? (attach preservation sheet, excluding VOCs) ...	NA	YES	NO
Were all VOC vials free of air bubbles?	NA	YES	NO
Was sufficient amount of sample sent in each bottle?		YES	NO
Date VOC Trip Blank was made at ARI.....................	NA	______	

Were the sample(s) split by ARI? NA YES Date/Time: ______ Equipment: ______ Split by: ______

Samples Logged by: RP Date: 12/2/21 Time: 1553 Labels checked by: ______

***** Notify Project Manager of discrepancies or concerns *****

Sample ID on Bottle	Sample ID on COC	Sample ID on Bottle	Sample ID on COC

Additional Notes, Discrepancies, & Resolutions:

By: Date:

Fremont Analytical	Project: Anions	
3600 Fremont Avenue N.	Project Number: 2111472	**Reported:**
Seattle WA, 98103	Project Manager: Brianna Barnes	14-Dec-2021 12:51

B5R-112221

21L0034-01 (Water)

Wet Chemistry

Method: EPA 300.0 — Sampled: 11/22/2021 10:20

Instrument: IC930 Analyst: BF — Analyzed: 12/06/2021 20:30

Analysis by: Analytical Resources, LLC

Sample Preparation: Preparation Method: No Prep Wet Chem — Extract ID: 21L0034-01 A

Preparation Batch: BJL0144 — Sample Size: 10 mL

Prepared: 12/06/2021 — Final Volume: 10 mL

Analyte	CAS Number	Dilution	Detection Limit	Reporting Limit	Result	Units	Notes
Bromide	24959-67-9	1	0.100	0.100	1.24	mg/L	

Analyte	CAS Number	Dilution	Detection Limit	Reporting Limit	Result	Units	Notes
Fluoride	16984-48-8	1	0.100	0.100	0.293	mg/L	

Fremont Analytical	Project: Anions	
3600 Fremont Avenue N.	Project Number: 2111472	**Reported:**
Seattle WA, 98103	Project Manager: Brianna Barnes	14-Dec-2021 12:51

B5R-112221

21L0034-01RE1 (Water)

Wet Chemistry

Method: EPA 300.0 — Sampled: 11/22/2021 10:20

Instrument: IC930 Analyst: BF — Analyzed: 12/12/2021 05:10

Analysis by: Analytical Resources, LLC

Sample Preparation: Preparation Method: No Prep Wet Chem — Extract ID: 21L0034-01RE1 A

Preparation Batch: BJL0144 — Sample Size: 10 mL

Prepared: 12/06/2021 — Final Volume: 10 mL

Analyte	CAS Number	Dilution	Detection Limit	Reporting Limit	Result	Units	Notes
Chloride	16887-00-6	100	10.0	10.0	370	mg/L	D

Fremont Analytical	Project: Anions	
3600 Fremont Avenue N.	Project Number: 2111472	**Reported:**
Seattle WA, 98103	Project Manager: Brianna Barnes	14-Dec-2021 12:51

B5R-112221

21L0034-01RE2 (Water)

Wet Chemistry

Method: EPA 300.0 Sampled: 11/22/2021 10:20

Instrument: IC930 Analyst: BF Analyzed: 12/12/2021 05:30

Analysis by: Analytical Resources, LLC

Sample Preparation: Preparation Method: No Prep Wet Chem Extract ID: 21L0034-01RE2 A

Preparation Batch: BJL0144 Sample Size: 10 mL

Prepared: 12/06/2021 Final Volume: 10 mL

Analyte	CAS Number	Dilution	Detection Limit	Reporting Limit	Result	Units	Notes
Sulfate	14808-79-8	10	1.00	1.00	29.0	mg/L	D

Fremont Analytical	Project: Anions	
3600 Fremont Avenue N.	Project Number: 2111472	**Reported:**
Seattle WA, 98103	Project Manager: Brianna Barnes	14-Dec-2021 12:51

B5R-112221

21L0034-02 (Water)

Wet Chemistry

Method: EPA 353.2 — Sampled: 11/22/2021 10:20

Instrument: LACHAT2 Analyst: AGM — Analyzed: 12/09/2021 15:58

Analysis by: Analytical Resources, LLC

Sample Preparation: Preparation Method: No Prep Wet Chem — Extract ID: 21L0034-02 A

Preparation Batch: BJL0222 — Sample Size: 10 mL

Prepared: 12/09/2021 — Final Volume: 10 mL

Analyte	CAS Number	Dilution	Detection Limit	Reporting Limit	Result	Units	Notes
Nitrate + Nitrite as N		1	0.010	0.010	ND	mg/L	U

Fremont Analytical	Project: Anions	
3600 Fremont Avenue N.	Project Number: 2111472	**Reported:**
Seattle WA, 98103	Project Manager: Brianna Barnes	14-Dec-2021 12:51

MW12-112221

21L0034-03 (Water)

Wet Chemistry

Method: EPA 300.0 — Sampled: 11/22/2021 13:15

Instrument: IC930 Analyst: BF — Analyzed: 12/06/2021 20:50

Analysis by: Analytical Resources, LLC

Sample Preparation: Preparation Method: No Prep Wet Chem — Extract ID: 21L0034-03 A

Preparation Batch: BJL0144 — Sample Size: 10 mL

Prepared: 12/06/2021 — Final Volume: 10 mL

Analyte	CAS Number	Dilution	Detection Limit	Reporting Limit	Result	Units	Notes
Bromide	24959-67-9	1	0.100	0.100	0.804	mg/L	
Fluoride	16984-48-8	1	0.100	0.100	0.877	mg/L	
Sulfate	14808-79-8	1	0.100	0.100	0.110	mg/L	

Fremont Analytical	Project: Anions	
3600 Fremont Avenue N.	Project Number: 2111472	**Reported:**
Seattle WA, 98103	Project Manager: Brianna Barnes	14-Dec-2021 12:51

MW12-112221

21L0034-03RE2 (Water)

Wet Chemistry

Method: EPA 300.0 — Sampled: 11/22/2021 13:15

Instrument: IC930 Analyst: BF — Analyzed: 12/13/2021 14:59

Analysis by: Analytical Resources, LLC

Sample Preparation: Preparation Method: No Prep Wet Chem — Extract ID: 21L0034-03RE2 A

Preparation Batch: BJL0144 — Sample Size: 10 mL

Prepared: 12/06/2021 — Final Volume: 10 mL

Analyte	CAS Number	Dilution	Detection Limit	Reporting Limit	Result	Units	Notes
Chloride	16887-00-6	20	2.00	2.00	79.5	mg/L	D

Fremont Analytical	Project: Anions	
3600 Fremont Avenue N.	Project Number: 2111472	**Reported:**
Seattle WA, 98103	Project Manager: Brianna Barnes	14-Dec-2021 12:51

MW12-112221

21L0034-04RE1 (Water)

Wet Chemistry

Method: EPA 353.2 — Sampled: 11/22/2021 13:15

Instrument: LACHAT2 Analyst: AGM — Analyzed: 12/09/2021 16:19

Analysis by: Analytical Resources, LLC

Sample Preparation: Preparation Method: No Prep Wet Chem — Extract ID: 21L0034-04RE1 A

Preparation Batch: BJL0222 — Sample Size: 10 mL

Prepared: 12/09/2021 — Final Volume: 10 mL

Analyte	CAS Number	Dilution	Detection Limit	Reporting Limit	Result	Units	Notes
Nitrate + Nitrite as N		5	0.050	0.050	ND	mg/L	Y1, U

Fremont Analytical	Project: Anions	
3600 Fremont Avenue N.	Project Number: 2111472	Reported:
Seattle WA, 98103	Project Manager: Brianna Barnes	14-Dec-2021 12:51

MW9-112221

21L0034-05 (Water)

Wet Chemistry

Method: EPA 300.0 — Sampled: 11/22/2021 13:55

Instrument: IC930 Analyst: BF — Analyzed: 12/06/2021 21:10

Analysis by: Analytical Resources, LLC

Sample Preparation: Preparation Method: No Prep Wet Chem — Extract ID: 21L0034-05 A

Preparation Batch: BJL0144 — Sample Size: 10 mL

Prepared: 12/06/2021 — Final Volume: 10 mL

Analyte	CAS Number	Dilution	Detection Limit	Reporting Limit	Result	Units	Notes
Bromide	24959-67-9	1	0.100	0.100	0.900	mg/L	

Analyte	CAS Number	Dilution	Detection Limit	Reporting Limit	Result	Units	Notes
Fluoride	16984-48-8	1	0.100	0.100	0.772	mg/L	

Analyte	CAS Number	Dilution	Detection Limit	Reporting Limit	Result	Units	Notes
Sulfate	14808-79-8	1	0.100	0.100	ND	mg/L	U

Fremont Analytical	Project: Anions	
3600 Fremont Avenue N.	Project Number: 2111472	**Reported:**
Seattle WA, 98103	Project Manager: Brianna Barnes	14-Dec-2021 12:51

MW9-112221

21L0034-05RE2 (Water)

Wet Chemistry

Method: EPA 300.0 — Sampled: 11/22/2021 13:55

Instrument: IC930 Analyst: BF — Analyzed: 12/13/2021 15:18

Analysis by: Analytical Resources, LLC

Sample Preparation: Preparation Method: No Prep Wet Chem — Extract ID: 21L0034-05RE2 A

Preparation Batch: BJL0144 — Sample Size: 10 mL

Prepared: 12/06/2021 — Final Volume: 10 mL

Analyte	CAS Number	Dilution	Detection Limit	Reporting Limit	Result	Units	Notes
Chloride	16887-00-6	20	2.00	2.00	74.1	mg/L	D

Fremont Analytical	Project: Anions	
3600 Fremont Avenue N.	Project Number: 2111472	**Reported:**
Seattle WA, 98103	Project Manager: Brianna Barnes	14-Dec-2021 12:51

MW9-112221

21L0034-06RE1 (Water)

Wet Chemistry

Method: EPA 353.2 Sampled: 11/22/2021 13:55

Instrument: LACHAT2 Analyst: AGM Analyzed: 12/09/2021 16:22

Analysis by: Analytical Resources, LLC

Sample Preparation: Preparation Method: No Prep Wet Chem Extract ID: 21L0034-06RE1 A

Preparation Batch: BJL0222 Sample Size: 10 mL

Prepared: 12/09/2021 Final Volume: 10 mL

Analyte	CAS Number	Dilution	Detection Limit	Reporting Limit	Result	Units	Notes
Nitrate + Nitrite as N		20	0.200	0.200	ND	mg/L	Y1, U

Fremont Analytical	Project: Anions	
3600 Fremont Avenue N.	Project Number: 2111472	**Reported:**
Seattle WA, 98103	Project Manager: Brianna Barnes	14-Dec-2021 12:51

MW7-112221

21L0034-07 (Water)

Wet Chemistry

Method: EPA 300.0 Sampled: 11/22/2021 15:00

Instrument: IC930 Analyst: BF Analyzed: 12/06/2021 21:30

Analysis by: Analytical Resources, LLC

Sample Preparation: Preparation Method: No Prep Wet Chem Extract ID: 21L0034-07 A

Preparation Batch: BJL0144 Sample Size: 10 mL

Prepared: 12/06/2021 Final Volume: 10 mL

Analyte	CAS Number	Dilution	Detection Limit	Reporting Limit	Result	Units	Notes
Bromide	24959-67-9	1	0.100	0.100	0.287	mg/L	

Analyte	CAS Number	Dilution	Detection Limit	Reporting Limit	Result	Units	Notes
Fluoride	16984-48-8	1	0.100	0.100	0.487	mg/L	

Fremont Analytical	Project: Anions	
3600 Fremont Avenue N.	Project Number: 2111472	**Reported:**
Seattle WA, 98103	Project Manager: Brianna Barnes	14-Dec-2021 12:51

MW7-112221

21L0034-07RE1 (Water)

Wet Chemistry

Method: EPA 300.0 — Sampled: 11/22/2021 15:00

Instrument: IC930 Analyst: BF — Analyzed: 12/12/2021 06:29

Analysis by: Analytical Resources, LLC

Sample Preparation: Preparation Method: No Prep Wet Chem — Extract ID: 21L0034-07RE1 A

Preparation Batch: BJL0144 — Sample Size: 10 mL

Prepared: 12/06/2021 — Final Volume: 10 mL

Analyte	CAS Number	Dilution	Detection Limit	Reporting Limit	Result	Units	Notes
Chloride	16887-00-6	10	1.00	1.00	34.7	mg/L	D

Analyte	CAS Number	Dilution	Detection Limit	Reporting Limit	Result	Units	Notes
Sulfate	14808-79-8	10	1.00	1.00	48.9	mg/L	D

Analytical Resources, LLC
Analytical Chemists and Consultants

Analytical Report

Fremont Analytical	Project: Anions	
3600 Fremont Avenue N.	Project Number: 2111472	**Reported:**
Seattle WA, 98103	Project Manager: Brianna Barnes	14-Dec-2021 12:51

MW7-112221

21L0034-08 (Water)

Wet Chemistry

Method: EPA 353.2 — Sampled: 11/22/2021 15:00

Instrument: LACHAT2 Analyst: AGM — Analyzed: 12/09/2021 16:02

Analysis by: Analytical Resources, LLC

Sample Preparation: Preparation Method: No Prep Wet Chem — Extract ID: 21L0034-08 A

Preparation Batch: BJL0222 — Sample Size: 10 mL

Prepared: 12/09/2021 — Final Volume: 10 mL

Analyte	CAS Number	Dilution	Detection Limit	Reporting Limit	Result	Units	Notes
Nitrate + Nitrite as N		1	0.010	0.010	ND	mg/L	U

Fremont Analytical	Project: Anions	
3600 Fremont Avenue N.	Project Number: 2111472	Reported:
Seattle WA, 98103	Project Manager: Brianna Barnes	14-Dec-2021 12:51

Analysis by: Analytical Resources, LLC

Wet Chemistry - Quality Control

Batch BJL0144 - No Prep Wet Chem

Instrument: IC930 Analyst: BF

QC Sample/Analyte	Result	Detection Limit	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Blank (BJL0144-BLK1)					Prepared: 06-Dec-2021 Analyzed: 06-Dec-2021 19:50						
Bromide	ND	0.100	0.100	mg/L							U
Chloride	ND	0.100	0.100	mg/L							U
Fluoride	ND	0.100	0.100	mg/L							U
Sulfate	ND	0.100	0.100	mg/L							U
LCS (BJL0144-BS1)					Prepared: 06-Dec-2021 Analyzed: 06-Dec-2021 20:10						
Bromide	4.89	0.100	0.100	mg/L	5.00		97.8	90-110			
Chloride	4.82	0.100	0.100	mg/L	5.00		96.4	90-110			
Fluoride	5.08	0.100	0.100	mg/L	5.00		102	90-110			
Sulfate	5.24	0.100	0.100	mg/L	5.00		105	90-110			

Fremont Analytical	Project: Anions	
3600 Fremont Avenue N.	Project Number: 2111472	**Reported:**
Seattle WA, 98103	Project Manager: Brianna Barnes	14-Dec-2021 12:51

Analysis by: Analytical Resources, LLC

Wet Chemistry - Quality Control

Batch BJL0222 - No Prep Wet Chem

Instrument: LACHAT2 Analyst: AGM

QC Sample/Analyte	Result	Detection Limit	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Blank (BJL0222-BLK1)					Prepared: 09-Dec-2021 Analyzed: 09-Dec-2021 15:38						
Nitrate + Nitrite as N	ND	0.010	0.010	mg/L							U
LCS (BJL0222-BS1)					Prepared: 09-Dec-2021 Analyzed: 09-Dec-2021 15:40						
Nitrate + Nitrite as N	0.495	0.010	0.010	mg/L	0.500		99.0	90-110			

Fremont Analytical	Project: Anions	
3600 Fremont Avenue N.	Project Number: 2111472	**Reported:**
Seattle WA, 98103	Project Manager: Brianna Barnes	14-Dec-2021 12:51

Certified Analyses included in this Report

Analyte	Certifications
EPA 300.0 in Water	
Bromide	DoD-ELAP,WADOE,NELAP
Chloride	DoD-ELAP,WADOE,WA-DW,NELAP
Fluoride	DoD-ELAP,WADOE,WA-DW
Sulfate	DoD-ELAP,WADOE,WA-DW,NELAP
EPA 353.2 in Water	
Nitrate + Nitrite as N	NELAP,DoD-ELAP,WADOE

Code	Description	Number	Expires
ADEC	Alaska Dept of Environmental Conservation	17-015	03/28/2023
DoD-ELAP	DoD-Environmental Laboratory Accreditation Program	66169	02/28/2022
NELAP	ORELAP - Oregon Laboratory Accreditation Program	WA100006-012	05/12/2022
WADOE	WA Dept of Ecology	C558	06/30/2022
WA-DW	Ecology - Drinking Water	C558	06/30/2022

Fremont Analytical	Project: Anions	
3600 Fremont Avenue N.	Project Number: 2111472	**Reported:**
Seattle WA, 98103	Project Manager: Brianna Barnes	14-Dec-2021 12:51

Notes and Definitions

D	The reported value is from a dilution
U	This analyte is not detected above the reporting limit (RL) or if noted, not detected above the limit of detection (LOD).
Y1	Raised reporting limit due to interference
DET	Analyte DETECTED
ND	Analyte NOT DETECTED at or above the reporting limit
NR	Not Reported
dry	Sample results reported on a dry weight basis
RPD	Relative Percent Difference
[2C]	Indicates this result was quantified on the second column on a dual column analysis.

APPENDIX G

Field Forms

 11/17 Porter BBC

0700 Aspect & Cascade on site.
0730 Cascade sets up to drill AB-06. Begin developing MW-14.
0850 Begin drilling AB-06.
1030 Finish MW-14 development. Begin drilling AB-03
1200 Begin drilling AB-02.
1310 Begin drilling AB-01. Moved ~ 12 ft. S. to avoid storm-water line and overhead power line obstacles.
1440 Calibrate YSI. Cascade decontaminating equipment.
1450 Begin installing temp GW points in AB-04. 3 ft. screens 14-17' bgs, 18-21' bgs, and 22-25' bgs.
1500 Begin purging AB-04 14-17' bgs.

	5'	10'	15'	
Temp(°C)	15.1	15.7	15.8	°C
pH	6.15	6.50	6.58	-
Cond	2091	1754	1738	µS/cm
DO %	27.3	17.6	~~14.~~16.3	-
ORP	120.1	50.5	13.0	mV
Turbidity	>1000	83.0	53.5	NTU

1515 Collect sample AB4-14-111721
1530 Cascade begins monument completion on MW-14.

~~11/17~~ 11/17 Porter BBC

1540 Begin purging AB-04 - 18-21' bgs.

	5'	10'	15'	
Temp	14.6	15.4	14.6	°C
pH	6.92	6.94	6.98	-
Cond	2012	2772	2794	µS/cm
DO	13.2	11.0	7.3	%
ORP	-77.8	-89.5	-104.0	mV
Turb	>1000	61.4	50.2	NTU

1545 Collect sample AB4-18-111721
1615 Aspect off site.

Aspect CONSULTING

Field Staff: BBC

DAILY REPORT

Date: 11/18/21 **Project Name:** Portac **Project Number:** 210158 **Weather:** 45°F, rain **Arrival on site:** 0830 **Departure from site:** 1630	Equipment used: YSI (red) Turbidimeter (Green) Calibration: on site.

0830 Aspect on site. Cascade completing MW-14 monument. AB-04 22-25 ft. groundwater sample purging. Calibrate YSI (Red)

	soln	pre	post
pH 4	4.00	4.15	4.00
pH 7	7.00	6.99	7.00
COND	1413	4837	1412
ORP	232	234.5	231.7
DO %	100	92.9	102.0

AB-04 purged >20 min.
0900 Collect sample AB4-22-111821

0835 Begin installing temp GW point in AB-05. 3 ft screens from 11-14, 14-17, 18-21, and 22-25 ft.
Not able to produce water 11-14 ft.

1025 Begin pursing AB-05 14-17 ft.

	5 min	10 min	15 min	20 min
Temp (°C)	15.3	15.1	14.9	14.0
pH	6.75	6.84	6.98	6.92
cond (mS/cm)	2513	2527	2521	2515
DO %	23.2	43.6	47.8	51.0
ORP (mV)	101.6	89.1	79.0	69.7
Turb (NTU)	>1000	>1000	87.2	85.8

* DO showed high, slow GW recharge, air bubbles in purge water.

1045 Collect sample ABS-~~18~~ 14-111821

~~1200 B~~ 1115 Begin pursing AB-05 18-21 ft.

	5 min	10 min	15 min	25 min
Temp	14.7	15.4	15.5	15.1
pH	6.90	6.77	6.75	6.77
cond	3117	3148	3156	3101
~~ORP~~ DO	54.7	37.3	31.9	34.7
ORP	62.3	51.7	43.9	36.3
Turb	>1000	>1000	>1000	90.8

1140 Collect sample ABS-18-111821

Aspect CONSULTING

Field Staff: BB C

DAILY REPORT

Date: 11/18/21 **Project Name:** Porter **Project Number:** **Weather:** **Arrival on site:** **Departure from site:**	Equipment used: Calibration:

1200 Begin purging AB-05 22-25 ft.

	15 min	30 min
Temp	14.0	13.3
pH	6.66	6.75
COND	353	3214
DO	26.1	35.6
ORP	34.0	36.5
Turb.	>1000	>1000

* Very turbid, very slow recharge.

1240 Collect sample AB5-22-111821

1225 Begin advancing AB-06 temp well screen. Setting 3ft screens 14-17 18-21, and 22-25 ft.

1250 Begin purging AB-06 14-17ft.

	5 min	10 min	15 min
Temp	15.2	16.1	15.4
pH	6.65	6.72	6.70
Cond	2842	2897	2894
DO	17.0	4.9	8.9
ORP	18.3	6.1	-15.7
Turb.	>1000	>1000	75.9

1320 Collect sample AB6-14-111821

1300 Begin purging AB-06 18-21 ft.

	5 min	10 min	15 min	50 min
Temp	15.9	14.6	14.7	14.2
pH	6.67	6.74	6.64	6.59
Cond	3209	2412	1797	1931
DO	31.0	4.0	6.7	15.1
ORP	13.8	-7.0	-21.5	-30.8
Turb.	>1000	>1000	>1000	>1000

1335 Collect sample AB6-18-111821

Aspect CONSULTING

Field Staff: BBC

DAILY REPORT

Date: 11/18/21 **Project Name:** Porter **Project Number:** **Weather:** **Arrival on site:** **Departure from site:**	Equipment used: Calibration:

1345 Begin purging AB-06 22-25 ft.

	5 min	10 min	30 min
Temp	13.8	14.3	14.4
pH	6.51	6.55	6.55
Cond	3891	3771	4039
DO	12.1	9.4	11.5
ORP	-29.7	-33.9	-37.5
Turb.	>1000	>1000	>1000

1415 Collect sample AB6-22-111821

1440 Begin advancing AB-03 temp well screens. 3 ft. screens 14-17, 18-21, and 22-25 ft.

1510 Begin purging AB-03 22-25 ft.

	5 min	10 min	15 min
Temp	11.7	11.2	10.7
pH	6.86	6.87	6.96
cond	2787	2723	2734
DO	55	57.2	59.1
ORP	-23.7	-16.5	-12.5
Turb.	>1000	>1000	99.5

* Very ~~slow rech~~ slow groundwater recharge.

1530 Collect sample AB3-22-111821

1525 Begin purging AB-03 18-21 ft.

	5 min	10 min	15 min	30 min
Temp	13.9	14.1	14.6	14.1
pH	6.47	6.37	6.34	6.37
cond	1843	1825	1828	1.827
DO ~~ORP~~	10.0	4.7	3.0	1.7
ORP	-23.3	-25.7	-28.2	-32.7
Turb.	>1000	>1000	>1000	>1000

1600 Collect sample AB3-18-111821

Collect samples
- AB-03-16.5
- AB-03-20
- AB-03-22

To be submitted for GSA.

Temp well screens 14-17 ft. in AB-03 is dry, not able to produce water.

1630 Aspect off site

Aspect CONSULTING

Field Staff: BBL

DAILY REPORT

Date: 11/19/21 **Project Name:** Port of Tacoma Parcel **Project Number:** 210158 **Weather:** 40 °F, overcast **Arrival on site:** 0630 **Departure from site:** 1525	**Equipment used:** YSI (Blue), Turbidimeter (Blue) **Calibration:** on site

0630 Aspect & Cascade on site. Cascade demobilizing drill eqpt. from AB-03. Calibrate YSI (Blue).

0745 Begin advancing temp GW screens in AB-02. 3 ft. screens 14-17, 18-21, and 22-25 ft. MW-14 ecology well ID BNR 144 installed.

0810 Begin purging AB-02 18-21 ft.

	5 min	15 min	25 min	30 min	
Temp	13.8	15.2	15.3	15.1	°C
pH	6.61	6.59	6.73	6.78	–
cond	2234	2022	2030	2057	µS/cm
DO	9.7	10.8	12.2	13.3	%
ORP	-62.9	-108.6	-111.3	-101.9	mV
Turb	>1000	>1000	>1000	>1000	NTU

*AB-02 22-25 ft. not producing enough water to sample. Very slow recharge. Pushing to 22-26 ft. to improve recharge.

0840 Collect sample AB2-18-111921

0850 Collect sample AB2-22-111921. Not enough water produced to collect field parameters. (Turb >1000 NTU)

0855 Begin purging AB-02 14-17 ft.

	5 min	10 min	25 min
Temp	13.1	14.0	13.7
pH	6.71	6.68	6.68
cond	1862	1873	1804
DO	10.2	10.0	9.2
ORP	-102.5	-101.5	-99.2
Turb.	>1000	>1000	84.9

0925 Collect sample AB2-14-111921

1025 Begin advancing AB-01 temp GW screens. 3 ft. screens 14-17 ft, 18-21 ft, and 22-25 ft.

Aspect CONSULTING

Field Staff: BBC

DAILY REPORT

Date: 11/19/21 **Project Name:** **Project Number:** ~~17~~ 210158 **Weather:** **Arrival on site:** **Departure from site:**	**Equipment used:** **Calibration:**

1035 Begin purging AB-01 18-21 ft.

	5 min	10 min	20 min
Temp	14.9	14.9	14.9
pH	6.68	6.55	6.49
Cond	1645	1507	1486
DO	13.1	12.6	12.7
ORP	-50.0	-44.1	-44.3
Turb	>1000	>1000	79.2

1055 Collect sample AB1-18-111921

1050 Begin purging AB-01 22-25 ft.

	15 min	20 min	25 min	30 min
Temp	15.1	14.6	14.5	14.2
pH	6.59	6.67	6.65	6.66
Cond	683	650	643	621.5
DO	9.8	12.1	11.6	12.1
ORP	-57.2	-74.0	-70	-71.8
Turb	>1000	>1000	>1000	>1000

1120 Collect sample AB1-22-111921

1115 Begin purging AB-01 14-17 ft.

	5 min	30 min
Temp	14.8	14.8
pH	6.52	6.34
Cond	9583	10040
DO	10.1	15.8
ORP	-36.0	-30.1
Turb	>1000	>1000

1150 Collect sample AB1-14-111921

1230 Begin purging MW-14.

1310 Collect sample MW-14-111921

1330 Begin decon & demobilization, and surface restoration.

1525 Aspect off site.

X:\Aspect Forms\Field Forms\Field Note Template.docx

Aspect CONSULTING

Sample number: MW-14-111921

GROUNDWATER SAMPLING RECORD

WELL NUMBER: MW-14 **Page:** 1 **of** 1

Project Name: ~~Tux Shop~~ Porter

Date: 11/19/21

Sampled by: BBC

Measuring Point of Well: N TOC

Screened Interval (ft. TOC): 15-25

Filter Pack Interval (ft. TOC): 14-25

Project Number: ~~090030-004~~ 210158

Starting Water Level (ft TOC): ~~13.95~~ 14.1

Casing Stickup (ft): -0.2

Total Depth (ft TOC): 22.6

Casing Diameter (inches): 2

Casing Volume 8.5 (ft Water) x 0.62 (Lpf)(gpf) = 5.27 (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): 20

PURGING MEASUREMENTS

Criteria:		Typical 0.1-0.5 Lpm	Stable	na	± 3%	± 10%	± 0.1	± 10 mV	± 10%	
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
1230	0	0.2	14.1							Started pumping
1235	1	0.1	14.38	16.1	1350	2.5	6.47	-79.8	41.5	No odor, no sheen
1240	1.5	0.1	14.40	16.2	1323	2.2	6.45	-83.5	69.9	
1245	2.0	0.1	14.40	16.2	1308	2.3	6.44	-85.7	67.1	
1250	2.5	0.1	14.41	16.2	1321	2.2	6.44	-89.2	42.8	
1255	3.0	0.1	14.43	16.4	1322	2.1	6.44	-91.9	27.7	
1300	3.5	0.1	14.44	16.3	1327	2.2	6.44	-94.1	19.6	
1305	4.0	0.1	14.45	16.3	1323	2.2	6.44	-95.2	22.9	
1310	4.5	0.1	14.45	16.4	1327	2.2	6.44	-95.8	23.6	

Total Gallons Purged:

Total Casing Volumes Removed:

Ending Water Level (ft TOC):

Ending Total Depth (ft TOC): 22.6

SAMPLE INVENTORY

Time	Volume (mL)	Bottle Type	Quantity	Filtration	Preservation	Appearance: Color	Appearance: Turbidity & Sediment	Remarks
	~~40~~	~~VOA~~	~~3~~	~~N~~	~~HCl~~			
1310	250	Poly	1	Y	N			
1310	250	Poly	1	N	Y			
1310	250	amber	1	N	Y			
1310	500	amber	1	N	Y			
1310	500	Poly	1	N	N			

METHODS

Parameters measured with (instrument model & serial number) YSI: Blue Turbidimeter: Green WLI: Blue

Purging Equipment: Peristaltic pump and ~~dedicated tubing~~ disposable tubing Decon Equipment: Alconox and water

Disposal of Discharged Water: Drum on site

Observations/Comments:

APPENDIX H

All Groundwater Results (Point of Compliance Wells)

Table H-1. All Groundwater Results (Point of Compliance Wells)

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

Analyte	Unit	Cleanup Level (ug/L)	MW-2R 05/31/2016	MW-2R 08/15/2016	MW-2R 11/17/2016	MW-2R 02/20/2017	MW-2R 02/19/2019	MW-2R 08/12/2019	MW-2R 11/22/2021	B-5R 06/01/2016	B-5R 08/17/2016	B-5R 11/17/2016	B-5R 02/22/2017	B-5R 11/22/2021	MW-7 06/01/2016	MW-7 08/16/2016	MW-7 11/16/2016	MW-7 02/22/2017	MW-7 02/19/2019	MW-7 08/12/2019	MW-7 11/22/2021
Dissolved Metals																					
Arsenic	ug/L	5	3.39	3.65	3.31	2.27	--	--	--	0.311 J	0.521 J	0.44 J	< 1.01 U	< 5 UJ	21.5	27.5	13.2	1.14	31	27	31.1
Arsenate	ug/L		--	--	--	--	--	--	--	--	--	--	--	--	--	30.5	9.71	0.221 J	--	--	--
Arsenite	ug/L		--	--	--	--	--	--	--	--	--	--	--	--	--	0.924 J	3.75	0.591	--	--	--
DiMethyl Arsenic	ug/L		--	--	--	--	--	--	--	--	--	--	--	--	--	< 1.05 U	< 1.05 U	0.077 J	--	--	--
Calcium	mg/L		87	--	--	--	--	--	--	18	--	--	--	45.6 J	160	150	53	18	--	--	77.2 J
Iron	ug/L		34.6	< 21.5 U	8.94 J	< 21.5 U	--	--	--	25300	32200	27600 J	25700	28,600	118000	123000	59100 J	1880	--	--	56,800
Magnesium	mg/L		< 1.1 U	--	--	--	--	--	--	22	--	--	--	37.1	110	100	30	8.6	--	--	49
Manganese	ug/L		1.2 J	1.13 J	< 1.59 U	< 1.59 U	--	--	--	1000	1060	1010	880	1,130	7180	7980	2770	781	--	--	2,500
Nickel	ug/L		--	--	--	--	--	--	--	--	--	--	--	< 130 U	--	--	--	--	--	--	< 130 U
Potassium	mg/L		5.5	--	--	--	--	--	--	13	--	--	--	--	37	38	24	15	--	--	--
Potassium	ug/L		--	--	--	--	--	--	--	--	--	--	--	21,900 J	--	--	--	--	--	--	29,800 J
Sodium	mg/L		9.2	--	--	--	--	--	--	58	--	--	--	--	200	260	37	7.1	--	--	--
Iron, Ferric, Fe+3	ug/L		17.6 J	--	--	--	--	--	--	1960	--	--	--	--	11500	--	--	--	--	--	--
MonoMethyl Arsenic	ug/L		--	--	--	--	--	--	--	--	--	--	--	--	--	< 1.15 U	< 1.15 U	< 0.575 U	--	--	--
Total Metals																					
Arsenic	ug/L		3.56	5.21	4.39	2.6	--	--	--	0.29 J	< 1.06 U	1.7	0.317 J	< 2.63 U	20.8	25.7	12	0.951 J	47	45	16.2
Calcium	ug/L		--	--	--	--	--	--	--	--	--	--	--	38,200 J	--	--	--	--	--	--	66,400 J
Iron	ug/L		--	--	--	--	--	--	--	--	--	--	--	27,800	--	--	--	--	--	--	53,100
Magnesium	ug/L		--	--	--	--	--	--	--	--	--	--	--	26,300	--	--	--	--	--	--	31,100
Manganese	ug/L		--	--	--	--	--	--	--	--	--	--	--	862	--	--	--	--	--	--	1,720
Nickel	ug/L		--	--	--	--	--	--	--	--	--	--	--	< 60 U	--	--	--	--	--	--	< 300 U
Potassium	ug/L		--	--	--	--	--	--	--	--	--	--	--	13,500 J	--	--	--	--	--	--	18,800 UJ
SVOCs																					
Pentachlorophenol	ug/L	1	18	22	21	7.8	12	31	14.6	0.089	0.049	< 0.088 U	0.43	--	--	--	--	--	--	--	--
Conventionals																					
Alkalinity as Bicarbonate	mg/L		< 5 U	--	--	--	--	--	--	230	--	--	--	--	940	1100	310	70	--	--	--
Alkalinity as Carbonate	mg/L		56	--	--	--	--	--	--	< 5 U	--	--	--	--	< 5 U	< 5 U	< 5 U	< 5 U	--	--	--
Alkalinity as Hydroxide	mg/L		150	--	--	--	--	--	--	< 5 U	--	--	--	--	< 5 U	< 5 U	< 5 U	< 5 U	--	--	--
Alkalinity, Total	mg/L		210	--	--	--	--	--	--	230	--	--	--	195	940	1100	310	70	--	--	294
Bromide	mg/L		< 0.5 U	--	--	--	--	--	--	< 0.5 U	--	--	--	--	0.49 J	1.9	< 0.5 U	< 0.100 U	--	--	--
Chloride	mg/L		3.9 J	--	--	--	--	--	--	28	--	--	--	--	240	260	26	3.56	--	--	--
Dissolved Organic Carbon	mg/L		7.9	12	5.8	3.4 J	--	--	--	17	18	15	17 J	--	66	80	23	5.1 J	--	--	--
Iron, Ferrous, Fe+2	mg/L		17	--	--	--	--	--	--	23.3	--	--	--	45.6	107	--	--	--	--	--	76.4
Fluoride	mg/L		0.09 J	--	--	--	--	--	--	0.54	--	--	--	--	1.2	0.97	0.73	0.359	--	--	--
Nitrate as Nitrogen	mg/L		< 0.2 U	--	--	--	--	--	--	< 0.2 U	--	--	--	--	0.14 J	0.16 J	0.13 J	< 0.100 U	--	--	--
Nitrite as Nitrogen	mg/L		< 0.4 U	--	--	--	--	--	--	< 0.4 U	--	--	--	--	< 4 UJ	< 0.4 U	< 0.4 U	< 0.100 U	--	--	--
Orthophosphate	mg/L		0.11	--	--	--	--	--	--	0.48	--	--	--	--	0.12	0.14	< 0.1 U	0.11	--	--	--
Sulfate	mg/L		16	--	--	--	--	--	--	< 1.2 U	--	--	--	--	0.71 J	1.2	95 J	44.2	--	--	--
Sulfide	mg/L		< 0.05 U	--	--	--	--	--	--	0.029 J	< 1 U	0.047 J	< 0.05 U	--	< 0.05 U	< 0.5 U	< 0.05 U	< 0.05 U	--	--	--
Phosphorus	mg/L		--	--	--	--	--	--	--	--	--	--	--	1.18	--	--	--	--	--	--	1.24
Total Organic Carbon	mg/L		8.7	12	5.8	3.2	4300	22	--	18 J	19	17	17 J	10.7	64	79	12	6.1	--	--	28.6
Total Suspended Solids	mg/L		--	< 2 U	< 2 U	2	--	--	--	--	< 2 U	< 2 U	3.2	--	--	87	55	5.2	--	--	--
Field Parameters																					
Temperature	deg C		--	--	--	--	--	--	12.7	--	--	--	--	15.6	--	--	--	--	--	--	15.6
Specific Conductance	uS/cm		--	--	--	--	--	--	629.8	--	--	--	--	1675	--	--	--	--	--	--	818
Dissolved Oxygen	mg/L		--	--	--	--	--	--	10.1	--	--	--	--	2.2	--	--	--	--	--	--	1.8
pH	pH units		--	--	--	--	--	--	11.86	--	--	--	--	6.47	--	--	--	--	--	--	6.42
Oxidation Reduction Potential	mV		--	--	--	--	--	--	27.4	--	--	--	--	88.3	--	--	--	--	--	--	81
Turbidity	NTU		--	--	--	--	--	--	100	--	--	--	--	100	--	--	--	--	--	--	100
pH	pH units		11.6	--	--	--	--	--	--	6.47	--	--	--	--	--	--	--	--	--	--	--

Notes

Bold - detected

Blue Shading - exceeds Groundwater Cleanup Level

J - Analyte was positively identified. The reported result is an estimate.

U - Analyte was not detected at or above the reported result.

Arsenic, iron, and manganese results at B-5R and MW-7 were analyzed by both SW6020B and EPA1638M. For events where metals analyzed for both, the lowest value or reporting limit is shown.

Table H-1. All Groundwater Results (Point of Compliance Wells)

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

Analyte	Unit	Cleanup Level (ug/L)	MW-9 06/01/2016	MW-9 08/16/2016	MW-9 11/16/2016	MW-9 02/23/2017	MW-9 02/20/2019	MW-9 08/12/2019	MW-9 11/22/2021	MW-12 06/01/2016	MW-12 08/18/2016	MW-12 11/16/2016	MW-12 02/23/2017	MW-12 02/19/2019	MW-12 08/13/2019	MW-12 11/22/2021
Dissolved Metals																
Arsenic	ug/L	5	**87.4**	**54.5**	**83.6**	**74.4**	**170**	**62**	**88.4**	**16.7**	**10 J**	**36.5**	**15.4**	**61**	**20**	**40.1**
Arsenate	ug/L		**90.2**	**50.8**	**45.5**	**74.2**	--	--	--	--	**13.9**	**29**	**13.7**	--	--	--
Arsenite	ug/L		**4.92**	**3.11 J**	**40.2**	**2.4**	--	--	--	--	**0.318 J**	**3.2**	**1.19**	--	--	--
DiMethyl Arsenic	ug/L		**0.179 J**	< 4.2 U	**0.249 J**	**0.169 J**	--	--	--	--	< 1.05 U	**0.247 J**	**0.18 J**	--	--	--
Calcium	mg/L		**78**	**92**	**50**	**44**	--	--	**82.5 J**	**62**	**64**	**93**	**84**	--	--	**100 J**
Iron	ug/L		**243000**	**201000**	**225000 J**	**207000**	--	--	**190,000**	**107000**	**105000**	**138000 J**	**126000**	--	--	**147,000**
Magnesium	mg/L		**65**	**88**	**31**	**25**	--	--	**61.6**	**60**	**63**	**41**	**40**	--	--	**50.6**
Manganese	ug/L		**4450**	**4960**	**3250**	**2990**	--	--	**3,230**	**6540**	**6610**	**7130**	**5870**	--	--	**7,190**
Nickel	ug/L		--	--	--	--	--	--	< 130 U	--	--	--	--	--	--	< 130 U
Potassium	mg/L		**30**	**37**	**21**	**18**	--	--	--	**50**	**55**	**38**	**32**	--	--	--
Potassium	ug/L		--	--	--	--	--	--	**33,000 J**	--	--	--	--	--	--	**47,900 J**
Sodium	mg/L		**130**	**190**	**61**	**32**	--	--	--	**310**	**310**	**37**	**72**	--	--	--
Iron, Ferric, Fe+3	ug/L		**26000**	--	--	--	--	--	--	**36500**	--	--	--	--	--	--
MonoMethyl Arsenic	ug/L		< 1.15 U	< 4.6 U	< 1.15 U	**0.265 J**	--	--	--	--	**0.211 J**	< 1.15 U	< 0.575 U	--	--	--
Total Metals																
Arsenic	ug/L		**72.8**	**53.7**	**95.8**	**82.5**	**470**	**540**	**80.4**	**18.5**	**14.7**	**39.2**	**17.5**	**100**	**18**	**23.6**
Calcium	ug/L		--	--	--	--	--	--	**71,600 J**	--	--	--	--	--	--	**92,400 J**
Iron	ug/L		--	--	--	--	--	--	**198,000**	--	--	--	--	--	--	**136,000**
Magnesium	ug/L		--	--	--	--	--	--	**45,100**	--	--	--	--	--	--	**38,100**
Manganese	ug/L		--	--	--	--	--	--	**2,500**	--	--	--	--	--	--	**5,480**
Nickel	ug/L		--	--	--	--	--	--	< 300 U	--	--	--	--	--	--	< 300 U
Potassium	ug/L		--	--	--	--	--	--	**22,400 J**	--	--	--	--	--	--	**36,000 J**
SVOCs																
Pentachlorophenol	ug/L	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Conventionals																
Alkalinity as Bicarbonate	mg/L		**830**	**880**	**660**	**430**	--	--	--	**920**	**920**	**650**	**490**	--	--	--
Alkalinity as Carbonate	mg/L		< 5 U	< 5 U	< 5 U	< 5 U	--	--	--	< 5 U	< 5 U	< 5 U	< 5 U	--	--	--
Alkalinity as Hydroxide	mg/L		< 5 U	< 5 U	< 5 U	< 5 U	--	--	--	< 5 U	< 5 U	< 5 U	< 5 U	--	--	--
Alkalinity, Total	mg/L		**830**	**880**	**660**	**430**	--	--	**573**	**920**	**920**	**650**	**490**	--	--	**662**
Bromide	mg/L		**0.87**	**1.8**	**0.69**	**0.262**	--	--	--	**0.69**	**1.7 J**	< 0.5 U	**0.403**	--	--	--
Chloride	mg/L		**130**	**160**	**47**	**19.4**	--	--	--	**200**	**190 J**	**14**	**47.8**	--	--	--
Dissolved Organic Carbon	mg/L		**93**	**100**	**60**	**42**	--	--	--	**85**	**84**	**64**	**52**	--	--	--
Iron, Ferrous, Fe+2	mg/L		**217**	--	--	--	--	--	**267**	**70.4**	--	--	--	--	--	**196**
Fluoride	mg/L		**0.98**	**0.97**	**0.87**	**0.912**	--	--	--	**1.5**	**1.2**	**0.62**	**0.778**	--	--	--
Nitrate as Nitrogen	mg/L		< 0.2 U	**0.26**	< 0.2 U	**1.79**	--	--	--	< 0.2 U	< 0.2 U	< 0.2 U	**0.46**	--	--	--
Nitrite as Nitrogen	mg/L		< 0.4 U	< 0.4 U	< 0.4 U	< 0.100 U	--	--	--	< 0.4 U	< 0.4 U	< 0.4 U	< 0.100 U	--	--	--
Orthophosphate	mg/L		< 0.1 U	**0.17**	< 0.1 U	**0.13**	--	--	--	< 0.1 U	**0.1**	< 0.1 U	**0.12**	--	--	--
Sulfate	mg/L		**0.58 J**	< 1.2 U	**9.9**	**1.06**	--	--	--	**0.52 J**	< 1.2 U	**28**	**7.35**	--	--	--
Sulfide	mg/L		< 0.05 U	< 0.5 U	< 0.05 U	< 0.05 U	--	--	--	< 0.05 U	< 1 U	< 0.05 U	< 0.05 U	--	--	--
Phosphorus	mg/L		--	--	--	--	--	--	**1.81**	--	--	--	--	--	--	**1.66**
Total Organic Carbon	mg/L		**89**	**100**	**66**	**45**	--	--	**79.3**	**68**	**75**	**64**	**47**	--	--	**83**
Total Suspended Solids	mg/L		--	**160**	**150**	**170**	--	--	--	--	**37**	**130**	**190**	--	--	--
Field Parameters																
Temperature	deg C		--	--	--	--	--	--	**14.1**	--	--	--	--	--	--	**14.2**
Specific Conductance	uS/cm		--	--	--	--	--	--	**1604**	--	--	--	--	--	--	**1680**
Dissolved Oxygen	mg/L		--	--	--	--	--	--	**2**	--	--	--	--	--	--	**1.8**
pH	pH units		--	--	--	--	--	--	**6.72**	--	--	--	--	--	--	**6.85**
Oxidation Reduction Potential	mV		--	--	--	--	--	--	**71.2**	--	--	--	--	--	--	**70.8**
Turbidity	NTU		--	--	--	--	--	--	**100**	--	--	--	--	--	--	**100**
pH	pH units		--	--	--	--	--	--	--	--	--	--	--	--	--	--

Notes

Bold - detected

Blue Shading - exceeds Groundwater Cleanup Level

J - Analyte was positively identified. The reported result is an estimate.

U - Analyte was not detected at or above the reported result.

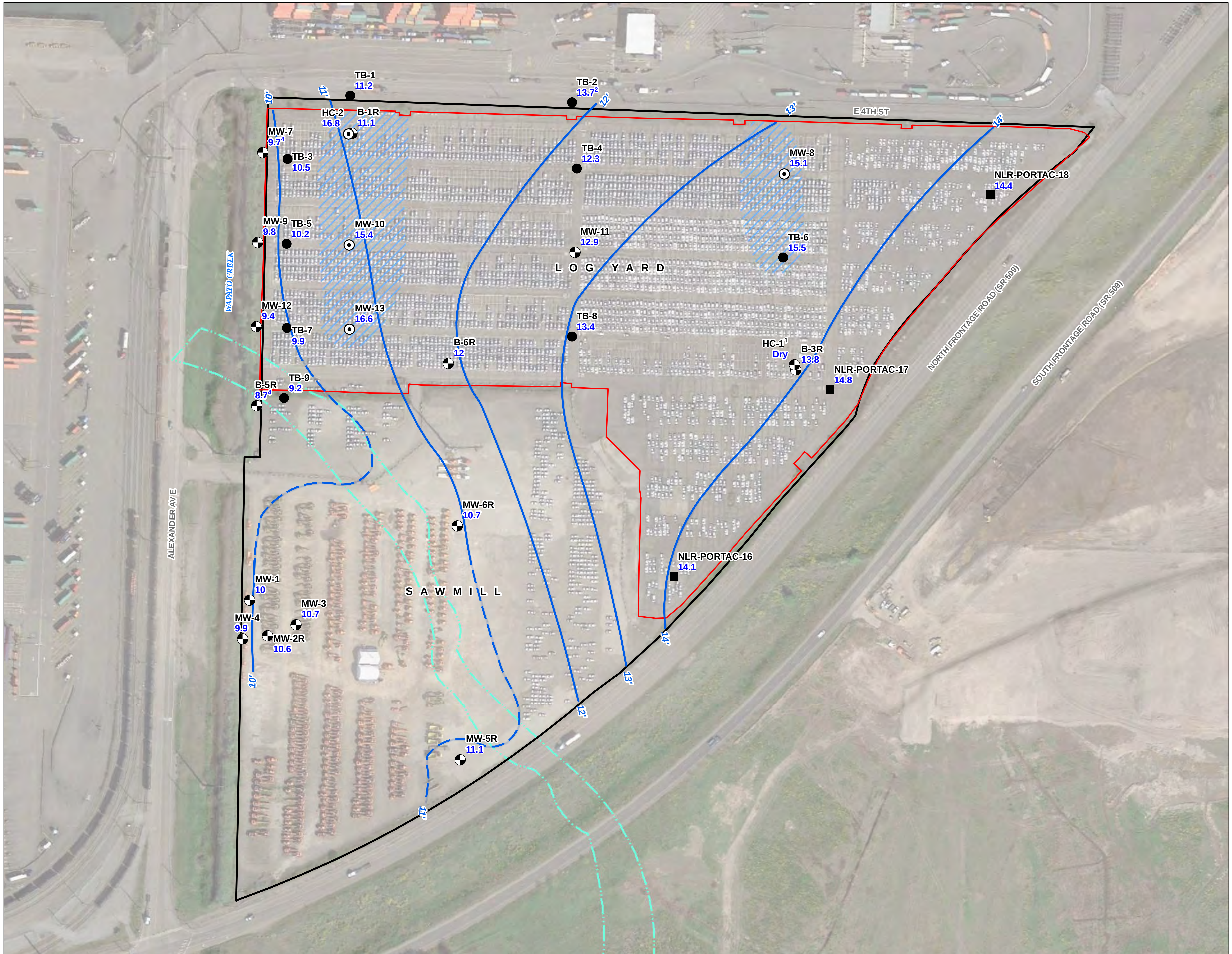
APPENDIX I

Groundwater Contour Maps from Remedial Investigation

FIGURE 4-12

Event 1: May 2016
Groundwater Contour Map

Remedial Investigation Report
Parcel 15
Tacoma, WA



LEGEND

- Monitoring Well[3]
- Perched Monitoring Well[3]
- Piezometer[3]
- Temporary Boring[3]
- Groundwater Elevation Contour (ft MLLW), Dashed Where Inferred
- Observed Perched Zone

All Other Features

- Site Boundary[5]
- Cap[6]
- Former Wapato Creek Channel[7]

NOTES:

1. HC-1 was dry.
2. TB-2 reading not included in contours.
3. Monitoring well, piezometer, and temporary boring locations surveyed in May 2016.
4. With the exception of monitoring wells MW-7 and B-5R, the 24-hour average that was calculated from 72-hours of transducer data equalled the manual water level measurement collected during the central portion of that time period. The tidally corrected 24-hour average is shown for wells MW-7 and B-5R.
5. Site Boundary defined in Exhibit A of the Draft Agreed Order No. DE 11237 (Ecology, 2015).
6. Cap extent defined on Figure 2 of the Former Portac Inc. Site (AQEA, 2014).
7. Former Wapato Creek Channel alignment based on figure provided in the Review Comments on the 2011 Groundwater Monitoring Reports (HC, 2012) and 1931, 1936, 1940 historical aerial photographs.
8. MLLW: Mean low low water

N

0 115 230 345
Feet

Date: January 27, 2017
Data Sources: PORTAC, Aerial photo taken on April 19, 2015 by Google Earth

GSI Water Solutions, Inc.

Document Path: P:\Portland\603-Port of Tacoma\GIS\Project_mxds\RI\Figure4-12_GW_Contour_Event1.mxd

Document Path: P:\Portland\603-Port of Tacoma\GIS\Project_mxds\RI\Figure4-13_GW_Contour_Event2.mxd

FIGURE 4-13

Event 2: August 2016 Groundwater Contour Map

Remedial Investigation Report
Parcel 15
Tacoma, WA

LEGEND

- Monitoring Well
- Perched Monitoring Well
- Piezometer
- Groundwater Elevation Contour (ft MLLW), Dashed Where Inferred
- Observed Perched Zone

All Other Features

- Site Boundary[3]
- Cap[4]
- Former Wapato Creek Channel[5]

NOTES:

1. HC-1 was dry.
2. Monitoring well and piezometer locations surveyed in May 2016.
3. Site Boundary defined in Exhibit A of the Draft Agreed Order No. DE 11237 (Ecology, 2015).
4. Cap extent defined on Figure 2 of the Former Portac Inc. Site (AQEA, 2014).
5. Former Wapato Creek Channel alignment based on figure provided in the Review Comments on the 2011 Groundwater Monitoring Reports (HC, 2012) and 1931, 1936, 1940 historical aerial photographs.
6. MLLW: Mean low low water

N

0 115 230 345
Feet

Date: January 27, 2017
Data Sources: PORTAC, Aerial photo taken on April 19, 2015 by Google Earth

GSI Water Solutions, Inc.

Document Path: P:\Portland\603-Port of Tacoma\GIS\Project_mxds\RI\Figure4-14_GW_Contour_Event3.mxd

FIGURE 4-14

Event 3: November 2016 Groundwater Contour Map

Remedial Investigation Report
Parcel 15
Tacoma, WA

LEGEND

- Monitoring Well
- Perched Monitoring Well
- Piezometer
- Groundwater Elevation Contour (ft MLLW), Dashed Where Inferred
- Observed Perched Zone

All Other Features

- Site Boundary[3]
- Cap[4]
- Former Wapato Creek Channel[5]

NOTES:

1. HC-1 had standing water in the well due to a leaking well cap. Insufficient water to sample.
2. Monitoring well and piezometer locations surveyed in May 2016.
3. Site Boundary defined in Exhibit A of the Draft Agreed Order No. DE 11237 (Ecology, 2015).
4. Cap extent defined on Figure 2 of the Former Portac Inc. Site (AQEA, 2014).
5. Former Wapato Creek Channel alignment based on figure provided in the Review Comments on the 2011 Groundwater Monitoring Reports (HC, 2012) and 1931, 1936, 1940 historical aerial photographs.
6. MLLW: Mean low low water

N

0 115 230 345
Feet

GSI Water Solutions, Inc.

Date: June 29, 2017
Data Sources: PORTAC, Aerial photo taken on April 19, 2015 by Google Earth

FIGURE 4-15

Event 4: February 2017 Groundwater Contour Map

Remedial Investigation Report
Parcel 15
Tacoma, WA

LEGEND

- Monitoring Well
- Perched Monitoring Well
- Piezometer
- Groundwater Elevation Contour (ft MLLW), Dashed Where Inferred
- Observed Perched Zone

All Other Features

- Site Boundary[2]
- Cap[3]
- Former Wapato Creek Channel[4]

NOTES:

1. Monitoring well and piezometer locations surveyed in February 2017.
2. Site Boundary defined in Exhibit A of the Draft Agreed Order No. DE 11237 (Ecology, 2015).
3. Cap extent defined on Figure 2 of the Former Portac Inc. Site (AQEA, 2014).
4. Former Wapato Creek Channel alignment based on figure provided in the Review Comments on the 2011 Groundwater Monitoring Reports (HC, 2012) and 1931, 1936, 1940 historical aerial photographs.
5. MLLW: Mean low low water

N

0 115 230 345
Feet

GSI Water Solutions, Inc.

Date: June 29, 2017
Data Sources: PORTAC, Aerial photo taken on April 19, 2015 by Google Earth

Document Path: P:\Portland\603-Port of Tacoma\GIS\Project_mxds\RI\Figure4-15_GW_Contour_Event4.mxd

APPENDIX B

Treatability Testing Report

TREATABILITY TESTING REPORT

Parcel 15 (Portac) Cleanup Phase 1

Prepared for: Port of Tacoma

Project No. 210158 • June 10, 2022 FINAL

earth + water

TREATABILITY TESTING REPORT

Parcel 15 (Portac) Cleanup Phase 1

Prepared for: Port of Tacoma

Project No. 210158 • June 10, 2022 FINAL

Aspect Consulting, LLC

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Aspect Consulting, LLC is responsible for the column testing design, operation, and sampling part of the remedial design. Haley & Aldrich, Inc is responsible for the geochemical modeling part of remedial design.

V:\210158 Port of Tacoma Parcel 15 Cleanup Phase 1\Deliverables\TTR\FINAL\Treatability Testing Report_FINAL.docx

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1 Introduction

Aspect Consulting, LLC (Aspect) and Haley & Aldrich have prepared this Treatability Testing Report as an appendix to the Engineering Design Report (EDR) 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 Treatability Testing Report was prepared for remedial design of the permeable reactive barrier (PRB) element of the Cleanup Phase 1 project at the Site. The treatability testing included column testing and geochemical modeling to determine the PRB composition and evaluate groundwater quality at the PRB alignment and in the presence of the PRB treatment media (zero-valent iron [ZVI]).

A Remedial Design Work Plan defined Pre-Remedial Design Investigation (PRDI) activities of a PRB alignment investigation and treatability testing (Aspect, 2021). This Treatability Testing Report presents the results and evaluation of all treatability testing, and establishes a basis of design for PRB width and composition.

2 Column Testing

Flow-through column testing was conducted by Aspect at the Site to achieve the following treatability test objectives (Aspect, 2021):

1. Verify ZVI reactivity in the presence of Site groundwater.
2. Collect basis of design parameters of reaction rate and arsenic uptake capacity for determining PRB width and iron composition.
3. Evaluate secondary water quality factors that may impact PRB performance (i.e., mineral precipitation).

As part of the PRB alignment investigation, a new monitoring well, MW-14, was installed for production of groundwater to be used in column testing. The column testing was conducted at the Site using MW-14 groundwater generated from low-flow pumping as the column influent. The testing was conducted on Site because groundwater at the Site is anaerobic and reducing. Flow-through columns were operated by in-line groundwater routing to minimize exposure to air and maintain the *in situ* groundwater redox potential to the greatest extent practical. All column testing field records are included in Appendix A.

Three columns were operated with a test variable of ZVI percentage: 10 percent ZVI (C10), 20 percent ZVI (C20), and a control column (0 percent; CC). The ZVI was mixed with sand to 10 percent and 20 percent by mass. The control column was packed with sand only. The ZVI used was Connelly-GPM, Inc CC-1004 (Appendix B). The sand mix was produced in-house from native soils to match the grain-size distribution for sand observed on the Site.

2.1 Design

The columns were 36 inches long and constructed of 3-inch-diameter clear PVC. Two sample ports located approximately one-thirds (Port 1) and two-thirds (Port 2) along the total length were installed in each column. A pressure relief port was installed at the top of each column. The columns were installed within a temporary structure in a vertical position with the influent at the bottom and effluent at the top for up-flow.

Aliquots of dry ZVI reactive material and sand were packed vertically in lift sections to achieve a homogeneous mixture

Influent groundwater was introduced to each column using Geopump II peristaltic pumps with precision pump heads installed to achieve low-flow pumping rates. Construction materials, pumping method, and tubing were chosen to minimize oxygen introduction to the columns. The intake and delivery tubing were polyethylene, and peristaltic tubing was Tygon.

2.2 Operation and Sampling

Before introducing Site groundwater, the columns were prepped by flushing with nitrogen (N_2) gas introduced at the bottom of the columns for approximately 45 minutes to replace air contained in the pore spaces of the ZVI sand mix.

Column testing was conducted at the MW-14 location to minimize disturbance of column influent. The Site groundwater was routed directly to the bottom end of each column and out of the top end by dedicated high-precision peristaltic pumps. The initial dissolved arsenic concentration in MW-14 was 21.3 µg/L, which was too low for meeting column test objectives. Therefore, an inflatable packer was set at the middle of the MW-14 screen to increase arsenic influent in columns, which proved successful.

Effluent from each column and influent Site groundwater were sampled five times during the test. The same influent was used for all three columns and there are only influent results for each day sampled. Influent and effluent groundwater were analyzed for total metals, dissolved metals, anions, alkalinity, total organic carbon, and ferrous iron (Fe). Sample ports were sampled four times during the test. The sample ports were only analyzed for total and dissolved arsenic. Measurements of field parameters (pH, dissolved oxygen [DO], specific conductance [SC], and oxidation reduction potential [ORP]) were collected daily at influent, effluent, and the sample ports using a YSI water quality meter.

Column operation began on November 29, 2021, and continued for a total of 8 days until December 6, 2021. Flow rates varied from 10 to 55 milliliters per minute (mL/min) during the column testing, with flow-rate adjustments on Day 2, Day 3, and Day 4 (Table 1). After Day 2, based on the lack of pH change (indicator of ZVI corrosion), the flow rate was increased to ensure ZVI corrosion and reactivity. After Day 4, the flow rate was decreased to the minimum flow rate possible with the pump, and targeting the same flow rate in each column. Only field parameters were measured on Day 5 (Friday), and the columns were set to flow over the weekend to establish a steady-state condition for the final sampling event on Day 8 (Monday).

After column test completion, the two ZVI columns were frozen and retained for geochemical evaluations, discussed further in Section 3.2. The control column was disassembled, emptied of media, and used for physical parameter estimation. Estimated values of bulk density, porosity, and pore volume were determined gravimetrically using field methods for each column (Table 2).

2.3 Results

The flow-through column testing verified ZVI reactivity and removal of arsenic from Site groundwater. Influent-dissolved arsenic from MW-14 ranged from 43.8 micrograms per liter (µg/L; Day 2) to 126 µg/L (Day 8), and total arsenic ranged from 44.3 µg/L (Day 2) to 91.2 µg/L (Day 4). Effluent concentrations of dissolved arsenic on Day 8 were 82.5 µg/L in the CC, 8.72 µg/L in the C10, and 5.38 µg/L in the C20. Effluent concentrations of total arsenic on Day 8 were 73.0 µg/L in the CC, 10.3 µg/L in the C10, and 6.44 µg/L in the C20. All analytical results are included in Table 3.

Column pore volume estimates were calculated in Table 4 using the observed average flow rate of 30 to 40 mL/min to represent actual flow through the columns. In total, 109, 91, and 98 pore volumes of MW-14 groundwater were routed through the CC, C10, and C20, respectively. A total MW-14 groundwater volume of 172 gallons was used for the test.

Column profile results for total and dissolved arsenic on each day of operation are shown on Figures 1a through 1d. Column profile results for water quality parameters (temperature, ORP, pH, SC, and DO) on each day of operation are shown on Figures 2a through 2d.

Column profile results for total and dissolved arsenic at each column (CC, C10, and C20) are shown on Figures 3a through 3c. Column profile results for water quality parameters at each column are shown on Figures 4a through 4c. The groundwater elevation and specific conductance at MW-14 during column testing are shown on Figure 5.

Arsenic reaction rates were calculated by assuming a first-order reaction rate using the Day 8 results as the most representative of steady-state conditions. The arsenic concentration profiles collected along the length of the columns during the bench tests were used to determine arsenic uptake kinetics. After adjusting the total and dissolved arsenic results for arsenic loss observed in the control column, the first-order uptake rate of 3.9 day^{-1} was estimated from dissolved arsenic in the C20 column. This is consistent with literature values for first-order arsenic removal rates of 0.21 to 1.15 day^{-1} (Lien and Wilkin, 2005).

Column testing can be used to estimate the arsenic uptake capacity of ZVI if columns are operated until the ZVI treatment capacity is exhausted and the arsenic breaks through, but this was not an objective of this study. Literature values of total arsenic uptake capacity by ZVI range between 0.7 and 7.5 milligrams per gram (mg/g) (Su, 2006), with values for Connelly GPM ranging between 0.77 and 4.4 mg/g (Nikolaidis et al., 2003). A literature-derived value of 1.0 mg/g for Connelly GPM ZVI was used in the PRB design calculations.

A detailed discussion of reaction rate and arsenic uptake capacity estimates and design basis are presented in the PRB Design Calculations Report in Appendix D of the EDR.

3 Geochemical Evaluation

3.1 Overview

3.1.1 Fate and Transport of Arsenic in Subsurface

Arsenic (As) is a redox sensitive element occurring as either As (III; arsenite) or As (V; arsenate). When dissolved in groundwater, arsenic speciation is highly controlled by redox condition and pH (e.g., Cheng et al., 2009). Arsenic occurs as either oxyanionic species under oxidizing conditions (e.g., $H_2AsO_4^-$) or hydroxide species under reducing conditions (H_3AsO_3) (Vlassopoulos et al., 2010).

There are three dominant arsenic attenuation mechanisms:

- Direct mineral precipitation
- Co-precipitation
- Adsorption

Direct mineral precipitation, which occurs when ferric or ferrous arsenates precipitate out of solution, depends highly on redox condition and iron and arsenic concentrations. High concentrations of dissolved iron in the system, as is the case for this Site, drives the precipitation of Fe-arsenate minerals, immobilizing arsenic. Direct mineral precipitation of mixed ferrous/ferric iron arsenates was observed in previous induced precipitation studies performed on Site groundwater (S.S. Papadopulos & Associates, Inc. [SSPA], 2017) and is likely a relevant arsenic-attenuating process at the Site.

Mineral co-precipitation occurs when arsenic is incorporated into the crystal structure of a precipitating mineral. This mechanism is common during precipitation of iron oxyhydroxide minerals (such as ferrihydrite and goethite) and some carbonate minerals (such as siderite). Co-precipitation processes are especially important because arsenic-containing phases are typically more insoluble than arsenate minerals, thus ensuring arsenic immobilization even when redox conditions or dissolved species concentrations change in the aquifer.

Arsenic adsorption is the process whereby dissolved arsenic either adheres to the surface of soil particles or is incorporated into the crystal lattice of an existing mineral grain. Adsorption strongly depends on arsenic concentrations, pH, redox, and the nature of the sorbing mineral (e.g., surface area, net charge). The most common control on arsenic adsorption is iron oxyhydroxide mineralogy and quantity in aquifer solids, like goethite or ferrihydrite. These iron oxyhydroxides are common as discrete particles or coatings on soil grains. The presence of these mineral phases is dictated by redox conditions within the aquifer. Under redox conditions where both ferric iron and ferrous iron coexist, as is the case at the Site, green rusts can commonly form acting as another arsenic adsorption surface. However, as the redox and pH change, iron oxyhydroxide minerals can become unstable and dissolve back into solution, re-releasing arsenic into the groundwater. In addition, redox can control the adsorption efficiency of arsenic. Previous experimental studies have demonstrated that arsenic (V) adsorption to Fe-oxides generally decreases with increasing pH (in the range of 3 to 10), and at pH greater than 7, As(III) will be attenuated more efficiently by adsorption compared with As(V) (Su and Puls, 2001; Wilkin et al., 2009). In addition, under certain redox and pH conditions, As(V) and As(III) will experience different adsorption affinities on Fe-oxide minerals (Su and Puls, 2001).

Arsenic re-mobilization is predominately controlled by changes in dissolved constituent concentrations (iron and arsenic in particular at this Site) and redox. Increases in pH could favor dissolution of arsenic-bearing phases (e.g., Sadiq et al., 1997; Dixit and Hering, 2003; Cheng et al., 2009; Tokoro et al., 2010).

3.1.2 Mineral Precipitation in the Presence of ZVI

The removal of metals using ZVI in a PRB is neither a purely chemical/electrochemical reduction, nor a purely physical adsorption process. The metal removal process can include complex interfacial pathways such as dissolution, adsorption, surface complexation, mineral precipitation, and co-precipitation. The rate of removal is largely dependent on residence time, grain size and specific surface area of the ZVI, and the geochemical conditions of the aquifer, like redox (e.g., Obiri-Nyarko et al., 2014). The ZVI acts as a reducing agent. As groundwater passes through ZVI, dissolved constituents begin reacting with the iron corrosion products to generate hydroxyl-free radicals and ferrous iron. This reaction and subsequent reactions result in a reduction in ORP, increase in pH, and the precipitation of minerals, some of which will either co-precipitate the contaminant (e.g., oxyhydroxides, like ferrihydrite, co-precipitate arsenic), or directly precipitate the contaminant (e.g., arsenates) (Obiro-Nyarko et al., 2014).

In general, mineral precipitation is an important process as certain minerals, like Fe-oxyhydroxides, can co-precipitate the contaminant, arsenic. However, there can be other minerals, such as some carbonates, which do not co-precipitate arsenic and potentially reduce the porosity and hydraulic conductivity of PRB over time and/or passivate the ZVI surface preventing arsenic immobilization (e.g., Wilkin and McNeil., 2003; Li et al., 2005).

Non-arsenic sequestering mineral precipitation can have negative effects on the long-term functionality, performance, and effective lifetime of a PRB. The potential for these non-arsenic sequestering mineral precipitates to form in the presence of ZVI is important and forms the primary basis for geochemical modeling discussed in subsequent sections. The primary mechanism detrimental to PRB performance is passivation of ZVI particles, or a decrease in reactive surface area that occurs when the ZVI surface becomes coated by non-arsenic sequestering minerals. Iron corrosion is a natural product of ZVI reactions and over time decreases iron reactivity due to reactive consumption (Li et al., 2005). A second mechanism detrimental to PRB performance is the formation of non-arsenic sequestering mineral precipitates, which consume PRB pore spaces, and their formation can act to scale out, cement, inhibit, or impede the formation of arsenic-sequestering minerals.

There are three classes of non-arsenic sequestering minerals that can affect PRB performance: 1) carbonates (calcite, rhodochrosite, kutnohorite); 2) sulfates (gypsum, anhydrite); and 3) non-ferrous oxides (Mn-oxides, Al-oxides). Amorphous ferric oxyhydroxides, in particular, can bridge or cement the individual ZVI filings together to effectively block pore space from water flow (Mackenzie et al., 1999). Other identified cementing agents are aragonite ($CaCO_3$), siderite ($FeCO_3$; Roh et al, 2000), and calcite ($CaCO_3$). The inherent increase in pH associated with ZVI reactions can trigger increased stability and precipitation of carbonates and even dissolution of certain arsenic-containing phases within the PRB, resulting in more pore filling by minerals and the liberation of arsenic itself. Clogging or plugging generally occurs at the entrance of a PRB (Mackenzie et al., 1999). If mineral precipitation is occurring in large quantities, preferential flow paths within the PRB can form, which reduces residence time or even allows contaminated groundwater to bypass the reactive portions of the PRB (Li et al., 2005).

3.1.3 Geochemical Changes Downgradient of the PRB

Because the PRB effluent has a higher pH, manipulated Eh conditions, and significantly lower arsenic concentrations than ambient groundwater, it is in disequilibrium with the downgradient soils in the aquifer. The shift in equilibrium with PRB effluent will alter geochemical conditions and change soil-groundwater interactions downgradient of the PRB alignment. This shift in equilibrium can result in a fundamental shift in arsenic sorption/desorption as well as mineral formation/dissolution, whereby arsenic in aquifer solids on the downgradient side of the PRB becomes a source of arsenic leaching into groundwater. The dynamic equilibrium established in the presence of a ZVI PRB can be predicted and modeled to estimate the impact on the time frame for achieving remedial goals at downgradient compliance wells.

In order to ensure the long-term functionality of the ZVI PRB in removing arsenic, geochemical modeling is performed to predict the minerals that may precipitate from the groundwater, given water compositions and physical conditions (see Section 3.2). One-dimensional (1D) transport modeling is performed to predict the change in groundwater quality downgradient of the PRB as a result of changes in geochemical condition of the PRB effluent (see Section 3.3).

3.2 Geochemical Modeling of Mineral Precipitation in ZVI PRB

3.2.1 Modeling Approach

The purpose of this task was to determine the potential for mineral precipitate formation and fouling of the ZVI PRB wall. The Geochemist's Workbench® (GWB) SpecE8 modeling program (release 12), Eh-pH diagrams, and column test groundwater data were utilized to predict whether the precipitating minerals within the PRB are arsenic-sequestering or non-arsenic-sequestering. The SpecE8 program is an equilibrium thermodynamic modeling tool used to predict elemental distribution between dissolved species and mineral precipitates. All speciation modeling was performed using the Minteq thermodynamic database, which contains the appropriate iron and arsenic speciation data as well as the largest number of carbonate and Fe-oxide mineral phases. The modeling was conducted in four steps:

1. Check column groundwater sample equilibrium using cation and anion balance.
2. Estimate mineral saturation indices using column groundwater results water chemistry and create Eh-pH diagrams.
3. Estimate rate of precipitation for minerals most likely to precipitate given results from Step 2.
4. Use X-ray diffraction and scanning electron microscopy to verify predicted mineral forms using column test sediment.

The first modeling step used SpecE8 to check samples for charge neutrality, which ensures that each sample abides by the Law of Conservation of Mass. Cation and anion charges must balance each other in each groundwater sample chemical analysis. If there is an excess of either anions or cations, then either a relevant analyte was not measured, or, more likely, some amount of an existing analyte has been lost between sampling and laboratory analysis.

The second modeling step used equilibrium speciation modeling to calculate mineral saturation indices (ratio of solution ion concentration to ion concentration required for precipitation) for each groundwater sample. Mineral saturation indices indicate whether a given groundwater sample could be saturated (precipitating from the groundwater) or undersaturated (dissolving into the groundwater). The mineral saturation index analysis is based on equilibrium thermodynamics but not reaction kinetics, therefore assuming all phases that *could* be present *are* present. Eh-pH diagrams are used to assess what minerals are most likely to occur based on the physical conditions of the system and whether these minerals are arsenic-sequestering.

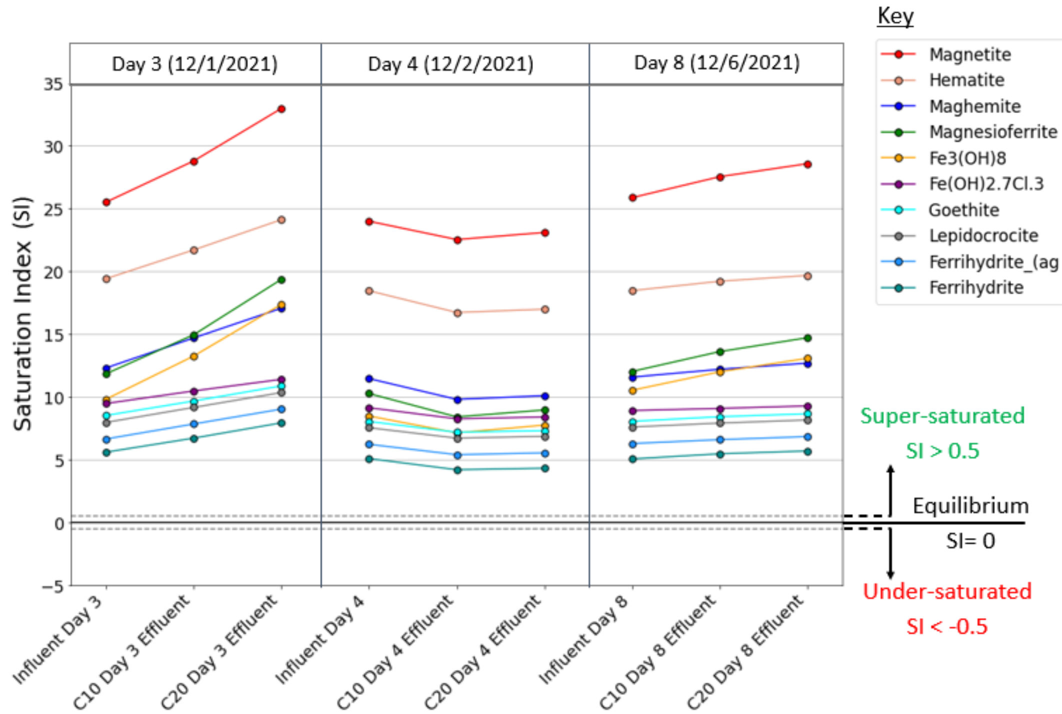
The third modeling step used SpecE8 to calculate the rate of mineral formation for those minerals identified in Step 2 to be the most likely to precipitate. The rate of mineral formation calculation provides a basis for estimating PRB porosity loss in the PRB Design Calculations Report in Appendix D of the EDR.

3.2.2 Inputs

Only influent and effluent data from Days 3, 4, and 8 were used in geochemical modeling as these days approached steady state. For the speciation calculations, major dissolved cation and anion water chemistry of the influent, C10 effluent, and C20 effluent samples from each of days 3, 4 and 8 were used as model inputs, in addition to pH, temperature, electrical conductivity, and redox potential (see Table 5 for geochemical input data). For the Eh-pH diagrams constructed using GWB, input parameters include temperature, pressure, water sample compositions, total concentrations of the plotted constituents, mineral phase/surface sites to consider, and a selection of phases to suppress (if applicable).

3.2.3 Results

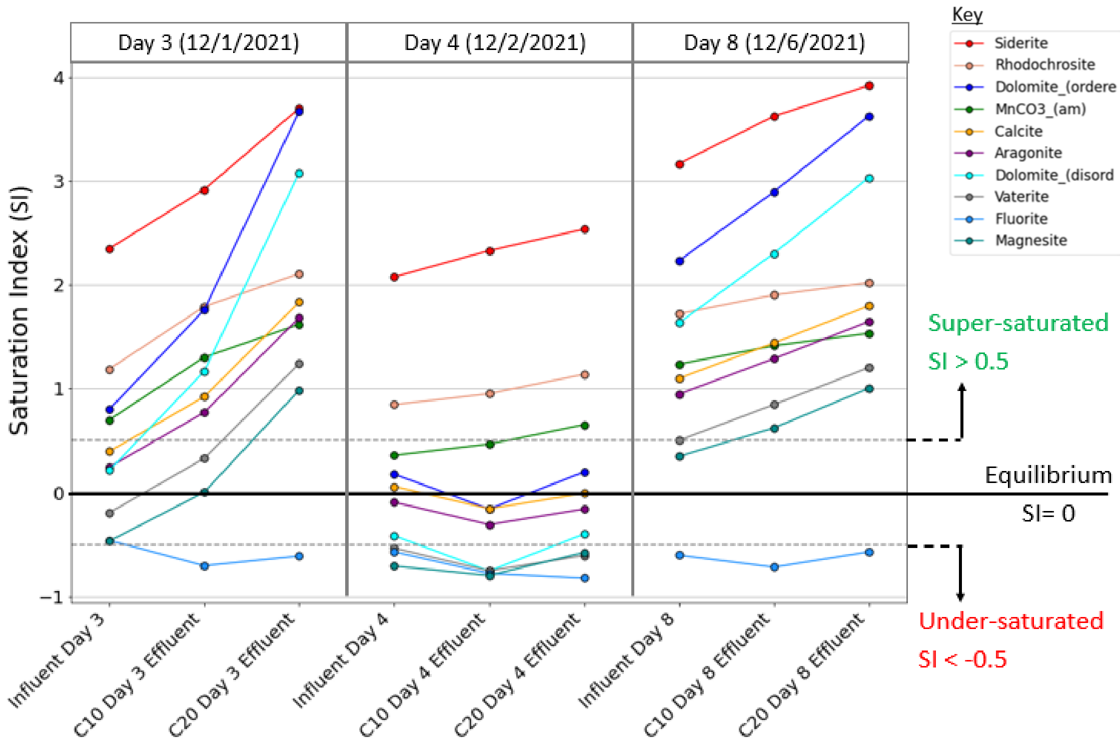
Using SpecE8, mineral saturation indices (SI) calculated for each water sample show that predominately Fe-oxides and oxyhydroxides (e.g., magnetite, hematite, FeOH, goethite, ferrihydrite) and some carbonates are likely to be super-saturated (SI greater than 0.5) in all influent and effluent samples from days 3, 4 and 8 (see Table 6 for mineral saturation indices). Magnetite and hematite exhibit the highest saturation indices (SI greater than 15) for all samples, and all Fe-oxide and oxyhydroxide minerals are super-saturated for all samples except for K--jarosite (Figure 6).



Fe-oxide and oxyhydroxide saturation indices for days 3-8 column test samples. Vertical gray lines denote sampling days. Dashed horizontal lines denote a SI = 0.5 (super-saturation) and SI = -0.5 (under-saturation). The black solids horizontal line indicates SI = 0 (equilibrium).

Figure 6. FE-Oxide and Oxyhydroxide Mineral Saturation Indices

Carbonate minerals, siderite and rhodochrosite, are super-saturated for all samples, with siderite having the highest saturation index. Dolomite (ordered and disordered), $MnCO_3$, calcite, aragonite, and vaterite exhibit super-saturation for some samples and under-saturation (SI<-0.5) for others (Figure 7).



Carbonate mineral indices for days 3-8 column test samples. Vertical gray lines denote sampling days. Dashed horizontal lines denote a SI = 0.5 (super-saturation) and SI = -0.5 (under-saturation). The black solids horizontal line indicates SI = 0 (equilibrium).

Figure 7. Carbonate Mineral Saturation Indices

Considering Eh and pH for each sample, goethite, ferrihydrite, and siderite ($FeCO_3$) are the most likely mineral phases to precipitate for all influent and effluent samples. When goethite, ferrihydrite, and siderite are included in the Eh-pH calculation, goethite is the most likely mineral to be present in all Site groundwater samples. When goethite is not considered (suppressed), ferrihydrite is the most likely mineral to be present, whereas siderite is the most likely phase when goethite and ferrihydrite are suppressed (see Figures 8 and 9). These results are consistent with the induced precipitation test results (precipitated predominately ferrihydrite), sequential extraction results, and the batch adsorption tests performed during previous Site geochemical studies (SSPA, 2017). Goethite and ferrihydrite are both arsenic-sequestering minerals anticipated to form as by-products of the ZVI corrosion process.

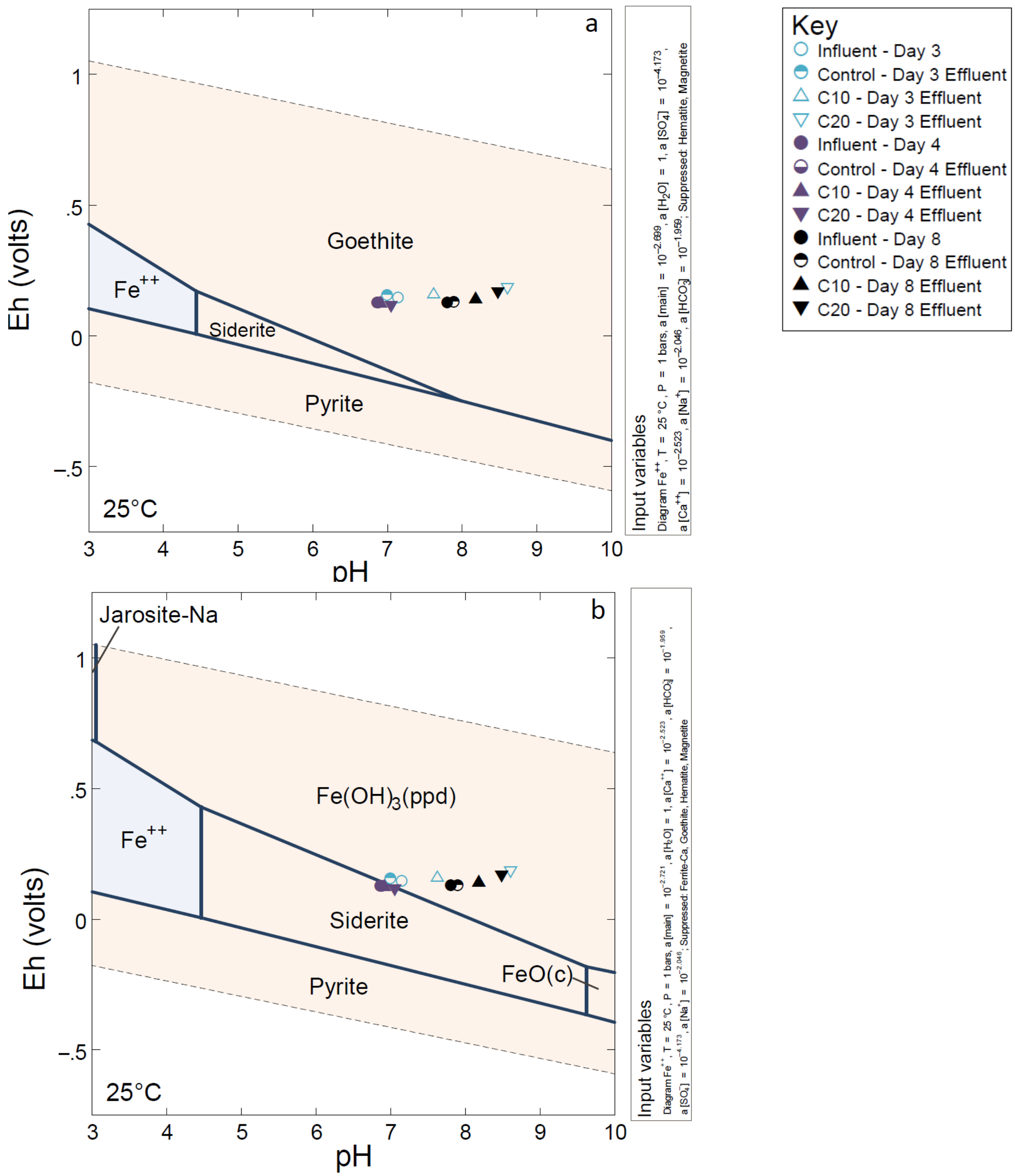


Figure 8. FE-Oxyhydroxide Eh-pH Diagrams

Because excess goethite, ferrihydrite, and other carbonate mineral species were predicted to be supersaturated in influent samples, their precipitation and formation within the PRB is likely. GWB was used to predict the rates of mineral formation from ambient groundwater within the PRB. Influent sample chemistry from Day 3 of the column test was used as input to quantify the rates of mineral formation within the PRB. Based on these parameters, the predicted rate of mineral formation (r) was 0.11 cubic centimeters per liter H_2O (cm^3/L H_2O, or 0.011 percent volume); dominant mineral precipitates were siderite, goethite, and rhodochrosite. It should be noted that this calculation is only an estimate of mineral rates predicted to form from supersaturated conditions in ambient groundwater and is not a prediction of ZVI corrosion product rates.

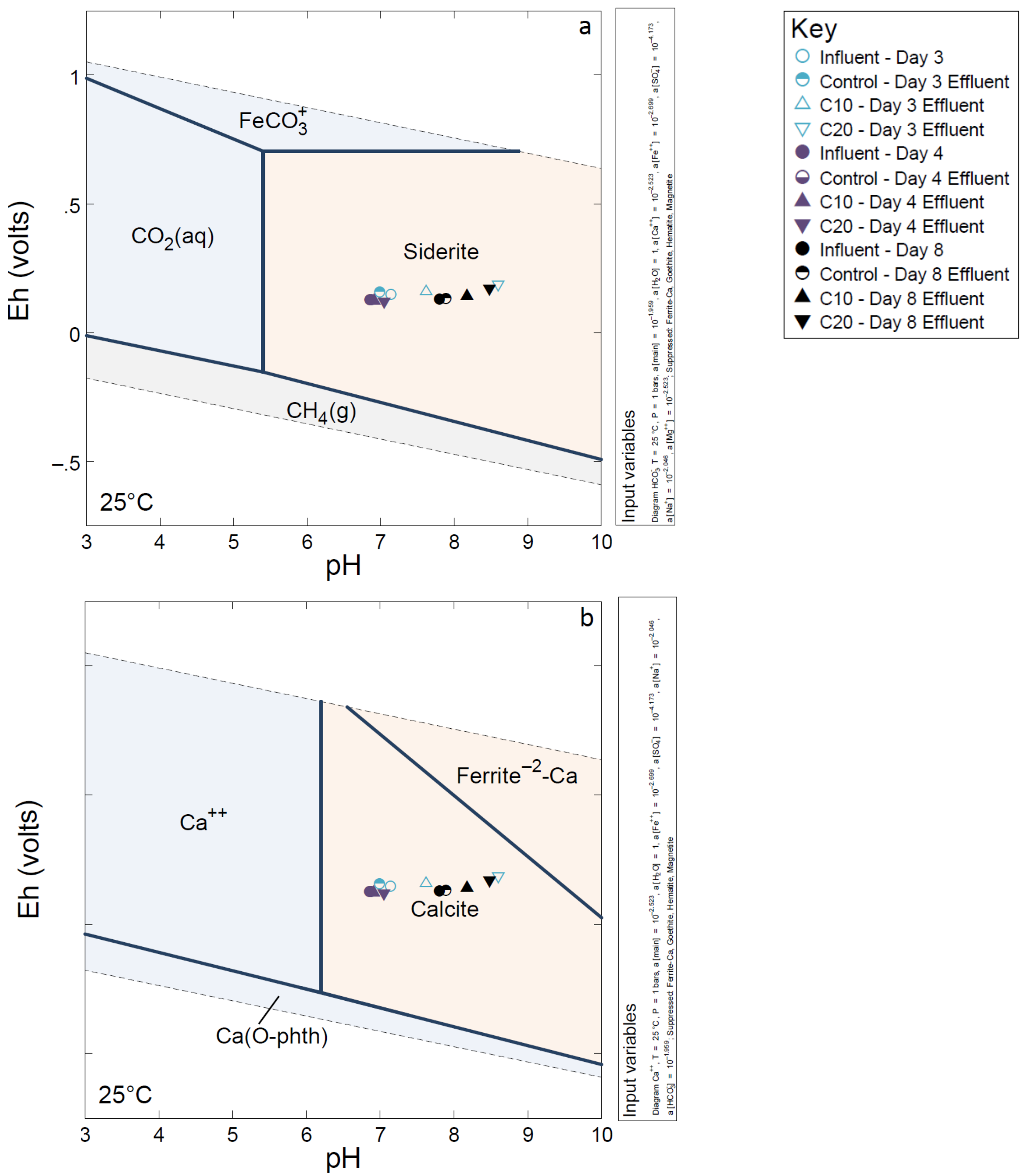


Figure 9. Carbonate Eh-pH Diagrams

Samples of sand/ZVI mixture were collected from the C10 and C20 columns and submitted to the RJ Lee Group, Inc. (Monroeville, Pennsylvania) for qualitative X-ray diffraction (XRD) and scanning electron microscopy (SEM) testing. The purpose of this test is to confirm the presence or absence of precipitated minerals predicted by geochemical modeling. One sample each was collected from C10 and C20 immediately adjacent to the column influent (i.e., column bottom). Each sample was crushed in a ball mill prior to analysis for XRD. A representative portion of each sample prepared for XRD was then filtered onto a 0.2-µm pore hole size polycarbonate filter, using vacuum filtration, for analysis by SEM. Lab reports for XRD and SEM are provided in Appendix D and E, respectively. Results show that in general, aside from the host minerals present in the sand/ZVI column media (e.g., quartz, feldspars, micas, amphibole), abundant arsenic-sequestering minerals such as Fe-oxides/oxyhydroxides and likely siderite are present in the solids. Specifically, SEM results show that among the approximately 3,000 sediment grains analyzed, 13 percent are Ca-rich and 9 percent are Mg-rich. All the Ca-rich grains were present as either Ca-phosphates (likely apatite) or Ca-silicates, and all the Mg-rich grains were positively identified as Mg-silicates. None of the detected Mg- or Ca-rich grains appear to be carbonate phases, thus there was little evidence of Ca-, Mg-, or any other non-ferrous carbonate mineral precipitation. These data suggest that the likelihood of passivation and/or cementing of arsenic-sequestering minerals with non-arsenic sequestering minerals in the PRB is relatively low.

Lastly, it is important to note that analysis of charge balances on each water sample (n=9) reveals that all samples have charge imbalances greater than 10 percent, with two samples greater than 20 percent, indicating an excess of cations (see Table 7). One potential explanation is bicarbonate loss between column sampling and laboratory analysis due to re-equilibration with atmospheric conditions (Puls and Powell, 1992). Due to uncertainty over which analyte(s) could be causing the imbalance, the modeling effort proceeded using SpecE8 without using a make-up anion for charge balancing. However, on average the charge imbalance is about 15 percent, which is within laboratory analytical measurement uncertainty and thus, in the geochemists' professional judgment, the results of the modeling effort are still useful..

3.3 Geochemical Modeling of Groundwater Downgradient of PRB

3.3.1 Modeling Approach

In order to understand the potential for arsenic mobilization, re-mobilization, and flushing downgradient of the PRB alignment, 1D reactive transport modeling was performed using the X1t modeling program of GWB. The X1t model simulates groundwater transport along a flow path where the water can react with soils over a defined distance.

The 1D reactive transport model simulates how the PRB effluent interacts with arsenic-bearing soils downgradient of the PRB that have been interacting with ambient arsenic-contaminated groundwater since the mid-1970s. In the model, the soils are loaded with arsenic first and are then flushed with PRB-treated groundwater to simulate the downgradient impacts of the PRB.

A 100-year simulation was conducted using three sets of groundwater chemistry at different times.

- Background conditions represent initial aquifer conditions prior to the presence of slag material.
- Contaminated conditions represent the 50-year period where arsenic leached from slag to groundwater from 1972 to 2022. This is done to simulate the 50-year time frame when aquifer solids were in contact with arsenic-laden groundwater from the Site.
- The "flushing" period is a 50-year simulation that predicts downgradient aquifer conditions and groundwater quality after the PRB is installed. The system was subsequently flushed with "clean" groundwater represented by column test effluent water quality for a duration of 50 years. The simulated arsenic concentrations indicate the amount of arsenic re-mobilization from the soils, which could occur in the aquifer downgradient of the PRB, and the time frame necessary to reach the arsenic cleanup level of 5 µg/L at monitoring wells MW-7, MW-9, and MW-12 located approximately 25 feet (ft) downgradient of the PRB.

The GWB module X1t was used to simulate surface complexation reactions by which arsenic in solution sorbed onto mineral surfaces at 25 degrees Centigrade. The program employs the modified double-layer model surface complexation, as presented by Dzombak and Morel (1990). In this model, surface complexes form by reaction of aqueous arsenic species with sites on an iron mineral surface. The dataset "FeOH.sdat" was used as the primary sorbing surface model because it contains reactions for hydrous ferric hydroxide, the most likely mineral present in this portion of the aquifer. The Minteq surface complexation model for ferrihydrite was also used to simulate sorption/desorption kinetics onto ferrihydrite. Both the "FeOH.sdat" dataset and Minteq's ferrihydrite sorbing surfaces dataset considers two types of sites, labeled as >(s)FeOH and >(w)FeOH. These sites represent, respectively, strong and weak sorbing sites on the surface of minerals. The "FeOH.sdat" dataset specifies that the sites occur on the surfaces of three minerals—hematite, $Fe(OH)_3$ precipitate, and goethite—and sets specific surface areas and site densities for each. The ferrihydrite-sorbing surfaces dataset only accounts for sorption sites on ferrihydrite.

3.3.2 Inputs

Inputs to the 1D reactive transport model include chemical compositions of background aquifer conditions, contaminated groundwater, and flush groundwater, reactants within the soils, and physical characteristics of the aquifer hydrogeologic properties and groundwater flow (Table 8).

The initial input parameters for the three groundwater compositions (i.e., background, contaminated, and flush) include: ferrihydrite content, Fe^{3+}, AsO_4^{3-}, Ca^{2+}, dissolved oxygen, HCO_3^{2-}, pH, and temperature. Under background conditions, initial groundwater arsenic concentration is assumed to be 2 µg/L, with a ferrihydrite content of 0.0002 percent by volume in the aquifer matrix. With the exception of arsenic and calcium content, Day 8 influent water chemistry from the column test results were used as the contaminated groundwater composition. The arsenic concentration in "contaminated groundwater" was set to 15 mg/L, which was determined through an iterative modeling process. This process was set up where AsO_4^{3-} was increased stepwise in 1,000 µg/L increments, beginning from Day 8 Site influent concentrations (approximately 130 µg/L) up to a value that resulted in the simulated AsO_4^{3-} concentrations in groundwater to be within the range observed in actual Site groundwater. The Day 8 effluent from the C10 column was used as the "flushing" water composition, with the exception of Ca, which was set to 150 mg/L (a median value of influent and effluent results). Bicarbonate was used in the model as a make-up anion to balance the charges.

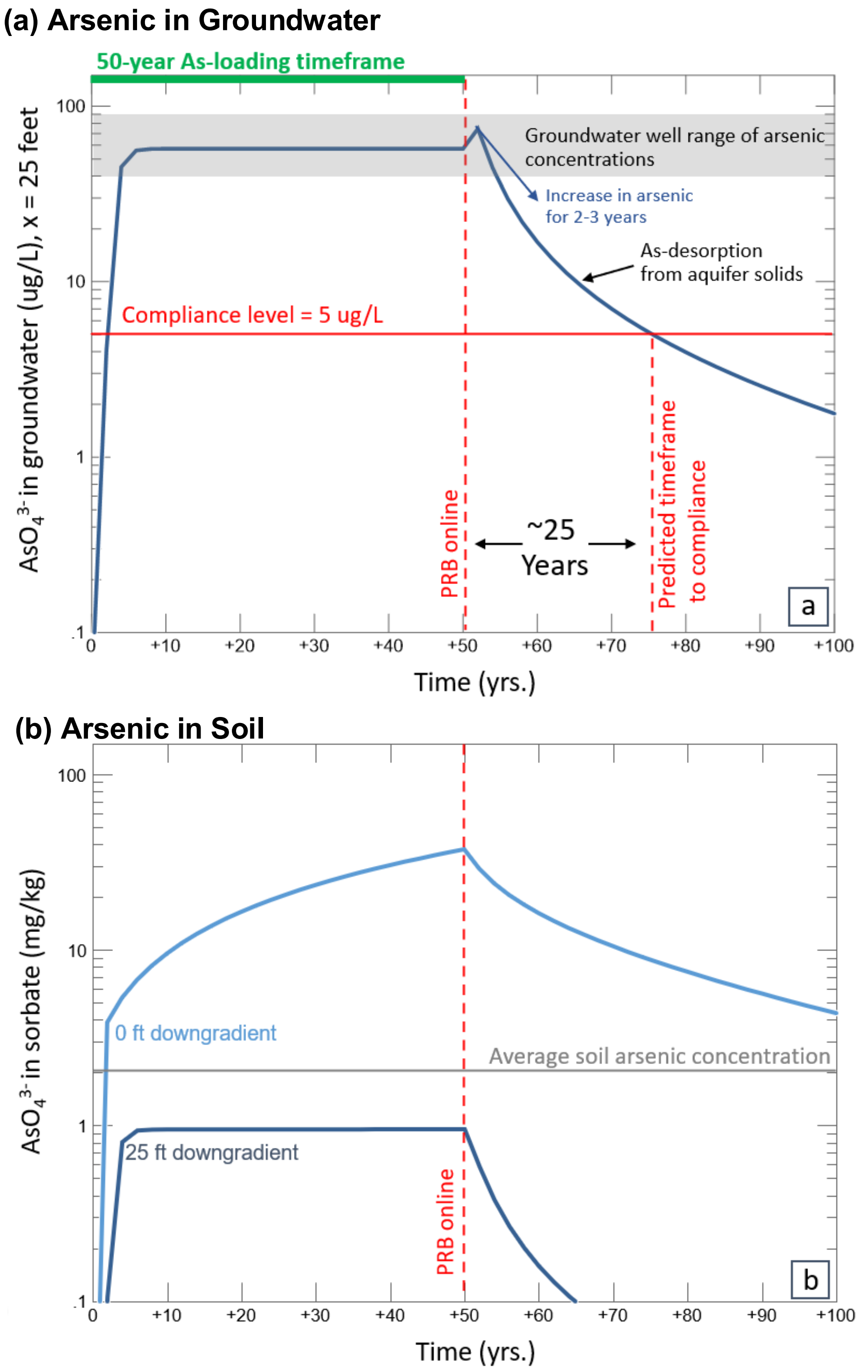
The length of the 1D model domain is 25 ft, which is the approximate distance between the PRB and monitoring wells MW-7, MW-9, and MW-12. The 25-foot domain is discretized into five nodal blocks, each of which is 5 ft long. The porosity of the aquifer is set to 10 percent based on Site lithology. Dispersivity is set to 1/10th of the domain length at 2.5 ft. The average Darcy's flux estimate of 0.047 ft/day was used in the model; the same value used in the PRB Design Calculations (Appendix D of the EDR).

Ferrihydrite in soil was simulated as the sorbing surface mineral for arsenic. Two models were tested in this work using two different soil ferrihydrite compositions. In addition to the inputs described above, the first model (referred to as Model 1 moving forward) uses an average amount of ferrihydrite in the soil equal to approximately 11,000 mg/kg. This value was calculated by averaging Fe concentrations in the Site soil data from field X-ray fluorescence (XRF) results during PRDI reported in Appendix A of the EDR. Major outliers within the data were first removed prior to averaging the Fe concentration. However, in order to account for the high degree of variability observed in XRF data, the second model (Model 2) has identical input parameters to Model 1, except the amount of ferrihydrite was reduced by an order of magnitude to 1,100 mg/kg (see Section 3.3.3). Increasing the ferrihydrite concentration only acts to lower time to compliance compared with using the average value, and models of higher values are not presented.

Lastly, simulation results for two nodes were evaluated. Node 0 represents water quality and aquifer chemistry proximal to the PRB, while Node 1 represents water quality and aquifer chemistry at a downgradient location that is located 25 ft downgradient of the PRB. The intention of Node 1 is to predict the evolution of water quality at the anticipated compliance point.

3.3.3 Results

Model 1 simulated AsO_4^{3-} concentrations (in groundwater at a location 25 ft downgradient of the PRB (Node 1)) increase up to levels observed in natural Site groundwater (approximately 60 µg/L AsO_4^{3-} on average) within the first 5 years (during the arsenic sediment loading period; see Figure 10a). Groundwater AsO_4^{3-} reaches steady state at concentrations of about 60 µg/L and remains at steady state until PRB implementation at year 50. Once the PRB is installed, groundwater AsO_4^{3-} spikes for 2 to 3 years reaching concentrations up to approximately 75 µg/L (approximately 25 percent increase due to desorption). AsO_4^{3-} concentrations then begin declining steadily over time reaching the cleanup level of 5 µg/L after *about 25 years post PRB installation*.



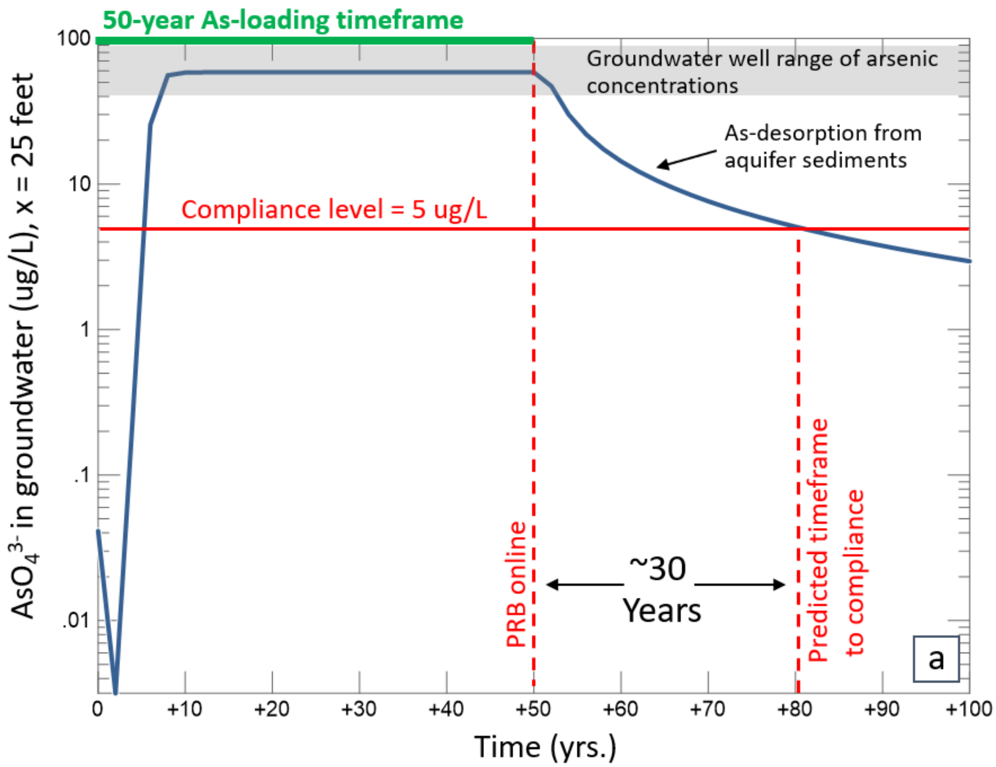
Notes:
(a) 1D transport model showing arsenic concentration in groundwater versus time using a discharge of 0.047 ft/day and sediment ferrihydrite concentration of 1,100 mg/kg (see Table 4, model 3 for all input parameters). Loading of the aquifer sediments with arsenic takes place from 0 to 50 years (as denoted by the green solid line) prior to the PRB implementation at year 50 (denoted by leftmost red dashed line). The predicted amount of time after PRB implementation for arsenic concentrations to reach compliance (5 ug/L, as denoted by red horizontal line) is denoted by the rightmost red dashed line and is approximately 30 years. The range of observed groundwater well arsenic concentrations at the Site is denoted by the gray shaded region.

(b) Arsenic concentrations in the sediment sorbate (ferrihydrite in this model) versus time. The average Site soil arsenic concentration (2.1 mg/kg) is denoted by the horizontal gray line. The PRB implementation timing is denoted by the vertical dashed, red line. The light blue line denotes the arsenic concentrations over time at the PRB (or 0 feet downgradient) and the dark blue line represents the arsenic concentrations in the sorbate 25 feet from the PRB (location of compliance well).

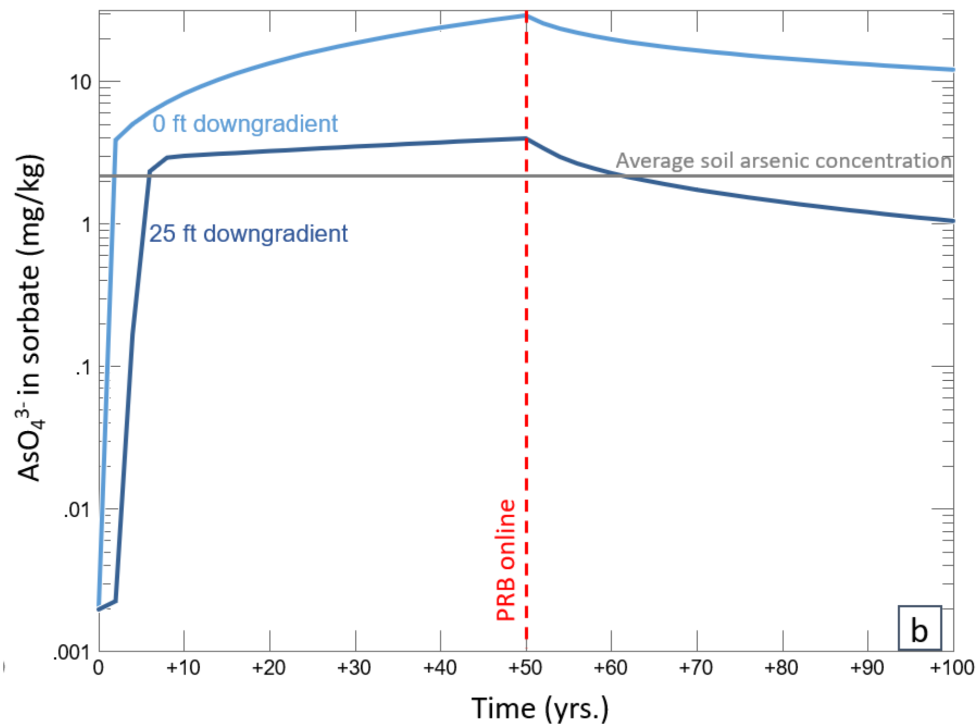
Figure 10. Model 1: 1D Transport Model Results (Average Darcy's Flux)

Meanwhile, during the first 50 years in Model 1, simulated AsO_4^{3-} concentrations in the aquifer soil immediately downgradient of (or adjacent to) the PRB (Node 0, see Figure 10b) initially increase rapidly to about 4 mg/kg within the first 1 to 2 years, and then the concentrations begin to increase more slowly reaching a high of about 40 mg/kg at year 50 when the PRB is implemented. A steady decline occurs once the PRB is implemented, reaching a low of approximately 4 mg/kg at year 100. At the location of the compliance well 25 ft downgradient of the PRB (Node 1), AsO_4^{3-} concentrations in soils never increase above 1 mg/kg and are the same order of magnitude as natural soil concentrations of approximately 2 mg/kg on average. It is likely that since Model 1 overpredicts the arsenic soil concentrations immediately adjacent to the PRB alignment (40 mg/kg compared with an average of approximately 2 mg/kg in natural soils), the predicted 2 to 3 year spike in AsO_4^{3-} groundwater concentrations immediately after PRB implementation could be overpredicted.

(a) Arsenic in Groundwater



(b) Arsenic in Soil



Notes:

(a) 1D transport model showing arsenic concentration in groundwater versus time using a discharge of 0.047 ft/day and sediment ferrihydrite concentration of 1,100 mg/kg (see Table 4, model 3 for all input parameters). Loading of the aquifer sediments with arsenic takes place from 0 to 50 years (as denoted by the green solid line) prior to the PRB implementation at year 50 (denoted by leftmost red dashed line). The predicted amount of time after PRB implementation for arsenic concentrations to reach compliance (5 ug/L, as denoted by red horizontal line) is denoted by the rightmost red dashed line and is approximately 30 years. The range of observed groundwater well arsenic concentrations at the Site is denoted by the gray shaded region.

(b) Arsenic concentrations in the sediment sorbate (ferrihydrite in this model) versus time. The average Site soil arsenic concentration (2.1 mg/kg) is denoted by the horizontal gray line. The PRB implementation timing is denoted by the vertical dashed, red line. The light blue line denotes the arsenic concentrations over time at the PRB (or 0 feet downgradient) and the dark blue line represents the arsenic concentrations in the sorbate 25 feet from the PRB (location of compliance well).

Figure 11. Model 2: 1D Transport Model Results Using an Average Darcy's Flux and Decreased Sorbate Concentration

Model 2 tests the sensitivity of reducing the sorbate (ferrihydrite) concentration by an order of magnitude but keeps all other input parameters the same as Model 1 The time to compliance increases to about 30 years compared with approximately 25 years for Model 1 (see Figure 11). Additionally, AsO_4^{3-} in the soils remains at relatively high levels immediately adjacent to the PRB (Node 0). AsO_4^{3-} concentrations in soils 25 ft downgradient of the PRB (Node 1) increased to above 3 mg/kg (Figure 11). If the sorbate concentration is increased, the time to compliance decreases compared with Model 1 (results not shown).

4 Conclusions

The conclusions of treatability testing are as follows:

1. Column testing verifies the reactivity of ZVI in the presence of Site groundwater, and the effective removal of arsenic from groundwater. There was a lower arsenic concentration in C20 effluent than in C10 effluent, indicating increased arsenic reaction kinetics with 20 percent ZVI.
2. Equilibrium speciation modeling on column influent and effluent samples suggests mineral formation of predominately Fe-oxide/oxyhydroxide and carbonates within the PRB.
3. The XRD and SEM results show the presence of mostly Fe-oxides/oxyhydroxides and little evidence of significant Ca- or Mg-bearing carbonate precipitation.
4. The combined mineral formation rate for predicted minerals in ambient groundwater (not including iron corrosion products) was predicted to be on the order of 0.11 cm^3/L H_2O, or 0.011 percent volume.
5. The 1D transport simulation predicts time frame to reach 5 µg/L in groundwater 25 ft downgradient of the PRB is about 25 years. This estimate is discussed further in the Engineering Design Report.

These conclusions satisfy the objectives of the treatability testing and serve as a basis of a PRB Design presented in the Engineering Design Report.

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6 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. Column Flow Measurements

Project No. 210158, Port of Tacoma Parcel 15 (Portac), Cleanup Phase 1, Tacoma, WA

Column	Day 1	Day 2	Day 3	Day 4[4]	Day 5	Day 8
	11/29/2021 17:30	11/30/2021 10:00	12/1/2021 7:15	12/2/2021 12:00	12/3/2021 9:20	12/6/2021 9:30
Control	14 mL/min	10 mL/min[1]	13 mL/min[2]	55 mL/min[3]	20 mL/min	25 mL/min
10 percent ZVI	10 mL/min	20 mL/min[1]	5 mL/min[2]	45 mL/min[3]	10 mL/min	20 mL/min
20 percent ZVI	18 mL/min	30 mL/min[1]	20 mL/min[2]	45 mL/min[3]	10 mL/min	20 mL/min

Notes:

[1] Replaced tygon peristaltic tubing to reduce flow rate

[2] Flow increased to 50 mL/min

[3] Pumps set to minimum flow rate for remainder of column test

[4] Observations of pumping action and discharge on Day 4 indicated that columns had been operating under desired 50 mL/min flow rate. Pore volume calculations were conducted using the observed average flow rate of 30 to 40 mL/min to represent the actual flow through the columns.

Table 2. Column Physical Properties

Project No. 210158, Port of Tacoma Parcel 15 (Portac), Cleanup Phase 1, Tacoma, WA

Column	Column Mass	Sand Mass	ZVI Mass	Total Mass	Mass of MW-14 Groundwater	Estimated Column Total Porosity	Estimated Column Pore Volume
	grams	grams	grams	grams	grams	%	gallons
Control	2400	5500	--	--	--	--	--
10 percent ZVI	2400	5610	850	11000	2140	0.51	0.57
20 percent ZVI	2400	4820	1680	11100	2200	0.53	0.58

Notes:

Assumed specific gravity of MW-14 groundwater is 1 g/cm^3

ZVI - zero valent iron

Table 3. Column Analytical Results

FINAL

Project No. 210158, Port of Tacoma Parcel 15 (Portac) Cleanup Phase 1, Tacoma, WA

		Day 1			
		Influent - Day 1	***Control - Day 1***	***C10 - Day 1***	***C20 - Day 1***
		11/29/2021	11/29/2021	11/29/2021	11/29/2021
		Influent	Effluent	Effluent	Effluent
Dissolved Metals					
Arsenic	ug/L	**60.8**	**18.6**	**2.88**	**2.77**
Calcium	ug/L	**143,000 J**	**223,000 J**	**273,000 J**	**201,000 J**
Iron	ug/L	**126,000**	< 10000 U	**41,400**	**100,000**
Magnesium	ug/L	**79,100**	**74,000**	**88,800**	**89,900**
Manganese	ug/L	**3,970**	**300**	**11,800**	**9,000**
Potassium	ug/L	**38,500 J**	**12,100 J**	**16,000 J**	**28,900 J**
Sodium	ug/L	**217,000**	**216,000**	**219,000**	**230,000**
Total Metals					
Arsenic	ug/L	**57.7**	**18.3**	**5.36**	**3.57**
Calcium	ug/L	**164,000 J**	**249,000 J**	**286,000 J**	**259,000 J**
Iron	ug/L	**141,000**	< 25000 U	**43,400**	**157,000**
Magnesium	ug/L	**87,600**	**81,000**	**92,300**	**102,000**
Manganese	ug/L	**4,520**	**339 J**	**11,800**	**9,910**
Potassium	ug/L	**40,800 J**	**10,300 J**	**14,500 J**	**25,400 J**
Sodium	ug/L	**238,000**	**241,000**	**226,000**	**245,000**
Conventionals					
Orthophosphate	mg/L	**0.15**	< 0.10 U	< 0.10 U	< 0.10 U
Alkalinity, Total	mg/L	**901**	**974**	**1,120**	**1,070**
Bromide	mg/L	**0.920**	**0.951**	**0.883**	**0.934**
Chloride	mg/L	**92.5**	**96.7**	**80.6**	**91.9**
Fluoride	mg/L	**0.948**	< 0.100 U	**0.240**	**0.384**
Iron, Ferrous, Fe+2	mg/L	**130**	**0.237**	**60.0**	**140**
Nitrate-Nitrite	mg/L	< 0.010 U	< 0.010 U	**0.991**	**0.012**
Nitrate as Nitrogen	mg/L	< 0.100 U	< 0.100 U	**0.807**	< 0.100 U
Nitrite as Nitrogen	mg/L	< 0.100 U	< 0.100 U	< 0.100 U	< 0.100 U
Sulfate	mg/L	**9.38**	**7.41**	**10.7**	**9.34**
Total Organic Carbon	mg/L	**71.9**	**66.7**	**51.7**	**53.9**
Field Parameters					
Temperature	deg C	**16.5**	**17.1**	**16.7**	**16.9**
Specific Conductance	uS/cm	**1013**	**974**	**1016**	**1086**
Dissolved Oxygen	mg/L	**12.6**	**29.4**	**13.4**	**8.3**
pH	pH units	**6.97**	**6.25**	**5.95**	**6.22**
Oxidation Reduction Potential	mV	**107.3**	**163.9**	**142.2**	**156.2**

Notes:

Bold - Analyte Detected

J - Analyte was positively identified. The reported result is an estimate.

U - Analyte was not detected at or above the reported result.

Table 3. Column Analytical Results

Project No. 210158, Port of Tacoma Parcel 15 (Portac) Cleanup Phase 1, Tacoma, WA

		Day 2									
		Influent - Day 2	***Control - Day 2***			***C10 - Day 2***			***C20 - Day 2***		
		11/30/2021	11/30/2021	11/30/2021	11/30/2021	11/30/2021	11/30/2021	11/30/2021	11/30/2021	11/30/2021	11/30/2021
		Influent	Port 1	Port 2	Effluent	Port 1	Port 2	Effluent	Port 1	Port 2	Effluent
Dissolved Metals											
Arsenic	ug/L	**43.8**	**26.5**	**30.5**	**23.8**	**8.64**	**4.15**	**2.85**	**11.2**	**6.93**	**3.61**
Calcium	ug/L	**152,000 J**	--	--	**142,000 J**	--	--	**159,000 J**	--	--	**139,000 J**
Iron	ug/L	**140,000**	--	--	< 10000 U	--	--	**188,000**	--	--	**218,000**
Magnesium	ug/L	**88,800**	--	--	**21,700**	--	--	**77,300**	--	--	**80,900**
Manganese	ug/L	**4,100**	--	--	**1,790**	--	--	**8,010**	--	--	**5,770**
Potassium	ug/L	**42,600 J**	--	--	< 20000 UJ	--	--	**35,000 J**	--	--	**36,900 J**
Sodium	ug/L	**215,000**	--	--	**233,000**	--	--	**197,000**	--	--	**205,000**
Total Metals											
Arsenic	ug/L	**44.3**	**39.5**	**26.6**	**25.5**	**13.3**	**8.42**	**4.58**	**20.4**	**8.96**	**4.95**
Calcium	ug/L	**153,000 J**	--	--	**211,000 J**	--	--	**195,000 J**	--	--	**174,000 J**
Iron	ug/L	**135,000**	--	--	< 25000 U	--	--	**220,000**	--	--	**268,000**
Magnesium	ug/L	**84,000**	--	--	**104,000**	--	--	**92,000**	--	--	**93,600**
Manganese	ug/L	**4,090**	--	--	**10,400**	--	--	**9,660**	--	--	**6,920**
Potassium	ug/L	**38,300 J**	--	--	**45,100 J**	--	--	**37,700 J**	--	--	**40,700 J**
Sodium	ug/L	**218,000**	--	--	**261,000**	--	--	**225,000**	--	--	**232,000**
Conventionals											
Orthophosphate	mg/L	< 0.10 U	--	--	< 0.10 U	--	--	< 0.10 U	--	--	< 0.10 U
Alkalinity, Total	mg/L	**813**	--	--	**881**	--	--	**865**	--	--	**838**
Bromide	mg/L	**0.931**	--	--	**0.988**	--	--	**0.874**	--	--	**0.936**
Chloride	mg/L	**94.7**	--	--	**107**	--	--	**79.6**	--	--	**91.7**
Fluoride	mg/L	**1.11**	--	--	**0.655**	--	--	**0.703**	--	--	**0.788**
Iron, Ferrous, Fe+2	mg/L	**153**	--	--	**0.536**	--	--	**171**	--	--	**242**
Nitrate-Nitrite	mg/L	< 0.010	--	--	**0.014**	--	--	**0.163**	--	--	**0.613**
Nitrate as Nitrogen	mg/L	--	--	--	--	--	--	--	--	--	--
Nitrite as Nitrogen	mg/L	--	--	--	--	--	--	--	--	--	--
Sulfate	mg/L	**4.57**	--	--	**4.30**	--	--	**5.72**	--	--	**4.92**
Total Organic Carbon	mg/L	**73.8**	--	--	**66.7**	--	--	**64.6**	--	--	**71.8**
Field Parameters											
Temperature	deg C	**15**	**14.4**	**14.2**	**14.1**	**14.3**	**14.1**	**14**	**14.7**	**14.6**	**14.2**
Specific Conductance	uS/cm	**1956**	**2006**	**1891**	**1917**	**2066**	**2138**	**2137**	**2117**	**2161**	**2087**
Dissolved Oxygen	mg/L	**9.3**	**5.1**	**6.6**	**25.6**	**3.2**	**2.2**	**4.8**	**5.7**	**2.6**	**1.7**
pH	pH units	**7.21**	**7.29**	**7.28**	**7.28**	**7.32**	**7.42**	**7.09**	**7.29**	**7.39**	**6.83**
Oxidation Reduction Potential	mV	**135.1**	**130**	**129.8**	**153.4**	**128.2**	**127.3**	**143.5**	**133.3**	**130.2**	**152.7**

Notes

Bold - Analyte Detected

J - Analyte was positively identified. The reported result is an estimate.

U - Analyte was not detected at or above the reported result.

Table 3. Column Analytical Results

Project No. 210158, Port of Tacoma Parcel 15 (Portac) Cleanup Phase 1, Tacoma, WA

		Day 3									
		Influent - Day 3	***Control - Day 3***			***C10 - Day 3***			***C20 - Day 3***		
		12/1/2021	12/1/2021	12/1/2021	12/1/2021	12/1/2021	12/1/2021	12/1/2021	12/1/2021	12/1/2021	12/1/2021
		Influent	Port 1	Port 2	Effluent	Port 1	Port 2	Effluent	Port 1	Port 2	Effluent
Dissolved Metals											
Arsenic	ug/L	**44.7**	**14.5**	**16**	**29.7**	**6.09**	**3.45**	**3.7**	**5.66**	**4.01**	**5.28**
Calcium	ug/L	**139,000 J**	--	--	**140,000 J**	--	--	**157,000 J**	--	--	**130,000 J**
Iron	ug/L	**133,000**	--	--	**28,900**	--	--	**166,000**	--	--	**104,000**
Magnesium	ug/L	**85,500**	--	--	**85,300**	--	--	**81,200**	--	--	**84,200**
Manganese	ug/L	**3,880**	--	--	**7,030**	--	--	**6,330**	--	--	**4,550**
Potassium	ug/L	**38,000 J**	--	--	**40,900 J**	--	--	**38,500 J**	--	--	**39,600 J**
Sodium	ug/L	**202,000**	--	--	**213,000**	--	--	**196,000**	--	--	**198,000**
Total Metals											
Arsenic	ug/L	**45.2**	**39.2**	**38.7**	**34.1**	**15.6**	**8.5**	**6.14**	**17.6**	**8.98**	**9.32**
Calcium	ug/L	**161,000 J**	--	--	**178,000 J**	--	--	**172,000 J**	--	--	**168,000 J**
Iron	ug/L	**145,000**	--	--	**38,400**	--	--	**225,000**	--	--	**245,000**
Magnesium	ug/L	**94,000**	--	--	**100,000**	--	--	**87,100**	--	--	**93,200**
Manganese	ug/L	**4,710**	--	--	**8,180**	--	--	**7,040**	--	--	**5,580**
Potassium	ug/L	**41,000 J**	--	--	**44,500 J**	--	--	**41,200 J**	--	--	**42,000 J**
Sodium	ug/L	**227,000**	--	--	**243,000**	--	--	**217,000**	--	--	**232,000**
Conventionals											
Orthophosphate	mg/L	< 0.10 U	--	--	< 0.10 U	--	--	< 0.10 U	--	--	< 0.10 U
Alkalinity, Total	mg/L	**868**	--	--	**862**	--	--	**838**	--	--	**843**
Bromide	mg/L	**1.04**	--	--	**1.05**	--	--	**0.895**	--	--	**0.995**
Chloride	mg/L	**119**	--	--	**120**	--	--	**81.9**	--	--	**106**
Fluoride	mg/L	**1.09**	--	--	**1.15**	--	--	**0.765**	--	--	**0.931**
Iron, Ferrous, Fe+2	mg/L	**156**	--	--	**35.8**	--	--	**210**	--	--	**237**
Nitrate-Nitrite	mg/L	--	--	--	--	--	--	--	--	--	--
Nitrate as Nitrogen	mg/L	< 0.100 U	--	--	**0.170**	--	--	**1.53**	--	--	**1.66**
Nitrite as Nitrogen	mg/L	< 0.100 U	--	--	< 0.100 U	--	--	< 0.100 U	--	--	< 0.100 U
Sulfate	mg/L	**1.64**	--	--	**2.30**	--	--	**2.93**	--	--	**2.61**
Total Organic Carbon	mg/L	**77.9**	--	--	**73.9**	--	--	**68.4**	--	--	**74.3**
Field Parameters											
Temperature	deg C	**16.1**	**15.2**	**15**	**14.6**	**14.8**	**14.9**	**14.9**	**15.1**	**15.2**	**15.4**
Specific Conductance	uS/cm	**1344**	**2125**	**2069**	**2034**	**2141**	**2004**	**1775**	**2187**	**2237**	**2929**
Dissolved Oxygen	mg/L	**9.5**	**11.2**	**14.3**	**10.1**	**3.7**	**3.8**	**15.9**	**3.2**	**5**	**9.8**
pH	pH units	**7.14**	**7.16**	**7.14**	**6.99**	**7.15**	**7.36**	**7.62**	**7.24**	**7.28**	**8.6**
Oxidation Reduction Potential	mV	**145.6**	--	--	**154.5**	--	--	**158.3**	--	--	**185.4**

Notes

Bold - Analyte Detected

J - Analyte was positively identified. The reported result is an estimate.

U - Analyte was not detected at or above the reported result.

Table 3. Column Analytical Results

FINAL

Project No. 210158, Port of Tacoma Parcel 15 (Portac) Cleanup Phase 1, Tacoma, WA

		Day 4									
		Influent - Day 4	*Control - Day 4*			*C10 - Day 4*			*C20 - Day 4*		
		12/2/2021	12/2/2021	12/2/2021	12/2/2021	12/2/2021	12/2/2021	12/2/2021	12/2/2021	12/2/2021	12/2/2021
		Influent	Port 1	Port 2	Effluent	Port 1	Port 2	Effluent	Port 1	Port 2	Effluent
Dissolved Metals											
Arsenic	ug/L	**83.7 J**	--	--	**36.4**	**27.0**	**14.4**	**2.83**	**26.0**	**12.4**	**3.30**
Calcium	ug/L	**144,000 J**	--	--	**98,200 J**	--	--	**76,800 J**	--	--	**76,400 J**
Iron	ug/L	**160,000**	--	--	**160,000**	--	--	**251,000**	--	--	**286,000**
Magnesium	ug/L	**105,000**	--	--	**90,500**	--	--	**71,900**	--	--	**83,500**
Manganese	ug/L	**3,670**	--	--	**5,100**	--	--	**4,120**	--	--	**4,580**
Potassium	ug/L	**48,800**	--	--	**41,700**	--	--	**40,200**	--	--	**44,100**
Sodium	ug/L	**294,000**	--	--	**218,000**	--	--	**181,000**	--	--	**213,000**
Total Metals											
Arsenic	ug/L	**91.2**	--	--	**78.6**	**44.8 J**	**20.8 J**	**18.0 J**	**39.4 J**	**20.4 J**	**12.0 J**
Calcium	ug/L	**158,000 J**	--	--	**152,000 J**	--	--	**150,000 J**	--	--	**135,000 J**
Iron	ug/L	**168,000**	--	--	**137,000**	--	--	**224,000**	--	--	**214,000**
Magnesium	ug/L	**108,000**	--	--	**106,000**	--	--	**92,100**	--	--	**90,100**
Manganese	ug/L	**3,850**	--	--	**4,940**	--	--	**4,390**	--	--	**4,390**
Potassium	ug/L	**46,400**	--	--	**49,000**	--	--	**43,600**	--	--	**39,100**
Sodium	ug/L	**229,000**	--	--	**257,000 J**	--	--	**234,000**	--	--	**229,000**
Conventionals											
Orthophosphate	mg/L	< 0.10 U	--	--	< 0.10 U	--	--	< 0.10 U	--	--	< 0.10 U
Alkalinity, Total	mg/L	**898**	--	--	**903**	--	--	**871**	--	--	**892**
Bromide	mg/L	**1.12**	--	--	**1.14**	--	--	**0.973**	--	--	**1.10**
Chloride	mg/L	**125**	--	--	**133**	--	--	**91.0**	--	--	**126**
Fluoride	mg/L	**0.962**	--	--	**1.01**	--	--	**0.956**	--	--	**0.938**
Iron, Ferrous, Fe+2	mg/L	**158**	--	--	**126**	--	--	**199**	--	--	**217**
Nitrate-Nitrite	mg/L	--	--	--	--	--	--	--	--	--	--
Nitrate as Nitrogen	mg/L	< 0.100 U	--	--	< 0.100 U	--	--	< 0.100 U	--	--	< 0.100 U
Nitrite as Nitrogen	mg/L	< 0.100 U	--	--	< 0.100 U	--	--	< 0.100 U	--	--	< 0.100 U
Sulfate	mg/L	**1.14**	--	--	**1.16**	--	--	**1.71**	--	--	**1.33**
Total Organic Carbon	mg/L	**78.8**	--	--	**78.1**	--	--	**76.4**	--	--	**76.9**
Field Parameters											
Temperature	deg C	**14.7**	**15.7**	**15.9**	**13.7**	**16.1**	**16.2**	**13.8**	**16**	**16.1**	**13.4**
Specific Conductance	uS/cm	**2066**	**2282**	**2197**	**2182**	**2045**	**2184**	**2017**	**2319**	**2301**	**2328**
Dissolved Oxygen	mg/L	**4.7**	**4.5**	**12.1**	**6.2**	**4.9**	**3.2**	**6.4**	**3.6**	**0.5**	**1.3**
pH	pH units	**6.86**	**7.1**	**7.1**	**6.88**	**7.11**	**7.13**	**6.91**	**7.11**	**7.15**	**7.05**
Oxidation Reduction Potential	mV	**125.7**	**78**	**76.6**	**125.7**	**92.6**	**94.9**	**124.9**	**92.6**	**79.4**	**116.4**

Notes

Bold - Analyte Detected

J - Analyte was positively identified. The reported result is an estimate.

U - Analyte was not detected at or above the reported result.

Table 3. Column Analytical Results

Project No. 210158, Port of Tacoma Parcel 15 (Portac) Cleanup Phase 1, Tacoma, WA

		Day 5									
		Influent - Day 5	***Control - Day 5***			***C10 - Day 5***			***C20 - Day 5***		
		12/3/2021	12/3/2021	12/3/2021	12/3/2021	12/3/2021	12/3/2021	12/3/2021	12/3/2021	12/3/2021	12/3/2021
		Influent	Port 1	Port 2	Effluent	Port 1	Port 2	Effluent	Port 1	Port 2	Effluent
Dissolved Metals											
Arsenic	ug/L	--	--	--	--	--	--	--	--	--	--
Calcium	ug/L	--	--	--	--	--	--	--	--	--	--
Iron	ug/L	--	--	--	--	--	--	--	--	--	--
Magnesium	ug/L	--	--	--	--	--	--	--	--	--	--
Manganese	ug/L	--	--	--	--	--	--	--	--	--	--
Potassium	ug/L	--	--	--	--	--	--	--	--	--	--
Sodium	ug/L	--	--	--	--	--	--	--	--	--	--
Total Metals											
Arsenic	ug/L	--	--	--	--	--	--	--	--	--	--
Calcium	ug/L	--	--	--	--	--	--	--	--	--	--
Iron	ug/L	--	--	--	--	--	--	--	--	--	--
Magnesium	ug/L	--	--	--	--	--	--	--	--	--	--
Manganese	ug/L	--	--	--	--	--	--	--	--	--	--
Potassium	ug/L	--	--	--	--	--	--	--	--	--	--
Sodium	ug/L	--	--	--	--	--	--	--	--	--	--
Conventionals											
Orthophosphate	mg/L	--	--	--	--	--	--	--	--	--	--
Alkalinity, Total	mg/L	--	--	--	--	--	--	--	--	--	--
Bromide	mg/L	--	--	--	--	--	--	--	--	--	--
Chloride	mg/L	--	--	--	--	--	--	--	--	--	--
Fluoride	mg/L	--	--	--	--	--	--	--	--	--	--
Iron, Ferrous, Fe+2	mg/L	--	--	--	--	--	--	--	--	--	--
Nitrate-Nitrite	mg/L	--	--	--	--	--	--	--	--	--	--
Nitrate as Nitrogen	mg/L	--	--	--	--	--	--	--	--	--	--
Nitrite as Nitrogen	mg/L	--	--	--	--	--	--	--	--	--	--
Sulfate	mg/L	--	--	--	--	--	--	--	--	--	--
Total Organic Carbon	mg/L	--	--	--	--	--	--	--	--	--	--
Field Parameters											
Temperature	deg C	**14.2**	**12.1**	**12.6**	**14.7**	**12.6**	**14.1**	**15.1**	**13.6**	**14.2**	**13.1**
Specific Conductance	uS/cm	**1203**	**2270**	**1327**	**2175**	**1922**	**2245**	**2346**	**1170**	**2316**	**2719**
Dissolved Oxygen	mg/L	**8.3**	**13.5**	**18.5**	**13.9**	**5.3**	**0.9**	**6.7**	**8**	**3.6**	**6.7**
pH	pH units	**7.26**	**7.31**	**7.46**	**7.27**	**7.44**	**7.51**	**7.53**	**7.47**	**7.47**	**8.29**
Oxidation Reduction Potential	mV	**128.4**	**129.6**	**127.8**	**127.3**	**125.7**	**117.4**	**128.7**	**118.3**	**116.3**	**163.1**

Notes

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Table 3. Column Analytical Results

Project No. 210158, Port of Tacoma Parcel 15 (Portac) Cleanup Phase 1, Tacoma, WA

		Day 8									
		Influent - Day 8	*Control - Day 8*			*C10 - Day 8*			*C20 - Day 8*		
		12/6/2021	12/6/2021	12/6/2021	12/6/2021	12/6/2021	12/6/2021	12/6/2021	12/6/2021	12/6/2021	12/6/2021
		Influent	Port 1	Port 2	Effluent	Port 1	Port 2	Effluent	Port 1	Port 2	Effluent
Dissolved Metals											
Arsenic	ug/L	**126**	**62.5**	**61.5**	**82.5 J**	**20.3**	**12.5**	**8.72**	**20.1**	**9.00**	**5.38**
Calcium	ug/L	**148,000 J**	--	--	**164,000 J**	--	--	**144,000 J**	--	--	**159,000 J**
Iron	ug/L	**185,000**	--	--	**150,000**	--	--	**236,000**	--	--	**227,000**
Magnesium	ug/L	**107,000**	--	--	**117,000**	--	--	**95,100**	--	--	**112,000**
Manganese	ug/L	**3,920**	--	--	**4,050**	--	--	**3,880**	--	--	**3,980**
Potassium	ug/L	**49,200**	--	--	**56,300**	--	--	**48,900**	--	--	**48,700**
Sodium	ug/L	**211,000**	--	--	**223,000**	--	--	**469,000**	--	--	**196,000**
Total Metals											
Arsenic	ug/L	**73.0 J**	**59.9**	**59.3**	**57.9 J**	**23.1**	**13.8**	**10.3**	**17.8**	**7.11**	**6.44**
Calcium	ug/L	**164,000 J**	--	--	**139,000 J**	--	--	**136,000 J**	--	--	**152,000 J**
Iron	ug/L	**136,000**	--	--	**113,000**	--	--	**199,000**	--	--	**179,000**
Magnesium	ug/L	**91,600**	--	--	**90,500**	--	--	**83,400**	--	--	**89,400**
Manganese	ug/L	**3,980**	--	--	**3,970**	--	--	**4,200**	--	--	**4,030**
Potassium	ug/L	**33,500**	--	--	**35,100**	--	--	**35,800**	--	--	**34,000**
Sodium	ug/L	**242,000 J**	--	--	**273,000 J**	--	--	**226,000 J**	--	--	**258,000 J**
Conventionals											
Orthophosphate	mg/L	< 0.10 U	--	--	< 0.10 U	--	--	< 0.10 U	--	--	< 0.10 U
Alkalinity, Total	mg/L	**960**	--	--	**926**	--	--	**892**	--	--	**926**
Bromide	mg/L	**1.12**	--	--	**1.23**	--	--	**0.998**	--	--	**1.19**
Chloride	mg/L	**125**	--	--	**148**	--	--	**102**	--	--	**141**
Fluoride	mg/L	**0.902**	--	--	**0.873**	--	--	**0.841**	--	--	**0.941**
Iron, Ferrous, Fe+2	mg/L	**142**	--	--	**123**	--	--	**206**	--	--	**174**
Nitrate-Nitrite	mg/L	--	--	--	--	--	--	--	--	--	--
Nitrate as Nitrogen	mg/L	< 0.100 U	--	--	< 0.100 U	--	--	< 0.100 U	--	--	< 0.100 U
Nitrite as Nitrogen	mg/L	< 0.100 U	--	--	< 0.100 U	--	--	< 0.100 U	--	--	< 0.100 U
Sulfate	mg/L	**0.799**	--	--	**0.578**	--	--	**1.21**	--	--	**0.639**
Total Organic Carbon	mg/L	**78.7**	--	--	**73.7**	--	--	**78.6**	--	--	**75.1**
Field Parameters											
Temperature	deg C	**13.4**	**12.9**	**13.1**	**15.7**	**12.5**	**13.6**	**14.9**	**12.7**	**12.8**	**14.6**
Specific Conductance	uS/cm	**1604**	**1251**	**2419**	**2308**	**2180**	**1882**	**1359**	**1808**	**2278**	**2037**
Dissolved Oxygen	mg/L	**10.2**	**19.7**	**11.1**	**7.5**	**9.4**	**9.6**	**2.7**	**8.8**	**6.1**	**6.8**
pH	pH units	**7.8**	**7.88**	**7.77**	**7.89**	**7.72**	**7.85**	**8.18**	**7.7**	**7.73**	**8.48**
Oxidation Reduction Potential	mV	**126.9**	**127.8**	**128.6**	**128.9**	**132.2**	**125.8**	**142.7**	**131.4**	**132.4**	**168.5**

Notes

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Table 4. Column Pore Volume Estimates

Project No. 210158, Port of Tacoma Parcel 15 (Portac), Cleanup Phase 1, Tacoma, WA

Column	Day 1		Day 2		Day 3		Day 4[2]		Day 8		Total Volume	
	First Sample	Last Sample	First Sample	Last Sample	First Sample	Last Sample	First Sample	Last Sample	First Sample	Last Sample	Gallons	Pore Volumes
Control[1]	4	4	9	9	18	21	38	39	108	109	63	109
10 percent ZVI[1]	3	3	9	10	17	19	33	34	90	91	52	91
20 percent ZVI[1]	5	5	15	16	25	28	41	42	97	98	57	98

Notes:

[1] Pore volume calculations done using observed column flow rates, and the estimated column physical properties in Table 2.

[2] Observations of pumping action and discharge on Day 4 indicated that columns had been operating under desired 50 mL/min flow rate. Pore volume calculations were conducted using the observed average flow rate of 30 to 40 mL/min to represent the actual flow through the columns.

Table 5. Geochemical Input Data for Speciation Modeling

Project No. 210158, Port of Tacoma Parcel 15 (Portac), Cleanup Phase 1, Tacoma, WA

Parameters	Unit	Influent Day 3	C10[a] Effluent Day 3	C20[b] Effluent Day 3	Influent Day 4	C10 Effluent Day 4	C20 Effluent Day 4	Influent Day 8	C10 Effluent Day 8	C20 Effluent Day 8
		12/1/2021	12/1/2021	12/1/2021	12/2/2021	12/2/2021	12/2/2021	12/6/2021	12/6/2021	12/6/2021
AsO_4^{3-}	µg/l	44.7	3.7	5.28	83.7	2.83	3.3	126	8.72	5.38
Ca^{2+}	µg/l	139,000	157,000	130,000	144,000	76,800	76,400	148,000	144,000	159,000
Mg^{2+}	µg/l	85,500	81,200	84,200	105,000	71,900	83,500	107,000	95,100	112,000
K^{+}	µg/l	38,000	38,500	39,600	48,800	40,200	44,100	49,200	48,900	48,700
Na^{+}	µg/l	202,000	196,000	198,000	294,000	181,000	213,000	211,000	469,000	196,000
Fe^{3+}	µg/l	12,000	59,000	141,000	8,000	1,000	1,000	1,000	1,000	1,000
Br^{-}	µg/l	1,040	895	995	1,120	973	1,100	1,120	998	1,190
Cl^{-}	µg/l	119,000	81,900	106,000	125,000	91,000	126,000	125,000	102,000	141,000
F^{-}	µg/l	1,090	765	931	962	956	938	902	841	941
NO_3^{-}	µg/l	-	1,530	1,660	-	-	-	-	-	-
SO_4^{2-}	µg/l	1,640	2,930	2,610	1,140	1,710	1,330	799	1,210	639
Temperature	°C	16.1	14.9	15.4	14.7	13.8	13.4	13.4	14.9	14.6
Electrical conductivity	µS/cm	1,344	1,775	2,929	2,066	2,017	2,328	1,604	1,359	2,037
pH	pH	7.14	7.62	8.6	6.86	6.91	7.05	7.8	8.18	8.48
Eh	mV	145.6	158.3	185.4	125.7	124.9	116.4	126.9	142.7	168.5
CO_3^{2-}	µg/l	868,000	838,000	843,000	898,000	871,000	892,000	960,000	892,000	926,000
Mn^{2+}	µg/l	3,880	6,330	4,550	3,670	4,120	4,580	3,920	3,880	3,980
Fe^{2+}	µg/l	133,000	166,000	104,000	160,000	251,000	286,000	185,000	236,000	227,000

Notes:

a. C10 refers to the column test containing 10% zero-valent iron (ZVI) by mass

b. C20 refers to the column test containing 20% zero-valent iron (ZVI) by mass

Table 6. Mineral Saturation Indices

Project No. 210158, Port of Tacoma Parcel 15 (Portac), Cleanup Phase 1, Tacoma, WA

Mineral name	Influent Day 3	C10 Effluent Day 3	C20 Effluent Day 3	Influent Day 4	C10 Effluent Day 4	C20 Effluent Day 4	Influent Day 8	C10 Effluent Day 8	C20 Effluent Day 8
Magnetite	25.529	28.8097	32.9897	24.0039	22.5472	23.1092	25.8833	27.5529	28.5892
Hematite	19.4308	21.7221	24.1306	18.4657	16.7389	16.9984	18.4777	19.225	19.6897
Maghemite	12.3221	14.7105	17.0784	11.4703	9.817	10.1093	11.5886	12.2134	12.7025
Magnesioferrite	11.8569	14.9655	19.3776	10.2787	8.4219	8.9733	12.0419	13.6214	14.7265
Fe3(OH)8	9.8328	13.2705	17.3849	8.4908	7.1529	7.7678	10.5419	12.0132	13.0892
Fe(OH)2.7Cl.3	9.4868	10.4878	11.4121	9.1498	8.269	8.4143	8.9269	9.0971	9.2951
Goethite	8.5364	9.6849	10.888	8.0572	7.1961	7.3268	8.0665	8.4363	8.6695
Lepidocrocite	7.9829	9.1771	10.3611	7.557	6.7304	6.8765	7.6162	7.9285	8.1731
Ferrihydrite_(ag)	6.6637	7.8578	9.0418	6.2377	5.4111	5.5572	6.2969	6.6091	6.8538
Ferrihydrite	5.6124	6.731	7.9465	5.0982	4.2145	4.3351	5.0747	5.4823	5.708
K-Jarosite	3.5628	6.1094	6.7356	2.7719	0.4113	0.1831	-0.2633	-0.0586	-0.7863
Siderite	2.3495	2.9192	3.7022	2.077	2.3301	2.5378	3.1696	3.6258	3.9213
Rhodochrosite	1.1893	1.792	2.1089	0.846	0.9526	1.139	1.7225	1.9033	2.0216
Dolomite_(ordere)	0.8003	1.7593	3.6726	0.177	-0.1592	0.1978	2.2328	2.897	3.6276
MnCO3_(am)	0.6994	1.3035	1.6199	0.3577	0.4655	0.6523	1.2358	1.4148	1.5335
Calcite	0.395	0.9224	1.8348	0.0577	-0.157	-0.0085	1.1003	1.4409	1.7987
Aragonite	0.2446	0.7712	1.6839	-0.0937	-0.3092	-0.1609	0.9478	1.2896	1.6472
Dolomite_(disord)	0.2131	1.1669	3.0824	-0.4162	-0.7564	-0.4012	1.6339	2.3046	3.0339
Vaterite	-0.1957	0.3283	1.2421	-0.537	-0.7543	-0.6069	0.5019	0.8468	1.2037
Fluorite	-0.4613	-0.7056	-0.6121	-0.5716	-0.78	-0.8251	-0.6046	-0.7192	-0.5726
Magnesite	-0.469	0.0021	0.9865	-0.7088	-0.8002	-0.5783	0.348	0.6214	1.0042
CaCO3xH2O	-0.9489	-0.4211	0.4911	-1.2858	-1.5	-1.3512	-0.2425	0.0972	0.4552
Na-Jarosite	-1.3462	1.1558	1.7833	-2.1124	-4.6188	-4.8253	-5.3241	-4.7377	-5.8498
Fe(OH)2_(c)	-1.5425	-0.4932	1.2533	-2.0326	-1.7173	-1.3946	-0.0998	0.747	1.3336
Fe(OH)2_(am)	-2.6364	-1.6561	0.1192	-3.2071	-2.9438	-2.6444	-1.3496	-0.4159	0.1534
Huntite	-2.7635	-0.9438	2.9723	-3.9615	-4.542	-3.7688	0.1189	1.4326	2.9083
Gypsum	-3.3799	-3.0942	-3.1945	-3.5586	-3.6077	-3.7529	-3.7114	-3.5818	-3.8042
MgF2	-3.4513	-3.7945	-3.6112	-3.5138	-3.6309	-3.6171	-3.5791	-3.7072	-3.5463
MgCO3:5H2O	-3.4982	-3.0421	-2.0515	-3.7558	-3.8582	-3.6416	-2.7153	-2.4233	-2.044
Nesquehonite	-3.4982	-3.0604	-2.0621	-3.777	-3.8933	-3.6828	-2.7565	-2.4414	-2.0667
FeAsO4:2H2O	-3.5588	-4.3244	-4.8797	-3.2871	-5.66	-5.6854	-4.7214	-6.3049	-6.8548
Anhydrite	-3.6736	-3.3941	-3.4917	-3.8594	-3.9133	-4.0605	-4.019	-3.8814	-4.1055

Table 6. Mineral Saturation Indices

Project No. 210158, Port of Tacoma Parcel 15 (Portac), Cleanup Phase 1, Tacoma, WA

Mineral name	Influent Day 3	C10 Effluent Day 3	C20 Effluent Day 3	Influent Day 4	C10 Effluent Day 4	C20 Effluent Day 4	Influent Day 8	C10 Effluent Day 8	C20 Effluent Day 8
Epsomite	-5.8048	-5.5877	-5.6108	-5.9006	-5.8351	-5.9112	-6.0522	-5.9749	-6.175
Melanterite	-5.8383	-5.4954	-5.7313	-5.935	-5.5044	-5.5855	-6.021	-5.7953	-6.0759
Manganite	-5.9149	-4.1239	-1.3932	-7.0967	-6.8881	-6.5945	-4.4133	-3.192	-2.029
Pyrochroite	-5.9689	-4.9637	-3.6511	-6.6199	-	-	-4.9874	-4.3189	-3.9287
Brucite	-6.2027	-5.3583	-3.3661	-6.7843	-6.8938	-6.5928	-5.0035	-4.2055	-3.5582
Halite	-6.208	-6.3837	-6.2657	-6.0289	-6.3631	-6.1574	-6.1715	-5.9259	-6.1578
KCl	-6.5319	-6.6914	-6.5629	-	-6.6204	-6.446	-6.4077	-6.508	-6.3627
H-Jarosite	-6.7601	-4.7892	-5.1189	-7.4826	-9.8832	-10.3191	-11.5608	-11.6142	-12.6655
Artinite	-6.7741	-	-2.4935	-7.6187	-7.8343	-7.3182	-4.8026	-3.7065	-2.6812
Mg(OH)2_(active)	-7.2822	-6.352	-	-7.7636	-7.8082	-7.4783	-	-5.1992	-4.5303
Natron	-7.8621	-7.356	-6.3732	-7.8218	-8.153	-7.8354	-7.0129	-6.028	-6.459
Mirabilite	-7.9408	-7.6722	-7.7038	-7.7369	-7.8991	-7.8737	-8.1184	-7.35	-8.3603
Mn3(AsO4)2:8H2O	-8.2817	-8.9669	-8.5989	-8.5838	-11.1789	-10.6219	-6.4339	-8.4963	-8.8594
Thenardite	-9.8512	-9.6493	-9.653	-9.7246	-9.9379	-9.9347	-10.1792	-9.3261	-10.3538
Thermonatrite	-10.2193	-9.7706	-8.7638	-10.2456	-10.6208	-10.3224	-9.4997	-8.4417	-8.8878
Periclase	-10.8873	-10.0709	-8.067	-11.5015	-11.6323	-11.3408	-9.7514	-8.918	-8.2778
Portlandite	-11.8887	-10.9787	-9.0623	-12.5569	-12.7831	-12.5524	-10.7806	-9.9267	-9.3022
MnCl2:4H2O	-12.4055	-12.6231	-13.0687	-12.3882	-12.5897	-12.2974	-12.5647	-12.9255	-12.8297
Mg2(OH)3Cl:4H2O	-12.6669	-11.4504	-8.4031	-13.3336	-13.6033	-12.946	-10.5242	-9.6186	-8.4361
MnSO4	-12.6881	-12.3805	-13.0539	-12.935	-12.703	-12.8282	-13.312	-13.275	-13.7503
Ca3(AsO4)2:4H2O	-12.7989	-13.6981	-11.5487	-13.0693	-16.6207	-16.1736	-10.4096	-12.0058	-11.6482
Hydromagnesite	-13.0481	-10.4582	-4.4704	-14.7511	-15.3308	-14.1893	-8.8948	-6.8285	-4.6846
Pyrolusite	-13.7441	-11.4451	-7.1803	-15.781	-15.6843	-15.4663	-12.3505	-10.2261	-8.36
Hausmannite	-14.7007	-10.3574	-3.4816	-17.9998	-17.6565	-16.8763	-11.2675	-7.8485	-
Arsenolite	-21.9193	-28.4585	-37.8278	-17.7891	-20.8782	-21.1171	-24.4071	-31.07	-35.619
Claudetite	-21.9679	-28.5084	-37.8772	-17.8391	-20.9291	-21.1685	-24.4585	-31.1198	-35.6691
Lime	-22.2357	-21.3748	-19.4379	-22.9612	-23.2246	-23.0105	-21.2387	-20.3227	-19.7106
As2O5	-31.5176	-35.4349	-38.9142	-30.1195	-33.2104	-33.5526	-33.1039	-36.8983	-38.4868
Fe2(SO4)3	-37.3736	-37.3329	-40.8164	-37.3108	-38.7924	-39.7879	-43.4995	-44.4482	-46.6196
Sulfur	-41.524	-46.4896	-57.1706	-37.413	-37.5422	-37.9011	-45.2394	-49.7509	-55.1415
Mackinawite	-47.9871	-53.3167	-65.1534	-43.1197	-43.01	-43.0291	-50.942	-55.9117	-62.2217
FeS_(ppt)	-48.6964	-54.0343	-65.8675	-43.8386	-43.7352	-43.7571	-51.67	-56.6293	-62.9413

Table 6. Mineral Saturation Indices

Project No. 210158, Port of Tacoma Parcel 15 (Portac), Cleanup Phase 1, Tacoma, WA

Mineral name	Influent Day 3	C10 Effluent Day 3	C20 Effluent Day 3	Influent Day 4	C10 Effluent Day 4	C20 Effluent Day 4	Influent Day 8	C10 Effluent Day 8	C20 Effluent Day 8
MnS_(grn)	-53.339	-58.6638	-70.9548	-48.5753	-48.6334	-48.6833	-56.6445	-61.8542	-68.3483
MnS_(pnk)	-56.1665	-61.4672	-73.7683	-51.3747	-51.4146	-51.4563	-59.4176	-64.6576	-71.1457
CaS	-62.6059	-67.978	-79.6853	-57.8036	-58.1622	-58.2406	-65.6765	-70.7613	-77.009
Realgar	-63.7015	-73.9769	-93.7292	-55.5624	-57.2904	-57.7162	-69.5036	-79.4049	-89.3089
MgS	-69.1028	-74.5515	-86.1783	-64.2266	-64.4769	-64.4888	-72.1071	-77.2339	-83.4617
Pyrite	-76.3912	-86.6366	-109.1751	-67.3547	-67.3365	-67.6977	-82.9489	-92.493	-104.181
Orpiment	-164.5475	-190.048	-240.2401	-144.1399	-147.7133	-148.9184	-179.8315	-204.1654	-229.36
As2S3(am)	-166.0494	-191.5641	-241.7503	-145.6584	-149.2425	-150.4525	-181.3656	-205.6815	-230.8797
NaF	-	-6.1769	-6.0803	-5.9161	-6.1052	-6.0549	-6.0877	-	-6.1086

Table 7. Charge Imbalance

Project No. 210158, Port of Tacoma Parcel 15 (Portac), Cleanup Phase 1, Tacoma, WA

Sample	Charge imbalance (%)[a]
Influent Day 3	15
C10 Day 3 Effluent	17
C20 Day 3 Effluent	11
Influent Day 4	21
C10 Day 4 Effluent	17
C20 Day 4 Effluent	17
Influent Day 8	14
C10 Day 8 Effluent	22
C20 Day 8 Effluent	15

Note:

a. Charge imbalance is calculated relative to the sum of anionic and cationic charge.

Table 8. 1D Transport Modeling Input Parameters

Project No. 210158, Port of Tacoma Parcel 15 (Portac), Cleanup Phase 1, Tacoma, WA

Input Variable	Units	Model 1	Model 2	Model 3
Initial Background Groundwater				
Fe^{3+} as Ferrihydrite	free volume %	0.0002		
AsO_4^{3-}	µg/L	2		
pH	pH unit	6		
dissolved oxygen	µg/L	7		
Ca^{2+}	mg/L	150		
Temperature	°C	25		
Groundwater During Loading Period (0 to 50 Years)				
Fe^{3+} as Ferrihydrite	free volume %	0.01		
AsO_4^{3-}	µg/L	15,000		
pH	pH unit	7.8		
dissolved oxygen	µg/L	10.2		
Ca^{2+}	mg/L	150		
Temperature	°C	13.4		
Groundwater During Flushing Period (51 to 100 Years)				
Fe^{3+} as Ferrihydrite	free volume %	0.01		
AsO_4^{3-}	µg/L	5		
pH	pH unit	8.18		
dissolved oxygen	µg/L	2.7		
Ca^{2+}	mg/L	150		
Temperature	°C	14.9		
Aquifer Characteristics and Properties				
Discharge	ft/day	0.047	0.011	0.047
Porosity	%	10		
Longitudinal dispersivity	ft	2.5		
Reactant Concentration				
Ferrihydrite	mg/kg	11,000	11,000	1,100

FIGURES

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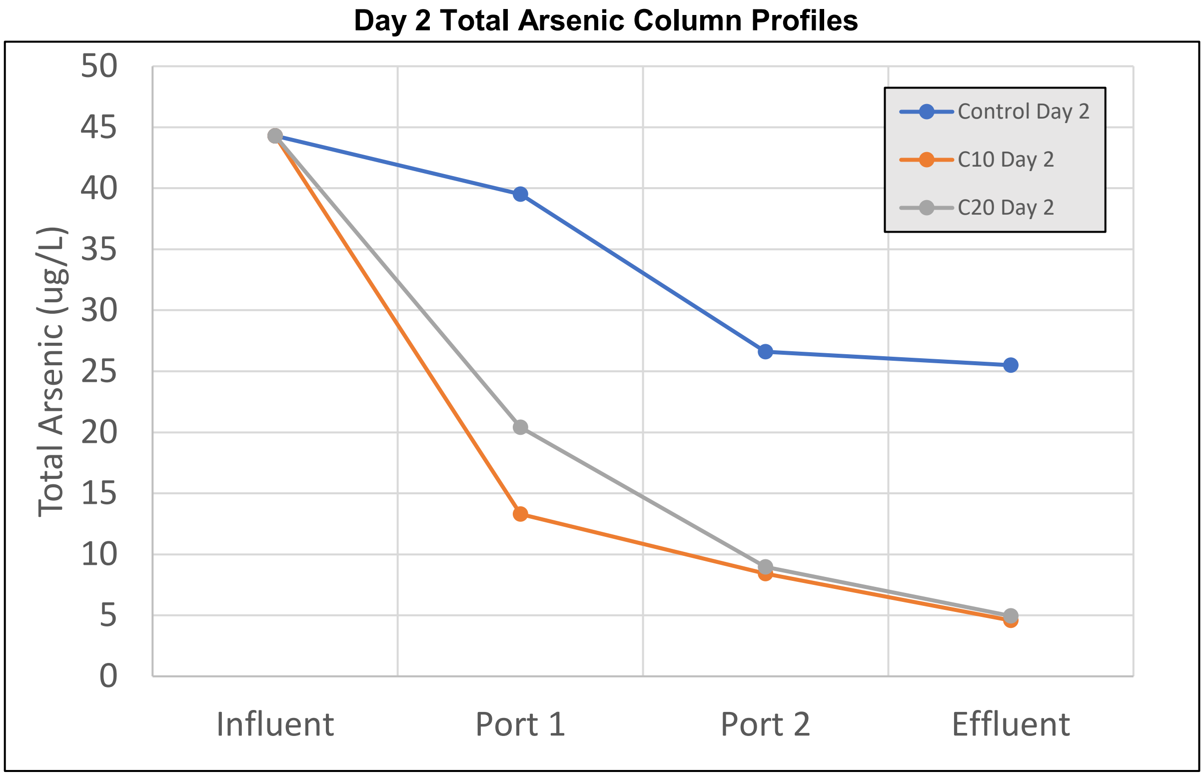

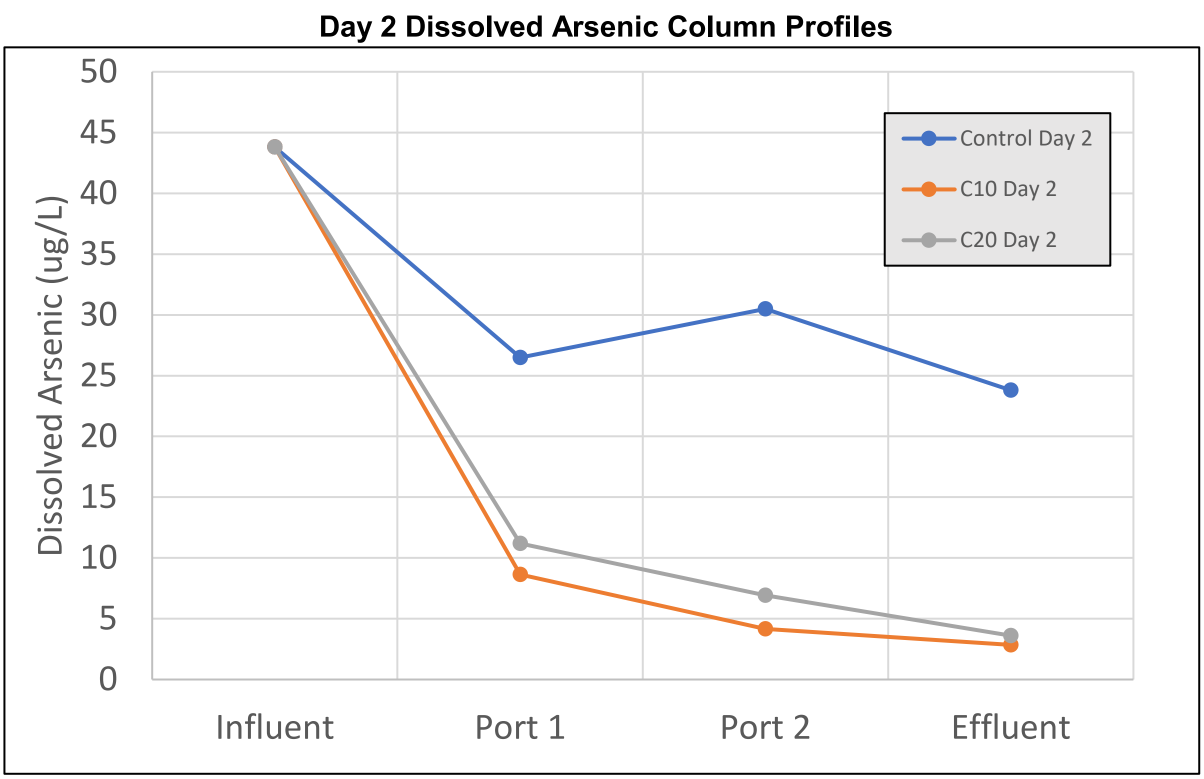

Figure 1a

Column Profiles - Total and Dissolved Arsenic (Day 2)

Treatability Testing Report
Parcel 15 Cleanup Phase 1, Tacoma, WA

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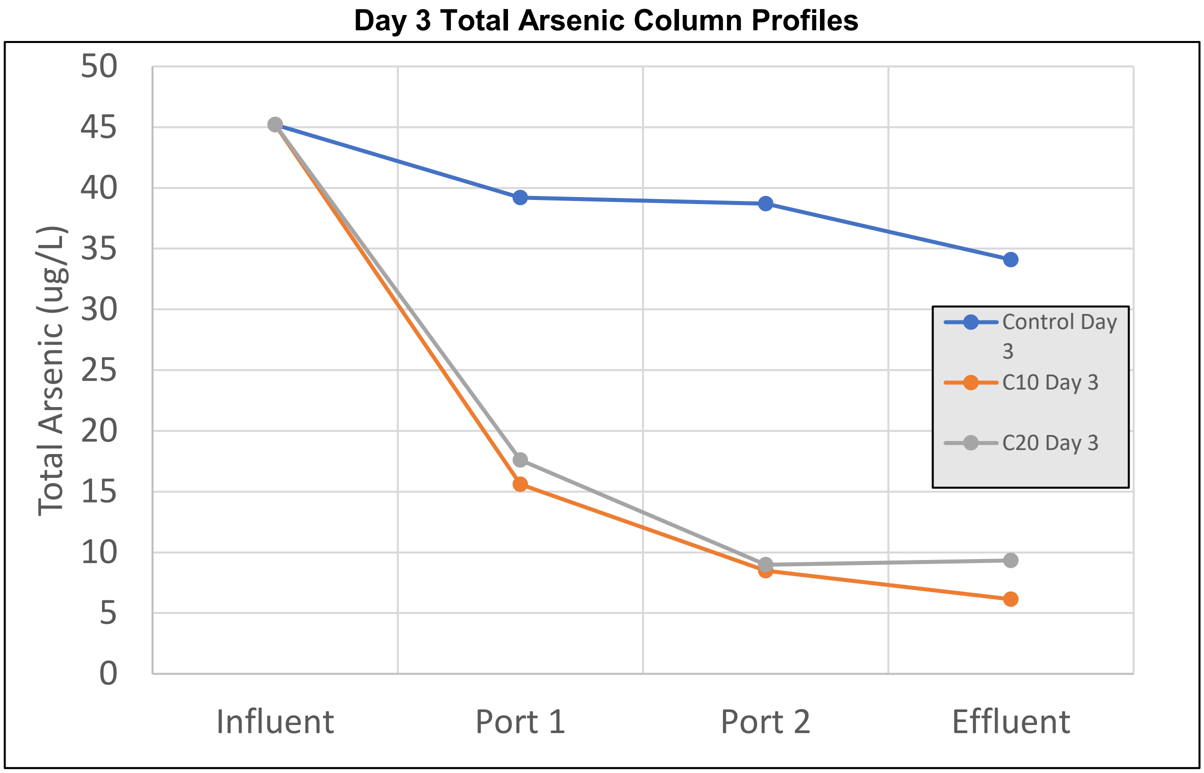


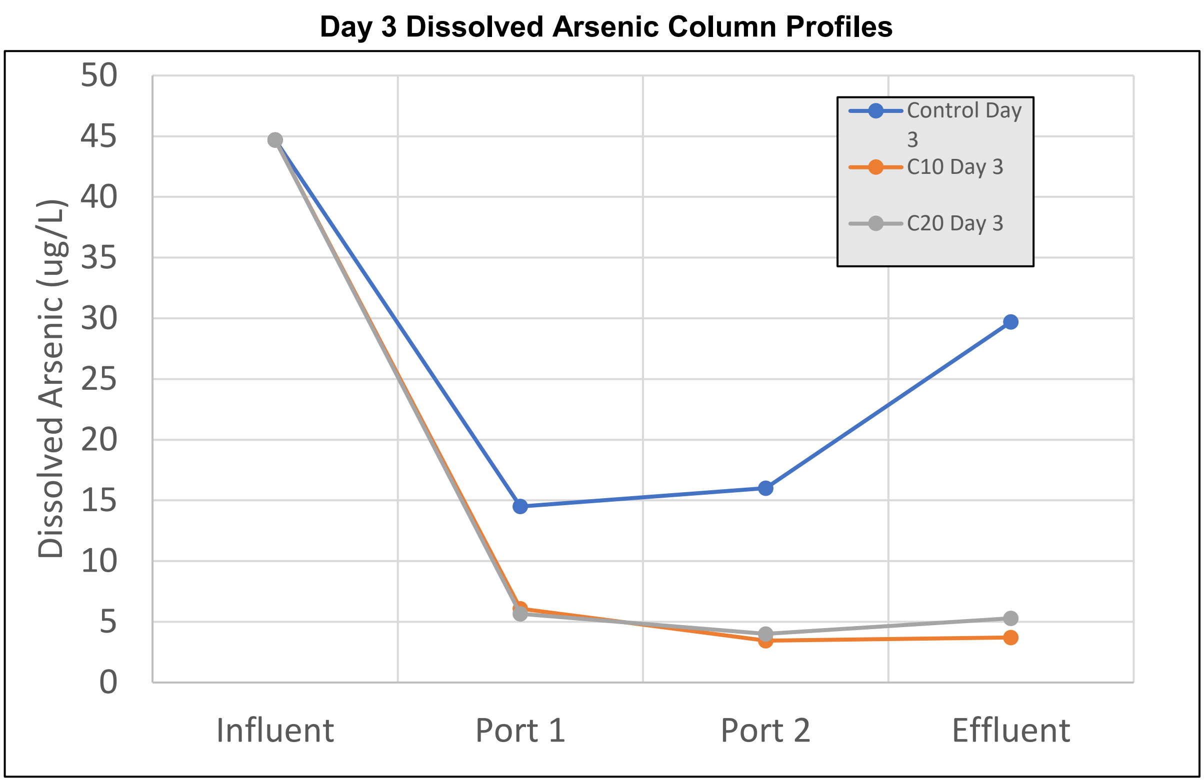
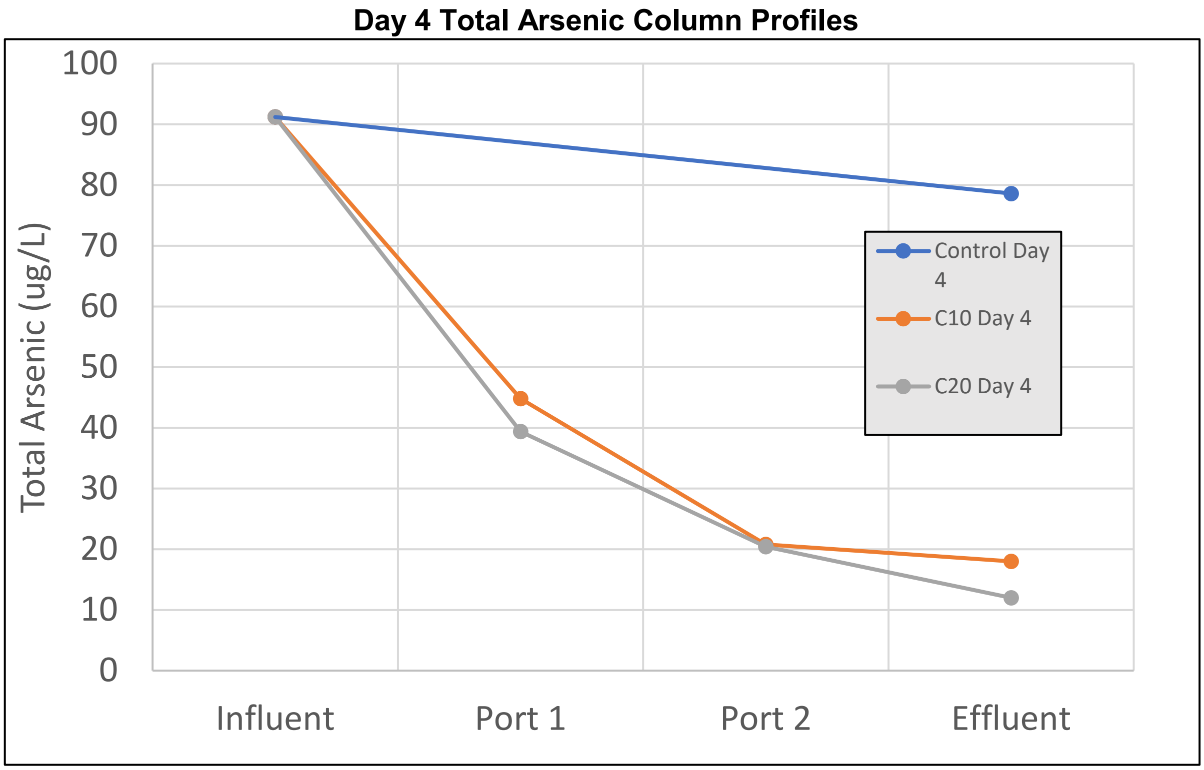


Figure 1b
Column Profiles - Total and Dissolved Arsenic (Day 3)
Treatability Testing Report
Parcel 15 Cleanup Phase 1, Tacoma, WA



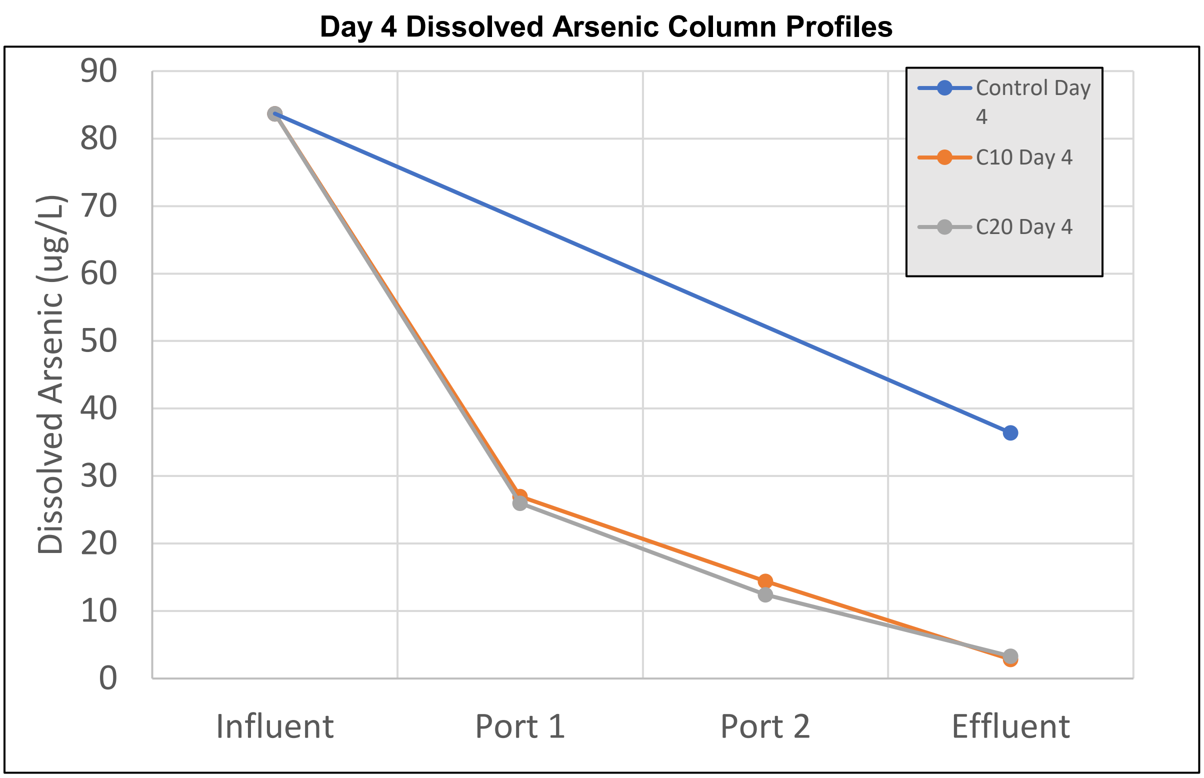
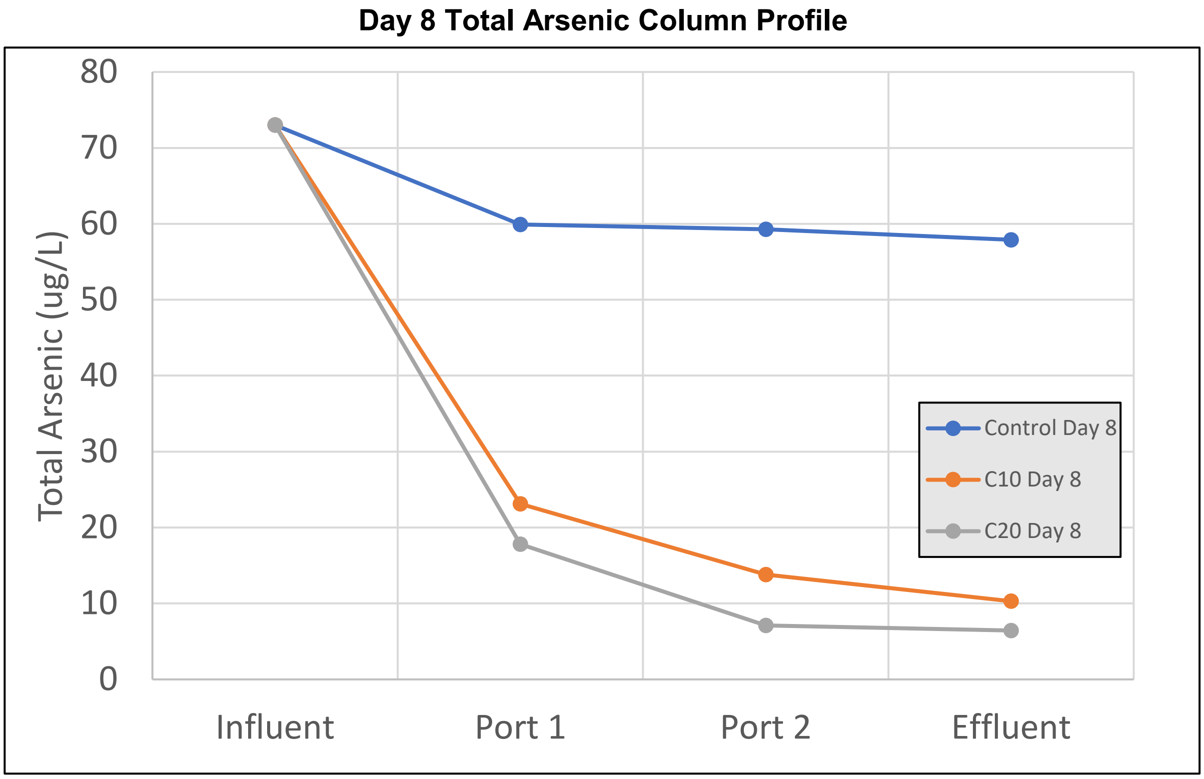


Figure 1c

Column Profiles - Total and Dissolved Arsenic (Day 4)

Treatability Testing Report
Parcel 15 Cleanup Phase 1, Tacoma, WA



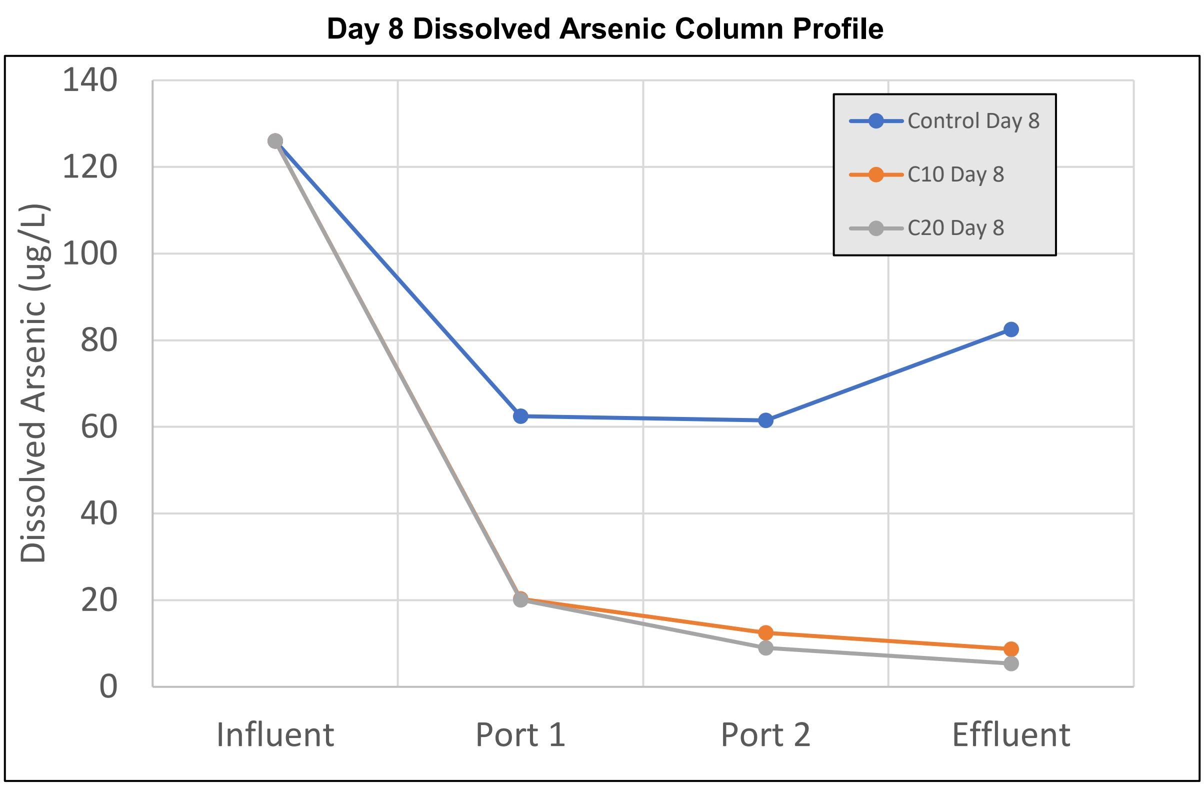


Figure 1d

Column Profiles - Total and Dissolved Arsenic (Day 8)

Treatability Testing Report

Parcel 15 Cleanup Phase 1, Tacoma, WA

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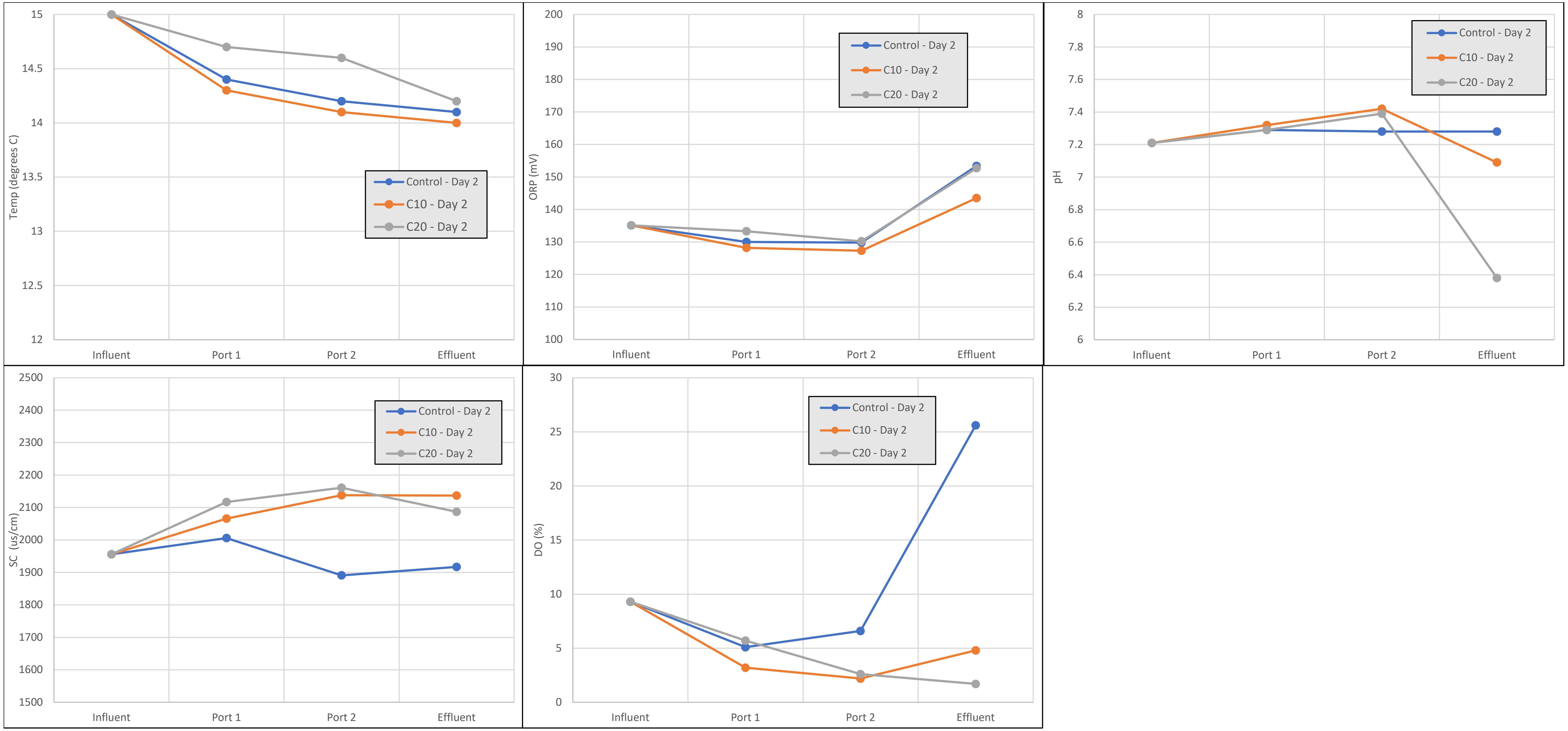

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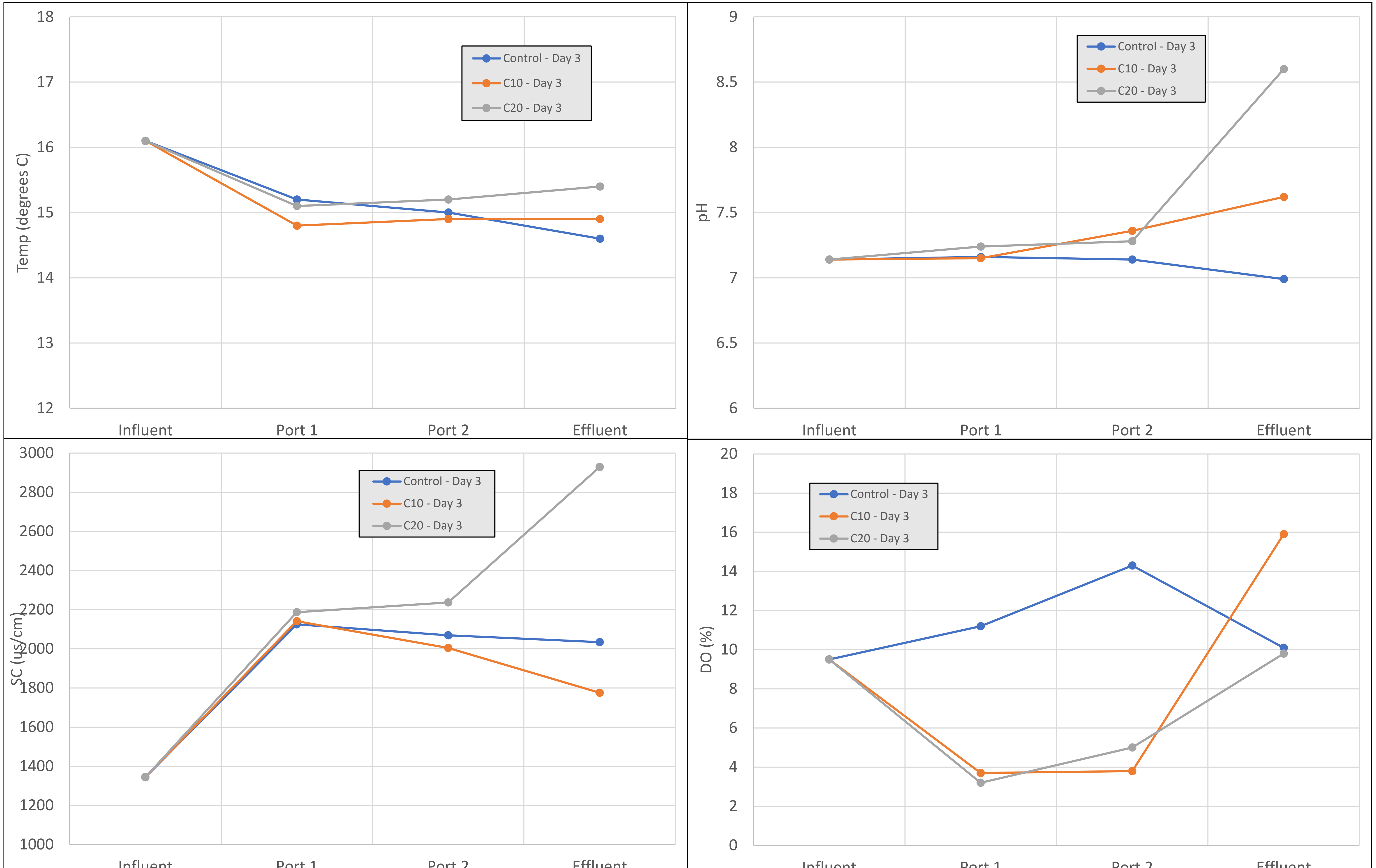
Figure 2a
Column Profiles - Water Quality Parameters (Day 2)
Treatability Testing Report
Parcel 15 Cleanup Phase 1, Tacoma, WA



Note: Water quality meter ORP sensor not working on day 3. No ORP measurements were collected

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Figure 2b
Column Profiles - Water Quality Parameters (Day 3)
Treatability Testing Report
Parcel 15 Cleanup Phase 1, Tacoma, WA

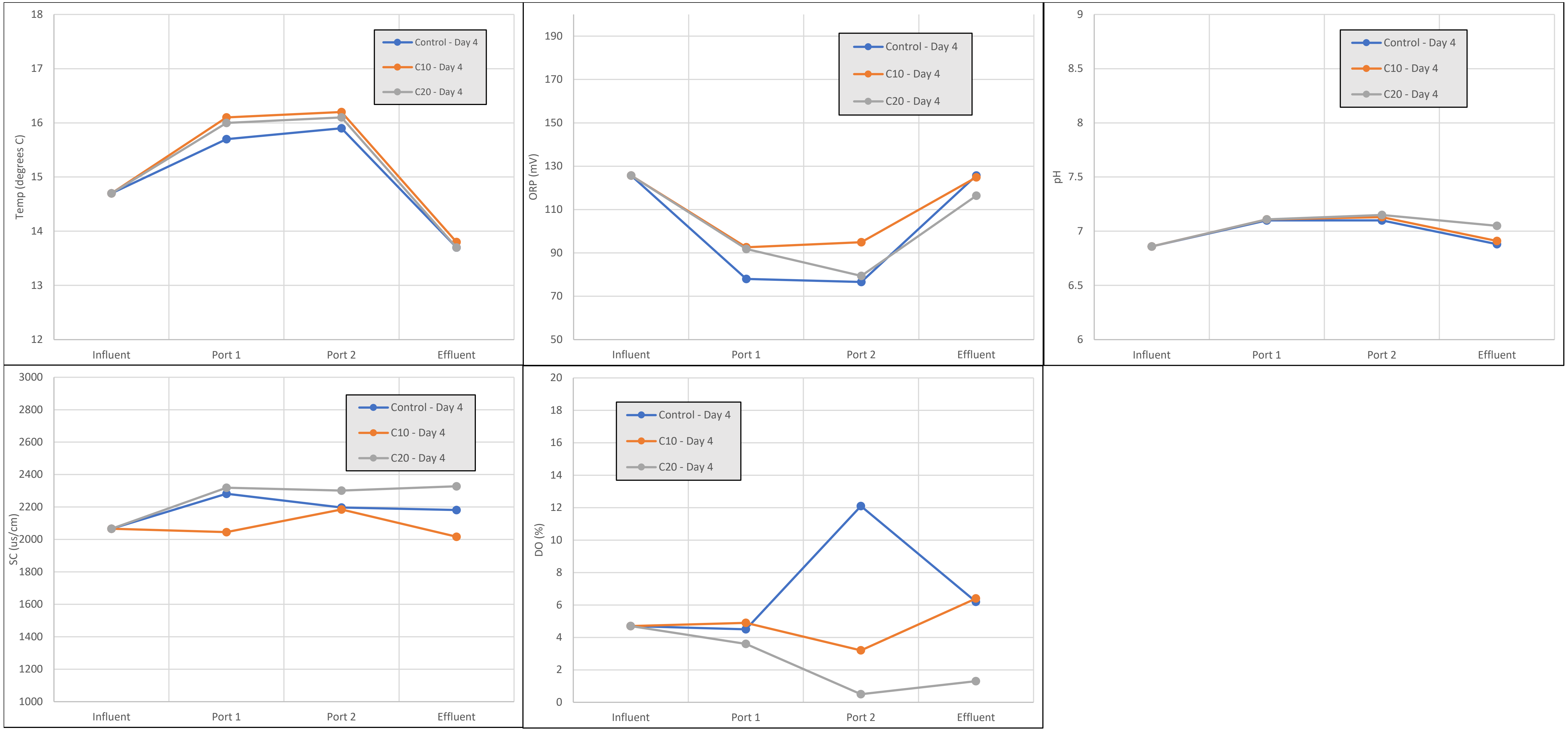

Figure 2c
Column Profiles - Water Quality Parameters (Day 4)
Treatability Testing Report
Parcel 15 Cleanup Phase 1, Tacoma, WA

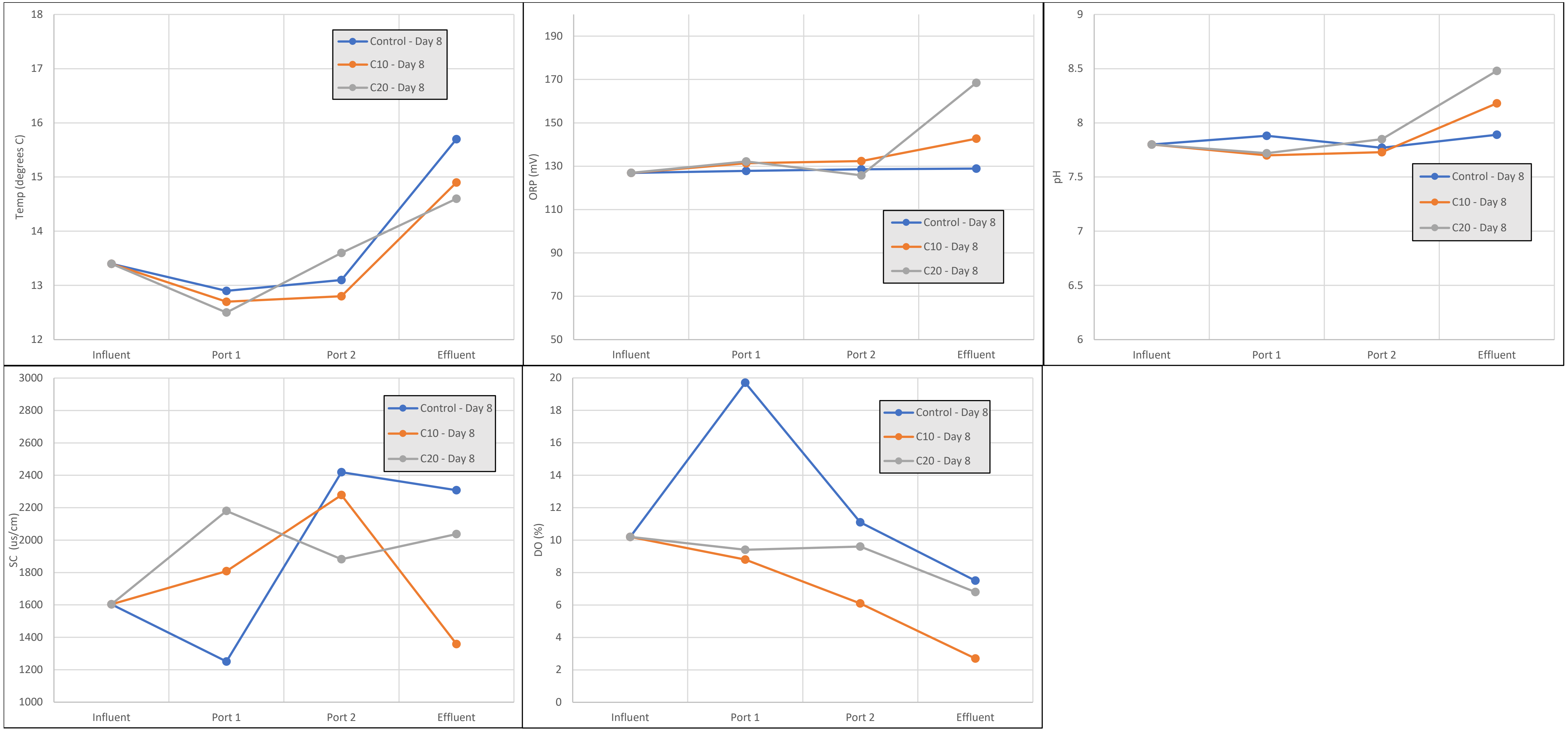

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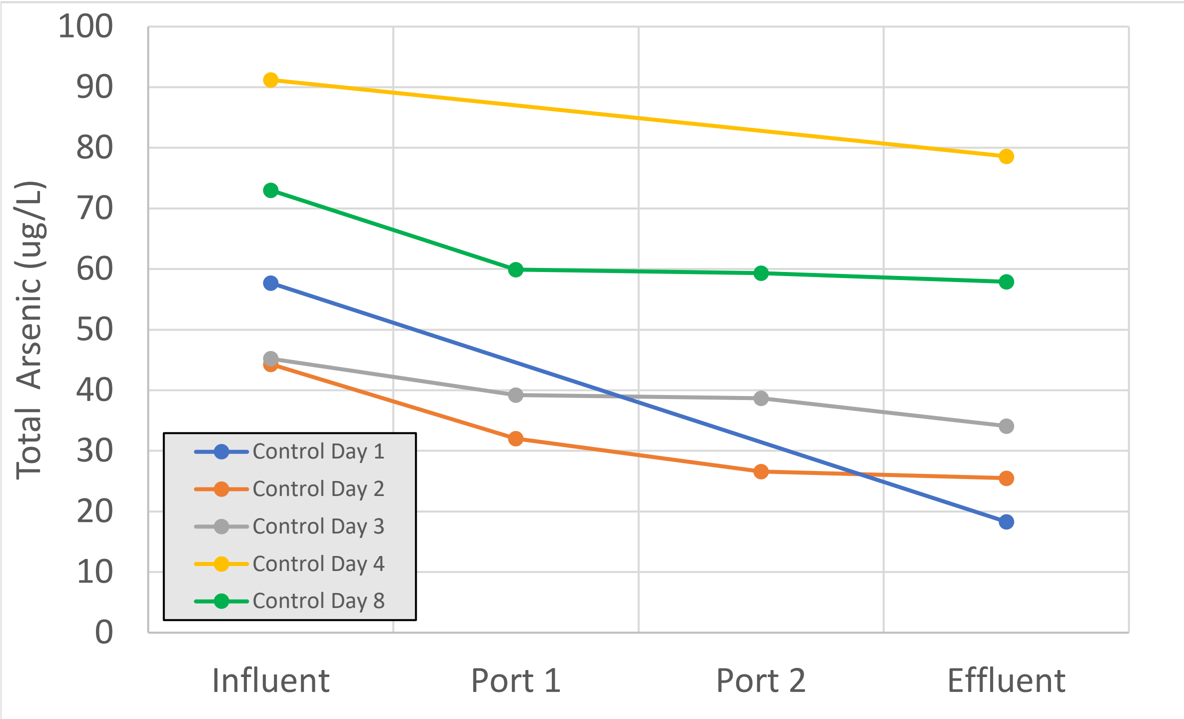
Figure 2d
Column Profiles - Water Quality Parameters (Day 8)
Treatability Testing Report
Parcel 15 Cleanup Phase 1, Tacoma, WA



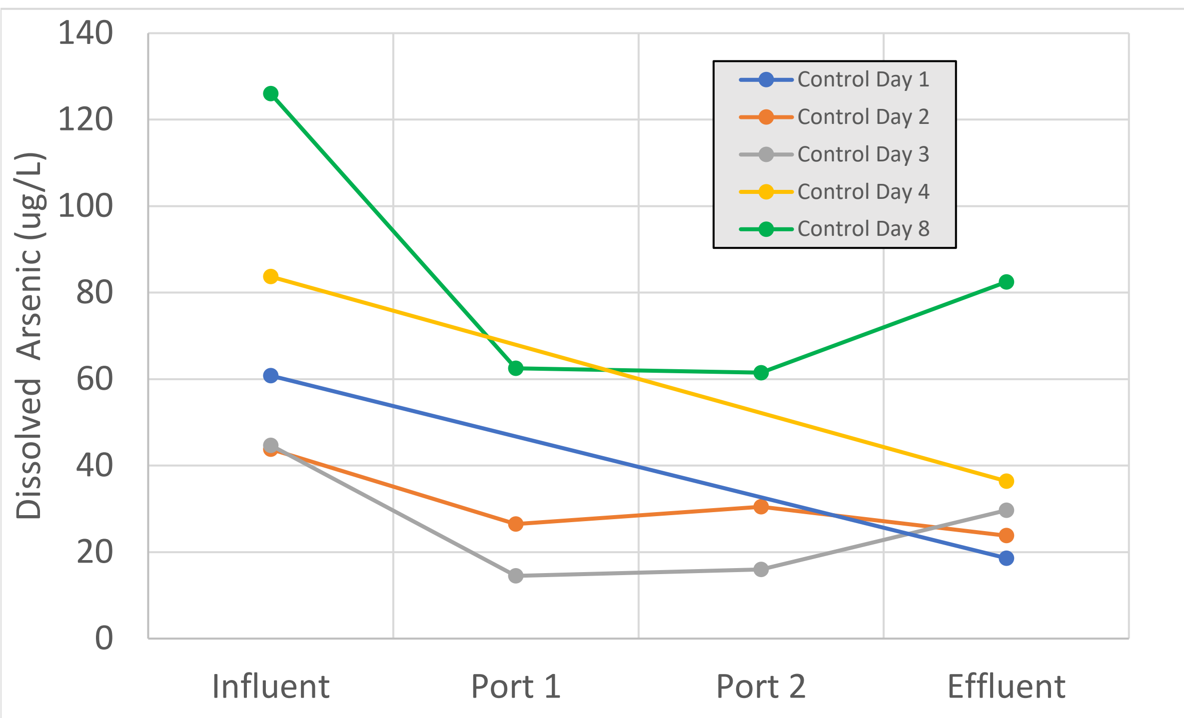
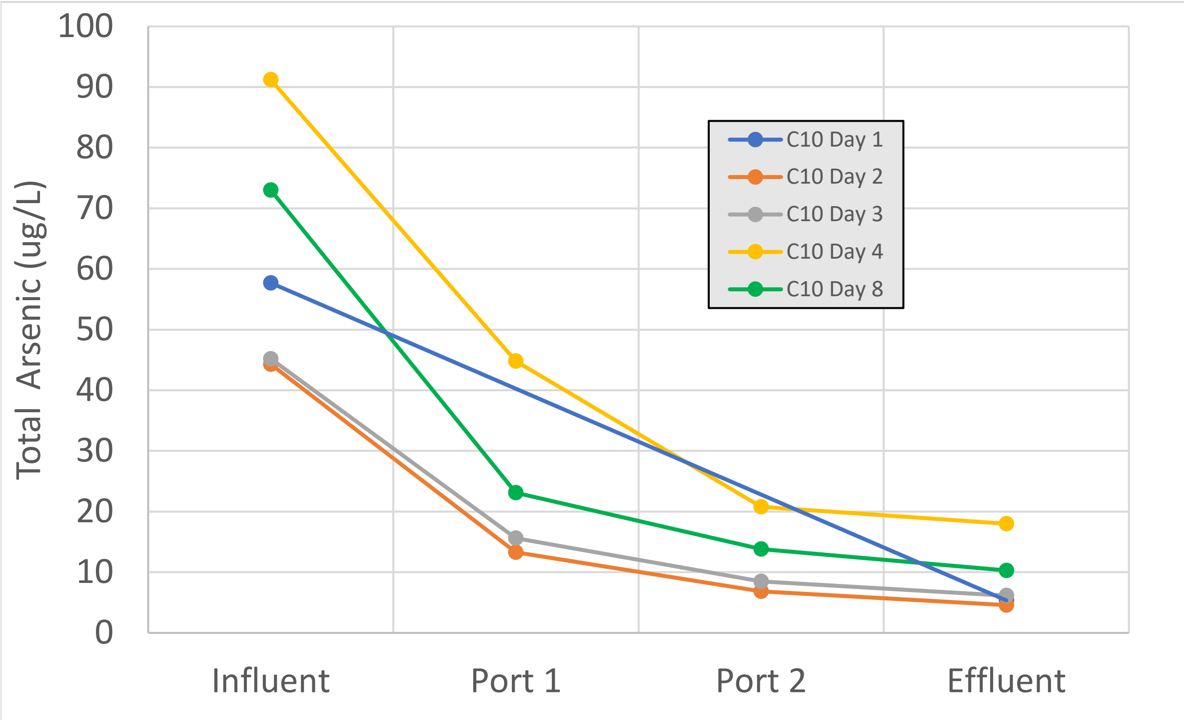


Figure 3a

Column Profiles - Total and Dissolved Arsenic (Control)



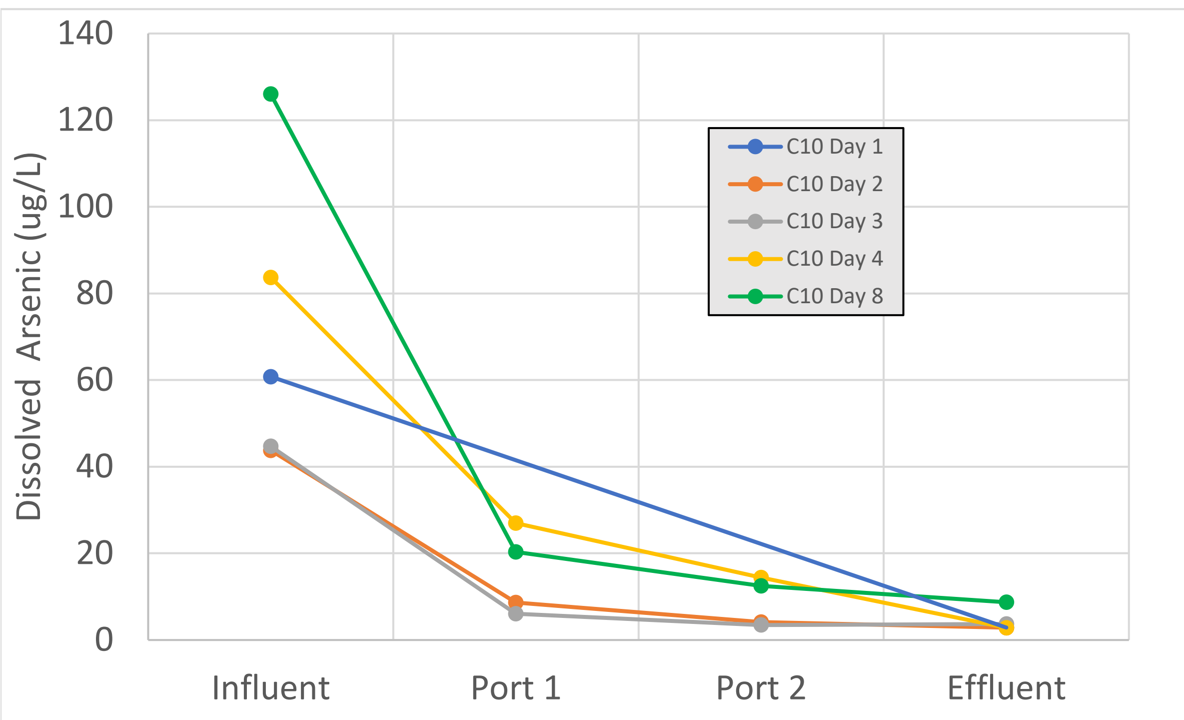
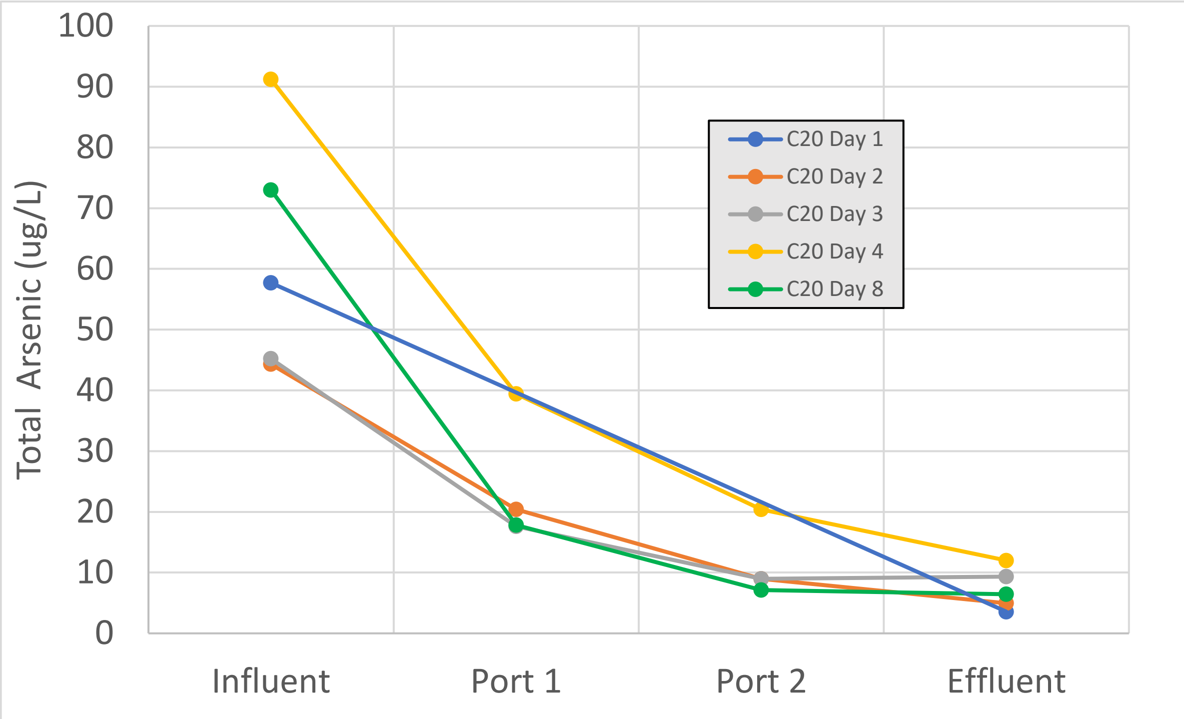


Figure 3b

Column Profiles - Total and Dissolved Arsenic (10% ZVI)



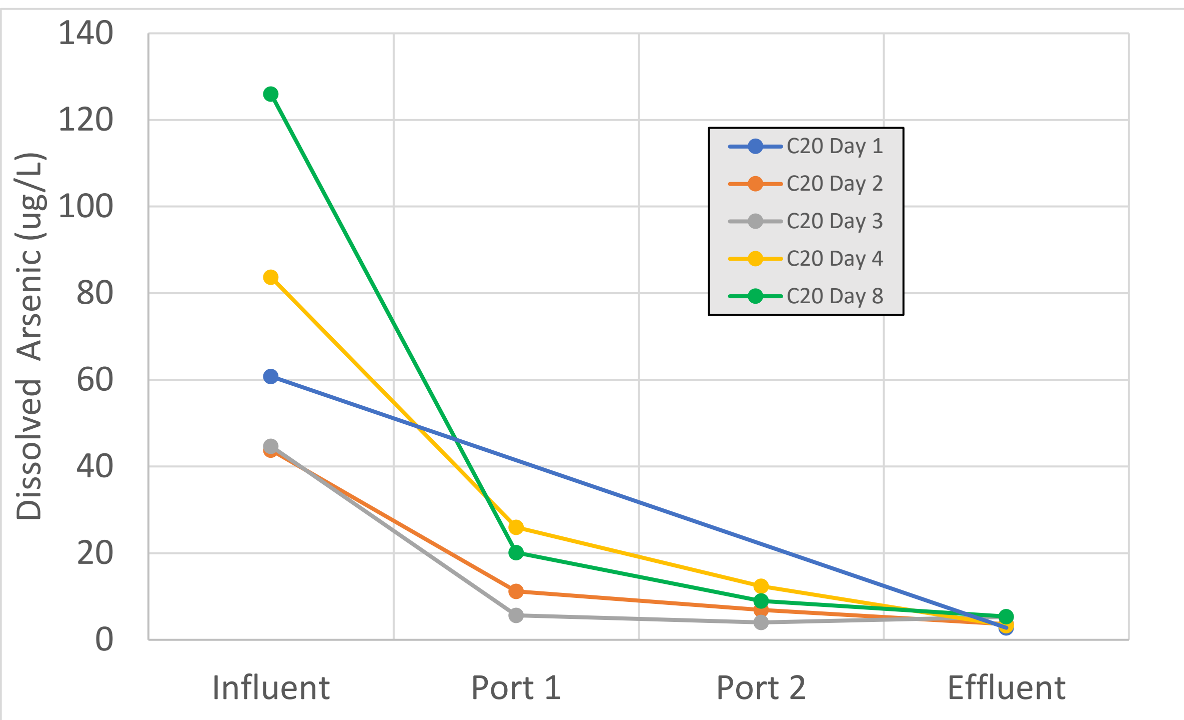
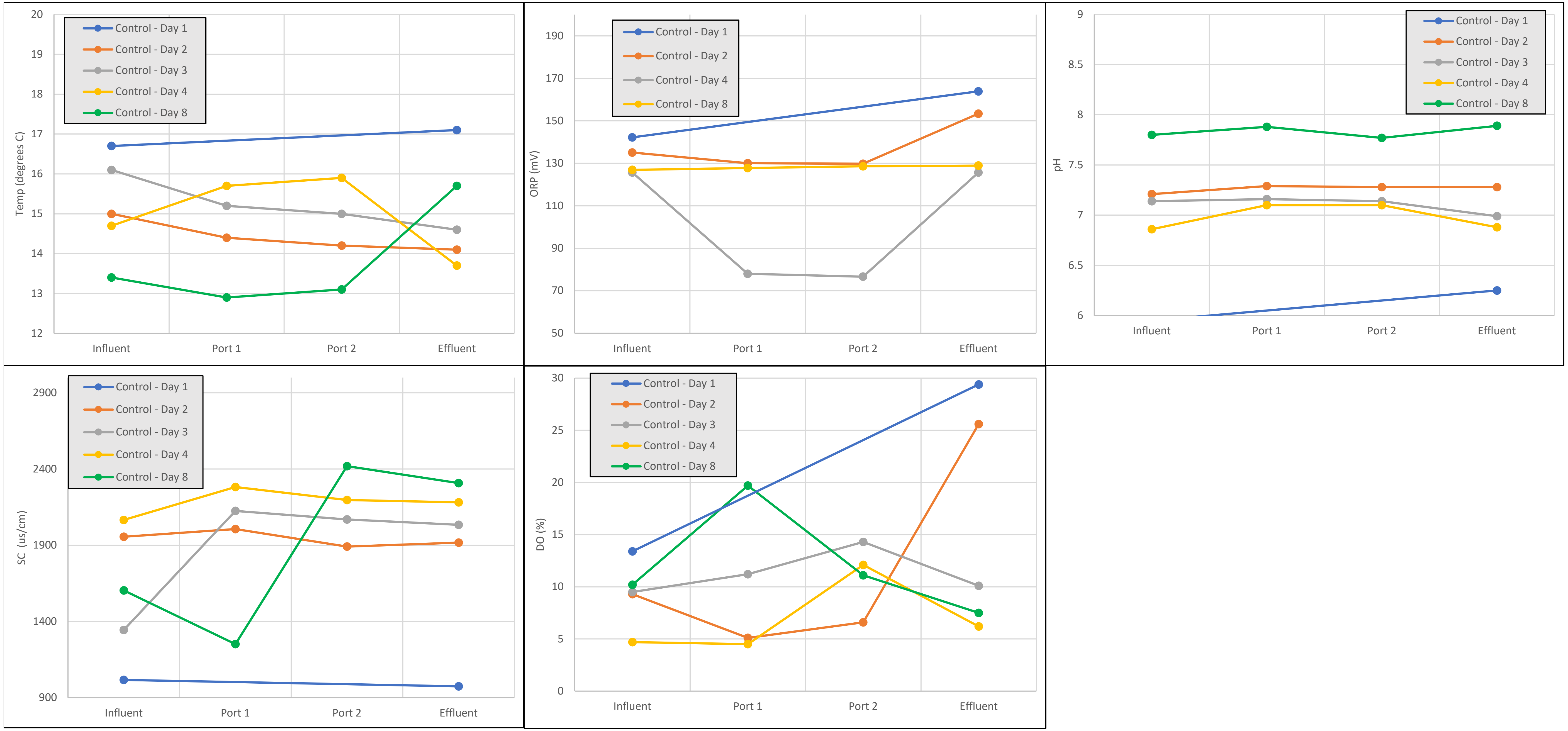


Figure 3c

Column Profiles - Total and Dissolved Arsenic (20% ZVI)

Treatability Testing Report

Parcel 15 Cleanup Phase 1, Tacoma, WA



Note: Water quality meter ORP sensor not working on day 3. No ORP measurements were collected

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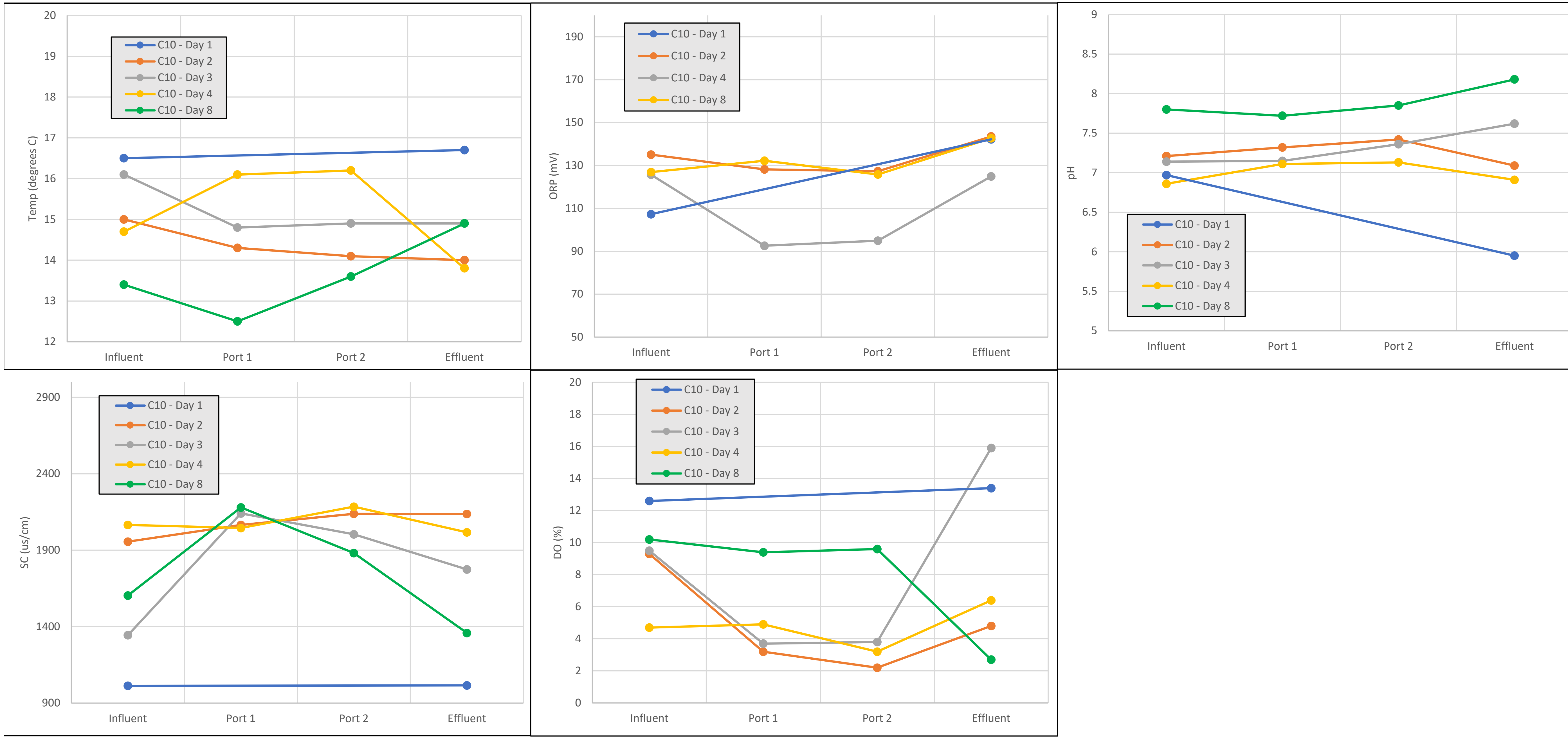
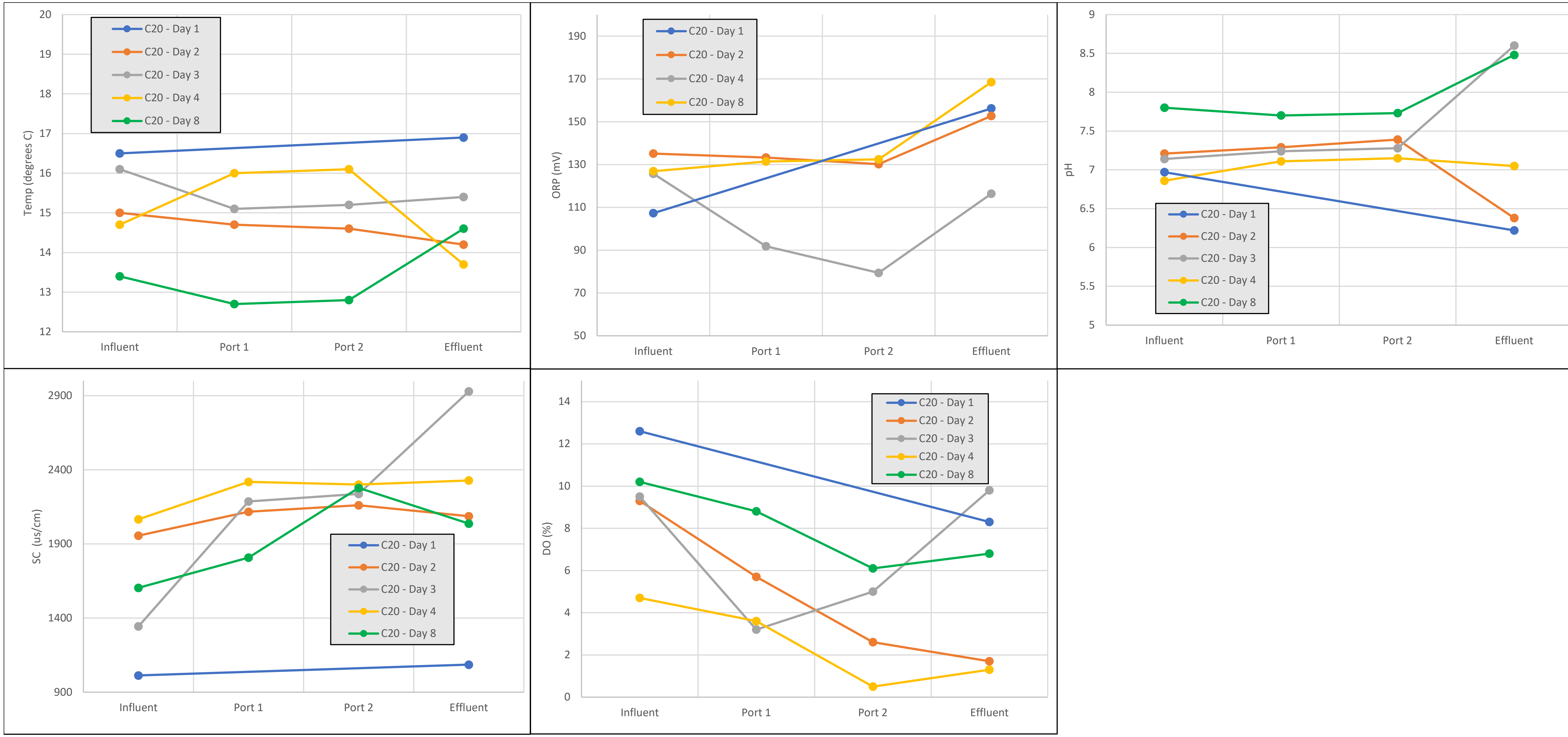
V:\210158 Port of Tacoma Parcel 15 Cleanup Phase 1\Deliverables\TTR\FINAL\Figures\Figures 1 2 3 4 Profiles

Figure 4a
Column Profiles - Water Quality Parameters (Control)
Treatability Testing Report
Parcel 15 Cleanup Phase 1, Tacoma, WA



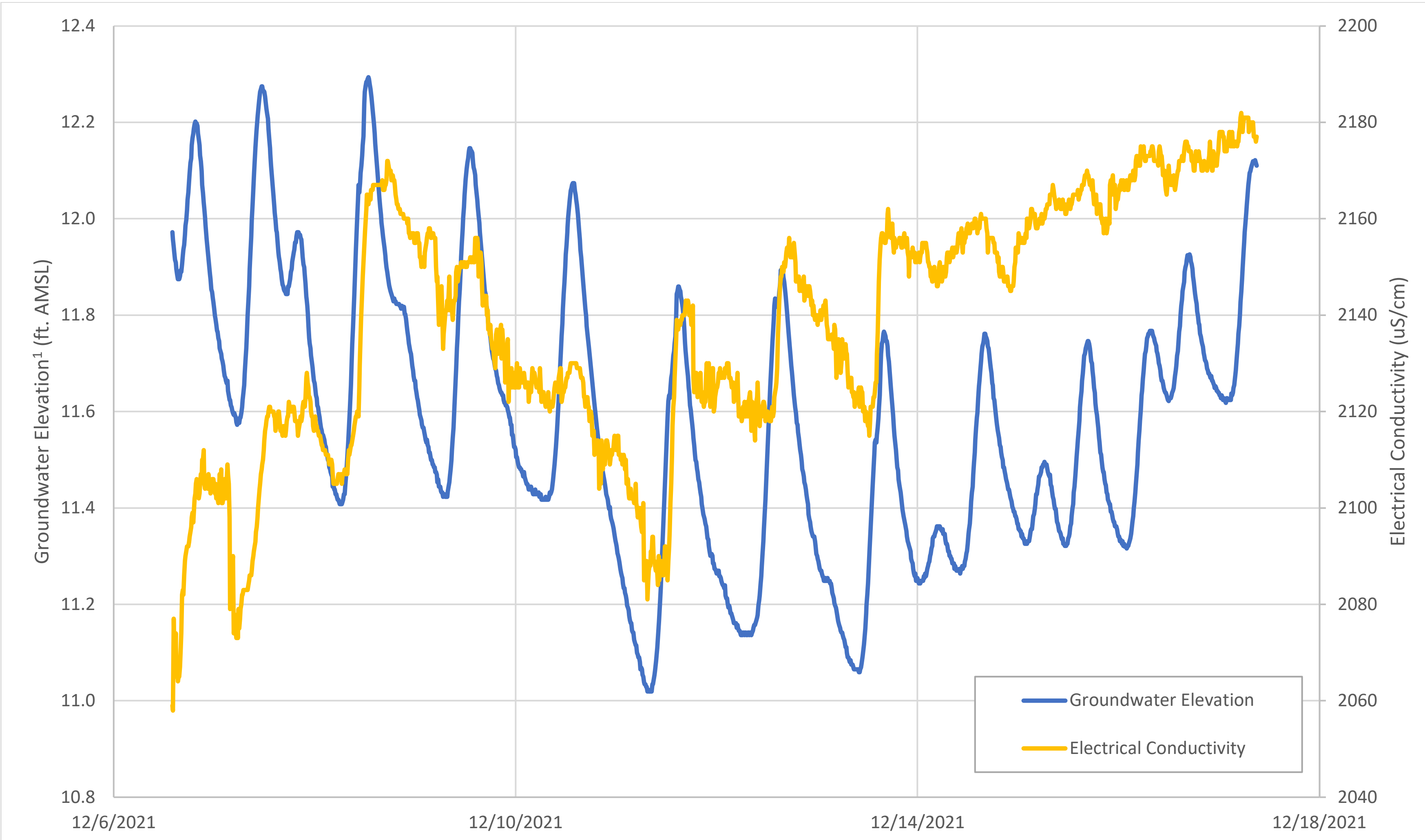
Note: Water quality meter ORP sensor not working on day 3. No ORP measurements were collected

Figure 4b
Column Profiles - Water Quality Parameters (10% ZVI)



Note: Water quality meter ORP sensor not working on day 3. No ORP measurements were collected

Figure 4c
Column Profiles - Water Quality Parameters (20% ZVI)



[1]Groundwater elevations are not corrected for changes in barometric pressure.

Figure 5
MW-14 Groundwater Elevation and Electrical Conductivity

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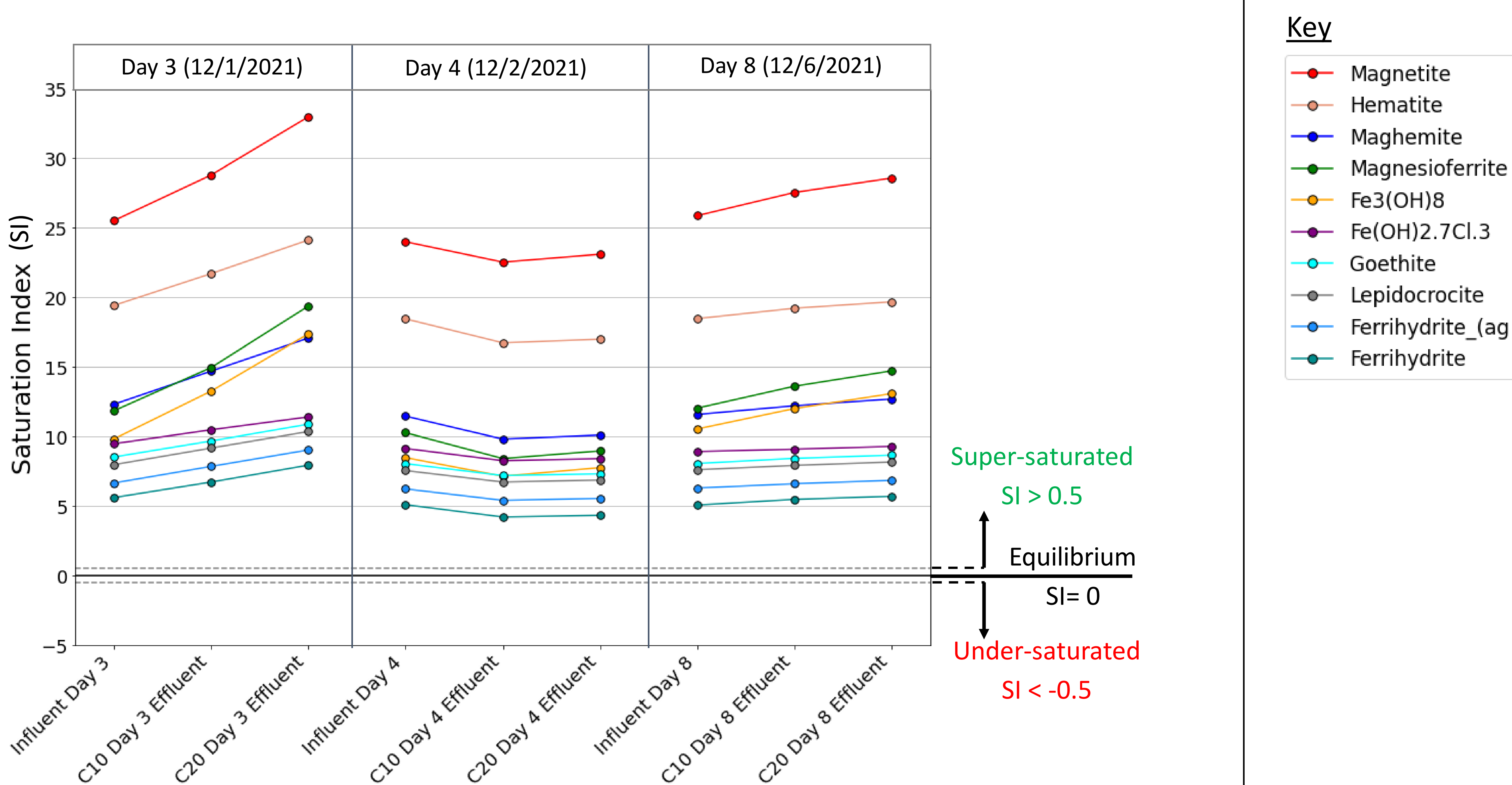
V:\210158 Port of Tacoma Parcel 15 Cleanup Phase 1\Deliverables\TTR\FINAL\Figures\Figure 5 transducer



Fe-oxide and oxyhydroxide saturation indices for days 3-8 column test samples. Vertical gray lines denote sampling days. Dashed horizontal lines denote a SI = 0.5 (super-saturation) and SI = -0.5 (under-saturation). The black solids horizontal line indicates SI = 0 (equilibrium).

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PORT OF TACOMA

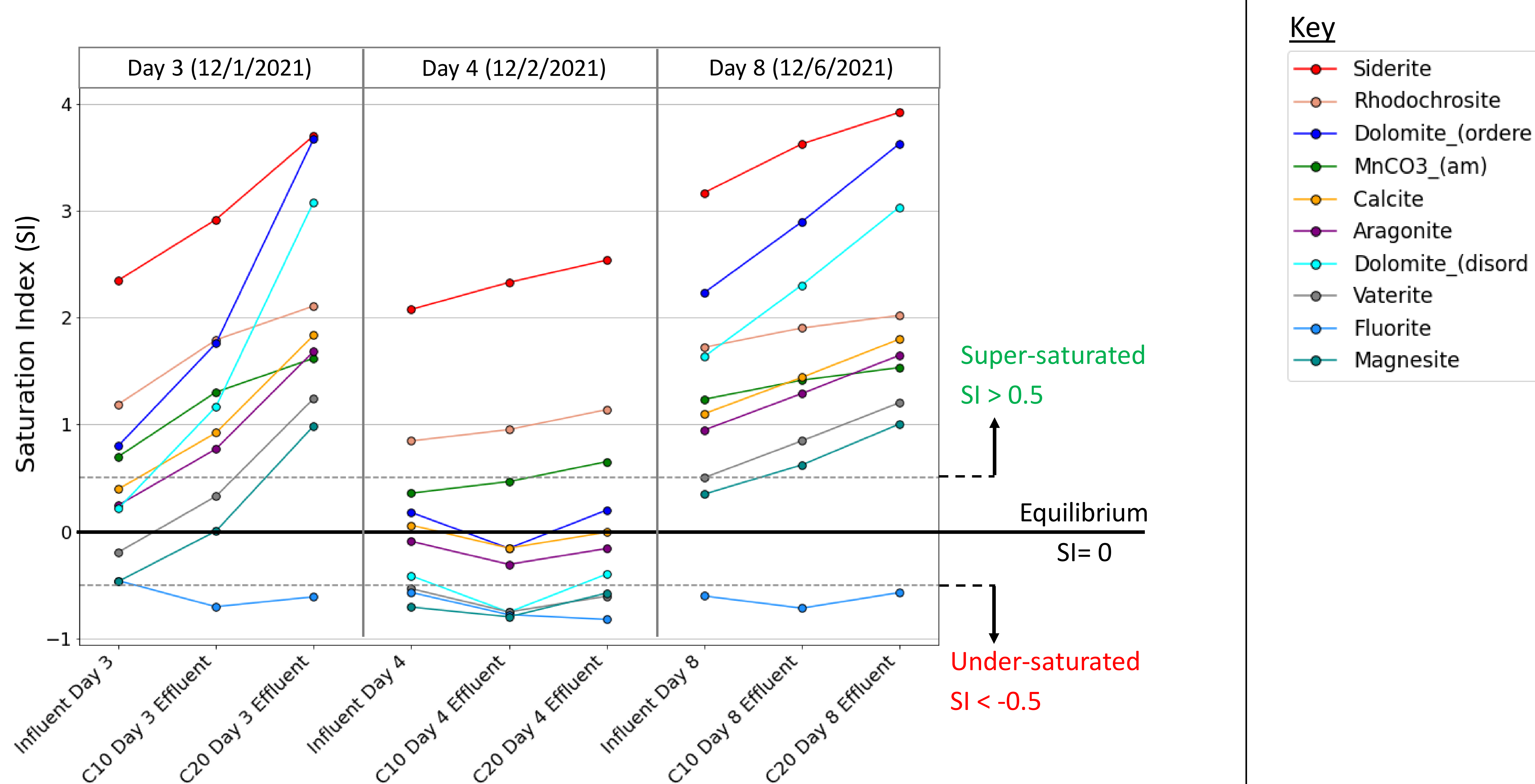
FE-OXIDE AND OXYHYDROXIDE MINERAL SATURATION INDICES

Treatability Testing Report

Parcel 15 Cleanup Phase 1, Tacoma, WA

MARCH 2022

FIGURE 6



Carbonate mineral indices for days 3-8 column test samples. Vertical gray lines denote sampling days. Dashed horizontal lines denote a SI = 0.5 (super-saturation) and SI = -0.5 (under-saturation). The black solids horizontal line indicates SI = 0 (equilibrium).

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CARBONATE MINERAL SATURATION INDICES

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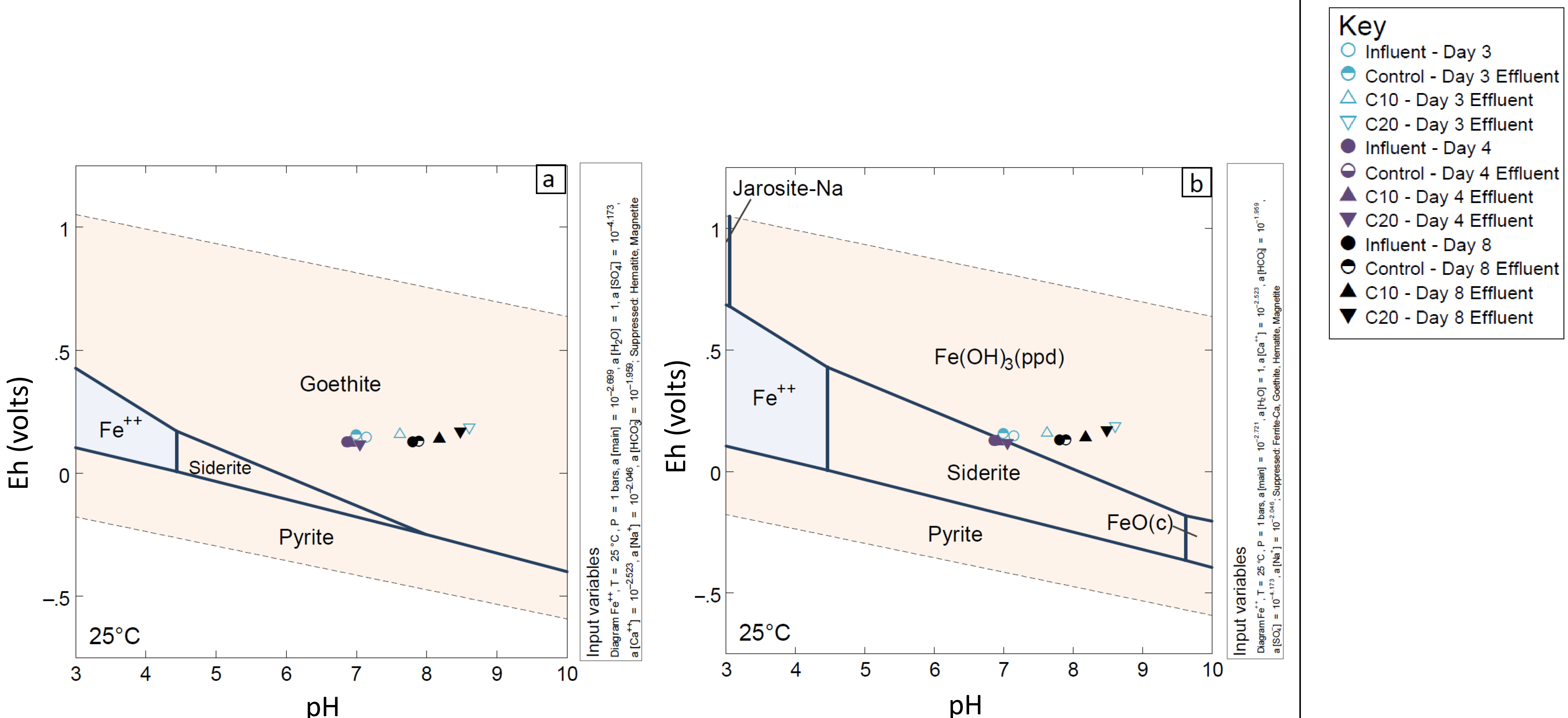
FIGURE 7



Eh-pH diagram, created using Geochemist's Workbench, showing the stability of days 3-8 influent, control, C10 effluent, and C20 effluent samples. (a) Eh-pH diagram with Fe oxides suppressed. (b) Eh-pH diagram with Fe- oxides and Goethite suppressed.

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FE-OXYHYDROXIDE EH-PH DIAGRAMS

Treatability Testing Report
Parcel 15 Cleanup Phase 1, Tacoma, WA

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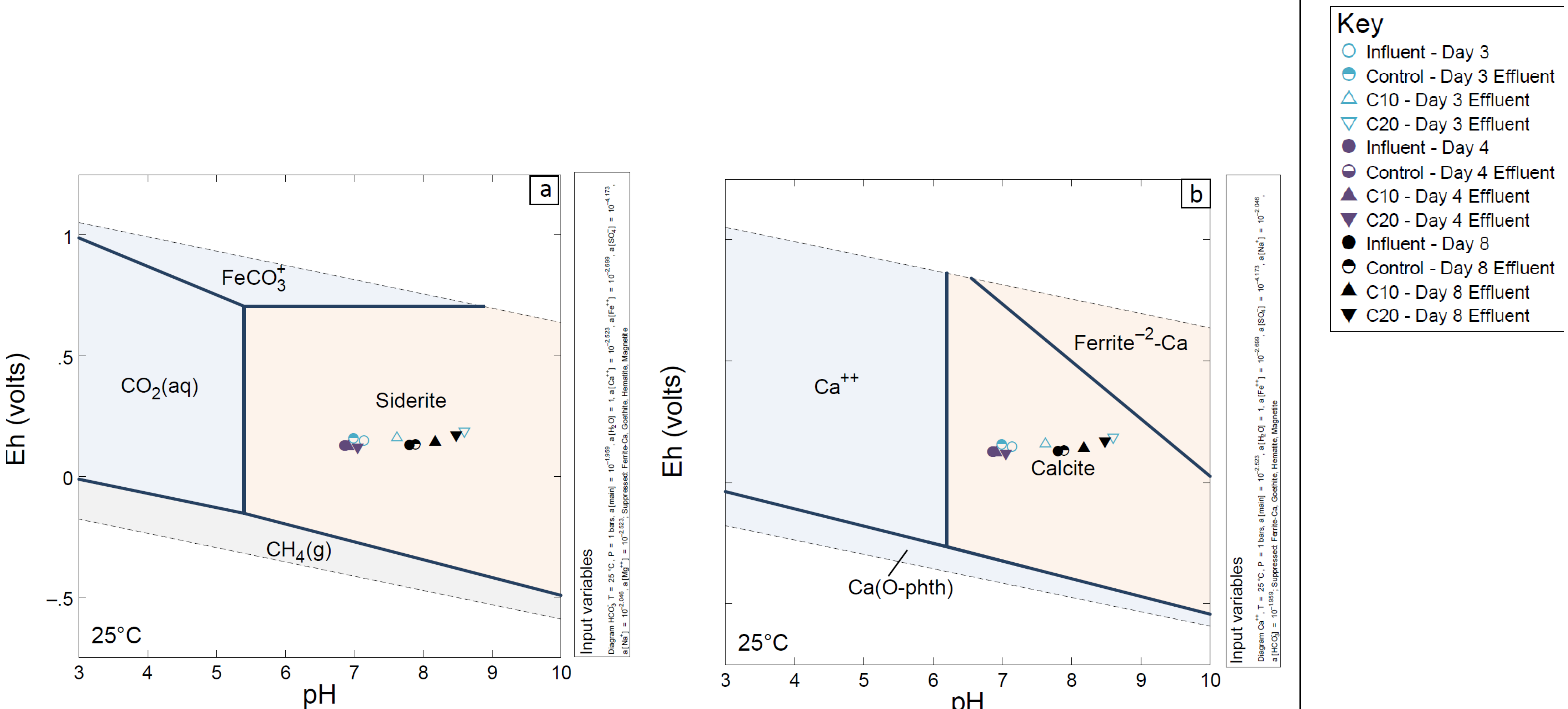
FIGURE 8



Eh-pH diagram, created using Geochemist's Workbench, showing the stability of days 3-8 influent, control, C10 effluent, and C20 effluent samples. (a) Eh-pH diagram with Fe oxides, Goethite, and ferrihydrite suppressed. (b) Eh-pH diagram with Fe-oxides, Goethite, ferrihydrite, and siderite suppressed.

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CARBONATE EH-PH DIAGRAMS
Treatability Testing Report
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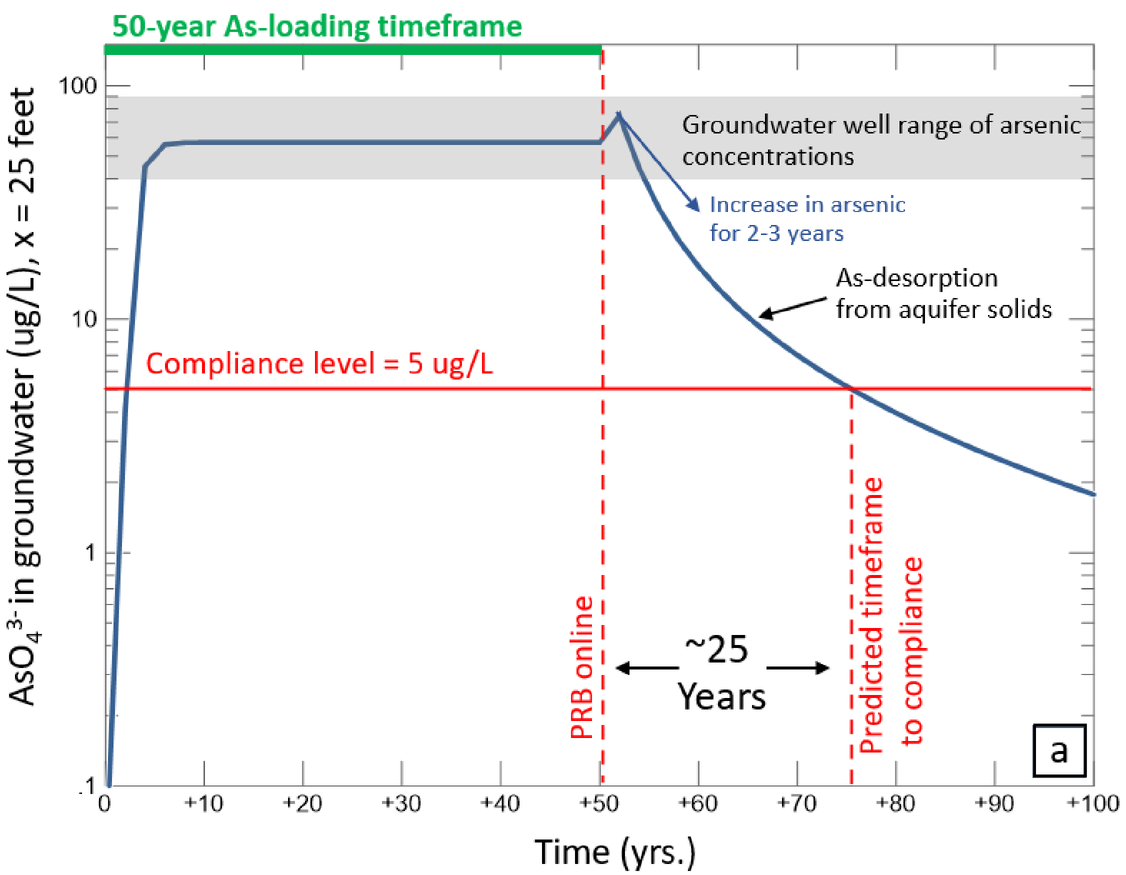
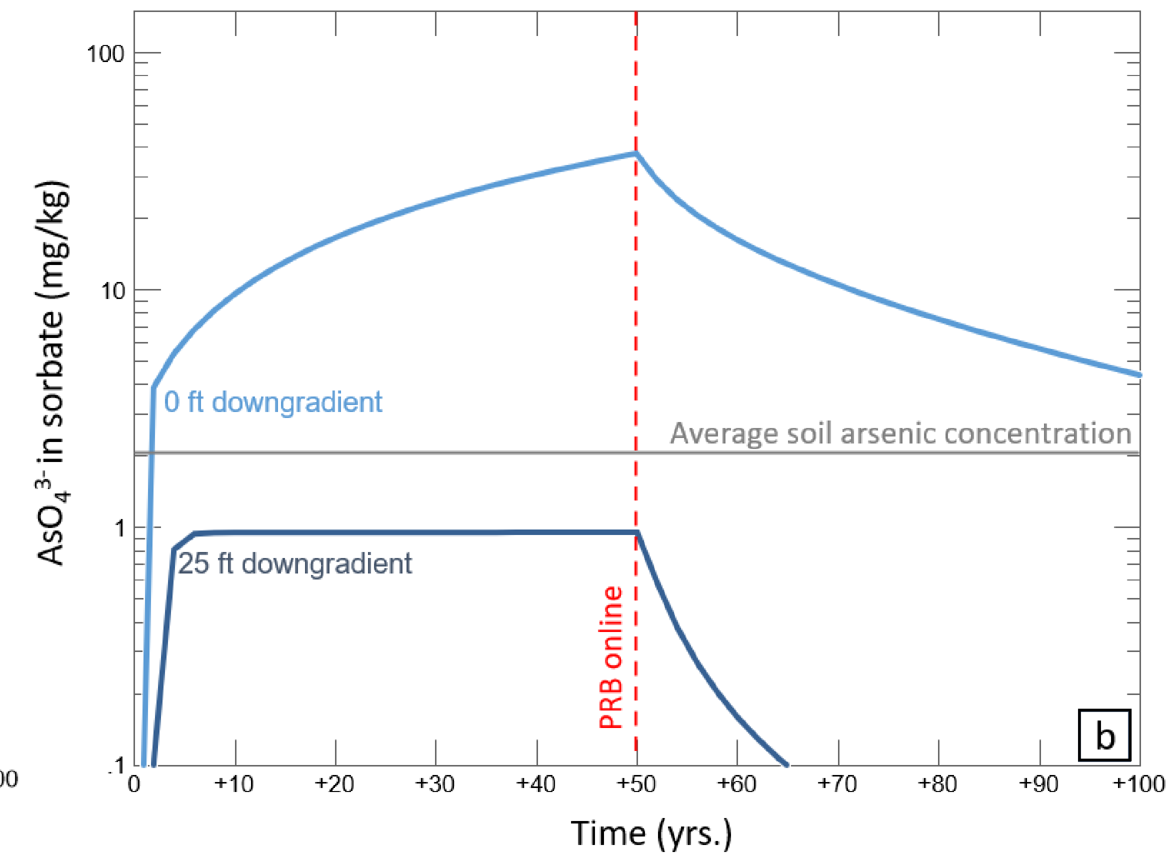
FIGURE 9

(a) Arsenic in Groundwater

(b) Arsenic in Soil





(a) 1D transport model showing arsenic concentration in groundwater versus time using a discharge of 0.047 ft/day (see Table 4, model 1 for all input parameters). Loading of the aquifer sediments with arsenic takes place from 0 to 50 years (as denoted by the green solid line) prior to the PRB implementation at year 50 (denoted by leftmost red dashed line). The predicted amount of time after PRB implementation for arsenic concentrations to reach compliance (5 ug/L, as denoted by red horizontal line) is denoted by the rightmost red dashed line and is approximately 25 years. The range of observed groundwater well arsenic concentrations at the Site is denoted by the gray shaded region. (b) Arsenic concentrations in the sediment sorbate (ferrihydrite in this model) versus time. The average Site soil arsenic concentration (2.1 mg/kg) is denoted by the horizontal gray line. The PRB implementation timing is denoted by the vertical dashed, red line. The light blue line denotes the arsenic concentrations over time at the PRB (or 0 feet downgradient) and the dark blue line represents the arsenic concentrations in the sorbate 25 feet from the PRB (location of compliance well).

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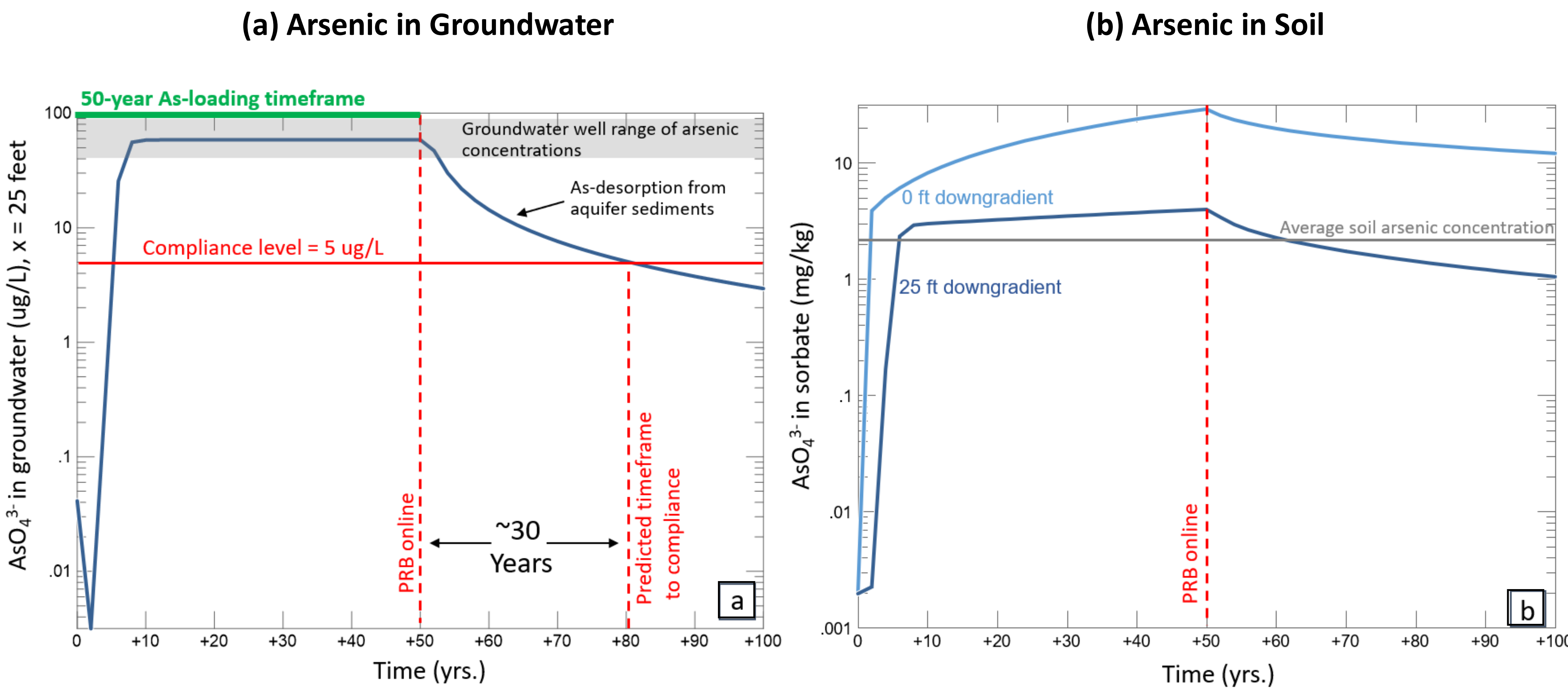
MODEL 1: 1D TRANSPORT MODEL (AVERAGE DARCY'S FLUX)
Treatability Testing Report
Parcel 15 Cleanup Phase 1, Tacoma, WA

MARCH 2022

FIGURE 10



(a) 1D transport model showing arsenic concentration in groundwater versus time using a discharge of 0.047 ft/day and sediment ferrihydrite concentration of 1,100 mg/kg (see Table 4, model 3 for all input parameters). Loading of the aquifer sediments with arsenic takes place from 0 to 50 years (as denoted by the green solid line) prior to the PRB implementation at year 50 (denoted by leftmost red dashed line). The predicted amount of time after PRB implementation for arsenic concentrations to reach compliance (5 ug/L, as denoted by red horizontal line) is denoted by the rightmost red dashed line and is approximately 30 years. The range of observed groundwater well arsenic concentrations at the Site is denoted by the gray shaded region. (b) Arsenic concentrations in the sediment sorbate (ferrihydrite in this model) versus time. The average Site soil arsenic concentration (2.1 mg/kg) is denoted by the horizontal gray line. The PRB implementation timing is denoted by the vertical dashed, red line. The light blue line denotes the arsenic concentrations over time at the PRB (or 0 feet downgradient) and the dark blue line represents the arsenic concentrations in the sorbate 25 feet from the PRB (location of compliance well).

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MODEL 2: 1D TRANSPORT MODEL RESULTS USING AN AVERAGE DARCY'S FLUX AND DECREASED SORBATE CONCENTRATION

Treatability Testing Report
Parcel 15 Cleanup Phase 1, Tacoma, WA

MARCH 2022

FIGURE 11

APPENDIX A

Field Forms

 11/24

Portar

BBC

0820 Aspect on site. Pac Van delivers job trailer. Unload and prep column test materials.

1020 Install packer in MW-14 at 20' bTOC. Calibrate YSI (red)

	soln	pre	post
pH4	4.00	4.12	4.00
pH7	7.01	6.87	7.00
COND	1413	1433	1413
ORP	232	235	232
DO	100	102	100

1040 Begin purging MW-14. Intake at 16' bTOC, purging at 200 mL/min

1140 Collect sample MW14-112421

1240 Sample picked up by courier. Begin assembling columns.

1730 Aspect off site.

10% ZVI Column	20% ZVI Column	Control Column
Total DW = 6.46 kg	Total DW = 6.5 kg	Total (Sand) DW = 5.5 kg
Iron DW = 0.85 kg	Iron DW = 1.68 kg	
Sand DW = 5.61 kg	Sand DW = 4.82 kg	

0745 Aspect on site. Begin purging columns w/ BBC
N_2 gas. Each column purged for 45 minutes.
0800 Install packer in MW-14 at 20 ft bgs. Install
pump intake tubing at 16 ft. bgs.
0940 Intake tubing installed. Tested flow rate.
1000 Begin purging through columns.
* Control column settled by 3 in. once wet.
1315 Aspect off site to pick up bottleware.
1730 Aspect on site. Collect WQ parameters.

	C10 Eff	C20 Eff	Cc Eff	In
Temp	16.5	16.9	17.1	16.7
Cond	1013	1086	974	1016
pH	6.97	6.22	6.25	5.95
DO	12.6	8.3	29.4	13.4
ORP	107.3	156.2	163.9	142.2

C10 Flow = 10 mL/min C20 flow = 18 mL/min
Cc Flow = 14 mL/min
1810 Collect sample In-112921
1825 Collect sample C20-Eff-112921
1840 Collect sample Cc-Eff-112921
1850 Collect sample C10-Eff-112921
1945 Aspect off site.

11/30 Portage BBC

0830 Airport on site. Calibrate YSI (red)
Begin collecting WQ parameters.

	Temp °C	Cond µS/cm	pH	DO %	ORP mV
In	15.0	1956	7.21	9.3	135.1
C20Eff	14.2	2037	6.38	1.7	152.7
C10Eff	14.0	2137	7.09	4.8	143.5
CcEff	14.1	1917	7.28	25.6	153.4
C20P1	14.7	2117	7.29	5.7	133.3
C20P2	14.6	2161	7.39	2.6	130.2
C10P1	14.3	2066	7.32	3.2	128.2
C10P2	14.1	2138	7.42	2.2	127.3
CcP1	14.4	2006	7.29	5.1	130.0
CcP2	14.2	1891	7.28	6.6	129.8

* P_1 = lower, P_2 = Upper

YSI Calibration

	Soln	Pre	Post
pH 7	7.00	6.90	7.00
pH 10	10.00	9.61	10.01
Cond	1413	1380	1412
ORP	230	226.4	230
DO%	100	87.3	99.1

Cc Flow ~ 10 mL/min C10 Flow ≈ 20 mL/min
C20 Flow ~ 30 mL/min

1020 Collect sample In-113021
1040 Collect sample C10-Eff-113021

1050 Collect sample C20-Eff-113021
1100 Collect sample CC-Eff-113021
1135 Collect sample C10-P1-113021
1140 Collect sample C10-P2-113021
1145 Collect sample C20-P1-113021
1150 Collect sample C20-P2-113021
1155 Collect sample CC-P1-113021
1200 Collect sample CC-P2-113021
1255 Replace Tygon peristaltic tubing to hopefully reduce flow rate. Tygon tubing is fairly rigid and has been worked in as pumping goes on.
1315 Aspect all site.

0715 Aspect on site. C20 Flow ≈ 20 mL/min
C10 Flow = 5 mL/min CC Flow = 13 mL/min

YSI (Red) Calibration

	soln	pre	post
pH7	7.00	7.65	7.02
pH10	10.00	9.66	10.02
COND	1413	1371	1412
ORP	230	* requires replacement	
DO	100	108.2	99.4

0800 Begin collecting field parameters.

	Temp	Cond	pH	DO%	*ORP
In	16.1	1344	7.14	9.5	—
C20 Eff	15.7	2929	8.60	9.8	—
C10 Eff	14.9	1775	7.62	15.9	—
Cc Eff	14.6	2034	6.99	10.1	—
C20 P1	15.1	2187	7.24	3.2	—
C20 P2	15.2	2237	7.28	5.0	—
C10 P1	14.8	2141	7.15	3.7	—
C10 P2	14.9	2004	7.36	3.8	—
Cc P1	15.2	2125	7.16	11.2	—
Cc P2	15.0	2069	7.14	14.3	—

Per Adam - increasing flow on each column to 50 mL/min.

1000 Aspect off site while pumps reach steady state.

1115 Aspect back on site. Collect field parameters.

	Temp	Cond	pH	DO%	ORP
In	16.1	2047	6.89	5.3	145.6
C20 Eff	16.5	2243	6.57	5.8	185.4
C10 Eff	16.5	2149	6.74	4.9	158.3
Cc Eff	16.4	2026	6.78	13.7	154.5

1200 Collect sample In-120121
1210 Collect sample C20-Eff-120121
1220 Collect sample C10-Eff-120121
1230 Collect sample CC-Eff-120121
1300 Collect sample C20-P1-120121
1310 Collect sample C20-P2-120121
1320 Collect sample C10-P1-120121
1330 Collect sample C10-P2-120121
1340 Collect sample CC-P1-120121
1350 Collect sample CC-P2-120121
1450 Aspect off site.

PBBC

12/2 Portage

0900 Arrived at site. Calibrate YSI (red)

	soln	pre	post
pH7.00	7.00	7.25	7.02
pH10	10.00	9.90	10.02
COND	1413	1431	1413
ORP	230	298.1	230.5
DO	100	98.8	100.4

0920 Begin collecting parameters.

	Temp	Cond	pH	DO%	ORP
In	14.7	2066	6.86	4.7	125.7
C20 Eff	13.4	2328	7.05	1.3	116.4
C10 Eff	13.8	2017	6.91	6.4	124.9
CC Eff	13.7	2182	6.88	6.2	125.7
*C 10 P1	16.1	2045	7.11	4.9	92.6
C ~~10~~ P2	16.2	2181	7.13	3.2	94.9
C20 P1	16.0	2319	7.11	3.6	91.8
C20 P2	16.1	2301	7.15	6.5	79.4
CC P1	15.7	2282	7.10	4.5	78.0
CC P2	15.9	2197	7.10	12.1	76.6

C10 Flow = C20 Flow = 45 mL/min

CC Flow = 55 mL/min * Port parameters measured at 1200

1320 Collect sample C20-Eff-120221

1330 Collect sample C10-Eff-120221

1340 Collect sample CC-Eff-120221

1350 Collect sample In-120221

 12/2

Portage

PBDC

1400 Collect sample C20-P1-120221
1410 Collect sample C20-P2-120221
1420 Collect sample C10-P1-120221
1430 Collect sample C10-P2-120221
1445 Pumps turned down to lowest setting, minimizing flow for remainder of pump test per Adam.
1500 AspectA off site.

 12/3

Portal BBC

0920 Aspect on site. C20 Flow ≈ 10 mL/min
C10 Flow ≈ 10 mL/min CC Flow ≈ 20 mL/min
Adjusted C20 Flow ≈ C10 Flow ≈ 10 mL/min
Calibrate YSI (red)

	soln	pre	post
pH 7	7.00	7.41	7.00
pH 10	10.00	9.38	10.02
COND	1413	1402	1413
ORP	230	220.8	231
DO	100	92.7	100.4

1030 ~~1033~~ Begin collecting field parameters.

	Temp	Cond	pH	DO %	ORP
In	14.2	1203	7.26	8.3	128.4
C20 Eff	13.1	2719	8.29	6.7	163.1
C10 Eff	15.1	2346	7.53	6.7	128.7
CC Eff	14.7	2175	7.27	13.9	127.7
C10 P1	13.6	1170	7.47	~~11.0~~ 8.0	118.3
C10 P2	14.2	2316	~~8~~ 7.47	3.6	116.3
C20 P1	12.6	1922	7.44	5.3	125.7
C20 P2	14.1	2275	7.51	0.9	117.4
CC P1	12.1	2270	7.31	13.5	129.6
CC P2	12.6	1327	7.46	18.5	127.8

1230 Aspect off site.

12/6 Parker BBC

0845 Arrive @ site. Calibrate YSI (red)

	soln	pre	post
pH 7	7.00	7.10	7.00
pH 10	10.00	9.42	10.03
COND	1413	1421	1415
ORP	230	229.5	229.5
DO	100	104.2	99.8

0930 Begin collecting field parameters

	Temp	Cond	pH	DO %	ORP
In	13.4	1604	7.80	10.2	126.9
C20 Eff	14.6	2037	8.48	6.8	168.5
C10 Eff	14.9	1357 ~~[illegible]~~	8.18	2.7	142.7
Cc Eff	15.7	2308	7.89	7.5	128.9
C10 P1	12.7	1808	7.70	8.8	131.4
C10 P2	12.8	2278	7.73	6.1	132.4
C20 P1	12.5	2180	7.72	9.4	132.2
C20 P2	13.6	1882	7.85	9.6 ~~12.4~~	125.8
Cc P1	12.9	1251	7.88	19.7	127.8
Cc P2	13.1	2417	7.77	11.1	128.6

C20 Flow ~ C10 Flow ≈ 20 mL/min

Cc Flow ≈ 25 mL/min

1010 Collect sample C20-Eff-120621

1020 Collect sample C10 Eff-120621

1030 Collect sample Cc-Eff-120621

1040 Collect sample In-120621

 12/6 Portage RBL

1050 Collect sample C10-P1-120621
1100 Collect sample C10-P2-120621
1110 Collect sample C20-P1-120621
1120 Collect sample C20-P2-120621
1130 Collect sample CC-P1-120621
1140 Collect sample CC-P2-120621
1205 Drain control column.
1230 Begin demobilizing column test setup.
1345 Confirm CTD-Diver calibration.
Air ≈ 0 µS/cm. ~~1413 µS/cm cal sol~~
1413 µS/cm cal soln. ~1400 µS/cm.
Deploy diver in MW-14 at 16' BTOC.
1415 Aspect site.
2 x 55 gallon soil drums
5 x 55 gallon water drums (4 full, 1 75% full)
on site from investigation and treatability
testing. Three drums remain from before
investigation.

Aspect CONSULTING

Field Staff:

DAILY REPORT

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

	Date	Column	PV's	Gallons.
Low Flow	11/29/21			
		C20	8.45	2.57
		C10	4.70	1.43
		CC	6.57	2.00
Low Flow	11/30/21			
		C20	25.98	7.89
		C10	15.65	4.76
		CC	15.34	4.66
High Flow	12/1/21			
		C20	44.50	13.52
		C10	28.43	8.64
		CC	31.41	9.54
High Flow	12/2/21			
		C20	72.67	22.08
		C10	56.60	17.20
		CC	65.84	20.00
Low Flow	12/6/21			
		C20	172.3	52.35
		C10	156.3	47.47
		CC	~~218.4~~ ~~199.4~~ 189.8	~~66.36~~ ~~60.58~~ 57.65

APPENDIX B

Material Specifications

CONNELLY – GPM, INC.

ESTABLISHED 1875

3154 SOUTH CALIFORNIA AVENUE   CHICAGO, ILLINOIS 60608-5176

PHONE: (773) 247-7231 • www.ConnellyGPM.com • FAX: (773) 247-7239

September 15, 2019

SCREEN SPECIFICATION ETI CC-1004
(-8 + 50 MESH)

U.S. SCREEN NUMBER	OPENING	% PASSING
4	4.75 mm	100
8	2.36 mm	95 - 100
16	1.18 mm	75 - 90
30	0.600 mm	25 - 45
50	0.300 mm	0 - 10
100	0.150 mm	0 - 5

MATERIAL WEIGHS APPROXIMATELY 140 - 160 POUNDS PER CUBIC FOOT

TYPICAL ANALYSIS OF IRON AGGREGATE

Iron/Iron Oxide	Balance
Total Carbon	2.48
Manganese	0.93
Sulphur	0.120
Phosphorous	ND
Silicon	0.35
Nickel	>0.01
Chromium	>0.01
Vanadium	ND
Molybdenum	0.33
Copper	0.10
Aluminum	>0.01
Magnesium	0.01
Boron	0.01
Zinc	0.01
Zirconium	0.01

GALEN B. DIXON
GENERAL MANAGER

APPENDIX C

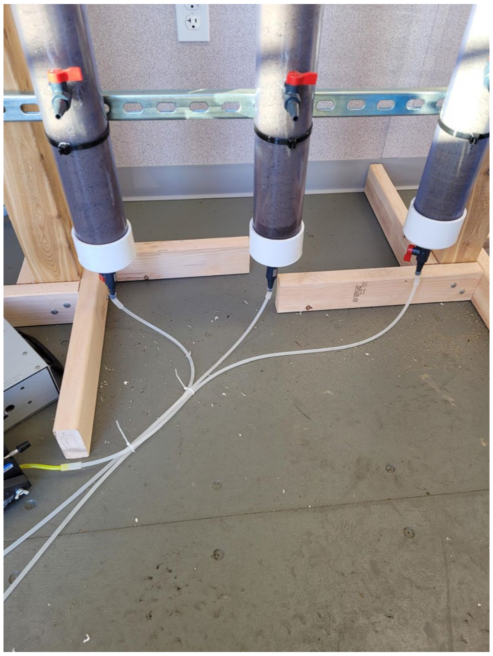
Column Testing Photo Log

Photograph 1. MW-14 well head with pump tubing (x3), inflatable packer, and water level meter.

Photograph 2. Flow-through column setup

Photograph 3. Low-flow peristaltic pumps.

Photograph 4. Flowing columns and effluent discharge.



Photograph 5. Column influent and Port 1.

Photograph 6. MW-14 Inflatable Packer.

APPENDIX D

X-Ray Diffraction (XRD) Results

LABORATORY REPORT

Haley and Aldrich, Inc.		Report Date:	March 08, 2022
702 West Idaho Street		Samples Received:	February 23, 2022
Boise, ID 83706		RJ Lee Group Job No.:	PA230220220015
ATTENTION:	Jenna Adams	Client Project No.:	0202268-000
Telephone:	360-908-2712	Purchase Order No.:	N/A

ANALYSIS: X-ray diffraction (XRD) for crystalline phases
METHOD: Qualitative Phase Identification

Samples were received at RJ Lee Group in good condition. A portion of each sample was dried at room temperature and ground in a ball mill. The ground samples were mounted into XRD holders for analysis. The samples were scanned on a PANalytical Empyrean diffractometer using copper radiation and standard run parameters. The resulting diffraction patterns were then search-matched with PANalytical X'Pert HighScore software against phases in the ICDD PDF4+ database. Concentrations presented below are estimated based on peak intensities of identified crystalline phases only. Major concentrations denote phases that are estimated to make up more than 20% of the material by weight, minor concentrations estimate concentrations in the material between 20% and 5% by weight and trace concentration estimates a phases present in the sample at concentrations less than 5% by weight. Estimations may vary, as factors such as preferred orientation and the ability of each material to diffract x-rays, as well as phased concentration will affect peak intensities. Additionally, amorphous material may not necessarily be detected by XRD. In certain cases where amorphous material is present in major concentrations, its presence is evidenced by a broad hump in the background signal of an XRD scan, however minor concentrations of amorphous material may be present in a material with no evidence in the scan. Further, XRD is generally accepted to have a detection limit of approximately a few weight percent, depending on phase. It is possible that trace phases are present in the samples that remain unidentified.

Client Sample No.: C10-In
RJ Lee Group Sample No.: 001

Phase*	Approximate Composition**	Estimated Concentration
Quartz	SiO_2	Major
Feldspar(s)	$(K,Na)AlSi_3O_8$	Major
Chlorite Group	$(Mg,Al,Fe,Ni,Mn)_6Al(Al,Si_3)O_{10}(OH)_8$	Trace
Mica/Illite	$K(Al,Mg,Fe)_2(AlSi_3O_{10})(F,OH)_2$	Trace
Dolomite	$CaMg(CO_3)_2$	Trace
Monoclinic Amphibole***	$(Na,Ca,Fe,Mg)_7Si_8O_{22}(OH)_2$	Trace

***Amorphous content, crystalline phases present at trace levels and phases that are not currently part of the ICDD PDF 4+ database may remain unidentified.**
****Compositions are approximate and represent an idealized formula for that structure, not including possible elemental substitutions into that crystal structure.**
*****Further testing is necessary to confirm amphibole phases.**

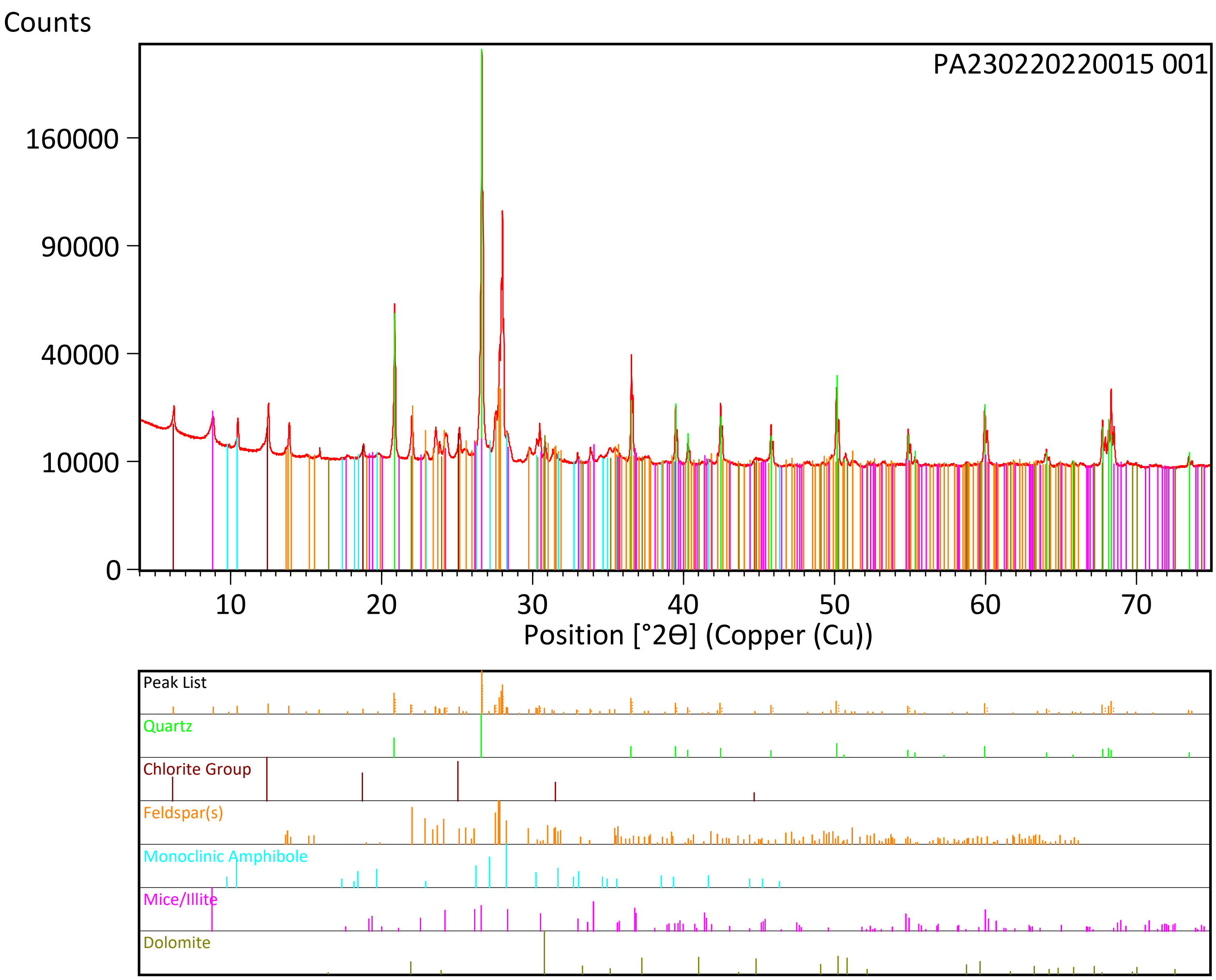


Figure 1 –X-ray diffraction pattern of sample *"C10-In"*, with position (degrees 2Θ) along the x-axis and intensity (counts) along the y-axis (top). Corresponding legend denoting phase matches (bottom).

Client Sample No.: C20-In
RJ Lee Group Sample No.: 002

Phase*	Approximate Composition**	Estimated Concentration
Quartz	SiO_2	Major
Feldspar(s)	$(K,Na)AlSi_3O_8$	Major
Chlorite Group	$(Mg,Al,Fe,Ni,Mn)_6Al(Al,Si_3)O_{10}(OH)_8$	Trace
Mica/Illite	$K(Al,Mg,Fe)_2(AlSi_3O_{10})(F,OH)_2$	Trace
Dolomite	$CaMg(CO_3)_2$	Trace
Monoclinic Amphibole***	$(Na,Ca,Fe,Mg)_7Si_8O_{22}(OH)_2$	Trace

***Amorphous content, crystalline phases present at trace levels and phases that are not currently part of the ICDD PDF 4+ database may remain unidentified.**
****Compositions are approximate and represent an idealized formula for that structure, not including possible elemental substitutions into that crystal structure.**
*****Further testing is necessary to confirm amphibole phases.**

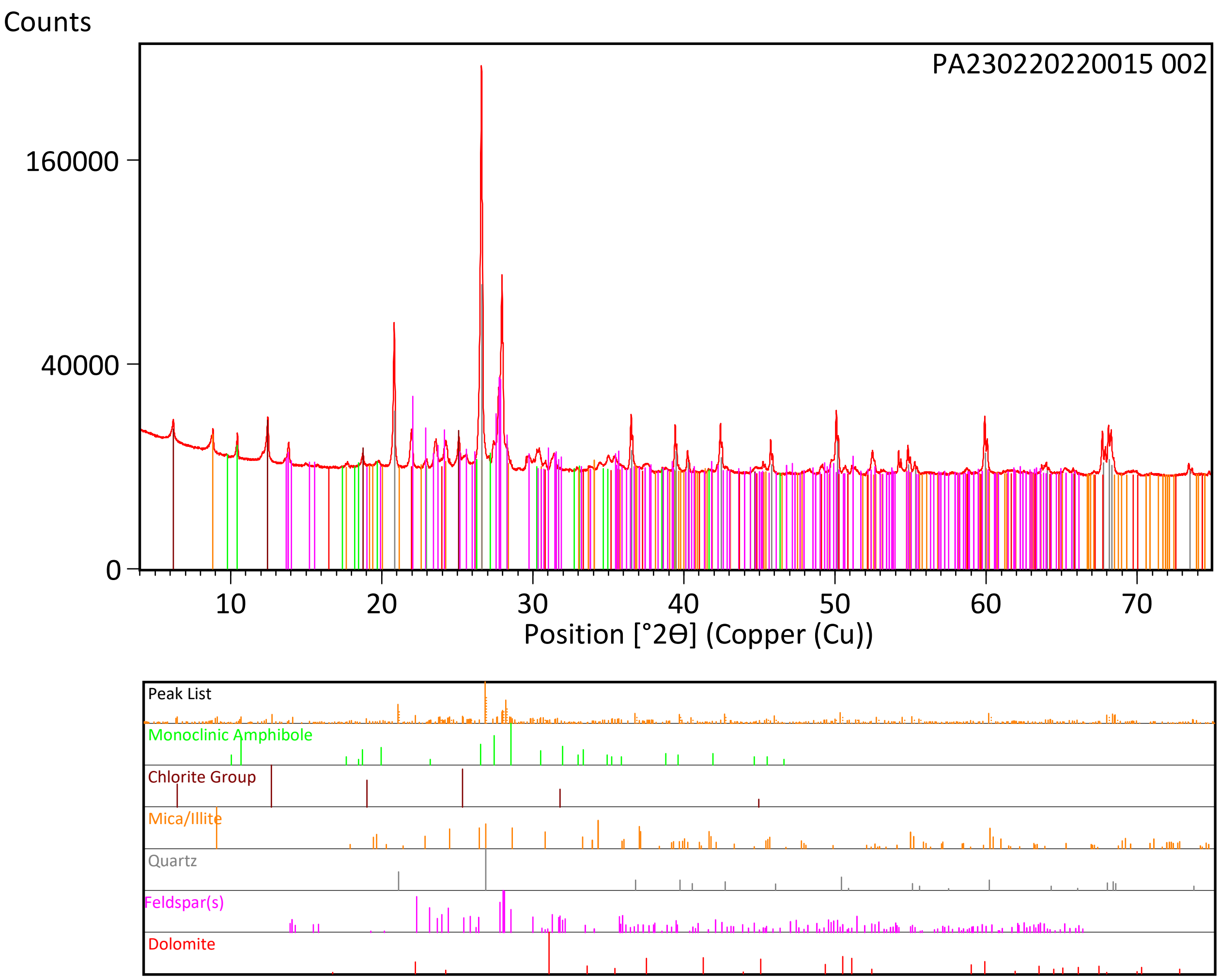


Figure 2 –X-ray diffraction pattern of sample *"C20-In"*, with position (degrees 2Θ) along the x-axis and intensity (counts) along the y-axis (top). Corresponding legend denoting phase matches (bottom).

These results are submitted pursuant to RJ Lee Group's current terms and conditions of sale, including the company's standard warranty and limitation of liability provisions. No responsibility or liability is assumed for the manner in which the results are used or interpreted. The results contained in this report relate only to the items tested or to the sample(s) as received by the laboratory. Data supplied by the client that can affect the validity of the results has been clearly identified. Measurement of uncertainty data available upon request. Any reproduction of this document must be in full for the report to be valid. Unless notified to return the samples covered by this report, RJ Lee Group will store them for a period of thirty (30) days before discarding.
This laboratory operates in accord with ISO 17025:2017 guidelines and holds a limited scope of accreditation. Please refer to http://www.rjlg.com/about-us/accreditations/ for more information and current status.

Please feel free to contact us should you have any questions regarding this analysis or if we can be of further assistance to you.

Sincerely,

Sarah Candiello

Sarah Candiello, Scientist

A2LA ACCREDITED
CERT #3985.01

APPENDIX E

Scanning Electron Microscopy (SEM) Results

RJ LEE GROUP
DELIVERING SCIENTIFIC RESOLUTION

March 22, 2022

Jenna Adams
Haley & Aldrich, Inc.
702 West Idaho Street
Suite 310
Boise, ID 83706

RE: Soil and Granular Iron Mixture
RJ Lee Group Project Number TMH1065334-0

Sample Overview and Discussion
Haley & Aldrich, Inc. recently submitted two samples to be analyzed by computer-controlled scanning electron microscopy (CCSEM). The samples were logged into an RJLG sample database, where unique tracking numbers were assigned. Sample identifications are listed below in Table 1.

Table 1. Haley & Aldrich, Inc. Identification and Corresponding RJLG Identification

Haley & Aldrich, Inc. Sample ID	RJLG Sample ID	Samlpe Description	Date Received
C10-In	10559729	Soil and granular iron mixture	03/03/22
C20-In	10559730	Soil and granular iron mixture	03/03/22

Sample Preparation and Analysis
A representative subsample was taken from each sample and filtered onto a 0.2 µm pore hole size polycarbonate filter using vacuum filtration. A portion of this filter was redeposited to obtain a suitable particle loading for CCSEM analysis.

Particle Characterization by SEM
Once prepared, the each sample was analyzed using CCSEM (computer-controlled scanning electron microscopy) to determine the size distribution of the particles by compositional type. The CCSEM analysis was performed using a Tescan MIRA 3 FE-SEM equipped with a Bruker XFlash 6160 EDS detector. The IntelliSEM™ or AFA (automated feature analysis) software was used to determine the number and size distribution of the particles by compositional type. The analysis was performed using the backscattered electron imaging mode to allow for the detection of all desired particulate species within the population. Once detected, each particle was measured, and its elemental constituents were identified. Size and morphological characteristics, as well as associated elemental constituents, were recorded on a particle by particle basis. As part of the analysis, a BE (backscattered electron) image and EDS (energy dispersive spectroscopy) spectrum were digitally recorded for each particle of interest. Additional particles within the population were similarly analyzed until a predetermined stopping criterion was met for each sample.

During the CCSEM analysis, particles were searched for, detected, and measured at the base magnifications. Once a particle was detected, however, the CCSEM analysis employed specific measurement and EDS algorithms that permitted the acquisition of images from individual particles at magnifications ranging between 1000× and 40,000×. These magnifications varied on a particle by particle basis, depending on the size of the particle that was being analyzed.

Post-CCSEM Analysis Data Summarization

To better characterize the individual particles detected during the CCSEM analysis, the data associated with each particle was reviewed. A total of 1500 individual particles were analyzed and identified by particle type based on classifying rules. The classifying rules are reported in Table 2 below.

Table 2. Classifying Rules Used to Create Particle Classes

Classification	Rule
Al/Si/Ca/Fe-rich	Al>=3 and Si>=3 and Ca>=3 and Fe>=3
Al/Si/Na-rich	Al>=3 and Si>=3 and Na>=3
Al/Si/Fe-rich	Al>=3 and Si>=3 and Fe>=3
Al/Si-rich	Al>=3 and Si>=3
Si-rich	Si>=90
Fe-rich	Fe>=90
Si/Fe-rich	Si>=3 and Fe>=3
Misc	True

A summary of the particle size and counts results based on particle types can be found in the attached Appendix A. Appendix B contains representative particles by various classes.

These results are submitted pursuant to RJ Lee Group's current terms and conditions of sale, including the company's standard warranty and limitation of liability provisions. No responsibility or liability is assumed for the manner in which the results are used or interpreted. This test report is not to be reproduced except in full, without written approval of the laboratory. Results of this study relate only to the items tested, and accurately reflect the test data.

Should you have any questions or feel that I may be of further assistance, please do not hesitate to contact me.

Sincerely,

Steven Schlaegle
Director, Bio-Medical Services

Jeremy Saulsbury
Project Scientist

RJ Lee Group, Inc.
350 Hochberg Road
Monroeville, PA 15146
Tel: (724) 325-1776 | Fax: (724) 733-1799

Client Name **Haley & Aldrich, Inc.**
RJLG Project Numl TMH1065334

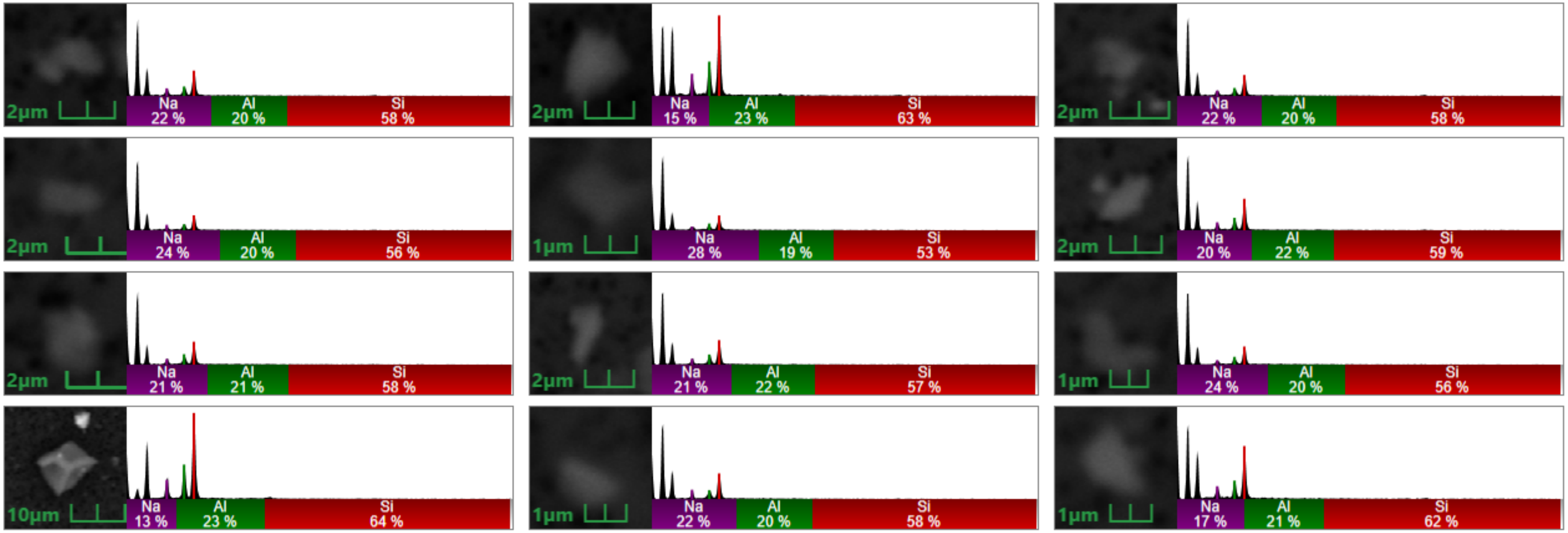
Size Distribution by Average Diameter (microns)

Classes	Number%	**0.2 to 1**	**1 to 2.5**	**2.5 to 5**	**5 to 10**	**10 to 20**	**20 to 50**	**50 to 100**	**>100**
Al/Si/Fe-rich	38.9	46.1	45.1	7.4	0.9	0.5	0.0	0.0	0.0
Al/Si/Na-rich	19.9	35.8	51.5	10.4	2.3	0.0	0.0	0.0	0.0
Al/Si-rich	14.2	50.2	41.3	6.1	1.9	0.5	0.0	0.0	0.0
Fe-rich	10.9	58.9	35.0	5.5	0.6	0.0	0.0	0.0	0.0
Si-rich	5.9	36.0	43.8	13.5	5.6	0.0	1.1	0.0	0.0
Al/Si/Ca/Fe-rich	5.3	22.8	55.7	13.9	6.3	1.3	0.0	0.0	0.0
Si/Fe-rich	3.6	61.1	31.5	7.4	0.0	0.0	0.0	0.0	0.0
Misc	1.3	45.0	40.0	10.0	5.0	0.0	0.0	0.0	0.0
Totals	100.0	44.7	44.7	8.3	1.9	0.3	0.1	0.0	0.0

Mass Distribution by Average Diameter (microns)

Classes	Mass%	**0.2 to 1**	**1 to 2.5**	**2.5 to 5**	**5 to 10**	**10 to 20**	**20 to 50**	**50 to 100**	**>100**
Al/Si/Fe-rich	25.4	1.8	12.7	17.8	13.6	54.1	0.0	0.0	0.0
Al/Si/Na-rich	8.6	1.4	19.3	26.8	52.6	0.0	0.0	0.0	0.0
Al/Si-rich	11.5	1.1	4.9	9.1	27.8	57.1	0.0	0.0	0.0
Fe-rich	3.2	5.9	25.2	39.9	29.0	0.0	0.0	0.0	0.0
Si-rich	42.2	0.1	0.8	1.2	9.0	0.0	89.0	0.0	0.0
Al/Si/Ca/Fe-rich	8.0	0.3	7.2	16.3	20.0	56.2	0.0	0.0	0.0
Si/Fe-rich	0.7	7.3	30.1	62.6	0.0	0.0	0.0	0.0	0.0
Misc	0.5	2.1	23.4	10.7	63.8	0.0	0.0	0.0	0.0
Totals	100.0	1.0	7.5	11.4	17.8	24.8	37.5	0.0	0.0

Representative Particles Collected from C10-In and C20-In and Classified as Al/Si/Na-rich



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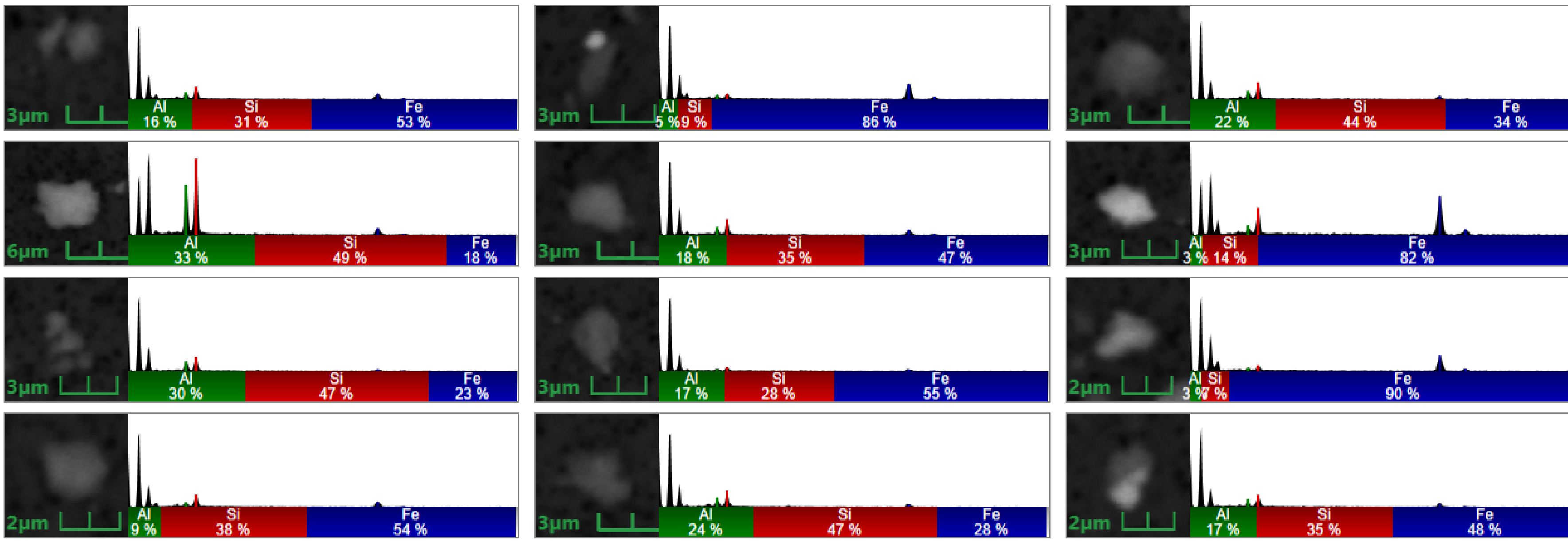

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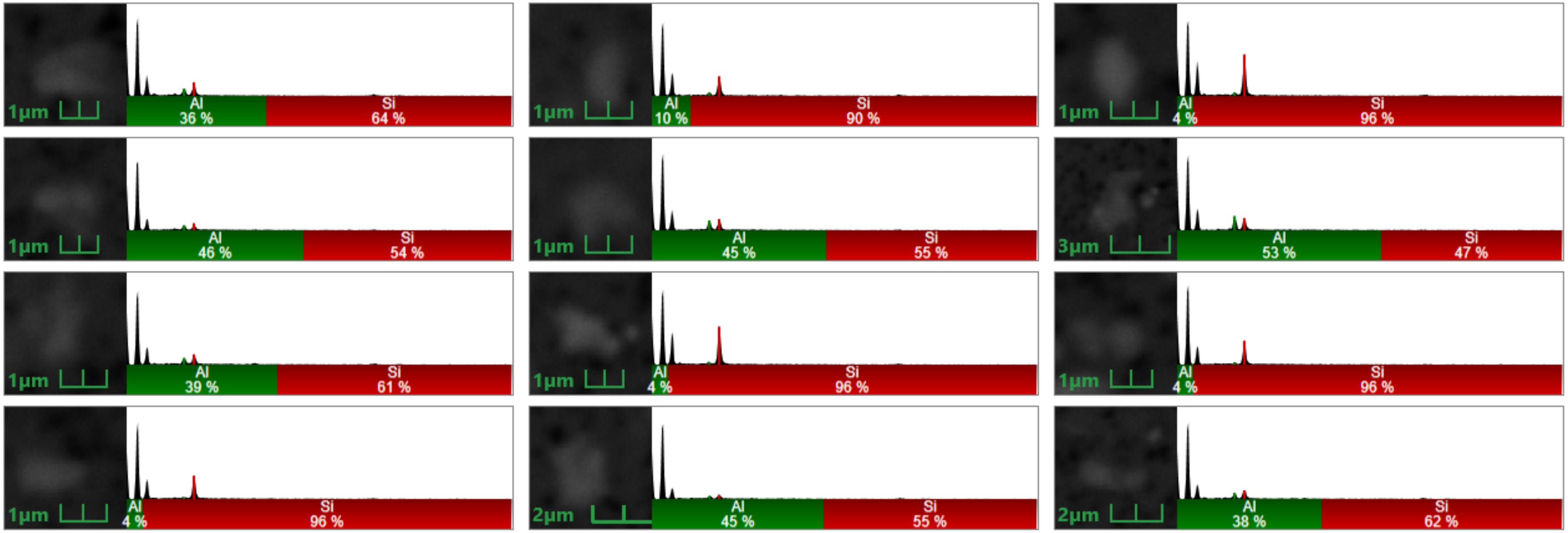

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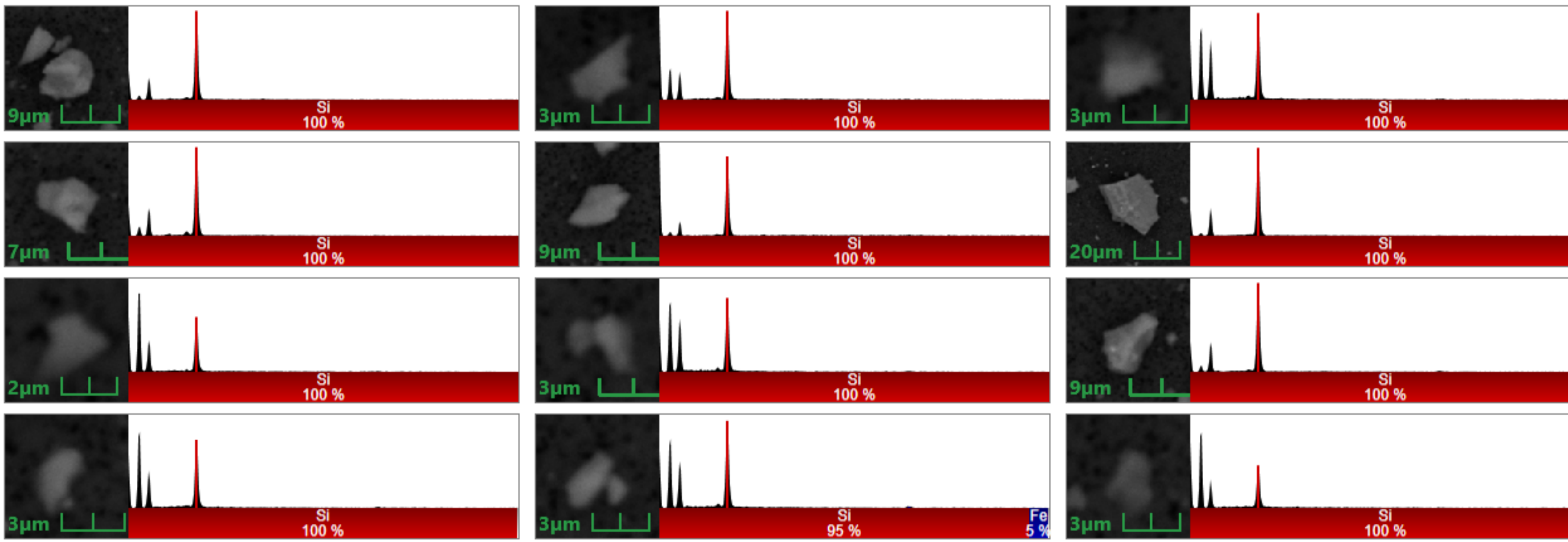
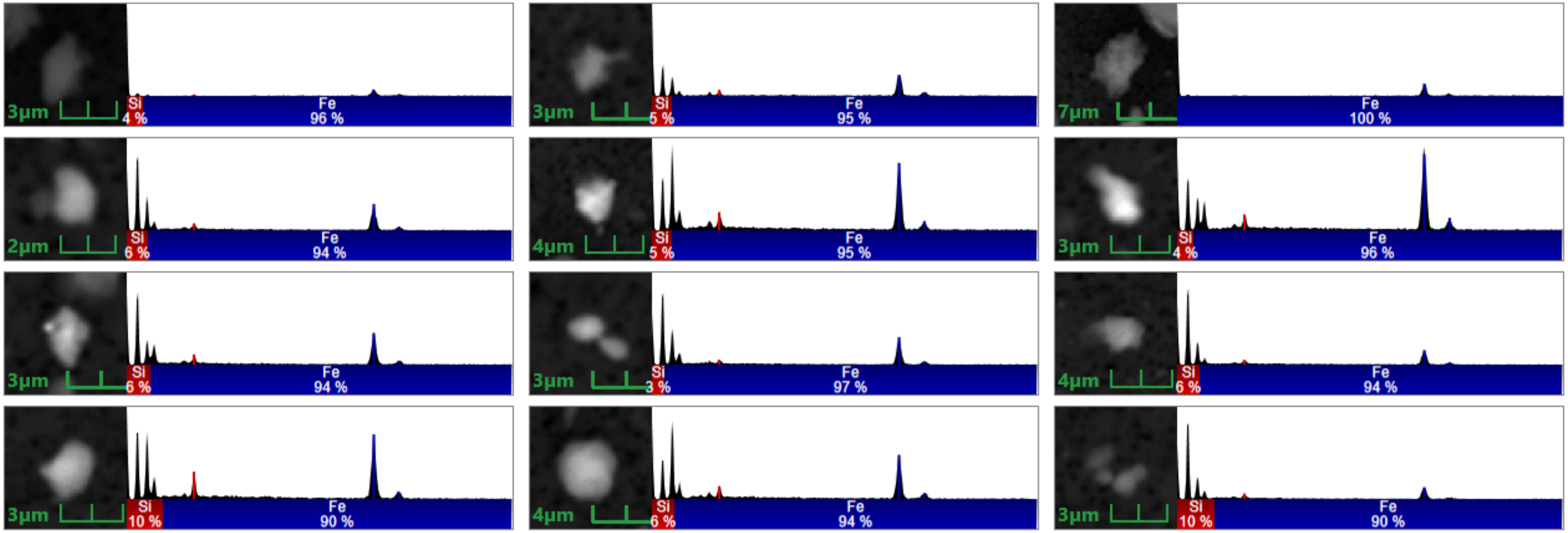
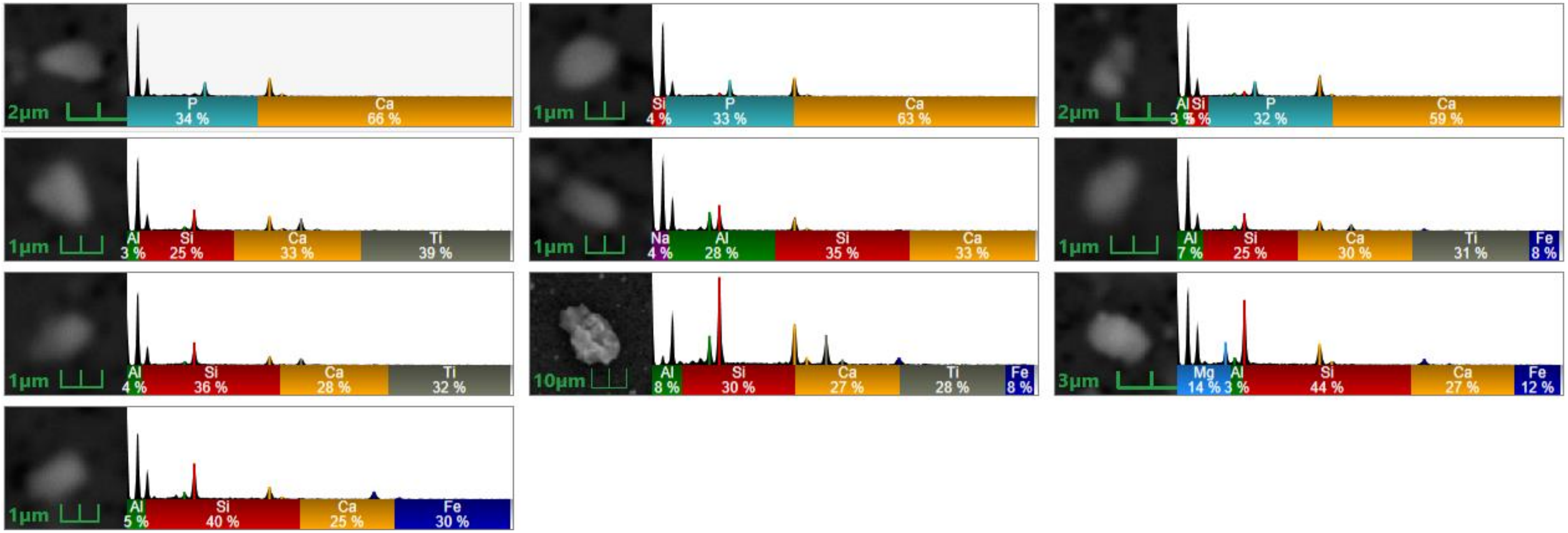


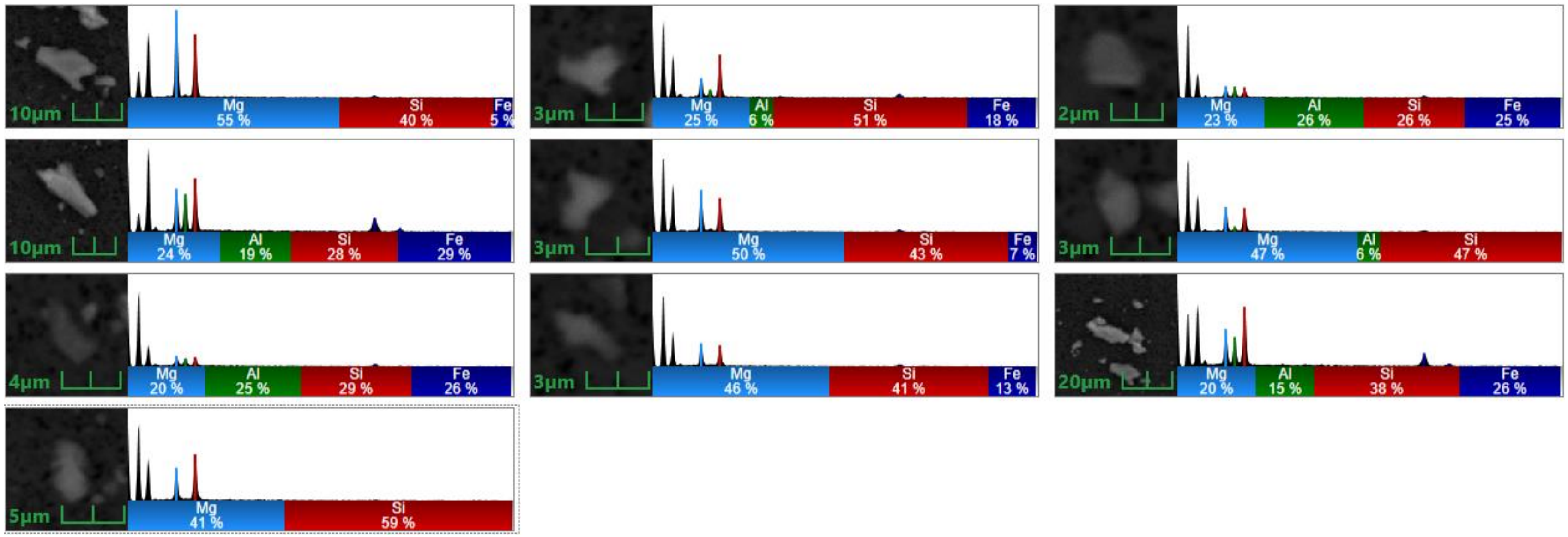
Representative Particles Collected from C10-In and C20-In and Classified as Fe-rich



Representative Particles Collected from C10-In and C20-In and Classified as Ca-rich

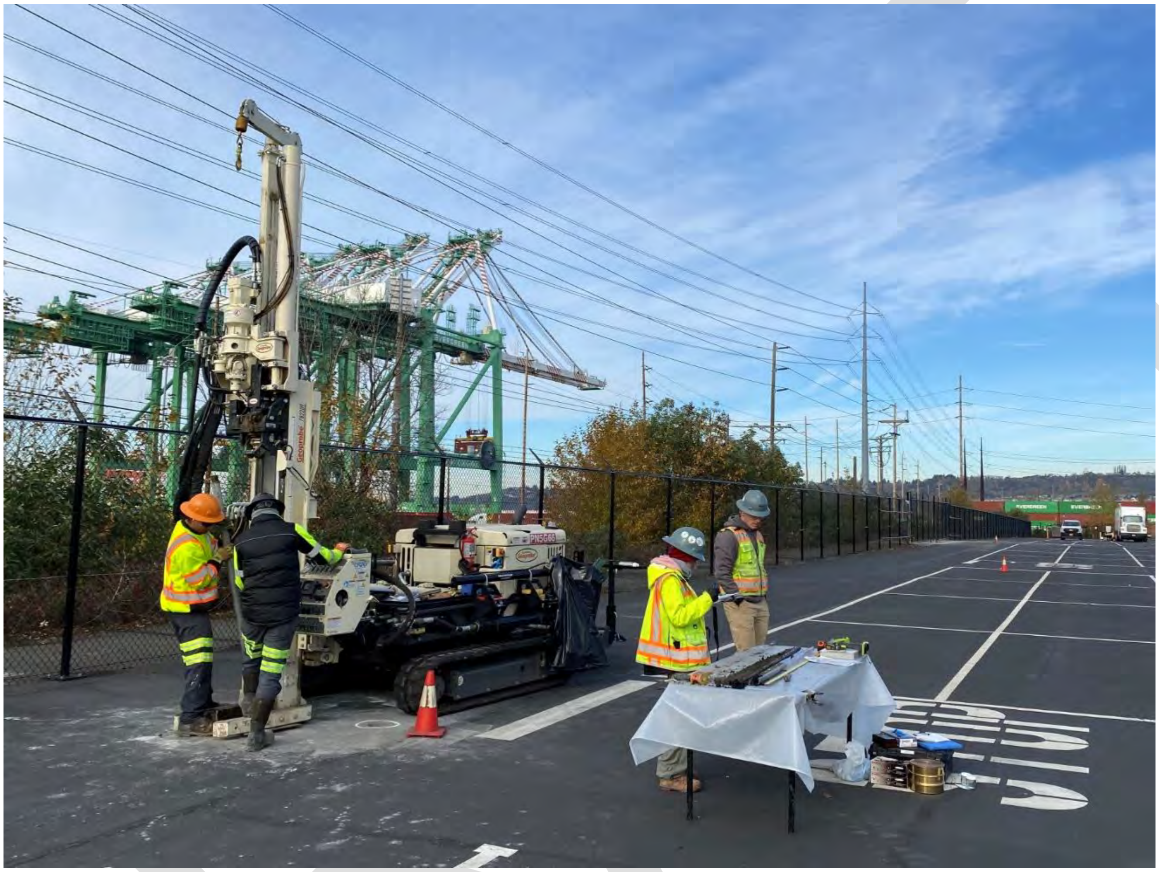


Representative Particles Collected from C10-In and C20-In and Classified as Mg-rich



APPENDIX C

Cultural Resources Assessment Report



Cultural Resources Assessment for the Port of Tacoma Parcel 15 (Portac) Cleanup Phase 1, Tacoma, Pierce County, Washington

Cultural Resources Assessment for the Port of Tacoma Parcel 15 (Portac) Cleanup Phase 1, Tacoma, Pierce County, Washington

Prepared by
Julia Kunas
Althea Fitzpow
Austin Jenkins

April 7, 2022

WillametteCRA Report No. 21-140
Seattle, Washington

Prepared for
Port of Tacoma
Tacoma, Washington

WILLAMETTE
CULTURAL RESOURCES ASSOCIATES, LTD.

Report Details

Project Name:	Port of Tacoma Parcel 15 (Portac) Cleanup Phase 1
SHPO/DAHP Number	2021-07-04616
Agency:	Washington State Department of Ecology
Agency Project Number	
Client:	Port of Tacoma
Project Undertaking:	Site Remediation
Regulatory Framework:	State Environmental Policy Act (SEPA)
County:	Pierce
Legal Description:	Township 20 North, Range 3 East, Section 1
USGS Quad	*Tacoma* 7.5-minute
Project Acreage:	5.8 acres
Survey Acreage:	5.8 acres
Permit Number:	N/A
Accession Number:	N/A
Curation Location:	N/A
Field Note location:	WillametteCRA, Seattle Office
Fieldwork Type:	Monitoring
Fieldwork Dates:	November 16-17, 2021
Field Personnel:	Julia Kunas
Findings:	No cultural resources
Recommendations:	Monitoring of Specific Project Activities

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Introduction

Willamette Cultural Resources Associates, LTD (WillametteCRA) is contracted with Aspect Consulting to provide the Port of Tacoma (Port) with a Cultural Resources Assessment for the Parcel 15 (Portac) Cleanup Phase 1 Project (Project). The Project is located in Section 1, Township 20 North, Range 3 East, in the City of Tacoma, Pierce County, Washington (Figure 1). 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 Project.

This Cultural Resources Assessment is limited to Phase 1 cleanup activities. Phase 1 includes construction of a permeable reactive barrier, slip lining two existing stormwater conveyance pipes and replacing two stormwater vaults (Figure 2). Existing outfall structures where the pipes discharge to Wapato Creek will also be repaired. The Project is intended to immobilize arsenic in groundwater and will prevent arsenic impacted groundwater from seeping into stormwater conveyance. Any future Phase 2 may include a low-permeability cap on the site. Phase 2 concepts are not meaningfully developed, dependent upon future site development, and have no clear timeline, therefore, Phase 2 activities cannot be meaningfully analyzed for potential impacts to cultural resources at this time.

The Cultural Resources Assessment included background research and review of subsurface conditions to determine the potential for deposits to bear cultural resources. Due to extensive fill onsite and challenges with accessing subsurface deposits with traditional archaeological testing, the investigation consisted of observing drilling activities during the Pre-Remedial Design Investigation and reviewing its geotechnical data. No cultural resources were observed during the Cultural Resources Assessment. Archaeological monitoring of PRB construction, as well as storm vault removals and preparation of the vault pits for the proposed vaults is recommended.

Project Setting

The Project is located at the Port's Parcel 15 (Portac) property southeast of Alexander Avenue East and 4th Stree East, Tacoma, Pierce County, Washington. The site is paved for use to short term parking of imported cars and for queuing trucks accessing the Port's operations.

Regulatory Context

The Project is subject to review under the State Environmental Policy Act (SEPA). Ecology approved a SEPA checklist, requiring adherence to the agency's standard Inadvertent Discoveries Plan (IDP). The Port's ongoing coordination with the Puyallup Tribe of Indians Tribal Historic Preservation staff identified the need for a Cultural Resources Assessment to determine whether the IPD should also include a monitoring component, as a Monitoring and Inadvertent Discovery Plan (MIDP).

Figure 1. Project Location on USGS 7.5' Topographic Quadrangle.

Figure 2. Project Location on Aerial Photograph.

Additionally, the Project requires completion of a Joint Aquatic Resource Permit Application (JARPA) Some Project activities are anticipated to require permitting from the United States Army Corps of Engineers (Corps) which would make the project subject to Section 106 of the National Historic Preservation Act (Section 106). The Corps may review this report, at its discretion, to consider potential effects to historic resources under Section 106.

Other Washington state laws apply to archaeological resources and Native American burials located on the private and non-federal public lands. The Archaeological Sites and Resources Act (RCW 27.53) prohibits knowingly excavating or disturbing prehistoric and historic archaeological sites. The Indian Graves and Records Act (RCW 27.44) prohibits knowingly destroying American Indian graves and provides a process for notifications and consultation in cases of inadvertent discoveries of human remains. To prevent the looting or depredation of sites, any maps, records, or other information identifying the location of archaeological sites, historic sites, artifacts, or the site of traditional ceremonial, or social uses and activities of Indian Tribes are exempt from disclosure (RCW 42.56.300).

Natural and Cultural Background

Natural Setting

The Project is located within the Puget Lowlands region, which is defined as the low-lying area between the Cascade Mountains and the Olympic Mountains (DNR 2021). Puget Lowland landscapes were shaped through various Quaternary glaciations that advanced through the area as the Puget Lobe of the Cordilleran Ice Sheet (Booth et al. 2003; DNR 2021). Glacial advances and retreats over a period of approximately 18,000 to 15,000 years resulted in the topography of the Puget Lowlands, in addition to more recent processes such as erosion, landslides, and volcanic eruptions (Booth et al. 2003).

The recent historic tidelands condition of the Project Location does not represent the environment conditions throughout human history on Commencement Bay. The glacial and deglacial processes and volcanic history in the Puget Lowlands contribute to a potentially complicated relationship between the Project Location and water levels. During the last glacial maximum, although global sea level was considerably lower, mass from the ice sheets depressed the underlying land (Booth et al. 2003). Vast amounts of local fresh water, isostatic rebound, rising global sea level and sedimentation within the Puyallup River Valley resulted in significant variations in hydrologic conditions at the Project Location. Shorelines were well below modern levels from 13,500 to 9,000 years ago (Booth et al. 2003) and the embayment of what is now Commencement Bay, reached the City of Puyallup until 5,700 years ago (Dragovich et al. 1994). Following the Osceola Mudflow, valley bottom and deltas would more closely approximate their present location (Dragovich et al. 1994).

The Project is situated near Commencement Bay, east of the current channelized Wapato Creek (Figure 2) and immediately north of its most recent natural course (Figure 3). The surface geology near the Project is dominated by tidal influence and deltaic features. The area is mapped as Holocene alluvial deposits (Qa) (Schuster et al. 2015). These deposits are described as loose, fluvial silt, sand, and gravels that are typically rounded and well sorted (Schuster et al. 2015).

The Project was filled to facilitate development in the Port (see Figure 4). Fill episodes in the Port took place over several decades through the twentieth century and coincided with the channelizing of Wapato Creek (see Figure 4). Soils are mapped as Urban land, 0 to 5 percent slopes (NRCS 2022), as is common in areas with extensive fill and substantial modification. The Surrounding soils are predominantly Sultan silt loam, which has a parent material of alluvium and consists of silt loam over stratified sand to silty clay loam (NRCS 2022).

The Project is located within the *Tsuga heterophylla* vegetation zone, which is characteristic of most of western Washington (Franklin and Dyrness 1988). Native flora in this woodland area is dominated by western red cedar, Douglas fir, western hemlock, red alder and big leaf maple over an understory including evergreen blackberry, Oregon grape, and oceanspray and ferns. Fauna found throughout the region include black-tailed deer, cougars, coyotes, beavers, grouse, and various waterfowl species. Common native fish species include trout, whitefish, suckers and multiple Pacific salmon species (Pietsch and Orr 2015).

Cultural Setting

Precontact Archaeological Context

The Project is within a region that has been used by humans for at least 10,000 years. The history of Native American settlement and subsistence in the nearby uplands, and river valleys both before and after European American contact reveals important patterns that speak to the potential for archaeological resources and culturally important places.

Not much is known, archaeologically about human activity in the Puget Lowlands during the Late Pleistocene to early Holocene periods. The Bear Creek Site (45KI839) north of the Project in Redmond provides one of the main sources of information on human activity during this period, with cultural deposits dating from approximately 10,000 and 12,500 years ago (Kopperl 2016). Olcott sites, usually referred to as sites in the region older than 4,000 years before present (YBP), are more common and are often located on Puget Lowland glacial outwash surfaces and inland foothill valleys (Chatters et al. 2011; Croes et al. 2008; Kidd 1964). Olcott sites are characterized by large, leaf-shaped stemmed points made from local cobbles, and have been interpreted as a reliance on highly mobile hunting and gathering resource acquisition. This trend appears to have lasted for at least 6,000 years until a shift towards the increasing use of marine and riverine resources (Taylor 2021).

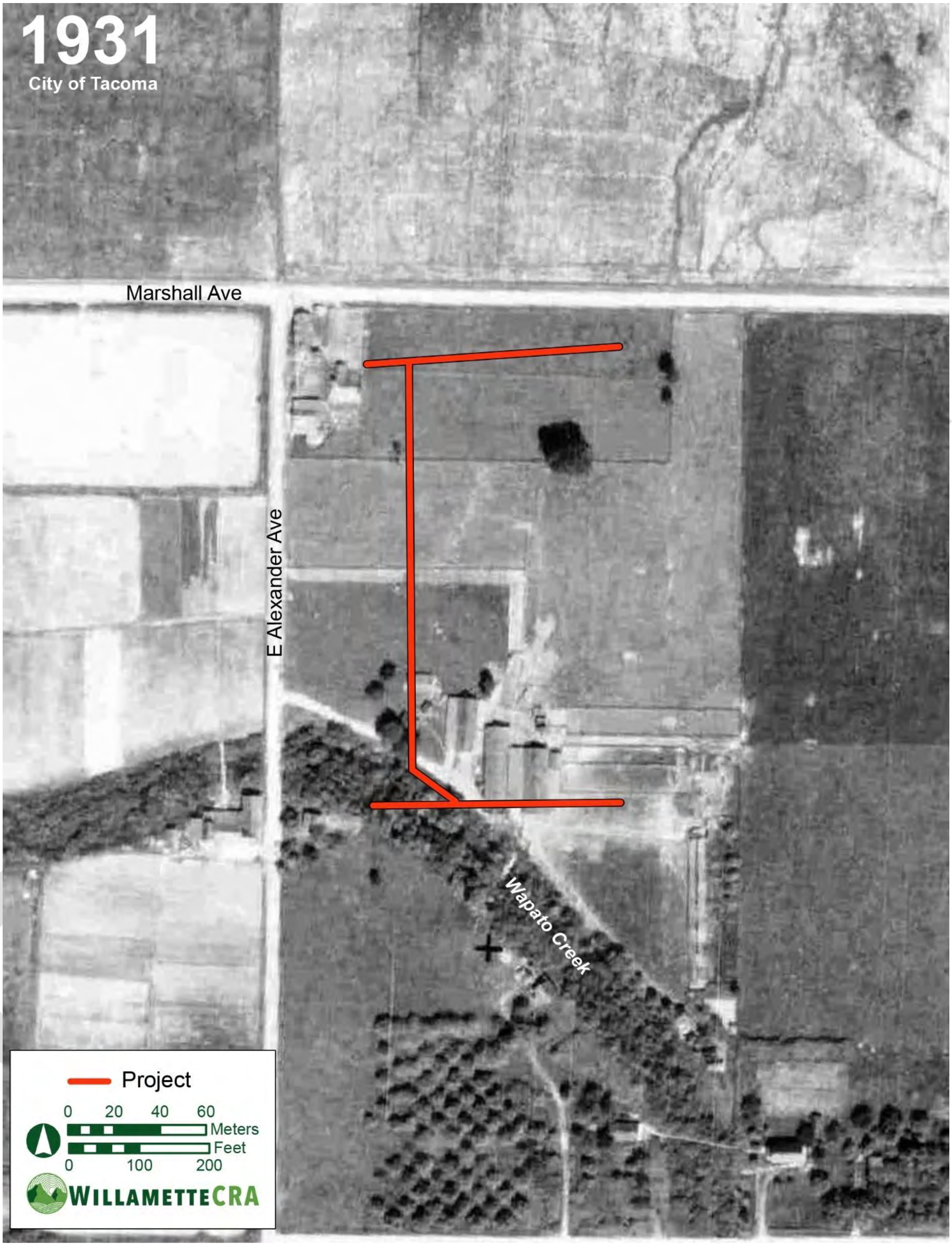

Figure 3. Project Location on 1931 Aerial Photograph.

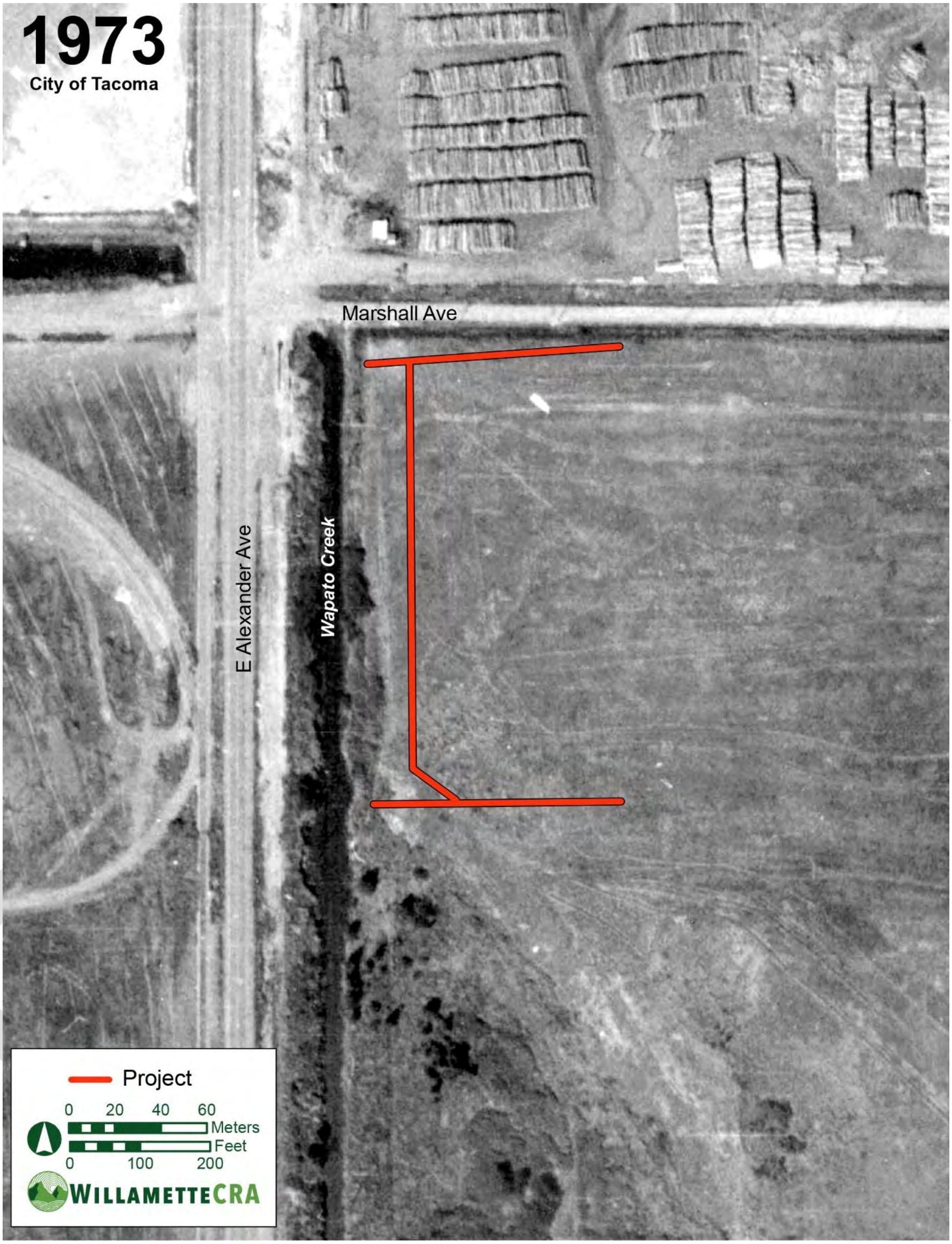

Figure 4. Project Location on 1973 Aerial Photograph.

After 5,000 years ago growing populations in the region resulted in a greater number of archaeological sites that often reflected the diverse array of resources available to people. Full-scale development of marine-oriented cultures on the coast and inland hunting, gathering, and riverine fishing traditions as represented in the ethnographic record are apparent after about 2,500 years ago (Blukis Onat 1987). Large semi-sedentary populations occupied cedar plank houses at river mouths and confluences and on protected shorelines (Ames and Maschner 1999; Blukis Onat 1987; Matson and Coupland 1995). European contact in the late 18th century led to drastic changes in Native American populations and community structures, primarily caused by disease pandemics, as well as major changes in native economies (Boyd 1999).

Native Peoples

The Project is located within the traditional lands of the Puyallup Tribe of Indians and is within the external boundary of the Puyallup Tribe's reservation. The Puyallup are a Lushootseed speaking group whose homeland ranges from the foothills of Mount Rainier (called *təqʷuʔmaʔ/təqʷuʔbəd* by the Puyallup) to the Puget Sound (Puyallup Tribe 2022).

Several traditional names are used by the Puyallup for places near the Project. The flats between Hylebos Creek and Wapato Creek were known as *Kalka'laqᵘ* , meaning "place around which the water passes" (Waterman 2001:248). The project is located on these flats. Wapato Creek just to the west of the project was called *Qa'1qalEqʷ*, meaning "making many turns", *Spiyaaqo'ts*, or "Indian potato", and *Sto'lagwali*, which means "where the river used to be" (Waterman 2001:248). Hylebos Creek to the northeast of the project was called *XaxtL!*, which means "brushy" (Waterman 2001:248).

Treaty Period

On December 24, 1854, the Treaty of Medicine Creek was signed by Governor Isaac I. Stevens and representatives of the Nisqually, Puyallup, Steilacoom, Squawskin, S'Homamish, Stehchass, T'Peeksin, Squi-aitl, and Sa-heh-wamish tribes and bands of Indians (Governor's Office of Indian Affairs 2022). Tribal representatives were invited to the treaty council under the impression that it was a potlatch and were instead pressured to sign the treaty papers despite many not being able to speak or read English (Puyallup Tribe of Indians 2022). The Treaty had the signing groups cede possession of their traditional lands to the United States Government for $32,500 (Governor's Office of Indian Affairs 1854). The Treaty established reservations at Puyallup, Nisqually, and on Squaxin Island that people had to move to within a year of its signing. Additionally, the Treaty secured tribal rights for certain practices.

The reservations established by the Treaty of Medicine Creek were too small for the local populations and were located far from the resources they traditionally relied on. Because of this the Puyallup Tribe and other groups participated in the Treaty Wars (also known as the Indian Wars) that occurred from 1855 to 1856. In August 1856, Isaac Stevens representing the U.S.

Government renegotiated the treaty at the Fox Island Council, where Puyallup Chief Squatahan led renegotiations that resulted in expansion or relocation of existing reservations and the formation of the Muckleshoot Reservation (Puyallup Tribe 2022).

Court Cases and Land Claims Settlement

Private land claims were made within the Puyallup Reservation following the 1854 Treaty (Figure 5). After the renegotiations of the Fox Island Council, the Puyallup reservation was further defined by executive orders in 1857 and 1873, granting the Tribe lands within modern-day Puyallup, Fife, Milton, and Tacoma (Douglas 2016). The General Allotment Act (also known as the Dawes Act) of 1887 allowed the federal government to break up tribal lands to sell to non-Native U.S. citizens, leading to the Tribe losing most of this land (National Park Service 2021). The Project land was claimed by Mary Sloan, an enrollee of the Puyallup Tribe (see Puyallup Indian Commission 1892; Figure 6). The Puyallup Tribe began asserting its rights to the lands originally designated under the Medicine Creek Treaty. The "Fishing Wars" of the 1960s and 1970s led to the 1974 Boldt decision, which reaffirmed the fishing rights of American Indians in Washington State (U.S. Department of Justice 2017). This legal victory led the Puyallup Tribe to pursue their claim to their original reservation land promised in the Medicine Creek Treaty, over 20,000 acres of land in the Tacoma region (Douglas 2016). In the 1978 case *Andrus v. City of Tacoma*, the Secretary of the Interior had been placing land within the Puyallup Reservation into a trust to restore that land to the Puyallup Tribe.

The 1983 Ninth Circuit court case *Puyallup Indian Tribe v. Port of Tacoma* recognized the Puyallup Tribe's rights to 12 acres of land along the Puyallup River exposed when the river was rechanneled (cite case). In 1984 the Puyallup Tribe filed a formal complaint against the Port of Tacoma and the Union Pacific Railroad to regain ownership of 120 acres of tideland along Commencement Bay and the Puyallup River (Douglas 2016). The lands claimed by the Tribe encompassed lands with industrial and harbor lands, as well as some segments of state highways. The U.S. House of Representatives report on the proposed Puyallup Land Claims Settlement estimated the claimed land to be worth approximately $750 million (Douglas 2016). Negotiations between the Tribe and non-native entities took place throughout the 1980s, and in 1990 the Puyallup Tribe accepted the settlement package called the Puyallup Land Claims Settlement. The settlement provided roughly $162 million in land, fisheries, and development. The Tribe received approximately 900 acres of land, and a trust fund created by the federal government that provided health, social, and welfare services to Tribal members (Douglas 2016). The settlement also gave each government entity the right to enforce environmental laws within their jurisdictions (Douglas 2016).

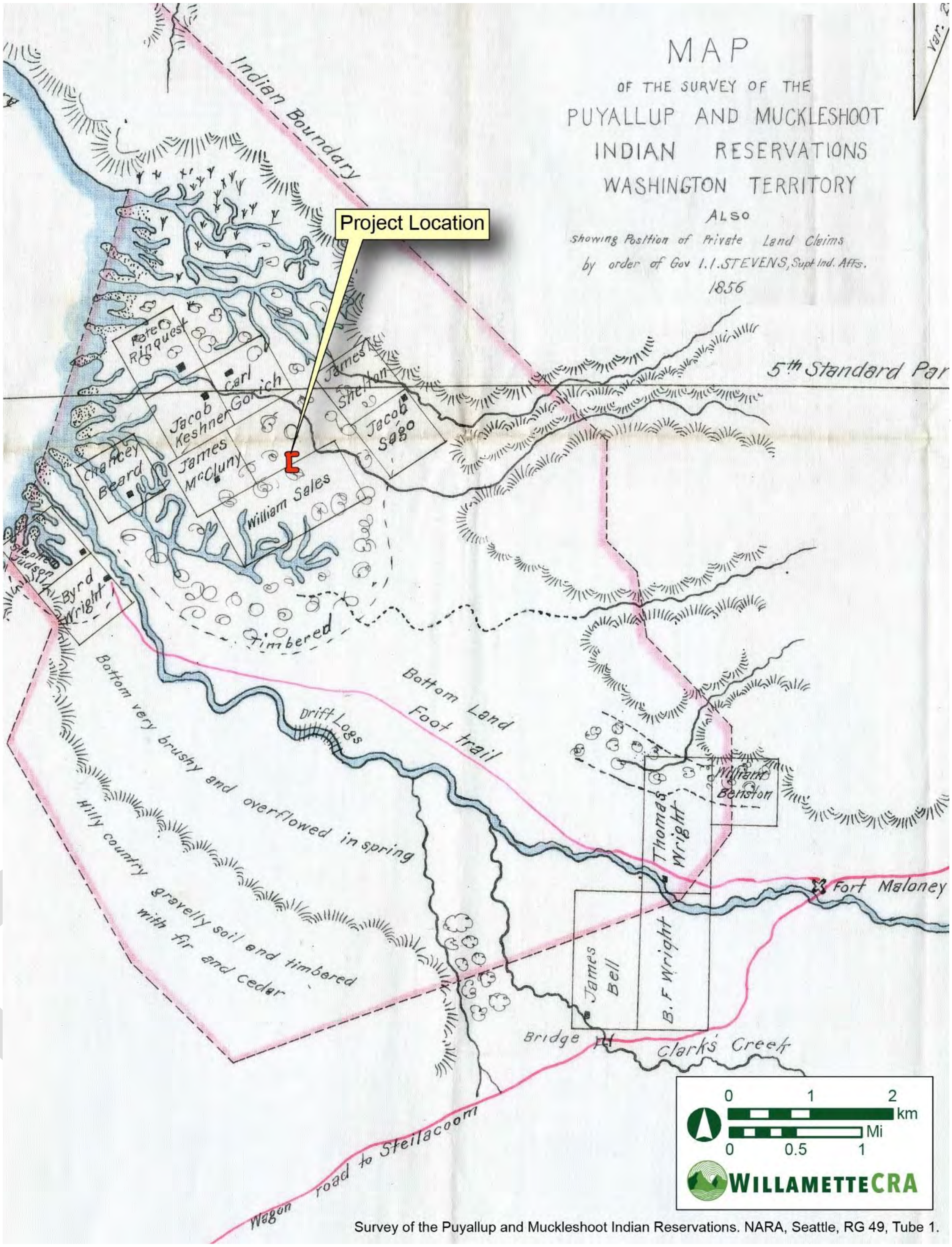

Figure 5. Project Location on 1856 Survey of the Puyallup Reservations.

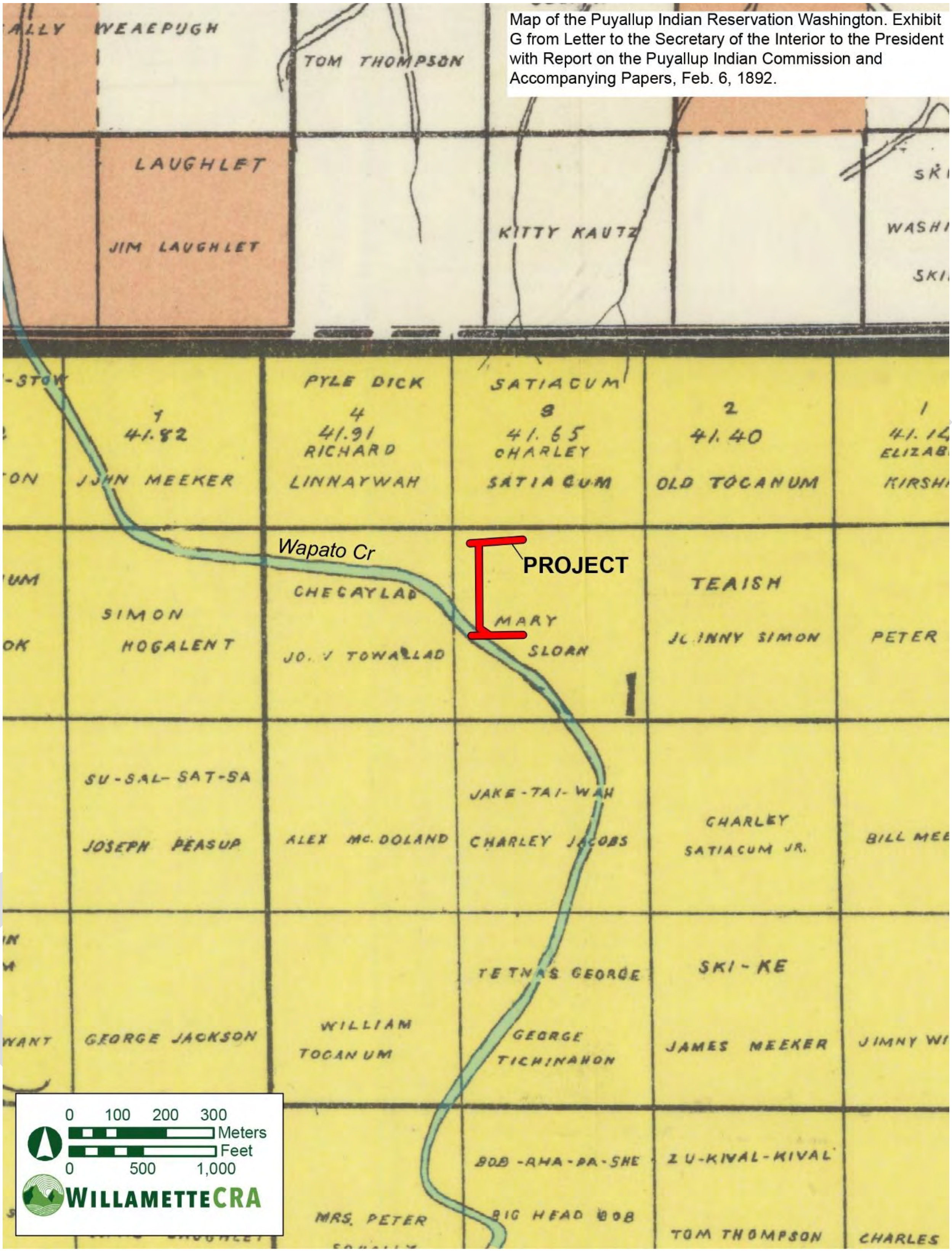

Figure 6. Project Location on 1892 Map of Puyallup Indian Reservation.

History and Land Ownership

Aerial photographs of the Project Location taken between 1940 and 2017 show changes that have been made to the landscape during the latter half of the twentieth century. By 1940, small farmsteads were scattered throughout the Project vicinity, and cultivated fields and orchards abutted the natural, meandering course of Wapato Creek (NETR 1940). By 1968, the entire landscape surrounding the Project Location had been completely cleared and levelled, and all aboveground buildings and structures had been removed. By this time, Wapato Creek had been channelized and State Route 509 had been constructed to the south of the Project (NETR 1968). A forest products processing facility was in place to the east of the Project and north of State Route 509 by 1980 (NETR 1969; 1980). This facility was removed between 2006 and 2009 (NETR 2006, 2009).

Previous Archaeological Investigations

WillametteCRA reviewed records on file with the Washington State Department of Archaeology and Historic Preservation (DAHP) online database (WISAARD) to identify previous cultural resources studies and archaeological or historical resources recorded though March 29, 2022, in the Project vicinity. The WISAARD review indicated six cultural resources studies within 0.5 miles of the Project Area (Table 1) and found none within the Project Area. Six archaeological sites are recorded within one mile of the Project Area (Table 2). Eight historic properties are recorded within 0.5 miles of the Project Area (Table 3). Due to the quantity of historic properties, the search was limited to a 0.5-mile radius.

The closest cultural resources investigation to the project was conducted by Parvey and Miss (2005). This investigation included monitoring test pit excavations for improvements in the Gog-le-hi-te II Mitigation Area. The investigation did not include fieldwork in the Blair Waterway due to extensive fill deposits and industrial development (Parvey and Miss 2005). 110 test pits were excavated to approximately 6 to 15 feet below surface. Monitors observed the top of landfill deposits between 1 fbs and 5.5 fbs underneath fill, and fine silt and sand was observed directly underneath landfill deposits at depths ranging from 2 to 12 fbs (Parvey and Miss 2005). Besides landfill material, no other cultural materials were observed.

Table 1. Previous Cultural Resource Studies within 0.5 Miles of the Project.

Author	Date	Project and Type of Investigation	Relation to Survey Area
Parvey and Miss	2005	Monitoring: Cultural Resources Assessment for the Port of Tacoma's Blair Waterway Infrastructure Improvements Project and Gog-le-hi-e II Mitigation Action Area, Pierce County, Washington	0.09 mi
Parvey	2007	Monitoring: Summary of 2006 Archaeological Monitoring Activities for the Blair Inner Reach Turning Basin Expansion Area and Southwest Corner Cutback	0.45 mi
Diedrich	2012	Monitoring: Archaeological Monitoring for Parcel 14, the East-West Road and Alexander Avenue, Tacoma, Pierce County, Washington	0.44 mi
Pierson and Johnson	2020	Monitoring: Results of Cultural Resources Monitoring for the Port of Tacoma – Parcel 14 Lower Wapato Combined Habitat Project Geotechnical Study, Pierce County, Washington	0.46 mi
Viloudaki and Amell	2019	Monitoring: Cultural Resource Monitoring of the Port of Tacoma Harbor Dredged Material Characterization Project, Tacoma, Pierce County, Washington	0.14 mi
Yamamoto e al.	2015	Survey: Cultural Resources Investigations for the Washington State Department of Transportation's SR 167 Tacoma to Puyallup New Freeway, Pierce County, Washington	0.5 mi

The nearest archaeological site to the Project, 45PI724, is a historic debris scatter likely representing a single dumping event (Cooper 2005). Historic artifacts recovered from an STP included machine cut square head nails, broken bottle glass, faunal bone fragments, brick fragments, charcoal, and white porcelain fragments, all likely dating from the 1920s-1950s (Cooper 2005). The site has not been given a determination of eligibility.

The closest pre-contact archaeological site to the project is 45PI974, called the Hylebos Estuarine Restoration Midden Site. The midden was identified approximately 2.14 meters below surface, buried by alluvium and fill (Shantry 2009). The shell midden is comprised of shell midden matrix, fire-modified rock (FMR), a bone point, and mammal and avian bone (Shantry 2009). The site was left buried and has not been given a determination of eligibility.

There are eight previously recorded historic properties within 0.5 miles of the project. The only property determined eligible for the NRHP is the Tacoma Bonneville Power Administration (BPA) Substation, located 0.31 miles north of the project area. The Substation includes the Control House, Condenser Building, and Switchyard. The property was determined eligible due to its original location and ability to convey association with the 1940s time period and BPA's Master Grid (Day 2016).

Table 2. Recorded Archaeological Sites within 1.0 Mile of the Project.

Site No.	Site Name	Site Type	Relation to Survey Area	Significance
45PI724	Wapato Creek Historic Debris Site	Historic Debris Scatter/Concentration	0.68 mi	No Determination
45PI974	Hylebos Estuarine Restoration Midden Site	Pre-contact Shell Midden	0.80 mi	No Determination
45PI047	Wapato Creek Fish Weir	Pre-contact Fish Weir	0.82 mi	No Determination
45PI1203	Sit’-chum	Pre-contact Camp	0.83 mi	No Determination
45PI1188	Kli’-e-ton	Pre-contact Projectile Point Isolate	0.89 mi	No Determination
45PI917	1st Wapato Creek Site	Historic Artifact Scatter	0.92 mi	No Determination

Expectations

The Washington State Department of Archaeology and Historic Preservation’s (DAHP) predictive model for precontact cultural materials classifies the Project Area as having Very High Risk to contain archaeological resources. The Project is known to be located atop large quantities fill overlying likely alluvium and deltaic deposits. Additionally, development prior to the mid-twentieth century filling episodes included homesteading by a Puyallup Tribal member and potentially an early private land claim. Deposits from these homesteading and land claimants or earlier use on the tidelands may be present beneath fill.

Fieldwork Methods

Monitoring documentation included recording observations of the environmental setting, field conditions, contacts, and sediments encountered on standard forms. The parking lot asphalt capping soils was cut and removed prior to drilling. Extracted soils were examined visually and photographed before geological samples were taken. Julia Kunas completed monitoring, and Austin Jenkins coordinated with the Project team and directed work.

WillametteCRA staff reviewed project plans, attended construction meetings for the duration of monitoring, reviewed the results of geotechnical exploration and the extracted sediments with the consulting geologist, and documented the progress of drilling. Digital photographs of the location and various stages of drilling were taken and recorded on photograph logs. All forms and photographs are on file at WillametteCRA, Seattle.

Table 3. Prev. Identified Historic Properties Extant within 0.5 mile of the Project Area.

Resource ID	Resource Name	Site Type	Relation to Project Area	Significance
721803	Switchyard, BPA Tacoma Substation	Historic Energy Facility	0.27 mi	No Determination
721836	Switchyard, BPA Tacoma Substation	Historic Hydroelectric Power Transmission	0.31 mi	No Determination
705968	Tacoma BPA Substation	Historic Hydroelectric Power Transmission	0.31 mi	Determined Eligible
721801	Control House, BPA Tacoma Substation	Historic Energy Facility	0.35 mi	No Determination
721802	Maintenance (Old Condenser Building), BPA Tacoma Substation	Historic Energy Facility	0.36 mi	No Determination
90826	Naval Reserve Training Center, Building 33	Naval Facility	0.45 mi	Not Eligible
721397	N/A	Single Family House	0.5 mi	No Determination
721399	N/A	Single Family Home	0.5 mi	No Determination

Results

Cascade Environmental drilled Monitoring Well 14 (MW-14) and Soil Borings (AB) 1, 2, 3, 4, 5, and 6 over two days, and Aspect Consulting took geological samples from the cores. MW-14 and AB-4 were drilled on November 16, 2021, and AB-1, 2, 3, 5, and 6 were drilled on November 17. All monitoring wells and borings were drilled with a Geoprobe 7822DT. MW-14 was drilled with a 6” wide auger (Figure 7), while all of the borings were taken with a direct-push drill (Figure 8). The borings taken were in 5-foot long cores, 2 inches wide. Kunas observed and photographed AB sediments prior to sampling, and spoils for MW-14 were taken and deposited for observation next to the drill from 12 to 25 feet below surface (fbs) for observation. All ABs and MW-14 were drilled to a final depth of 25 feet, so each AB had 5 cores for sampling.

Cultural Materials

No artifacts, features or other indications of human activity were observed during archaeological monitoring.

Figure 7. Drilling MW-14 with 6” auger and shoveling spoils for inspection. View northwest.

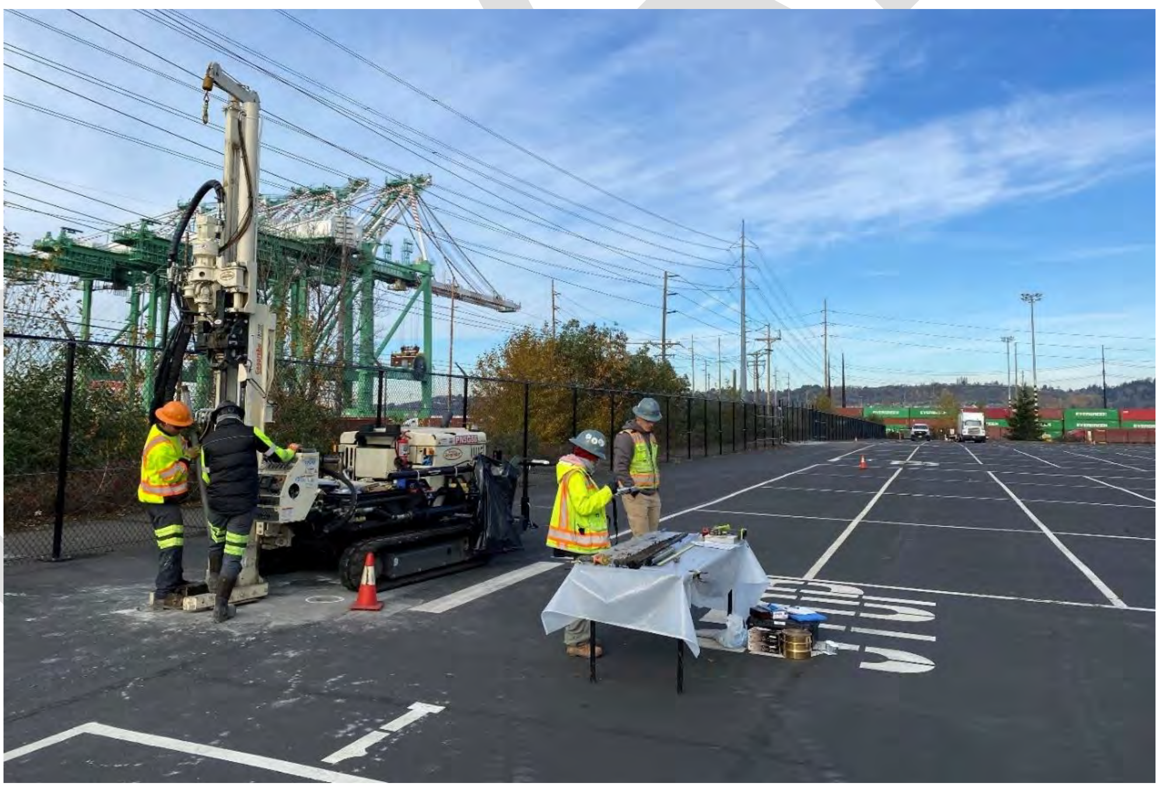

Figure 8. Boring for AB-2 with direct push drill, view northwest.

Stratigraphy

WCRA referred to the Aspect boring logs for stratigraphy information. Six soil borings and one monitoring well were excavated within the project area, reaching up to 25 feet below surface (fbs). In general, all of the borings had a fill/slag deposit from 0 to approximately 7 fbs. Silty sand to silt deposits were observed from approximately 7 to 20 fbs, and silty clay to clay deposits from about 20 to 25 fbs. AB-1 had a sandy silt deposit from 13 to 17 fbs, overlying a medium coarse black sand from 17 to 25 fbs that appeared to be alluvial creek deposits from elsewhere in the region (Figure 9). Woody organic materials were observed in the silt/clay in ABs 2-6 around 21 to 24.5 fbs. This deposit was approximately 6” thick, and generally appeared to be stringy woody debris (Figure 10). AB-1 had intact wood pieces in the coarse sand at 25 fbs (Figure 11), and the driller informed the sampling crew that the drilling was slower in that boring likely due to a log in the way. No cultural materials were observed within the native sediments.

Figure 9. Woody debris in AB-4, from approximately 24.5-25 fbs.

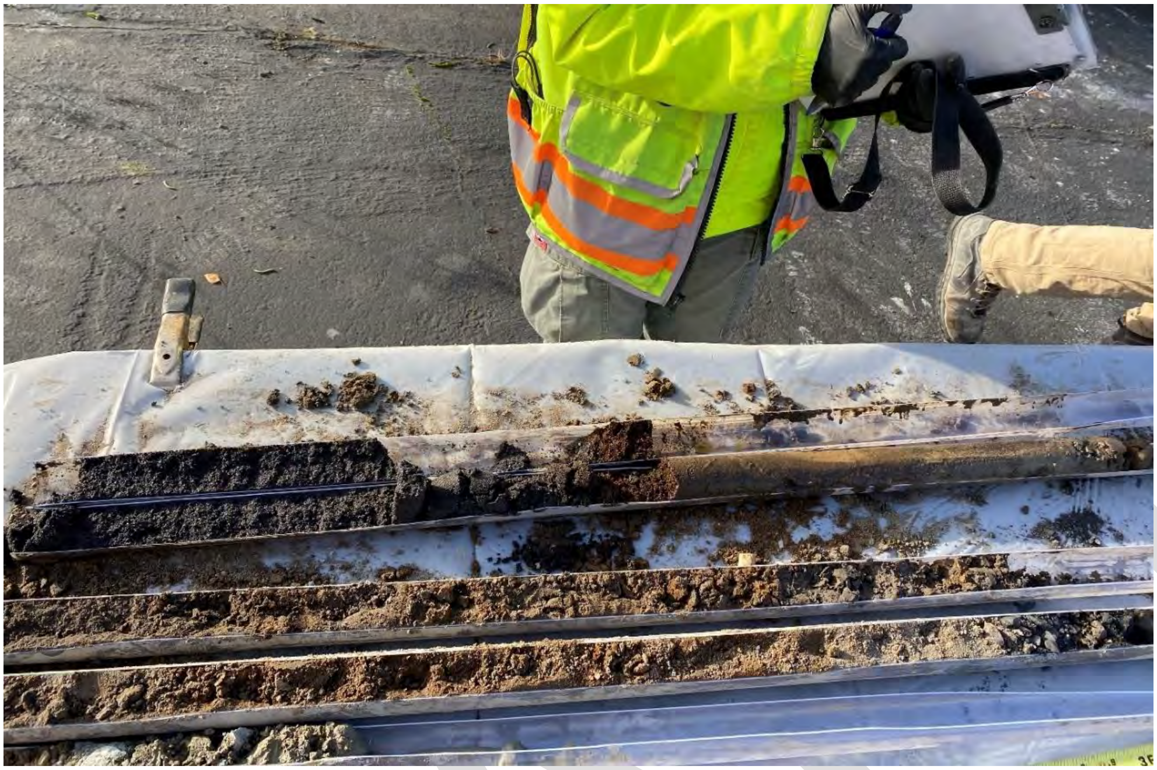

Figure 10. Core taken from AB-1, 15-20 fbs (top). Note transition from sandy silt (right) to coarse dark sand (left).

Figure 11. Wood debris from AB-1, taken from bottom of probe at 25 fbs.

Summary and Recommendations

WillametteCRA completed background research and observed drilling activities associated with the Pre-Remedial Design Investigation for the Project. No cultural resources were identified in the course of the work. WillametteCRA recommends that archaeological monitoring should occur where ground disturbance for the permeable reactive barrier will extend below existing fill and above restrictive clay. The southern vault replacement is expected to be located more closely to recent land claims. Due to the elevated potential for vault removal and any preparation of the pit for the future vault, WillametteCRA recommends monitoring vault removing and any leveling or excavation within the resultant pit. No additional work is recommended for the outfall restoration or slip lining activity, unless the slip lining requires additional excavation not otherwise associated with vault replacements.

Should the proposed work change from that depicted in Appendix A, these recommendations may not apply, and the changes should be reviewed by a professional archaeologist.

In the unlikely event that human remains are encountered at any time, the law (RCW 27.44.055) requires all activity to cease that may cause further disturbance to those remains, and the area of the find secured and protected from further disturbance. The finding of human skeletal remains will be reported to the Tacoma and Puyallup Tribal Police Department immediately. The remains will not be touched, moved, or further disturbed. The Coroner will assume jurisdiction over the human skeletal remains and determine whether those remains are forensic or non-forensic. If the Coroner determines the remains are non-forensic, they will report that finding to the DAHP, who will take jurisdiction over the remains. The DAHP will notify any appropriate cemeteries and all affected tribes of the find. The State Physical Anthropologist will determine whether the remains are Indian or Non-Indian, and report that finding to any appropriate cemeteries and the affected tribes. The DAHP will then handle all consultation with the affected parties as to the future preservation, excavation, and disposition of the remains.

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APPENDIX D

Permeable Reactive Barrier (PRB) Design Calculations

PERMEABLE REACTIVE BARRIER (PRB) DESIGN CALCULATIONS

Parcel 15 (Portac) Cleanup Phase 1

Prepared for: Port of Tacoma

Project No. 210158 • June 10, 2022 FINAL

earth + water

Aspect
CONSULTING

PERMEABLE REACTIVE BARRIER (PRB) DESIGN CALCULATIONS

Parcel 15 (Portac) Cleanup Phase 1

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1 Introduction

Aspect Consulting, LLC (Aspect) has prepared this Permeable Reactive Barrier (PRB) Design Calculations Report as an appendix to the Engineering Design Report (EDR) 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 Portac Phase 1 Cleanup activities. The scope of the EDR is limited to the Phase 1 Cleanup, consisting of two construction elements: stormwater conveyance improvements and a permeable reactive barrier (PRB). This EDR appendix presents all engineering design criteria and calculations for the remedial design of the PRB.

A Remedial Design Work Plan defined Pre-Remedial Design Investigation (PRDI) activities of a PRB Alignment Investigation and Treatability Testing (Aspect, 2021). The results of the PRB Alignment Investigation established the basis of design for PRB length and depth presented in the EDR. This PRB Design Calculations Report presents all other engineering design criteria for the PRB.

2 Aquifer Hydraulics

2.1 Hydraulic Conductivity Estimates for Aquifer

Grain-size analysis data from soil samples from the PRB Alignment Investigation boring AB-03 and the remedial investigation (RI) collected below the water table were used to estimate hydraulic conductivity (K) using the HydrogeoSieveXL (version 2.3.5) program[1]. Grain-size curves are included as Figure 1. HydrogeoSieveXL estimates hydraulic conductivity using 14 different methods, including Hazen and Kozeny-Carmen. Grain-size data from AB-03-16.5, AB-03-20, AB-03-22, TBS005-17_18, and TBS007-16.5_17.5 was input into HydrogeoSieveXL, and the exports from the program are included as Attachment A. The arithmetic mean of all methods that met the criteria of the program was calculated as follows:

[1] J.F. Devlin Software, http://www.people.ku.edu/~jfdevlin/Software.html.

Table 1. Hydraulic Conductivity Estimates

Sample Location	Methods Used	Average Estimated K (ft/day)
AB-03-16.5	Sauerbrei, Zunker, Barr, Krumbein and Monk, Shepherd	7.8
AB-03-20	Sauerbrei, Zunker, Barr, Krumbein and Monk, Shepherd	8.7
AB-03-22	Sauerbrei, Zunker, Barr, Krumbein and Monk, Shepherd	7.5
TBS005-17_18	Sauerbrei, Barr, Krumbein and Monk, Shepherd	5.0
TBS007-16.5_17.5	Sauerbrei, Barr, Shepherd	9.4
Average K (ft/day)		8.3
Maximum K (ft./day)		17.4

Notes:

- TBS005-17_18 was excluded from the average and was used as the minimum hydraulic conductivity value.
- Although the Alyamani and Sen method was considered to have its criteria met, hydraulic conductivities calculated by this method were rejected due to being outliers.
- Ft = feet

Based on these estimates of hydraulic conductivity, 8.3 ft/day was used for the average aquifer K and 17.4 ft/day was used as the maximum K in the PRB design calculations.

2.2 Hydraulic Gradients

The groundwater horizontal hydraulic gradient (i) in the PRB area is estimated using historical water levels from eight groundwater monitoring events from 2016 through 2022. Horizontal hydraulic gradients were calculated using the EPA Online Tool for Hydraulic Gradient Magnitude and Direction[2], which uses a least-squares fitting of the data to a plane. A three-point hydraulic gradient was calculated for each monitoring event using upgradient well B-1R and downgradient wells MW-7 and MW-9 as shown in Table 2 below.

[2] EPA Online Tool for Site Assessment Calculation, updated on August, 31, 2021, https://www3.epa.gov/ceampubl/learn2model/part-two/onsite/gradient4plus-ns.html.

Table 2. Horizontal Hydraulic Gradient (2016-2022)

Sample Date	Horizontal i (ft/ft)	Flow direction as degrees from West [1]
5/9/2016	0.007	9.3
8/31/2016	0.006	13.8
11/15/2016	0.007	22.5
2/7/2017	0.006	15.4
2/19/2019	0.008	15.3
8/1/2019	0.004	20.1
12/5/2021[2]	0.002	-104.7
3/28/2022	0.003	-28.7
Average i	0.006	

Notes:

1) Assuming west is zero degrees, positive values are clockwise, and negative values are counterclockwise.
2) Water levels were collected during high tide on December 5, 2021. MW-7 is tidally influenced, which affects the approximate flow direction. The hydraulic gradient from December 5, 2021, was not included in the average.

The horizontal hydraulic gradient was confirmed using water levels collected in December 2021 from monitoring wells MW-9 and MW-11, the closest downgradient and upgradient monitoring wells, respectively. These wells are approximately 761 feet apart. Additionally, groundwater elevation contours closest to the PRB alignment at 11 ft mean lower low water (MLLW) and 12 ft MLLW were also used to calculate the horizontal gradient by determining the distance between four different transects (a through d).

The horizontal hydraulic gradient is calculated as:

$$i = \frac{water\ level\ (WL)\ difference}{Horizontal\ Distance}$$

Therefore, at MW-9 (10.76 ft) and MW-11 (12.96 ft), which are 761 feet apart, the horizontal hydraulic gradient is:

$$i = \frac{12.96\ [ft] - 10.76\ [ft]}{761\ [ft]} = \frac{2.2\ [ft]}{761\ [ft]} = 0.003\left[\frac{ft}{ft}\right]$$

The hydraulic gradient from December 2021 is shown in Table 3. The locations labeled “a” through “d” are four transects where the difference between two contours on the potentiometric surface map was measured, as shown on Figure 2.

Table 3. Horizontal Hydraulic Gradient (December 2021)

Sample Location	WL Difference (ft)	Horizontal Distance (ft)	Horizontal i (ft/ft)
a	1	314	0.003
b	1	265	0.004
c	1	250	0.004
d	1	208	0.005
MW-9 to MW-11	2.2	761	0.003
		Average i (geomean)	0.004

The calculated gradient of 0.006 ft/ft from the historical data is slightly higher than the average gradient of 0.004 ft/ft estimated from December 2021 potentiometric surface map (Figure 2). Since the calculated gradient from December 2021 relies on the estimated groundwater contours, the higher estimate of 0.006 ft/ft is used for PRB design calculations to be more conservative. This higher estimate is conservative because it results in faster seepage velocities and shorter residence times in the PRB.

2.3 Aquifer Mobile Porosity

The mobile porosity of the silty sand (SM) and sand with silt (SP-SM) soils is estimated to be 10% based on the stratigraphic descriptions of the alluvium. Tracer tests have not been conducted to measure the mobile porosity in the field. A 10% mobile porosity is a reasonable estimate based on tracer testing conducted at other sites in similar soils (Payne et al, 2008).

2.4 Maximum Groundwater Elevations

The maximum groundwater elevation measured over eight events from monitoring wells MW-7, MW-9, and MW-12 downgradient of the PRB alignment is tabulated in Table 4. The location MW-14 was installed during the PRB Alignment Investigation, and the maximum value is from two events. Sitewide groundwater elevations from 2016 through 2022 are included as Table 5.

Table 4. Maximum Groundwater Elevation

Sample Location	Maximum Groundwater Elevation (ft MLLW)
MW-7	10.84
MW-9	11.31
MW-12	10.67
MW-14	11.16

The top of reactive material in the PRB should exceed the groundwater elevation for the lifetime of the PRB. The maximum groundwater elevation is 11.5 ft MLLW, as shown in the calculation below. Predicted future groundwater elevations is discussed in the next section.

$$Maximum\ groundwater\ elevation = maximum\ measured\ GW\ elevation + hydratulic\ gradient * distance\ of\ well\ from\ PRB$$

$$Maximum\ groundwater\ elevation = 11.31\ ft\ MLLW + 0.006 \left[\frac{ft}{ft}\right] * 30\ [ft] = 11.5\ ft\ MLLW$$

2.5 Aquifer Saturated Thickness

The aquifer saturated thickness was taken from soil borings in the vicinity of the PRB. The PRB Alignment Investigation determined there is a low permeability clay unit on the PRB alignment at elevations ranging from 5.3 to 4.0 ft MLLW, which serves as the basis of PRB depth. The construction of the PRB will be keyed into this low permeability clay unit to prevent groundwater flow under the PRB.

The saturated thickness is estimated based on groundwater head above the low permeability clay unit. The following points shown in Table 6 are in the immediate vicinity of the PRB:

Table 6. Saturated Thickness

Sample Location	Maximum Groundwater Elevation (ft MLLW)	Top of Clay Elevation (ft MLLW)	Saturated Thickness (b) (ft)
MW-7	10.84	4.0	6.8
MW-9	11.31	4.2	7.1
MW-12	10.67	5.3	5.4
MW-14	11.16	4.0	7.2
		Maximum	7.2

Notes: Clay elevations at MW-7, MW-9, and MW-12 were estimated based on AB-04, AB-03, and AB-02, respectively.

Therefore, the saturated thickness of the aquifer at the PRB area is assumed to be 7.2 feet for estimating arsenic loading. In order to determine the top of PRB elevation, a safety factor will be added to the maximum groundwater elevation to account for climate change and to span the fine-grained deposits beginning at an elevation of approximately 11 ft MLLW. Due to the proximity of the Site to Wapato Creek, which has a tidal influence, a safety factor of 2.5 ft will be included to account for possible sea level rise due to climate change in the next 30 years. Estimated sea level rise in the Puget Sound is projected to be +24 inches in the year 2100 (with a range of +4 to +54 inches) compared to the year 2000 (University of Washington, 2015). The top of the reactive backfill is therefore assumed to be at an elevation of 14.0 ft MLLW. The PRB will be keyed into the clay layer by 6 inches, resulting in a maximum bottom elevation of 3.5 ft MLLW, and a total PRB depth of 10.5 feet.

2.6 Aquifer Darcy Flux

The Darcy flux, which is the groundwater flux per unit area, can be calculated using Darcy's law:

$$q = K * i$$

Where:

K [ft/day]: hydraulic conductivity of the aquifer

i [ft/ft]: horizontal hydraulic gradient

$$q_{AQ}[ft/day] = Hydraulic\ Conductivity\ (K) * Hydraulic\ Gradient\ (i)$$

For the PRB area, the average Darcy flux in the aquifer is:

$$q_{AQ\ Avg} = 8.3 \left[\frac{ft}{day}\right] * 0.006 \left[\frac{ft}{ft}\right] = 0.05 \left[\frac{ft}{day}\right]$$

For the PRB area, the maximum Darcy flux in the aquifer is:

$$q_{AQ\ Max} = 17.4 \left[\frac{ft}{day}\right] * 0.006 \left[\frac{ft}{ft}\right] = 0.1 \left[\frac{ft}{day}\right]$$

2.7 Aquifer Seepage Velocity

The seepage velocity, which is the rate of advective groundwater flow, can be calculated with the following equation:

$$v = \frac{q}{\phi_{eff}}$$

Where:

v[ft/day] = aquifer seepage velocity;

q[ft/day] = Darcy flux from in the aquifer entering the PRB

ϕ_{eff} = mobile porosity of the aquifer (10%).

For the aquifer upgradient of the PRB the average seepage velocity is:

$$v_{AQ\ Avg} = \frac{q}{\phi_{eff}} = \frac{0.05 \left[\frac{ft}{day}\right]}{0.1} = 0.5 \left[\frac{ft}{day}\right]$$

For the aquifer upgradient of the PRB the maximum seepage velocity is:

$$v_{AQ\ Max} = \frac{q}{\phi_{eff}} = \frac{0.1\left[\frac{ft}{day}\right]}{0.1} = 1.0\left[\frac{ft}{day}\right]$$

2.8 Groundwater Flow Through PRB

The groundwater flow through the PRB is estimated for estimating arsenic loading and PRB lifetime. The saturated PRB cross-sectional area is estimated at 4,781 square feet (ft^2) based on a total length of 664 ft and saturated thickness of 7.2 ft.

$$GW\ Flow\ (Q) = Average\ Aquifer\ Darcy\ Flux * Area(b * design\ length)$$

$$Q_{PRB} = 0.05\left[\frac{ft}{day}\right] * 4{,}781[ft^2] = 227\left[\frac{cubic\ feet\ (ft^3)}{day}\right]$$

This is equivalent to an estimated groundwater flow through the PRB of 1.2 gallons per minute.

3 Influent Groundwater Quality

3.1 Influent Arsenic Concentration

The PRB influent arsenic concentration is based on upgradient monitoring well MW-14. MW-14 was installed approximately 30 feet upgradient of the PRB alignment, with the purpose of representing influent groundwater quality. The arsenic concentrations encountered at MW-14 are consistent with grab groundwater samples from the PRB alignment investigation, if not slightly higher. The arsenic concentration at MW-14 is a conservative basis for the PRB influent arsenic concentration. The average influent arsenic concentration is 68 µg/L, and the maximum influent arsenic concentration is 126 µg/L, as shown in Table 7 below.

Table 7. MW-14 Arsenic Concentration

Sample Location	Activity	Sample Date	Dissolved Arsenic (µg/L)	Total Arsenic (µg/L)
MW-14	Groundwater Monitoring	11/24/2021	48.7	49.9
MW-14	Column Testing Influent	11/29/2021	60.8	57.7
MW-14	Column Testing Influent	11/30/2021	43.8	44.3
MW-14	Column Testing Influent	12/1/2021	44.7	45.2
MW-14	Column Testing Influent	12/2/2021	83.7	91.2

Sample Location	Activity	Sample Date	Dissolved Arsenic (µg/L)	Total Arsenic (µg/L)
MW-14	Column Testing Influent	12/6/2021	126	73.0
		Average	68	60
		Maximum	126	91

3.2 Current Arsenic Loading Rate

Due to the variability in arsenic concentrations at MW-14, the maximum dissolved arsenic concentration was used as the most conservative value. The current maximum arsenic influent concentration at the PRB is 126 µg/L from MW-14.

$$Arsenic\ Loading\ (Load_{As}) = Arsenic\ concentration\ (C) * Groundwater\ flux\ (Q)$$

$$Load_{As} = 126 \left[\frac{\mu g\ As}{L}\right] * 226 \left[\frac{ft^3}{day}\right] * 28.3 \left[\frac{L}{ft^3}\right] * \frac{1}{4.54x10^8} \left[\frac{lb\ As}{\mu g\ As}\right] = 1.8x10^{-3} \left[\frac{lb\ As}{day}\right]$$

3.3 Arsenic Loading Rate Over PRB Lifetime

The arsenic loading rate over the lifetime of the PRB is calculated as follows. A 30-year lifetime is assumed.

$$Total\ Arsenic\ Load = Load_{As} * Design\ Lifetime$$

$$PRB\ Total\ Arsenic\ Load = 1.8x10^{-3} \left[\frac{lb\ As}{day}\right] * 30\ [years] = 20\ [lbs\ As]$$

4 ZVI and Arsenic Chemistry

4.1 Uptake Capacity

Literature values of total arsenic uptake capacity by ZVI range between 0.7 and 7.5 milligrams per gram (mg/g) (Su, 2006), with values for Connelly GPM ranging between 0.77 and 4.4 mg/g (Nikolaidis et al., 2003). A literature-derived value of 1.0 mg/g for Connelly GPM ZVI was used in the PRB design calculations.

Column testing can be used to estimate this value if columns are operated until the ZVI treatment capacity is exhausted and the arsenic breaks through. This was not an objective of the completed column testing, and the literature values are reliable for PRB design.

4.2 Calculated ZVI Demand

The amount of ZVI to be placed within the PRBs can be calculated based on the total arsenic load expected to occur over an assumed 30-year design life (Section 3.3) using the following equation:

$$ZVI_{PRB} = \frac{As\ Load_{PRB}}{ZVI_{AsUptake}}$$

Where:

ZVI_{PRB} [lbs] = ZVI mass to be placed with PRB

As $Load_{PRB}$ [lbs]: total mass of arsenic to be sequestered within PRB over design lifetime of 30 years

$ZVI_{AsUptake}$ [lbs/lbs]: the amount of arsenic in groundwater to be sequestered by a given amount of ZVI as assumed from literature values, 1 mg/g = 0.001lbs/lbs (Section 4.2).

For the PRB:

$$ZVI_{PRB} = \frac{20\ [lb\ As]}{0.001\left[\frac{lb\ As}{lb\ ZVI}\right]} = 19{,}513\ [lb\ ZVI] = 10\ [tons\ ZVI]$$

The minimum ZVI content based on an arsenic loading of 1 mg/g can also be calculated as a percentage of the total mass and volume of the PRB.

By weight:

$$Total\ \%\ ZVI\ Demand\ by\ weight = \frac{Weight\ of\ ZVI}{Weight\ of\ ZVI + Sand}$$

$$Total\ \%\ ZVI\ Demand\ by\ weight = \frac{19{,}513\ [lb\ ZVI]}{\left(4{,}781[ft^2] * 2\ [ft] - \frac{19{,}513\ [lb\ ZVI]}{160\left[\frac{lb\ ZVI}{ft^3}\right]}\right) * 125\left[\frac{lb\ sand}{ft^3}\right]} = 1.7\%\ ZVI\ by\ weight$$

By volume:

$$Total\ \%\ ZVI\ Demand\ by\ volume = \frac{Volume\ of\ ZVI}{Volume\ of\ PRB}$$

$$Total\ \%\ ZVI\ Demand\ by\ volume = \frac{\frac{19{,}513\ [lb\ ZVI]}{160\left[\frac{lb\ ZVI}{ft^3}\right]}}{4{,}781[ft^2] * 2\ [ft]} = 1.3\%\ ZVI\ by\ volume$$

4.3 PRB ZVI Content

The PRB will be backfilled with 20% ZVI, 80% sand by mass. The 20% column demonstrated a slightly better removal rate, without resulting in any undesired secondary water quality, like increased pH. The greater ZVI content will also result in a greater lifetime for arsenic removal.

4.4 Reaction Kinetics

The arsenic concentration profiles collected along the length of the columns in the bench tests were used to determine arsenic uptake kinetics. The primary goal in these tests was to choose flow rates that were sufficiently slow to yield complete uptake of arsenic and to be able to measure kinetic rates (e.g., Lien and Wilkin, 2005).

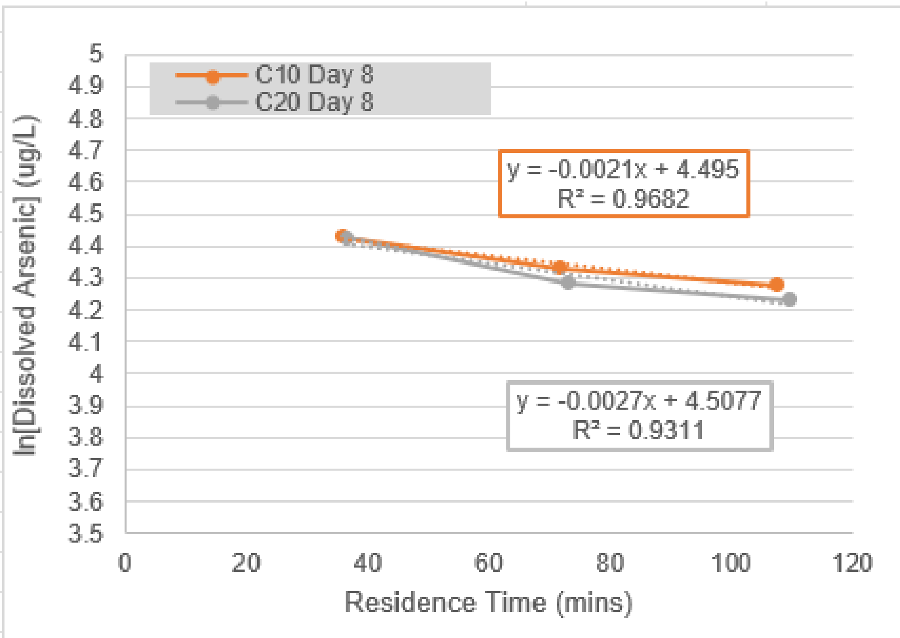

Figure 3. First-Order Reaction Rate (also shown as an attachment to this report).

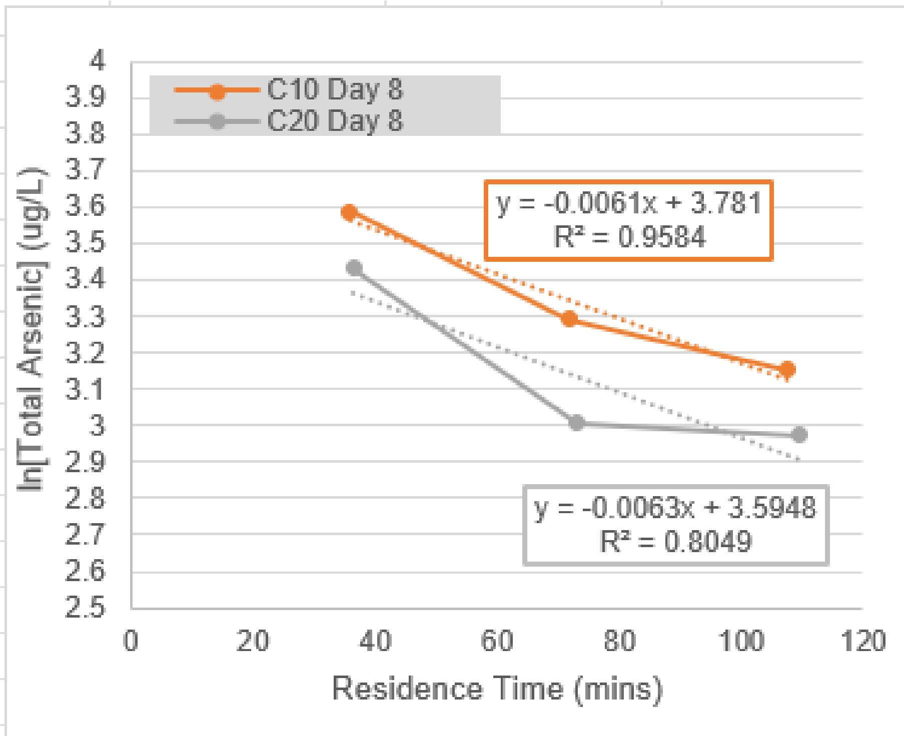

Figure 3. First-Order Reaction Rate (also shown as an attachment to this report).

The dissolved and total arsenic concentration profiles for the 10% ZVI (C10) and 20% ZVI (C20) columns are shown in the figure above. Arsenic uptake rates, half-life, and R^2 values for the first-order kinetic fits are included in Figure 3.

The total and dissolved arsenic results were adjusted for arsenic loss observed in the control column (CC). This adjustment used values of 63.5 micrograms per liter (µg/L) (dissolved) and 13.1 µg/L (total), based on the difference in influent and CC Port 1 concentrations. The first-order uptake rate of 3.9 day^{-1}, estimated from dissolved arsenic from the C20 column was used in the PRB design. This is consistent with literature values for first-order arsenic removal rates of 0.21 to 1.15 day^{-1} (Lien and Wilkin, 2005). Without the adjustment, the estimated first-order uptake rate was 9 to 25 $days^{-1}$, significantly higher than literature values. Other scenarios of arsenic loss adjustments, and/or fitting all four data points were estimated for uncertainty analysis all of which resulted in estimated first-order uptake rates greater than 3.9 day^{-1}, supporting the use of this value as a conservative estimate for estimating required residence time and PRB thickness.

5 PRB Hydraulics

5.1 Flow Regime

The PRBs are being designed assuming "plug flow" implying that transport within the PRBs is dominated by advective processes.

5.2 Darcy Flux in PRB

Applying the continuity equation between the groundwater flow in the aquifer and the flow in the PRBs implies that the Darcy flux in the aquifer entering the PRBs needs to be maintained:

$$q_{AQ} = q_{PRB}[ft/day] = Hydraulic\ Conductivity\ (K) * Hydraulic\ Gradient\ (i)$$

$$q_{AQ\ Avg} = q_{PRB\ Avg}[ft/day] = 8.3\left[\frac{ft}{day}\right] * 0.006\left[\frac{ft}{ft}\right] = 0.05\left[\frac{ft}{day}\right]$$

$$q_{AQ\ Max} = q_{PRB\ Max}[ft/day] = 17.4\left[\frac{ft}{day}\right] * 0.006\left[\frac{ft}{ft}\right] = 0.1\left[\frac{ft}{day}\right]$$

5.3 Minimum Residence Time in PRB

The minimum residence time is the minimum time based on an influent concentration and a reaction-rate to achieve a target concentration and is calculated using the following equation:

$$C_{target} = C_{in} * e^{-\lambda tmin}$$

Solving for t_{min}:

$$t_{min} = \frac{1}{\lambda} * Ln(\frac{C_{in}}{C_{target}})$$

Where:

C_{target} [µg/L]: target effluent concentration, design is based on C_{target} = 5 µg/L, which is the groundwater cleanup level for arsenic;

C_{in} [µg/L]: influent concentration to PRB;

λ [day^{-1}]: first order reaction rate, estimated at 3.9 day^{-1} from 20 wt% ZVI column;

t_{min} [days]: minimum time required to achieve target concentration of 5 µg/L

For the PRB:

C_{in} = 126 µg/L, based on maximum concentration at upgradient well MW-14

$$t_{\min}\,[days] = \frac{1}{3.9\,[days^{-1}]} * Ln\left(\frac{126\left[\frac{\mu g}{L}\right]}{5\left[\frac{\mu g}{L}\right]}\right) = 0.8\,[days]$$

The minimum residence time is 0.8 days, or 20 hours.

5.4 Porosity Reduction in PRB

Anticipated porosity reductions within the PRBs due to mineral fouling were estimated based on geochemical modeling. These estimates were based on the following assumptions:

- Consumption of dissolved oxygen resulting in Fe oxidation and the formation of iron oxides.
- Consumption of bicarbonate resulting first in the formation of $CaCO_3$, followed by $MnCO_3$, followed by $FeCO_3$ mineral phases.
- Consumption of sulfate resulting in the formation of FeS mineral phases.
- Consumption of arsenic resulting in the formation of As_2S_3. (Although As_2S_3 is assumed to be a minor arsenic phase, it accounts for the potential change in precipitate volume due to arsenic uptake.)

A mobile porosity of 0.4 and a total porosity of 0.5 are assumed within the PRB. All precipitation is conservatively assumed to occur in the mobile zone. The assumed mobile fraction of the total porosity is reasonable and conservative in comparison to the column studies.

Porosity reductions may also result from hydrogen gas formation and accumulation. For 100 wt% ZVI columns, typical porosity reductions of ~10% of the initial porosity have been observed in laboratory columns (e.g., Zhang and Gillham, 2005). Since the ZVI content of the PRBs is substantially lower than 100%, and no gas accumulation was observed in the 20 wt% ZVI column, a gas accumulation value of 5% of the initial porosity over the 30-year lifetime of the PRBs is assumed.

The total porosity reduction is calculated using the following equation:

$$\Delta\phi = d\phi_{precip} * t + \Delta\phi_{gas}$$

Where:

$\Delta\phi$ [unitless]: total cumulative reduction in mobile porosity over the PRB lifetime;

$d\phi_{precip}$ [$year^{-1}$]: annual reduction in mobile porosity due to secondary mineral formation, as calculated in the Treatability Testing Report

$\Delta\phi_{gas}$ [unitless]: cumulative reduction in mobile porosity due to gas accumulation, here assumed to be 5% of the mobile porosity;

t [years]: PRB lifetime

For the PRB:

$$d\phi_{precip} = 0.0007 \text{ year}^{-1}$$

$$\Delta\phi = 0.0007[years^{-1}] * 30[years] + 0.05 * 0.4 = 0.04$$

Typical values for the annual change in porosity due to mineral precipitation observed in other PRBs range from 0.0007 to 0.03 per year (Li et al., 2005), depending strongly on flow rate and groundwater chemistry. The estimate from the geochemical evaluation of cumulative porosity loss is below this range. Therefore, the total cumulative reduction in mobile porosity has been adjusted to 0.1 to provide a more conservative estimate for mineral precipitation, PRB seepage velocity, and for determining PRB thickness

5.5 Seepage Velocity in PRB

The seepage velocity in the PRBs is calculated using following equation:

$$v = \frac{q}{\phi_{eff}}$$

Where:

v[ft/day] = seepage velocity;

q[ft/day] = Darcy flux from the alluvium entering the PRB (calculated in section 2.6)

ϕ_{eff} [ ] = mobile porosity of the PRB

The estimated initial mobile porosity of the PRB is 40%.

For the PRB the initial seepage velocity is:

$$v_{PRB\ Initial} = \frac{q_{PRB}}{\phi_{eff\ Initial}} = \frac{0.1\left[\frac{ft}{day}\right]}{0.4} = 0.25\left[\frac{ft}{day}\right]$$

$$0.25\left[\frac{ft}{day}\right](inside\ PRB) < 1.0\ \left[\frac{ft}{day}\right](in\ aquifer)$$

$$v_{PRB\ Initial} < v_{AQ}$$

The initial seepage velocity of the PRB is lower than the groundwater in the aquifer entering the PRB.

However, as groundwater flows through the PRBs porosity reductions caused by mineral fouling will occur, which will result in increased seepage velocities and reduced residence times at the end of the design PRB lifetime of 30 years. For design purposes the minimum residence times need to be calculated at the end of the PRBs lifetime to meet design effluent concentrations throughout the PRBs operation period.

The mobile porosity reductions were calculated for both PRBs as described in section 5.4.

For the PRB, the maximum reduction in mobile porosity after 30 years is a total of 0.1, which results in a final mobile porosity of 0.3.

For the PRB the final seepage velocity is:

$$v_{PRB\ Final} = \frac{q_{PRB}}{\phi_{eff\ Final}} = \frac{0.1\left[\frac{ft}{day}\right]}{0.3} = 0.33\left[\frac{ft}{day}\right]$$

5.6 Minimum PRB Thickness

The minimum PRB thickness can then be calculated using the minimum residence time and the maximum seepage velocity within the PRB using the following equation:

$$W_{PRB\ Min} = t_{\min PRB} * v_{PRB\ Final}$$

Where:

W_{PRB} [ft] = minimum PRB flow through thickness to meet C_{target}

For the PRB:

$$W_{PRB\ Min} = t_{\min PRB} * v_{PRB\ Final} = 0.8\ [days] * 0.33\left[\frac{ft}{day}\right] * 12\left[\frac{in}{ft}\right] = 3\ [inch]$$

5.7 Pore Volume

The total pore volume of the PRB can be calculated as:

$$Pore\ Volume\ (PV)_{PRB} = PRB\ Volume * Mobile\ Porosity$$

$$PV_{PRB} = 9{,}562\ [ft^3] * 40\%$$

$$PV_{PRB} = 28{,}610\ [gallons]$$

The pore volume rate of the PRB can be calculated as:

$$Pore\ Volume\ Rate_{PRB} = \frac{Groundwater\ Flux\ (Q)}{Pore\ Volume\ (PV)}$$

$$PFR_{PRB} = \frac{1.2\ \left[\frac{gal}{min}\right]}{28{,}610\ [gallons]}$$

$$PFR_{PRB} = 0.059\ \left[\frac{PV}{day}\right] = 22\ \left[\frac{PV}{year}\right]$$

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TABLE

Table 5. Groundwater Elevations

FINAL

Project No. 210158, Port of Tacoma Parcel 15 (Portac), Cleanup Phase 1, Tacoma, Washington

Well ID	Groundwater Elevation (ft MLLW)								Minimum	Maximum
	Event 1	Event 2	Event 3	Event 4	Event 5	Event 6	Event 7	Event 8		
	5/9/2016	8/31/2016	11/15/2016	2/7/2017	2/19/2019	8/1/2019	12/17/2021	3/28/2022		
B-1R	11.16	10.81	12.06	12.05	11.93	10.12	11.18	11.43	10.12	12.06
B-3R	--	13.54	14.39	14.6	14.25	13.44	14.08	14.84	13.44	14.84
B-5R	8.09	8.37	9.17	10.69	9.06	8.9	10.4	9.01	8.09	10.69
B-6R	--	11.26	12.73	13.91	12.6	--	12.52	12.44	11.26	13.91
HC-2	16.78	16.23	15.97	16.3	15.56	15.49	16.11	16.55	15.49	16.78
MW-1	9.93	9.76	11.96	11.85	11.32	9.7	11.01	10.58	9.7	11.96
MW-2R	10.61	10	13.5	15.51	12.69	10.05	12.49	11.1	10	15.51
MW-3	10.69	10.04	11.36	12.56	11.63	10.08	11.11	10.77	10.04	12.56
MW-4	9.85	9.78	13.28	12.57	11.4	9.66	--	--	9.66	13.28
MW-5R	--	10.32	12.13	11.52	11.48	9.73	10.58	10.26	9.73	12.13
MW-6R	10.65	10.15	11.11	11.13	11.15	9.72	10.83	10.4	9.72	11.15
MW-7	9.65	9.72	10.82	10.81	10.42	9.44	11.2	10.84	9.44	11.2
MW-8	--	14.46	15.25	15.38	15.11	14.43	15.37	15.62	14.43	15.62
MW-9	9.82	9.94	11.31	11.1	10.77	9.67	10.76	10.52	9.67	11.31
MW-10	--	15.9	16.44	17.21	16.77	16.35	17.16	16.81	15.9	17.21
MW-11	13.02	12.4	13.19	13.2	13.12	12.25	12.96	13.36	12.25	13.36
MW-12	9.45	9.61	10.67	10.43	10.29	9.38	10.62	10.13	9.38	10.67
MW-13	16.59	16.05	16.53	17.3	16.77	16.43	17.16	16.83	16.05	17.3
MW-14	--	--	--	--	--	--	11.16	11.1	11.1	11.16

FIGURES

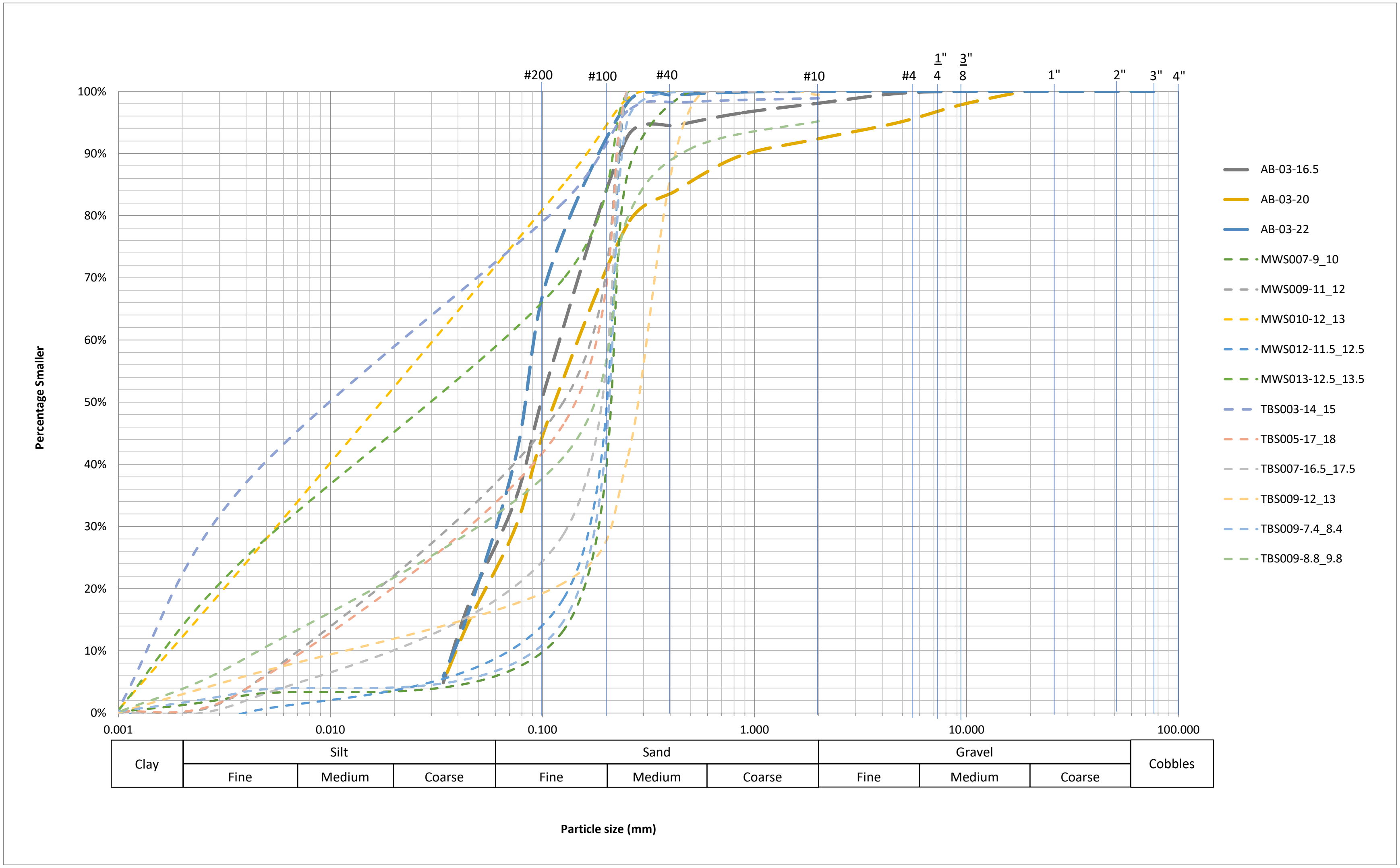
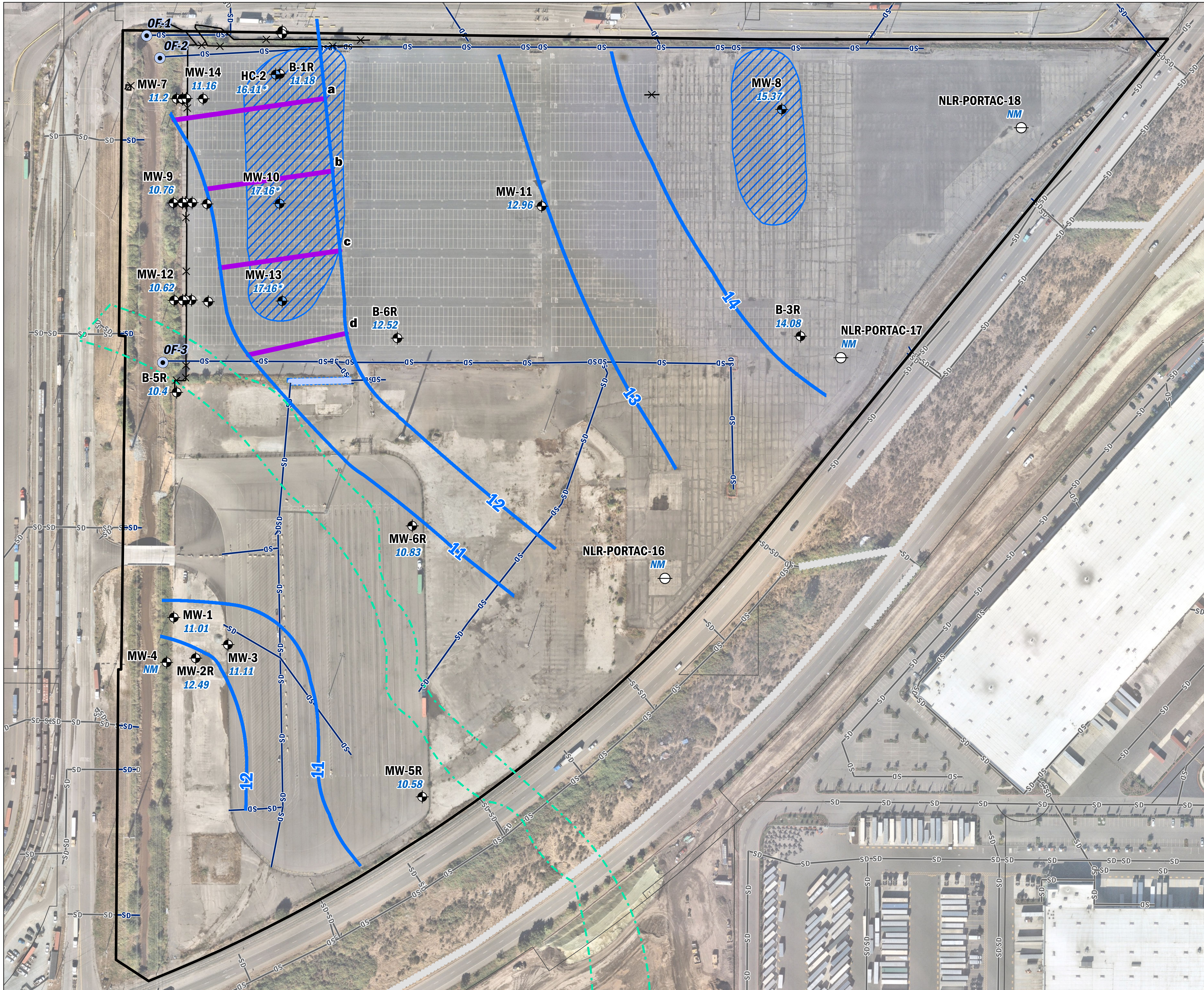


Figure 1
Grain-Size Analysis



Groundwater Elevation Contour (Feet Elevation, Mean Lower Low Water (MLLW))
Transect
Monitoring Well
Perched Monitoring Well
Piezometer
Fence
Stormwater Outfall
Storm Pipe
Ditch
Former Creek Channel
Observed Perched Zone
Port Parcel 15
Pierce County Tax Parcel

MW-11 ← Exploration Name
12.96 ← Groundwater Elevation (ft MLLW)

Notes:
* Not used in elevation contours
\- NM = Not measured

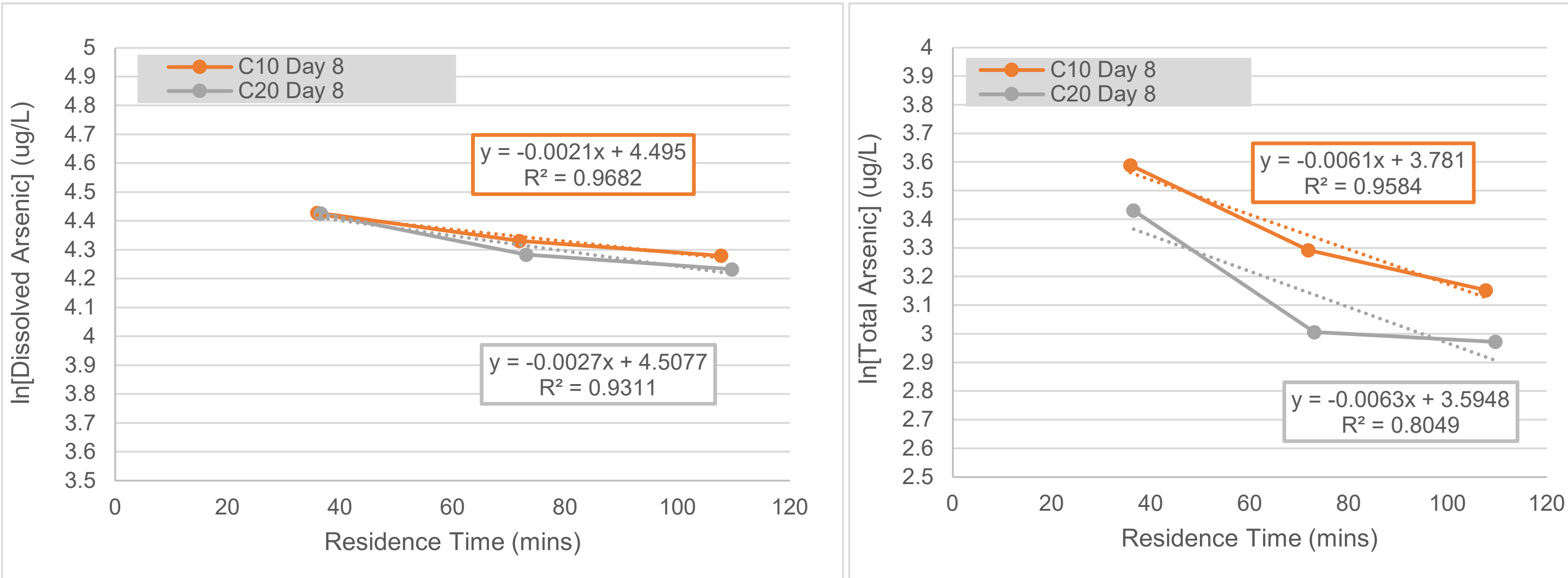
0 200 400
Feet

December 2021 Groundwater Contour Map

Engineering Design Report
Port of Tacoma - Parcel 15 (Portac)
Tacoma, Washington

Aspect CONSULTING	APR-2022	BY: DIM / SCC	FIGURE NO.
	PROJECT NO. 210158-4.1	REVISED BY: DIM / ACG / WEG	2

GIS Path: G:\projects\PortofTacoma\PortacParcel15_210158\Delivered\Engineering Design Report\02 December 2021 GW Contour Map.mxd || Coordinate System: NAD 1983 StatePlane Washington South FIPS 4602 Feet || Date Saved: 4/26/2022 || User: rkoche || Print Date: 4/26/2022



First Order Estimates	C10 Day 8		C20 Day 8	
	Dissolved Arsenic	Total Arsenic	Dissolved Arsenic	Total Arsenic
First Order Uptake Rate (mins^{-1})	0.0021	0.0061	0.0027	0.0063
First Order Uptake Rate (days^{-1})	3.0	8.8	3.9	9.1
First Order Half Life (hrs)	5.5	1.9	4.3	1.8
R^2 (hrs)	0.9682	0.9584	0.9311	0.8049

Notes:

1- The first order kinetic parameters are fit to the Port 1, Port 2, and Effluent total and dissolved arsenic results.

2 - The total and dissolved arsenic results were adjusted for arsenic loss observed in the control column (CC).

3 - Values of 63.5 ug/L (dissolved) and 13.1 ug/L (total) was used for adjustments, based on the difference in Influent and CC Port 1 concentrations.

Figure 3
First-Order Reaction Rate

Engineering Design Report
Project No. 210158, Port of Tacoma Parcel 15, Tacoma, Washington

Aspect Consulting
6/10/2022
V:\210158 Port of Tacoma Parcel 15 Cleanup Phase 1\Deliverables\EDR\FINAL\App D_PRB Design Calcs\Figures\Fig 3_1st order rxn rate

ATTACHMENT A

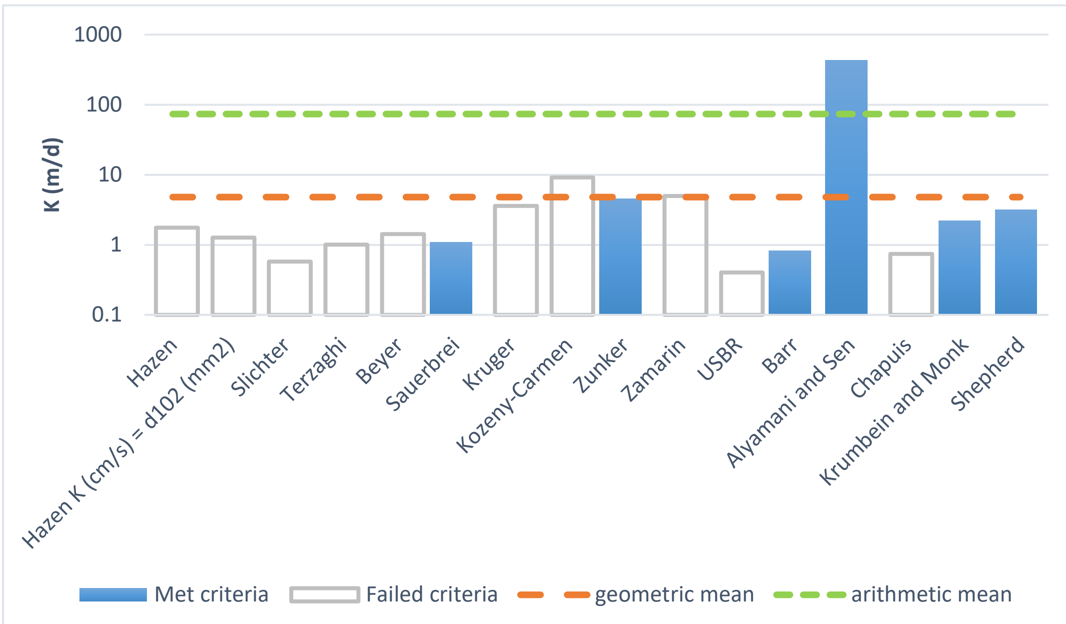
HydrogeoSieveXL Exports

K from Grain Size Analysis Report   Date: 2/17/2022

Sample Name: AB-03-16.5

Mass Sample (g): 100   T (oC) 20

Moderately well sorted sand low in fines



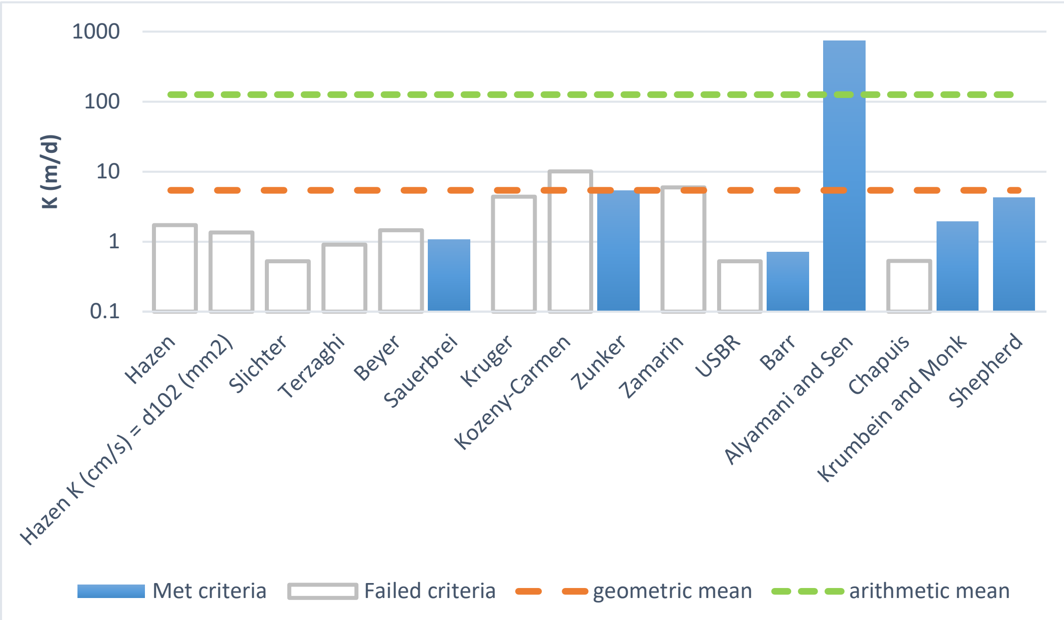
Estimation of Hydraulic Conductivity	cm/s	m/s	m/d	de
Hazen	.203E-02	.203E-04	1.76	
Hazen K (cm/s) = d_{10} (mm)	.147E-02	.147E-04	1.27	
Slichter	.670E-03	.670E-05	0.58	
Terzaghi	.117E-02	.117E-04	1.01	
Beyer	.165E-02	.165E-04	1.43	
Sauerbrei	.125E-02	.125E-04	1.08	
Kruger	.417E-02	.417E-04	3.60	
Kozeny-Carmen	.106E-01	.106E-03	9.15	
Zunker	.530E-02	.530E-04	4.58	
Zamarin	.574E-02	.574E-04	4.96	
USBR	.465E-03	.465E-05	0.40	
Barr	.952E-03	.952E-05	0.82	
Alyamani and Sen	.497E+00	.497E-02	429.58	
Chapuis	.854E-03	.854E-05	0.74	
Krumbein and Monk	.253E-02	.253E-04	2.19	
Shepherd	.369E-02	.369E-04	3.19	
geometric mean	.555E-02	.555E-04	4.80	
arithmetic mean	.852E-01	.852E-03	73.57	

K from Grain Size Analysis Report   Date: 2/17/2022

Sample Name: AB-03-20

Mass Sample (g): 100   T (oC) 20

Moderately well sorted sand low in fines



Estimation of Hydraulic Conductivity	cm/s	m/s	m/d	de
Hazen	.198E-02	.198E-04	1.71	
Hazen K (cm/s) = d_{10} (mm)	.157E-02	.157E-04	1.36	
Slichter	.605E-03	.605E-05	0.52	
Terzaghi	.105E-02	.105E-04	0.91	
Beyer	.168E-02	.168E-04	1.46	
Sauerbrei	.125E-02	.125E-04	1.08	
Kruger	.509E-02	.509E-04	4.40	
Kozeny-Carmen	.117E-01	.117E-03	10.11	
Zunker	.615E-02	.615E-04	5.32	
Zamarin	.688E-02	.688E-04	5.95	
USBR	.609E-03	.609E-05	0.53	
Barr	.820E-03	.820E-05	0.71	
Alyamani and Sen	.858E+00	.858E-02	741.67	
Chapuis	.613E-03	.613E-05	0.53	
Krumbein and Monk	.224E-02	.224E-04	1.94	
Shepherd	.495E-02	.495E-04	4.28	
geometric mean	.626E-02	.626E-04	5.41	
arithmetic mean	.146E+00	.146E-02	125.83	

K from Grain Size Analysis Report

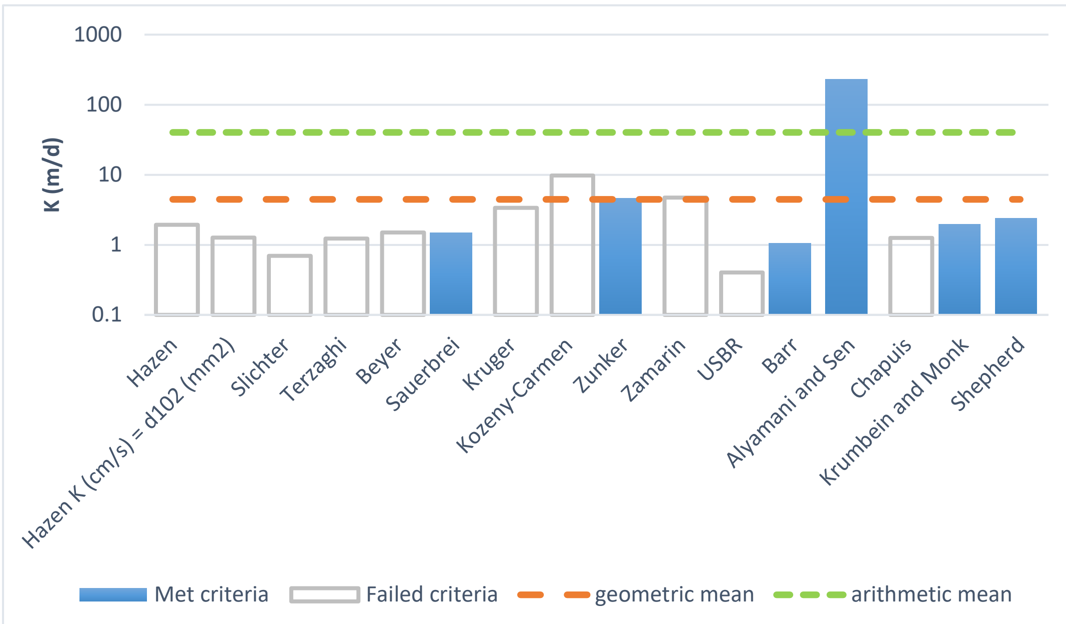
Date: 2/17/2022

Sample Name: AB-03-22

Mass Sample (g): 100

T (oC) 20

Moderately well sorted sand low in fines



Estimation of Hydraulic Conductivity	cm/s	m/s	m/d	de
Hazen	.223E-02	.223E-04	1.92	
Hazen K (cm/s) = d_{10} (mm)	.146E-02	.146E-04	1.26	
Slichter	.810E-03	.810E-05	0.70	
Terzaghi	.142E-02	.142E-04	1.23	
Beyer	.174E-02	.174E-04	1.50	
Sauerbrei	.171E-02	.171E-04	1.48	
Kruger	.389E-02	.389E-04	3.36	
Kozeny-Carmen	.113E-01	.113E-03	9.79	
Zunker	.531E-02	.531E-04	4.58	
Zamarin	.545E-02	.545E-04	4.71	
USBR	.468E-03	.468E-05	0.40	
Barr	.123E-02	.123E-04	1.06	
Alyamani and Sen	.266E+00	.266E-02	229.88	
Chapuis	.145E-02	.145E-04	1.25	
Krumbein and Monk	.226E-02	.226E-04	1.96	
Shepherd	.279E-02	.279E-04	2.41	
geometric mean	.515E-02	.515E-04	4.45	
arithmetic mean	.466E-01	.466E-03	40.23	

K from Grain Size Analysis Report

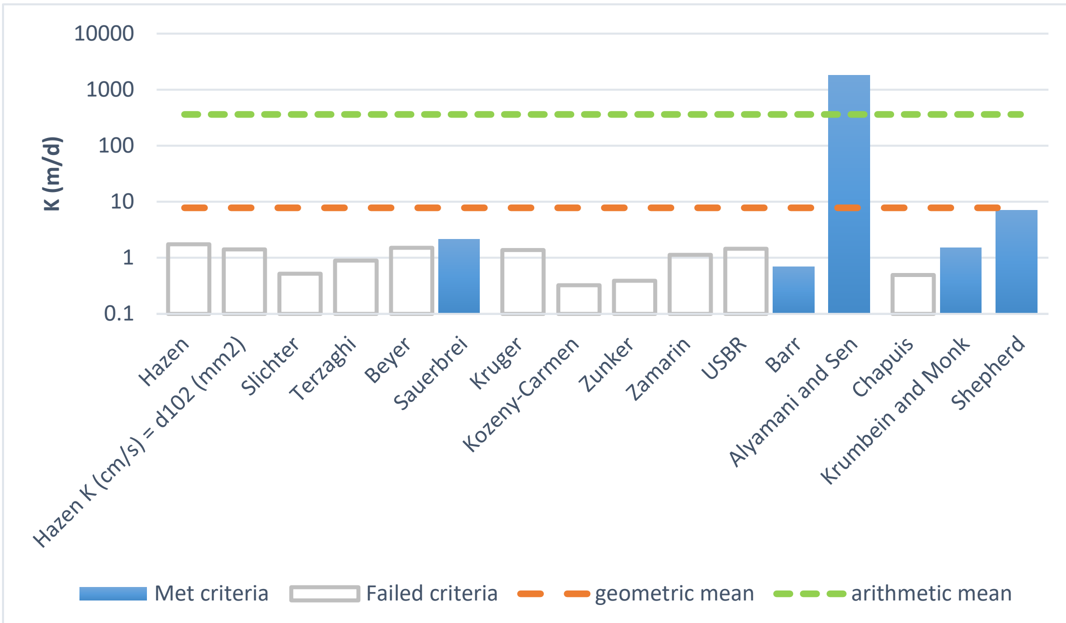
Date: 2/17/2022

Sample Name: TBS005-16.5_17.5

Mass Sample (g): 100

T (oC) 20

Moderately well sorted sand low in fines



Estimation of Hydraulic Conductivity	cm/s	m/s	m/d	de
Hazen	.202E-02	.202E-04	1.74	
Hazen K (cm/s) = d_{10} (mm)	.164E-02	.164E-04	1.42	
Slichter	.601E-03	.601E-05	0.52	
Terzaghi	.104E-02	.104E-04	0.90	
Beyer	.174E-02	.174E-04	1.50	
Sauerbrei	.250E-02	.250E-04	2.16	
Kruger	.159E-02	.159E-04	1.38	
Kozeny-Carmen	.376E-03	.376E-05	0.33	
Zunker	.450E-03	.450E-05	0.39	
Zamarin	.130E-02	.130E-04	1.13	
USBR	.168E-02	.168E-04	1.45	
Barr	.803E-03	.803E-05	0.69	
Alyamani and Sen	.208E+01	.208E-01	1797.45	
Chapuis	.573E-03	.573E-05	0.50	
Krumbein and Monk	.175E-02	.175E-04	1.51	
Shepherd	.824E-02	.824E-04	7.12	
geometric mean	.903E-02	.903E-04	7.80	
arithmetic mean	.419E+00	.419E-02	361.79	

K from Grain Size Analysis Report

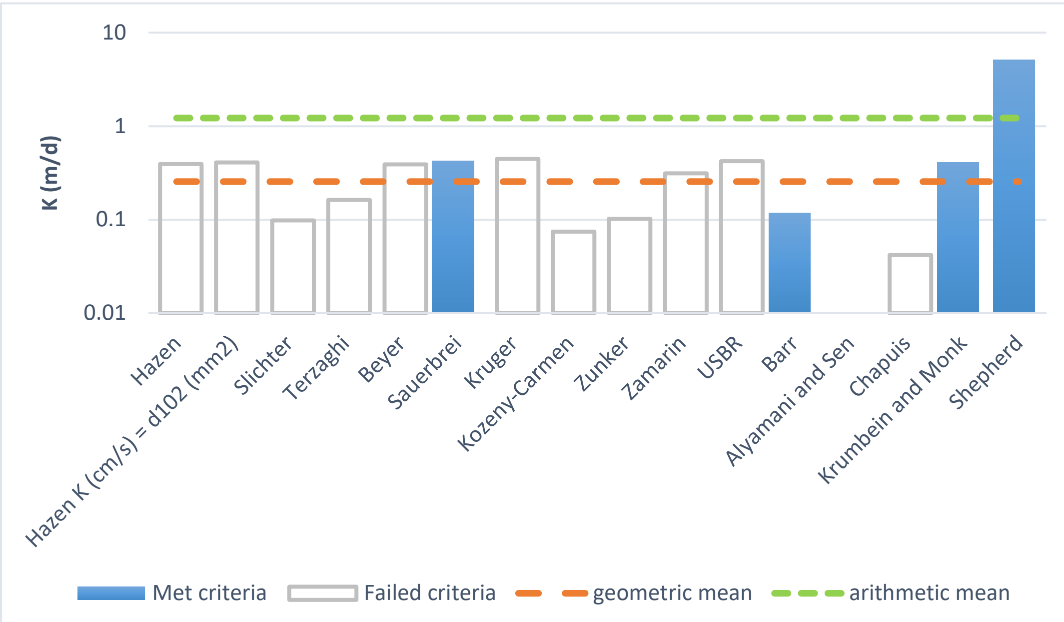
Date: 2/17/2022

Sample Name: TBS005-17_18

Mass Sample (g): 100

T (oC) 20

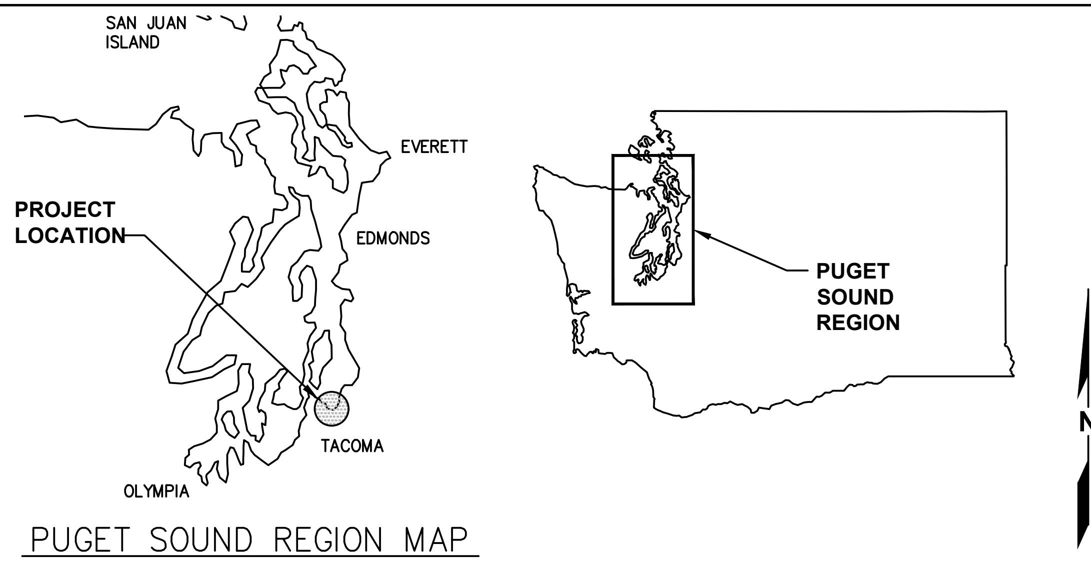
Poorly sorted sand with fines



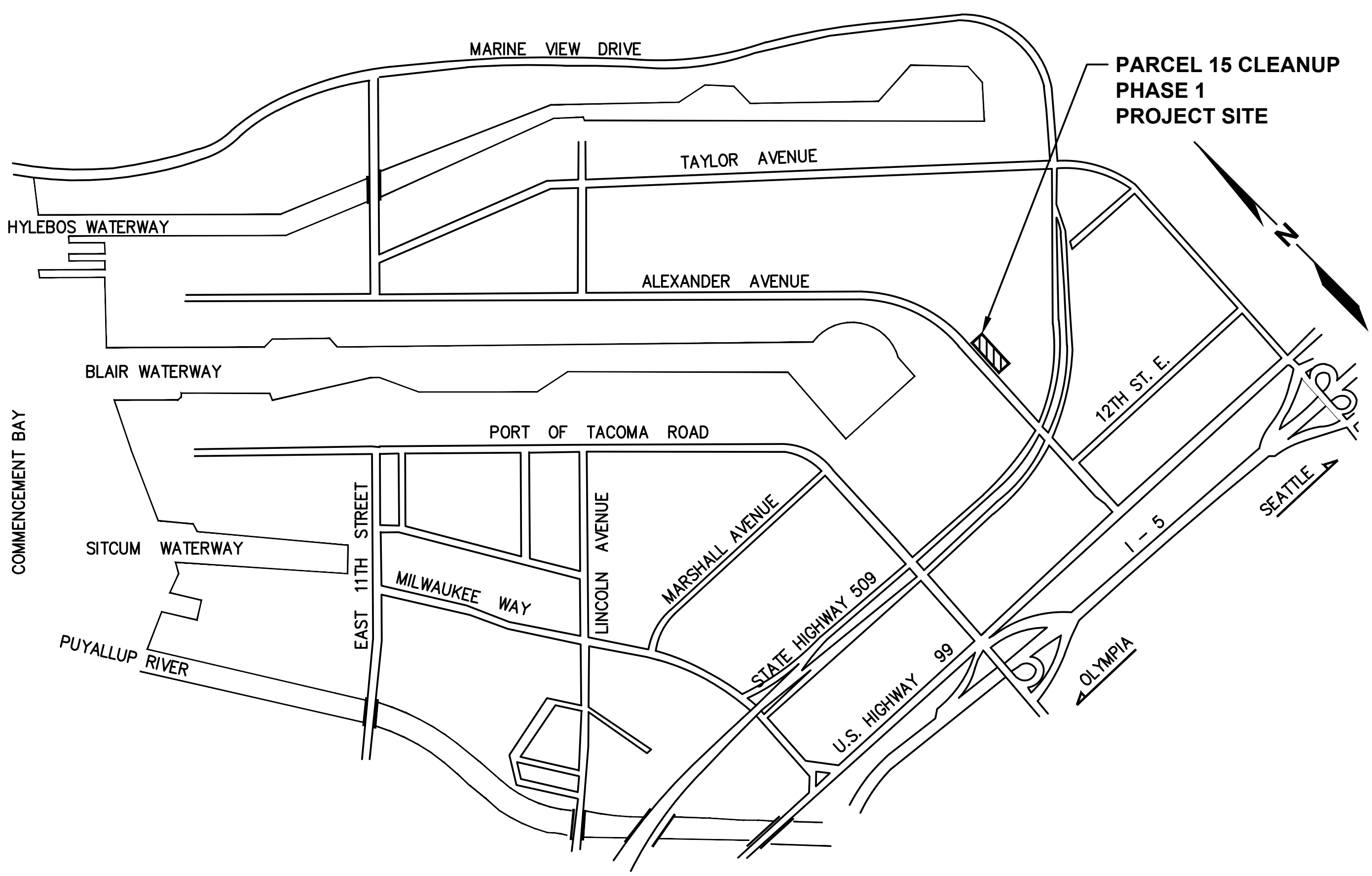
Estimation of Hydraulic Conductivity	cm/s	m/s	m/d	de
Hazen	.457E-03	.457E-05	0.39	
Hazen K (cm/s) = d_{10} (mm)	.474E-03	.474E-05	0.41	
Slichter	.113E-03	.113E-05	0.10	
Terzaghi	.188E-03	.188E-05	0.16	
Beyer	.451E-03	.451E-05	0.39	
Sauerbrei	.492E-03	.492E-05	0.42	
Kruger	.515E-03	.515E-05	0.44	
Kozeny-Carmen	.861E-04	.861E-06	0.07	
Zunker	.118E-03	.118E-05	0.10	
Zamarin	.362E-03	.362E-05	0.31	
USBR	.488E-03	.488E-05	0.42	
Barr	.137E-03	.137E-05	0.12	
Alyamani and Sen	.117E-04	.117E-06	0.01	
Chapuis	.485E-04	.485E-06	0.04	
Krumbein and Monk	.477E-03	.477E-05	0.41	
Shepherd	.595E-02	.595E-04	5.14	
geometric mean	.295E-03	.295E-05	0.26	
arithmetic mean	.141E-02	.141E-04	1.22	

APPENDIX E

Outfall Plans (JARPA Submission)



PUGET SOUND REGION MAP



VICINITY MAP NO SCALE

PORT OF TACOMA

REFERENCE #

PURPOSE: PHASE 1 ENVIRONMENTAL CLEANUP OF A FORMER LOGYARD

DATUM: PORT OF TACOMA DATUM
MLLW - ELEVATION 0.0'
HTL - ELEVATION 13.5'

ADJACENT PROPERTY OWNERS:
PORT OF TACOMA

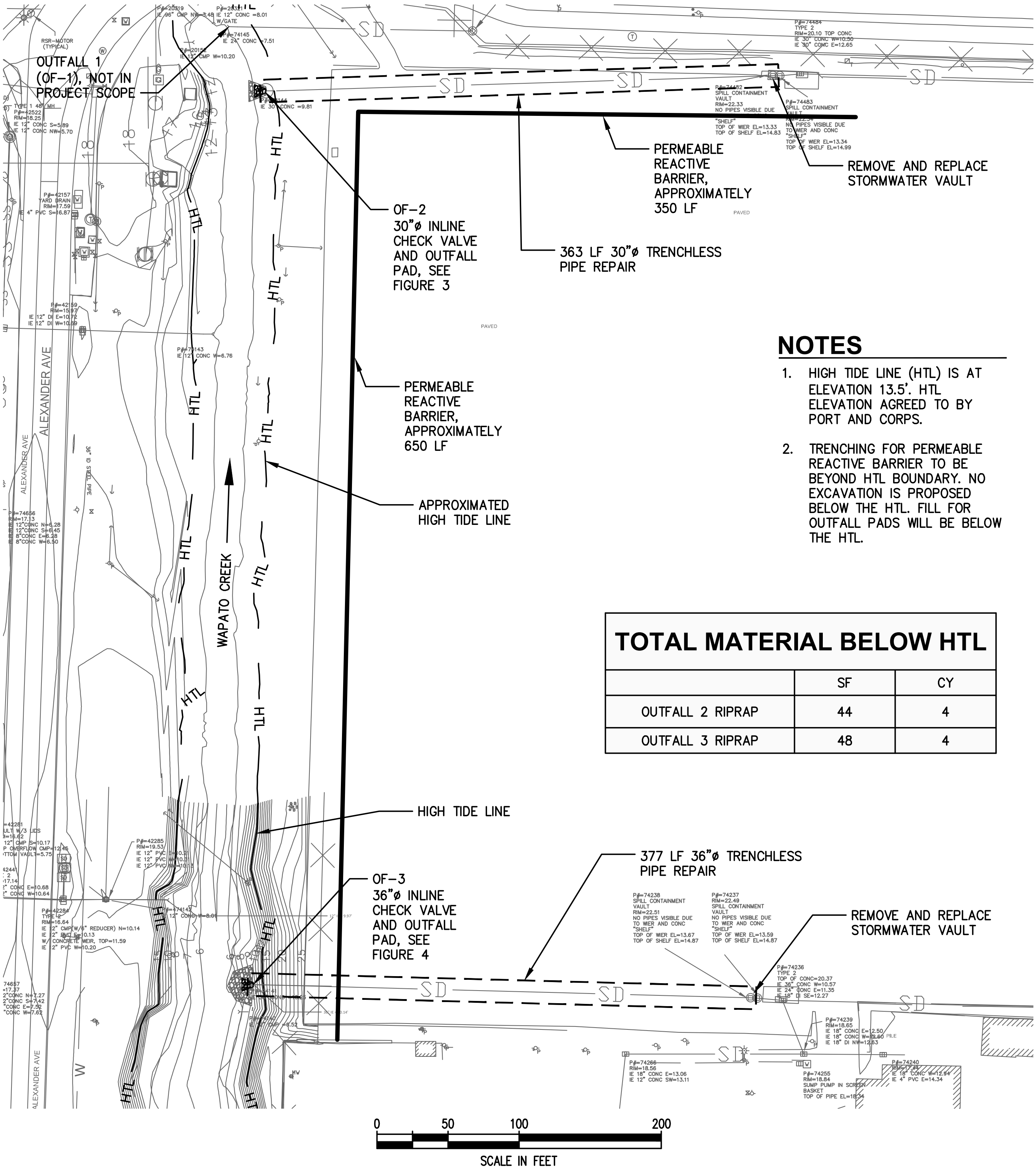
FIGURE 1 - VICINITY MAP

APPLICATION BY: PORT OF TACOMA

PROJECT: PARCEL 15 CLEANUP PHASE 1
ADDRESS: 4215 SR 509 N FRONTAGE RD,
TACOMA, WA 98421
LAT/LONG: 47.252639°N / 122.372089°W
SECT/TOWN/RANGE: S01 T20N R3E
IN: WAPATO CREEK
NEAR/AT: CITY OF TACOMA
COUNTY OF: PIERCE
STATE OF: WA

SHEET 1 OF 4 SEPTEMBER 2021

Plotted: Sep 10, 2021 – 11:20am rlambert Layout: VICINITY MAP
C:\Users\rlambert\appdata\local\temp\AcPublish_10528\JARPA-01-VICINITY MAP.dwg



NOTES

1. HIGH TIDE LINE (HTL) IS AT ELEVATION 13.5'. HTL ELEVATION AGREED TO BY PORT AND CORPS.
2. TRENCHING FOR PERMEABLE REACTIVE BARRIER TO BE BEYOND HTL BOUNDARY. NO EXCAVATION IS PROPOSED BELOW THE HTL. FILL FOR OUTFALL PADS WILL BE BELOW THE HTL.

TOTAL MATERIAL BELOW HTL

	SF	CY
OUTFALL 2 RIPRAP	44	4
OUTFALL 3 RIPRAP	48	4

REFERENCE #

PURPOSE: PHASE 1 ENVIRONMENTAL CLEANUP OF A FORMER LOGYARD

DATUM: PORT OF TACOMA DATUM
MLLW - ELEVATION 0.0'
HTL - ELEVATION 13.5'

ADJACENT PROPERTY OWNERS:
PORT OF TACOMA

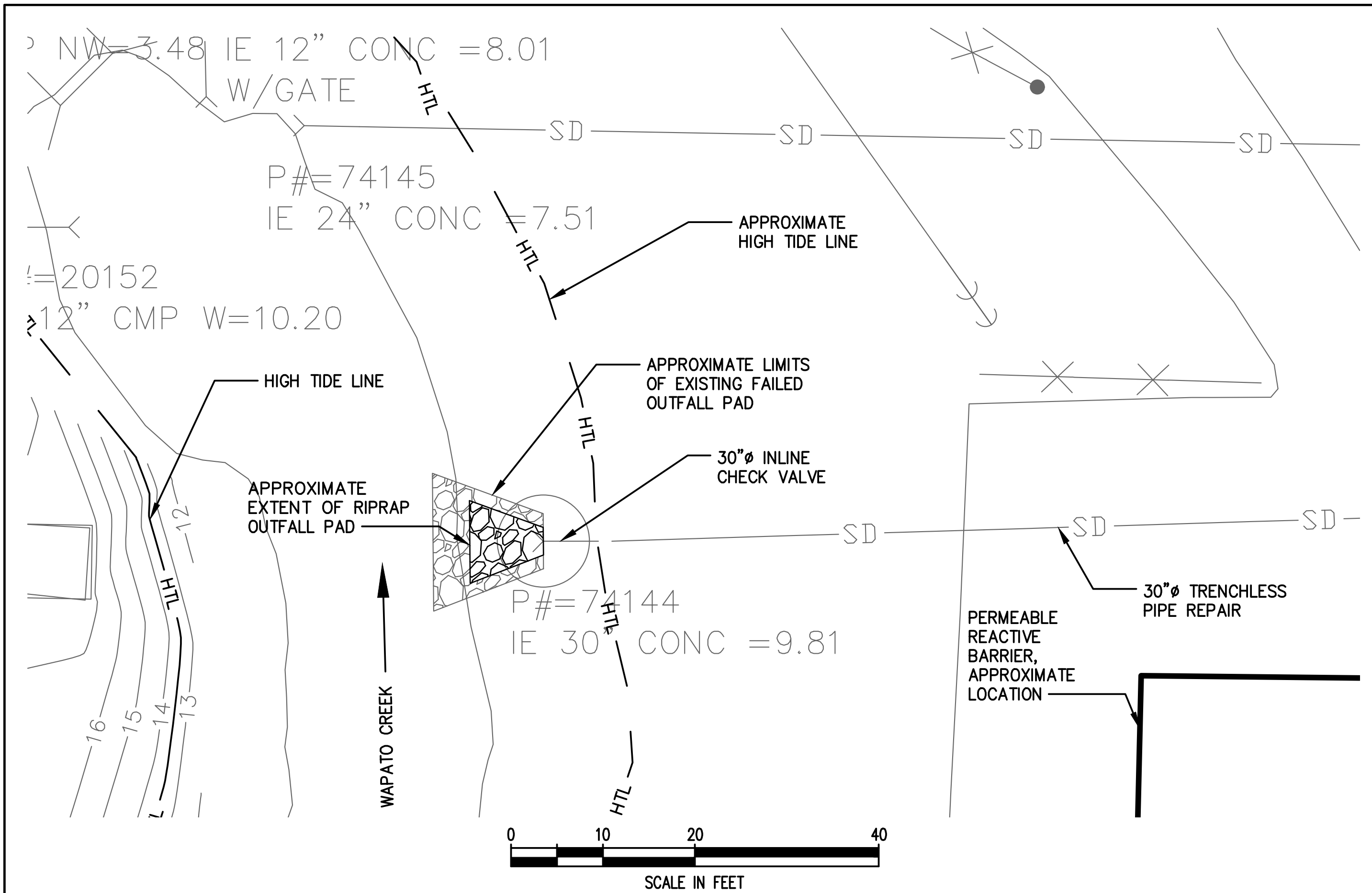
FIGURE 2 - SITE PLAN

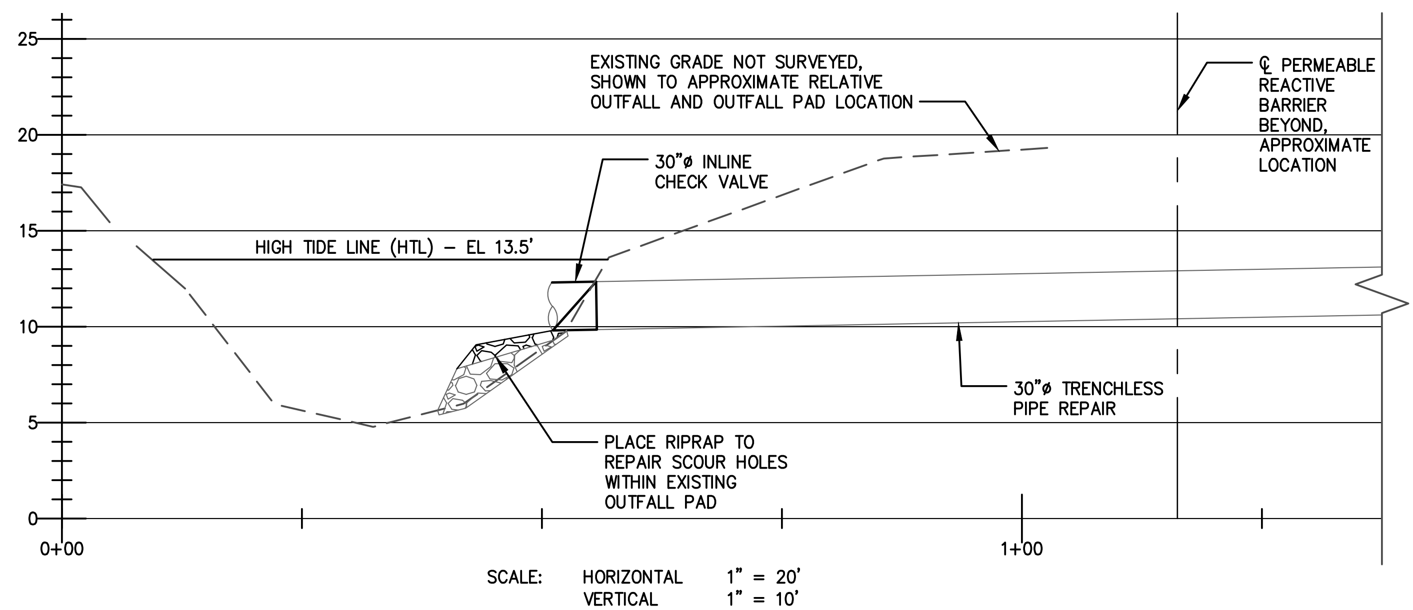
APPLICATION BY: PORT OF TACOMA

PROJECT: PARCEL 15 CLEANUP PHASE 1
ADDRESS: 4215 SR 509 N FRONTAGE RD, TACOMA, WA 98421
LAT/LONG: 47.252639°N / 122.372089°W
SECT/TOWN/RANGE: S01 T20N R3E
IN: WAPATO CREEK
NEAR/AT: CITY OF TACOMA
COUNTY OF: PIERCE
STATE OF: WA

SHEET 2 OF 4 SEPTEMBER 2021

Plotted: Sep 10, 2021 - 11:28am rlambert Layout: PLAN
N:\2021\Portac\Part 3 - KPFF Design\3.13 Drawings\JARPA\JARPA-02-PLAN VIEW.dwg





REFERENCE #

PURPOSE: PHASE 1 ENVIRONMENTAL CLEANUP OF A FORMER LOGYARD

DATUM: PORT OF TACOMA DATUM
MLLW - ELEVATION 0.0'
HTL - ELEVATION 13.5'

ADJACENT PROPERTY OWNERS:
PORT OF TACOMA

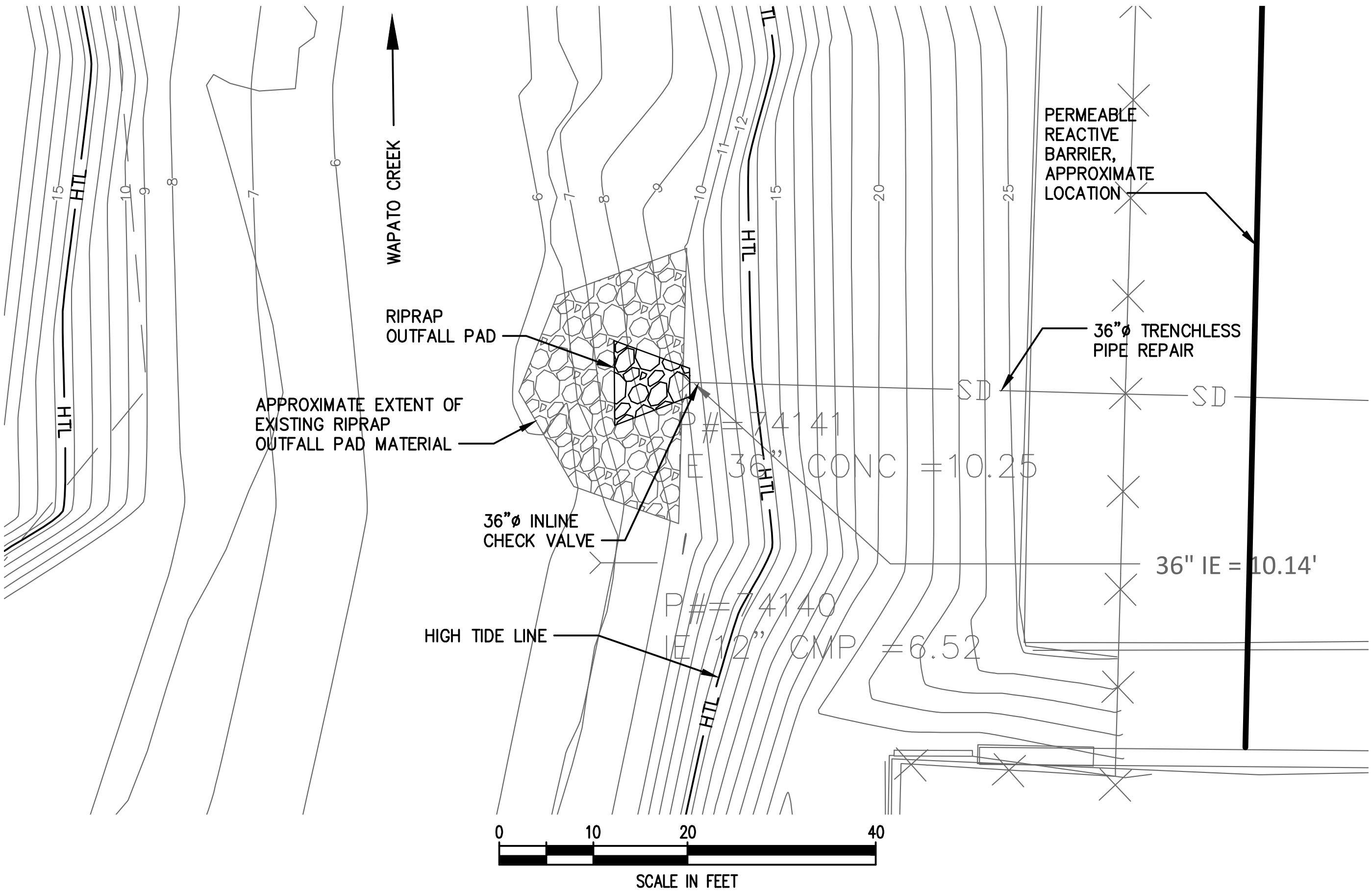
FIGURE 3 - OUTFALL 2 PLAN AND PROFILE

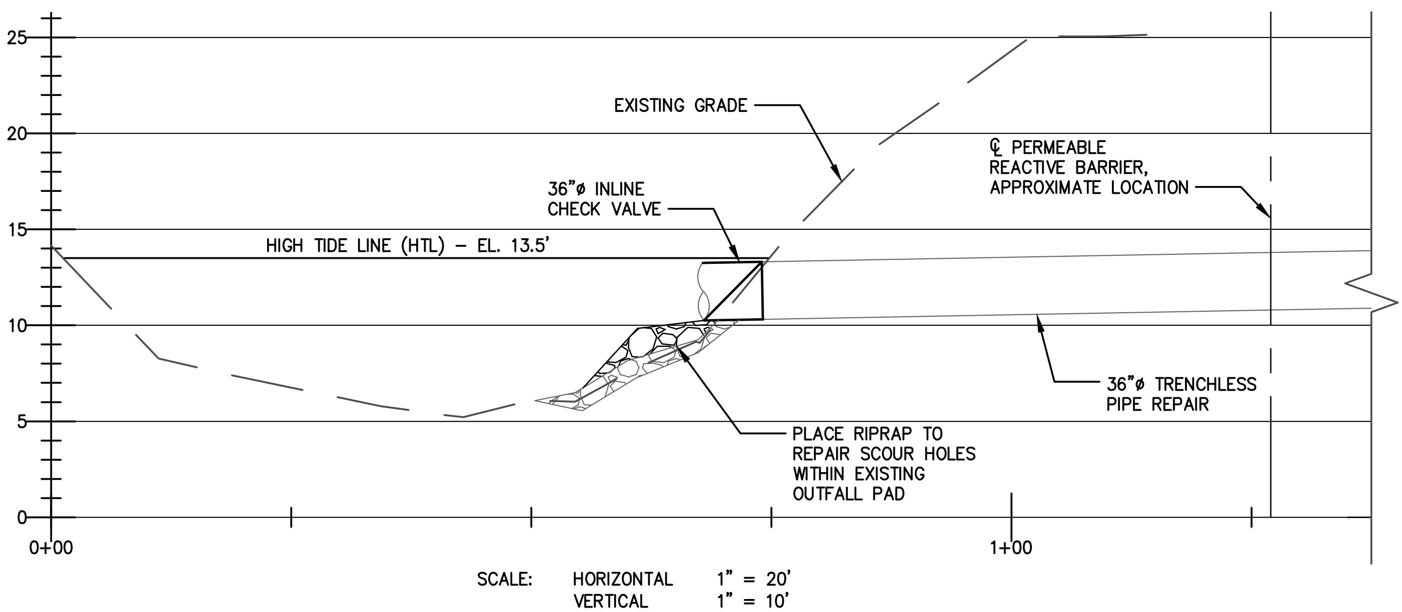
APPLICATION BY: PORT OF TACOMA

PROJECT: PARCEL 15 CLEANUP PHASE 1
ADDRESS: 4215 SR 509 N FRONTAGE RD, TACOMA, WA 98421
LAT/LONG: 47.252639°N / 122.372089°W
SECT/TOWN/RANGE: S01 T20N R3E
IN: WAPATO CREEK
NEAR/AT: CITY OF TACOMA
COUNTY OF: PIERCE
STATE OF: WA

SHEET 3 OF 4 SEPTEMBER 2021

Plotted: Sep 10, 2021 – 11:22am rlambert Layout: NORTH OUTFALL PLAN VIEW
C:\Users\rlambert\appdata\local\temp\AcPublish_10528\JARPA-02-PLAN VIEW.dwg





REFERENCE #

PURPOSE: PHASE 1 ENVIRONMENTAL CLEANUP OF A FORMER LOGYARD

DATUM: PORT OF TACOMA DATUM
MLLW - ELEVATION 0.0'
HTL - ELEVATION 13.5'

ADJACENT PROPERTY OWNERS:
PORT OF TACOMA

FIGURE 4 - OUTFALL 3 PLAN AND PROFILE

APPLICATION BY: PORT OF TACOMA

PROJECT: PARCEL 15 CLEANUP PHASE 1
ADDRESS: 4215 SR 509 N FRONTAGE RD, TACOMA, WA 98421
LAT/LONG: 47.252639°N / 122.372089°W
SECT/TOWN/RANGE: S01 T20N R3E
IN: WAPATO CREEK
NEAR/AT: CITY OF TACOMA
COUNTY OF: PIERCE
STATE OF: WA

SHEET 4 OF 4 SEPTEMBER 2021

Plotted: Sep 10, 2021 – 11:23am rlambert Layout: SOUTH OUTFALL PLAN VIEW
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APPENDIX F

Substantive Requirement Compliance Actions

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, SEATTLE DISTRICT
4735 EAST MARGINAL WAY SOUTH, BLDG 1202
SEATTLE, WA 98134-2388

Regulatory Branch May 20, 2022

Mr. Stanley Sasser
Port of Tacoma
P.O. Box 1837
Tacoma, Washington 98401

Reference: NWS-2021-950-WRD
Tacoma, Port of
(Parcel 15 Cleanup
Phase 1)

Dear Mr. Sasser:

We have reviewed your application to repair two stormwater outfalls as required by an Agreed Order with Washington Department of Ecology in Wapato Creek at Tacoma, Washington. Based on the information you provided to us, Nationwide Permit (NWP) 38, *Cleanup of Hazardous and Toxic Waste* (Federal Register December 27, 2021 Vol. 86, No. 245), authorizes your proposal as depicted on the enclosed drawings dated September 2021.

In order for this authorization to be valid, you must ensure the work is performed in accordance with the enclosed *NWP 38, Terms and Conditions* and the following special conditions:

a. You must implement and abide by the Endangered Species Act (ESA) requirements and/or agreements set forth in the No Effect Memo, dated September 30, 2021, in its entirety. The U.S. Army Corps of Engineers (Corps) made a determination of No Effect for all species and critical habitat based on this document. Failure to comply with the commitments made in this document constitutes non-compliance with the ESA and your Corps permit.

b. By accepting this permit, the permittee agrees to accept such potential liability for response costs, response activity and natural resource damages as the permittee would have under the Comprehensive Environmental Response, Compensation and Liability Act, 42 U.S.C. 9601 et seq. (CERCLA) or the Model Toxics Control Act, R.C.W. 70.105 (MTCA) absent the issuance of this permit. Further, the permittee agrees that this permit does not provide the permittee with any defense from liability under the CERCLA or the MTCA. Additionally, the permittee shall be financially responsible for any incremental response costs attributable under CERCLA or MTCA to the permittee's activities under this permit.

We have reviewed your project pursuant to the requirements of the Endangered Species Act, the Magnuson-Stevens Fishery Conservation and Management Act and the National Historic Preservation Act. We have determined this project complies with the requirements of these laws provided you comply with all of the permit general and special conditions.

The authorized work complies with the Washington State Department of Ecology's (Ecology) Water Quality Certification (WQC) requirements and Coastal Zone Management (CZM) consistency determination decision for this NWP. No further coordination with Ecology for WQC and CZM is required.

You have not requested a jurisdictional determination for this proposed project. If you believe the U.S. Army Corps of Engineers does not have jurisdiction over all or portions of your project you may request a preliminary or approved jurisdictional determination (JD). If one is requested, please be aware that we may require the submittal of additional information to complete the JD and work authorized in this letter may not occur until the JD has been completed.

Our verification of this NWP authorization is valid until March 14, 2026, unless the NWP is modified, reissued, or revoked prior to that date. If the authorized work for the NWP authorization has not been completed by that date and you have commenced or are under contract to commence this activity before March 14, 2026, you will have until March 14, 2027, to complete the activity under the enclosed terms and conditions of this NWP. Failure to comply with all terms and conditions of this NWP verification invalidates this authorization and could result in a violation of Section 404 of the Clean Water Act and/or Section 10 of the Rivers and Harbors Act. You must also obtain all local, State, and other Federal permits that apply to this project.

You are cautioned that any change in project location or plans will require that you submit a copy of the revised plans to this office and obtain our approval before you begin work. Deviating from the approved plans could result in the assessment of criminal or civil penalties.

Upon completing the authorized work, you must fill out and return the enclosed *Certificate of Compliance with Department of the Army Permit*. All compliance reports should be submitted to the U.S. Army Corps of Engineers, Seattle District, Regulatory Branch electronically at nws.compliance@usace.army.mil. Thank you for your cooperation during the permitting process. We are interested in your experience with our Regulatory Program and encourage you to complete a customer service survey. Referenced documents and information about our program are available on our website at www.nws.usace.army.mil, select “Regulatory Permit Information. If you have any questions, please contact Mr. Jason Sweeney at jason.t.sweeney@usace.army.mil or (206) 764-3450.

Sincerely,

Matt Bennett, Section Chief
Regulatory Branch

Enclosures

cc:
Ecology (ecyrefedpermits@ecy.wa.gov)

US Army Corps
of Engineers ®
Seattle District

NATIONWIDE PERMIT 38
Terms and Conditions

2021 NWPs - Final 41; Effective Date: February 25, 2022

A. Description of Authorized Activities
B. U.S. Army Corps of Engineers (Corps) National General Conditions for All Final 41 NWPs
C. Seattle District Regional General Conditions
D. Seattle District Regional Specific Conditions for this Nationwide Permit (NWP)
E. 401 Water Quality Certification (401 WQC) for this NWP
F. Coastal Zone Management Consistency Response for this NWP

In addition to any special condition that may be required on a case-by-case basis by the District Engineer, the following terms and conditions must be met, as applicable, for a Nationwide Permit (NWP) authorization to be valid in Washington State.

A. DESCRIPTION OF AUTHORIZED ACTIVITIES

38. Cleanup of Hazardous and Toxic Waste. Specific activities required to effect the containment, stabilization, or removal of hazardous or toxic waste materials that are performed, ordered, or sponsored by a government agency with established legal or regulatory authority. Court ordered remedial action plans or related settlements are also authorized by this NWP. This NWP does not authorize the establishment of new disposal sites or the expansion of existing sites used for the disposal of hazardous or toxic waste.

Notification: The permittee must submit a pre-construction notification to the district engineer prior to commencing the activity. (See general condition 32.) (Authorities: Sections 10 and 404)

Note: Activities undertaken entirely on a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) site by authority of CERCLA as approved or required by EPA, are not required to obtain permits under Section 404 of the Clean Water Act or Section 10 of the Rivers and Harbors Act.

B. CORPS NATIONAL GENERAL CONDITIONS FOR ALL 2021 NWPs - FINAL 41

Note: To qualify for NWP authorization, the prospective permittee must comply with the following general conditions, as applicable, in addition to any regional or case-specific conditions imposed by the division engineer or district engineer. Prospective permittees should contact the appropriate Corps district office to determine if regional conditions have been imposed on an NWP. Prospective permittees should also contact the appropriate Corps district office to determine the status of Clean Water Act Section 401 water quality certification and/or Coastal Zone Management Act consistency for an NWP. Every person who may wish to obtain permit authorization under one or more NWPs, or who is currently relying on an existing or prior permit authorization under one or more NWPs, has been and is on notice that all of the provisions of 33 CFR 330.1 through 330.6 apply to every NWP authorization. Note especially 33 CFR 330.5 relating to the modification, suspension, or revocation of any NWP authorization.

1. Navigation. (a) No activity may cause more than a minimal adverse effect on navigation.

(b) Any safety lights and signals prescribed by the U.S. Coast Guard, through regulations or otherwise, must be installed and maintained at the permittee's expense on authorized facilities in navigable waters of the United States.

(c) The permittee understands and agrees that, if future operations by the United States require the removal, relocation, or other alteration, of the structure or work herein authorized, or if, in the opinion of the Secretary of the Army or his or her authorized representative, said structure or work shall cause unreasonable obstruction to the free navigation of the navigable waters, the permittee will be required, upon due notice from the Corps of Engineers, to remove, relocate, or alter the structural work or obstructions caused thereby, without expense to the United States. No claim shall be made against the United States on account of any such removal or alteration.

2. Aquatic Life Movements. No activity may substantially disrupt the necessary life cycle movements of those species of aquatic life indigenous to the waterbody, including those species that normally migrate through the area, unless the activity's primary purpose is to impound water. All permanent and temporary crossings of waterbodies shall be suitably culverted, bridged, or otherwise designed and constructed to maintain low flows to sustain the movement of those aquatic species. If a bottomless culvert cannot be used, then the crossing should be designed and constructed to minimize adverse effects to aquatic life movements.

3. Spawning Areas. Activities in spawning areas during spawning seasons must be avoided to the maximum extent practicable. Activities that result in the physical destruction (e.g., through excavation, fill, or downstream smothering by substantial turbidity) of an important spawning area are not authorized.

4. Migratory Bird Breeding Areas. Activities in waters of the United States that serve as breeding areas for migratory birds must be avoided to the maximum extent practicable.

5. Shellfish Beds. No activity may occur in areas of concentrated shellfish populations, unless the activity is directly related to a shellfish harvesting activity authorized by NWPs 4 and 48, or is a shellfish seeding or habitat restoration activity authorized by NWP 27.

6. Suitable Material. No activity may use unsuitable material (e.g., trash, debris, car bodies, asphalt, etc.). Material used for construction or discharged must be free from toxic pollutants in toxic amounts (see section 307 of the Clean Water Act).

7. Water Supply Intakes. No activity may occur in the proximity of a public water supply intake, except where the activity is for the repair or improvement of public water supply intake structures or adjacent bank stabilization.

8. Adverse Effects From Impoundments. If the activity creates an impoundment of water, adverse effects to the aquatic system due to accelerating the passage of water, and/or restricting its flow must be minimized to the maximum extent practicable.

9. Management of Water Flows. To the maximum extent practicable, the pre-construction course, condition, capacity, and location of open waters must be maintained for each activity, including stream channelization, storm water management activities, and temporary and permanent road crossings, except as provided below. The activity must be constructed to withstand expected high flows. The activity must not restrict or impede the passage of normal or high flows, unless the primary purpose of the activity is to impound water or manage high flows. The activity may alter the pre-construction course, condition, capacity, and location of open waters if it benefits the aquatic environment (e.g., stream restoration or relocation activities).

10. Fills Within 100-Year Floodplains. The activity must comply with applicable FEMA-approved state or local floodplain management requirements.

11. Equipment. Heavy equipment working in wetlands or mudflats must be placed on mats, or other measures must be taken to minimize soil disturbance.

12. Soil Erosion and Sediment Controls. Appropriate soil erosion and sediment controls must be used and maintained in effective operating condition during construction, and all exposed soil and other fills, as well as any work below the ordinary high water mark or high tide line, must be permanently stabilized at the earliest practicable date. Permittees are encouraged to perform work within waters of the United States during periods of low-flow or no-flow, or during low tides.

13. Removal of Temporary Structures and Fills. Temporary structures must be removed, to the maximum extent practicable, after their use has been discontinued. Temporary fills must be removed in their entirety and the affected areas returned to pre-construction elevations. The affected areas must be revegetated, as appropriate.

14. Proper Maintenance. Any authorized structure or fill shall be properly maintained, including maintenance to ensure public safety and compliance with applicable NWP general conditions, as well as any activity-specific conditions added by the district engineer to an NWP authorization.

15. Single and Complete Project. The activity must be a single and complete project. The same NWP cannot be used more than once for the same single and complete project.

16. Wild and Scenic Rivers. (a) No NWP activity may occur in a component of the National Wild and Scenic River System, or in a river officially designated by Congress as a "study river" for possible inclusion in the system while the river is in an official study status, unless the appropriate Federal agency with direct management responsibility for such river, has determined in writing that the proposed activity will not adversely affect the Wild and Scenic River designation or study status.

(b) If a proposed NWP activity will occur in a component of the National Wild and Scenic River System, or in a river officially designated by Congress as a "study river" for possible inclusion in the system while the river is in an official study status, the permittee must submit a pre-construction notification (see general condition 32). The district engineer will coordinate the PCN with the Federal agency with direct management responsibility for that river. Permittees shall not begin the NWP activity until notified by the district engineer that the Federal agency with direct management responsibility for that river has determined in writing that the proposed NWP activity will not adversely affect the Wild and Scenic River designation or study status.

(c) Information on Wild and Scenic Rivers may be obtained from the appropriate Federal land management agency responsible for the designated Wild and Scenic River or study river (e.g., National Park Service, U.S. Forest Service, Bureau of Land Management, U.S. Fish and Wildlife Service). Information on these rivers is also available at: http://www.rivers.gov/.

17. Tribal Rights. No activity or its operation may impair reserved tribal rights, including, but not limited to, reserved water rights and treaty fishing and hunting rights.

18. Endangered Species. (a) No activity is authorized under any NWP which is likely to directly or indirectly jeopardize the continued existence of a threatened or endangered species or a species proposed for such designation, as identified under the Federal Endangered Species Act (ESA), or which will directly or indirectly destroy or adversely modify designated critical habitat or critical habitat proposed for such designation. No activity is authorized under any NWP which "may affect" a listed species or critical habitat, unless ESA section 7 consultation addressing the consequences of the proposed activity on listed species or critical habitat has been completed. See 50 CFR 402.02 for the definition of "effects of the action" for the purposes of ESA section 7 consultation, as well as 50 CFR 402.17, which provides further explanation under ESA section 7 regarding "activities that are reasonably certain to occur" and "consequences caused by the proposed action."

(b) Federal agencies should follow their own procedures for complying with the requirements of the ESA (see 33 CFR 330.4(f)(1)). If pre-construction notification is required for the proposed activity, the Federal permittee must provide the district engineer with the appropriate documentation to demonstrate compliance with those requirements. The district engineer will verify that the appropriate documentation has been submitted. If the appropriate documentation has not been submitted, additional ESA section 7 consultation may be necessary for the activity and the respective federal agency would be responsible for fulfilling its obligation under section 7 of the ESA.

(c) Non-federal permittees must submit a pre-construction notification to the district engineer if any listed species (or species proposed for listing) or designated critical habitat (or critical habitat proposed such designation) might be affected or is in the vicinity of the activity, or if the activity is located in designated critical habitat or critical habitat proposed for such designation, and shall not begin work on the activity until notified by the district engineer that the requirements of the ESA have been satisfied and that the activity is authorized. For activities that might affect Federally-listed endangered or threatened species (or species proposed for listing) or designated critical habitat (or critical habitat proposed for such designation), the pre-construction notification must include the name(s) of the endangered or threatened species (or species proposed for listing) that might be affected by the proposed activity or that utilize the designated critical habitat (or critical habitat proposed for such designation) that might be affected by the proposed activity. The district engineer will determine whether the proposed activity “may affect” or will have “no effect” to listed species and designated critical habitat and will notify the non-Federal applicant of the Corps’ determination within 45 days of receipt of a complete pre-construction notification. For activities where the non-Federal applicant has identified listed species (or species proposed for listing) or designated critical habitat (or critical habitat proposed for such designation) that might be affected or is in the vicinity of the activity, and has so notified the Corps, the applicant shall not begin work until the Corps has provided notification that the proposed activity will have “no effect” on listed species (or species proposed for listing or designated critical habitat (or critical habitat proposed for such designation), or until ESA section 7 consultation or conference has been completed. If the non-Federal applicant has not heard back from the Corps within 45 days, the applicant must still wait for notification from the Corps.

(d) As a result of formal or informal consultation or conference with the FWS or NMFS the district engineer may add species-specific permit conditions to the NWPs.

(e) Authorization of an activity by an NWP does not authorize the “take” of a threatened or endangered species as defined under the ESA. In the absence of separate authorization (e.g., an ESA Section 10 Permit, a Biological Opinion with “incidental take” provisions, etc.) from the FWS or the NMFS, the Endangered Species Act prohibits any person subject to the jurisdiction of the United States to take a listed species, where "take" means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct. The word “harm” in the definition of “take" means an act which actually kills or injures wildlife. Such an act may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding or sheltering.

(f) If the non-federal permittee has a valid ESA section 10(a)(1)(B) incidental take permit with an approved Habitat Conservation Plan for a project or a group of projects that includes the proposed NWP activity, the non-federal applicant should provide a copy of that ESA section 10(a)(1)(B) permit with the PCN required by paragraph (c) of this general condition. The district engineer will coordinate with the agency that issued the ESA section 10(a)(1)(B) permit to determine whether the proposed NWP activity and the associated incidental take were considered in the internal ESA section 7 consultation conducted for the ESA section 10(a)(1)(B) permit. If that coordination results in concurrence from the agency that the proposed NWP activity and the associated incidental take were considered in the internal ESA section 7 consultation for the ESA section 10(a)(1)(B) permit, the district engineer does not need to conduct a separate ESA section 7 consultation for the proposed NWP activity. The district engineer will notify the non-federal applicant within 45 days of receipt of a complete pre-construction notification whether the ESA section 10(a)(1)(B) permit covers the proposed NWP activity or whether additional ESA section 7 consultation is required.

(g) Information on the location of threatened and endangered species and their critical habitat can be obtained directly from the offices of the FWS and NMFS or their world wide web pages at http://www.fws.gov/ or http://www.fws.gov/ipac and http://www.nmfs.noaa.gov/pr/species/esa/ respectively.

19. <u>Migratory Birds and Bald and Golden Eagles</u>. The permittee is responsible for ensuring that an action authorized by an NWP complies with the Migratory Bird Treaty Act and the Bald and Golden Eagle Protection Act. The permittee is responsible for contacting the appropriate local office of the U.S. Fish and Wildlife Service to determine what measures, if any, are necessary or appropriate to reduce adverse effects to migratory birds or eagles, including whether "incidental take" permits are necessary and available under the Migratory Bird Treaty Act or Bald and Golden Eagle Protection Act for a particular activity.

20. Historic Properties. (a) No activity is authorized under any NWP which may have the potential to cause effects to properties listed, or eligible for listing, in the National Register of Historic Places until the requirements of Section 106 of the National Historic Preservation Act (NHPA) have been satisfied.

(b) Federal permittees should follow their own procedures for complying with the requirements of section 106 of the National Historic Preservation Act (see 33 CFR 330.4(g)(1)). If pre-construction notification is required for the proposed NWP activity, the Federal permittee must provide the district engineer with the appropriate documentation to demonstrate compliance with those requirements. The district engineer will verify that the appropriate documentation has been submitted. If the appropriate documentation is not submitted, then additional consultation under section 106 may be necessary. The respective federal agency is responsible for fulfilling its obligation to comply with section 106.

(c) Non-federal permittees must submit a pre-construction notification to the district engineer if the NWP activity might have the potential to cause effects to any historic properties listed on, determined to be eligible for listing on, or potentially eligible for listing on the National Register of Historic Places, including previously unidentified properties. For such activities, the pre-construction notification must state which historic properties might have the potential to be affected by the proposed NWP activity or include a vicinity map indicating the location of the historic properties or the potential for the presence of historic properties. Assistance regarding information on the location of, or potential for, the presence of historic properties can be sought from the State Historic Preservation Officer, Tribal Historic Preservation Officer, or designated tribal representative, as appropriate, and the National Register of Historic Places (see 33 CFR 330.4(g)). When reviewing pre-construction notifications, district engineers will comply with the current procedures for addressing the requirements of section 106 of the National Historic Preservation Act. The district engineer shall make a reasonable and good faith effort to carry out appropriate identification efforts commensurate with potential impacts, which may include background research, consultation, oral history interviews, sample field investigation, and/or field survey. Based on the information submitted in the PCN and these identification efforts, the district engineer shall determine whether the proposed NWP activity has the potential to cause effects on the historic properties. Section 106 consultation is not required when the district engineer determines that the activity does not have the potential to cause effects on historic properties (see 36 CFR 800.3(a)). Section 106 consultation is required when the district engineer determines that the activity has the potential to cause effects on historic properties. The district engineer will conduct consultation with consulting parties identified under 36 CFR 800.2(c) when he or she makes any of the following effect determinations for the purposes of section 106 of the NHPA: no historic properties affected, no adverse effect, or adverse effect.

(d) Where the non-Federal applicant has identified historic properties on which the proposed NWP activity might have the potential to cause effects and has so notified the Corps, the non-Federal applicant shall not begin the activity until notified by the district engineer either that the activity has no potential to cause effects to historic properties or that NHPA section 106 consultation has been completed. For non-federal permittees, the district engineer will notify the prospective permittee within 45 days of receipt of a complete pre-construction notification whether NHPA section 106 consultation is required. If NHPA section 106 consultation is required, the district engineer will notify the non-Federal applicant that he or she cannot begin the activity until section 106 consultation is completed. If the non-Federal applicant has not heard back from the Corps within 45 days, the applicant must still wait for notification from the Corps.

(e) Prospective permittees should be aware that section 110k of the NHPA (54 U.S.C. 306113) prevents the Corps from granting a permit or other assistance to an applicant who, with intent to avoid the requirements of section 106 of the NHPA, has intentionally significantly adversely affected a historic property to which the permit would relate, or having legal power to prevent it, allowed such significant adverse effect to occur, unless the Corps, after consultation with the Advisory Council on Historic Preservation (ACHP), determines that circumstances justify granting such assistance despite the adverse effect created or permitted by the applicant. If circumstances justify granting the assistance, the Corps is required to notify the ACHP and provide documentation specifying the circumstances, the degree of damage to the integrity of any historic properties affected, and proposed mitigation. This documentation must include any views obtained from the applicant, SHPO/THPO, appropriate Indian tribes if the undertaking occurs on or affects historic properties on tribal lands or affects properties of interest to those tribes, and other parties known to have a legitimate interest in the impacts to the permitted activity on historic properties.

21. Discovery of Previously Unknown Remains and Artifacts. Permittees that discover any previously unknown historic, cultural or archeological remains and artifacts while accomplishing the activity authorized by an NWP, they must immediately notify the district engineer of what they have found, and to the maximum extent practicable, avoid construction activities that may affect the remains and artifacts until the required coordination has been completed. The district engineer will initiate the Federal, Tribal, and state coordination required to determine if the items or remains warrant a recovery effort or if the site is eligible for listing in the National Register of Historic Places.

22. Designated Critical Resource Waters. Critical resource waters include, NOAA-managed marine sanctuaries and marine monuments, and National Estuarine Research Reserves. The district engineer may designate, after notice and opportunity for public comment, additional waters officially designated by a state as having particular environmental or ecological significance, such as outstanding national resource waters or state natural heritage sites. The district engineer may also designate additional critical resource waters after notice and opportunity for public comment.

(a) Discharges of dredged or fill material into waters of the United States are not authorized by NWPs 7, 12, 14, 16, 17, 21, 29, 31, 35, 39, 40, 42, 43, 44, 49, 50, 51, 52, 57 and 58 for any activity within, or directly affecting, critical resource waters, including wetlands adjacent to such waters.

(b) For NWPs 3, 8, 10, 13, 15, 18, 19, 22, 23, 25, 27, 28, 30, 33, 34, 36, 37, 38, and 54, notification is required in accordance with general condition 32, for any activity proposed by permittees in the designated critical resource waters including wetlands adjacent to those waters. The district engineer may authorize activities under these NWPs only after she or he determines that the impacts to the critical resource waters will be no more than minimal.

23. Mitigation. The district engineer will consider the following factors when determining appropriate and practicable mitigation necessary to ensure that the individual and cumulative adverse environmental effects are no more than minimal:

(a) The activity must be designed and constructed to avoid and minimize adverse effects, both temporary and permanent, to waters of the United States to the maximum extent practicable at the project site (i.e., on site).

(b) Mitigation in all its forms (avoiding, minimizing, rectifying, reducing, or compensating for resource losses) will be required to the extent necessary to ensure that the individual and cumulative adverse environmental effects are no more than minimal.

(c) Compensatory mitigation at a minimum one-for-one ratio will be required for all wetland losses that exceed 1/10-acre and require pre-construction notification, unless the district engineer determines in writing that either some other form of mitigation would be more environmentally appropriate or the adverse environmental effects of the proposed activity are no more than minimal, and provides an activity-specific waiver of this requirement. For wetland losses of 1/10-acre or less that require pre-construction notification, the district engineer may determine on a case-by-case basis that compensatory mitigation is required to ensure that the activity results in only minimal adverse environmental effects.

(d) Compensatory mitigation at a minimum one-for-one ratio will be required for all losses of stream bed that exceed 3/100-acre and require pre-construction notification, unless the district engineer determines in writing that either some other form of mitigation would be more environmentally appropriate or the adverse environmental effects of the proposed activity are no more than minimal, and provides an activity-specific waiver of this requirement. This compensatory mitigation requirement may be satisfied through the restoration or enhancement of riparian areas next to streams in accordance with paragraph (e) of this general condition. For losses of stream bed of 3/100-acre or less that require pre-construction notification, the district engineer may determine on a case-by-case basis that compensatory mitigation is required to ensure that the activity results in only minimal adverse environmental effects. Compensatory mitigation for losses of streams should be provided, if practicable, through stream rehabilitation, enhancement, or preservation, since streams are difficult-to-replace resources (see 33 CFR 332.3(e)(3)).

(e) Compensatory mitigation plans for NWP activities in or near streams or other open waters will normally include a requirement for the restoration or enhancement, maintenance, and legal protection (e.g., conservation easements) of riparian areas next to open waters. In some cases, the restoration or maintenance/protection of riparian areas may be the only compensatory mitigation required. If restoring riparian areas involves planting vegetation, only native species should be planted. The width of the required riparian area will address documented water quality or aquatic habitat loss concerns. Normally, the riparian area will be 25 to 50 feet wide on each side of the stream, but the district engineer may require slightly wider riparian areas to address documented water quality or habitat loss concerns. If it is not possible to restore or maintain/protect a riparian area on both sides of a stream, or if the waterbody is a lake or coastal waters, then restoring or maintaining/protecting a riparian area along a single bank or shoreline may be sufficient. Where both wetlands and open waters exist on the project site, the district engineer will determine the appropriate compensatory mitigation (e.g., riparian areas and/or wetlands compensation) based on what is best for the aquatic environment on a watershed basis. In cases where riparian areas are determined to be the most appropriate form of minimization or compensatory mitigation, the district engineer may waive or reduce the requirement to provide wetland compensatory mitigation for wetland losses.

(f) Compensatory mitigation projects provided to offset losses of aquatic resources must comply with the applicable provisions of 33 CFR part 332.

(1) The prospective permittee is responsible for proposing an appropriate compensatory mitigation option if compensatory mitigation is necessary to ensure that the activity results in no more than minimal adverse environmental effects. For the NWPs, the preferred mechanism for providing compensatory mitigation is mitigation bank credits or in-lieu fee program credits (see 33 CFR 332.3(b)(2) and (3)). However, if an appropriate number and type of mitigation bank or in-lieu credits are not available at the time the PCN is submitted to the district engineer, the district engineer may approve the use of permittee-responsible mitigation.

(2) The amount of compensatory mitigation required by the district engineer must be sufficient to ensure that the authorized activity results in no more than minimal individual and cumulative adverse environmental effects (see 33 CFR 330.1(e)(3)). (See also 33 CFR 332.3(f).)

(3) Since the likelihood of success is greater and the impacts to potentially valuable uplands are reduced, aquatic resource restoration should be the first compensatory mitigation option considered for permittee-responsible mitigation.

(4) If permittee-responsible mitigation is the proposed option, the prospective permittee is responsible for submitting a mitigation plan. A conceptual or detailed mitigation plan may be used by the district engineer to make the decision on the NWP verification request, but a final mitigation plan that addresses the applicable requirements of 33 CFR 332.4(c)(2) through (14) must be approved by the district engineer before the permittee begins work in waters of the United States, unless the district engineer determines that prior approval of the final mitigation plan is not practicable or not necessary to ensure timely completion of the required compensatory mitigation (see 33 CFR 332.3(k)(3)). If permittee-responsible mitigation is the proposed option, and the proposed compensatory mitigation site is located on land in which another federal agency holds an easement, the district engineer will coordinate with that federal agency to determine if proposed compensatory mitigation project is compatible with the terms of the easement.

(5) If mitigation bank or in-lieu fee program credits are the proposed option, the mitigation plan needs to address only the baseline conditions at the impact site and the number of credits to be provided (see 33 CFR 332.4(c)(1)(ii)).

(6) Compensatory mitigation requirements (e.g., resource type and amount to be provided as compensatory mitigation, site protection, ecological performance standards, monitoring requirements)

may be addressed through conditions added to the NWP authorization, instead of components of a compensatory mitigation plan (see 33 CFR 332.4(c)(1)(ii)).

(g) Compensatory mitigation will not be used to increase the acreage losses allowed by the acreage limits of the NWPs. For example, if an NWP has an acreage limit of 1/2-acre, it cannot be used to authorize any NWP activity resulting in the loss of greater than 1/2-acre of waters of the United States, even if compensatory mitigation is provided that replaces or restores some of the lost waters. However, compensatory mitigation can and should be used, as necessary, to ensure that an NWP activity already meeting the established acreage limits also satisfies the no more than minimal impact requirement for the NWPs.

(h) Permittees may propose the use of mitigation banks, in-lieu fee programs, or permittee-responsible mitigation. When developing a compensatory mitigation proposal, the permittee must consider appropriate and practicable options consistent with the framework at 33 CFR 332.3(b). For activities resulting in the loss of marine or estuarine resources, permittee-responsible mitigation may be environmentally preferable if there are no mitigation banks or in-lieu fee programs in the area that have marine or estuarine credits available for sale or transfer to the permittee. For permittee-responsible mitigation, the special conditions of the NWP verification must clearly indicate the party or parties responsible for the implementation and performance of the compensatory mitigation project, and, if required, its long-term management.

(i) Where certain functions and services of waters of the United States are permanently adversely affected by a regulated activity, such as discharges of dredged or fill material into waters of the United States that will convert a forested or scrub-shrub wetland to a herbaceous wetland in a permanently maintained utility line right-of-way, mitigation may be required to reduce the adverse environmental effects of the activity to the no more than minimal level.

24. Safety of Impoundment Structures. To ensure that all impoundment structures are safely designed, the district engineer may require non-Federal applicants to demonstrate that the structures comply with established state or federal, dam safety criteria or have been designed by qualified persons. The district engineer may also require documentation that the design has been independently reviewed by similarly qualified persons, and appropriate modifications made to ensure safety.

25. Water Quality. (a) Where the certifying authority (state, authorized tribe, or EPA, as appropriate) has not previously certified compliance of an NWP with CWA section 401, a CWA section 401 water quality certification for the proposed discharge must be obtained or waived (see 33 CFR 330.4(c)). If the permittee cannot comply with all of the conditions of a water quality certification previously issued by certifying authority for the issuance of the NWP, then the permittee must obtain a water quality certification or waiver for the proposed discharge in order for the activity to be authorized by an NWP.

(b) If the NWP activity requires pre-construction notification and the certifying authority has not previously certified compliance of an NWP with CWA section 401, the proposed discharge is not authorized by an NWP until water quality certification is obtained or waived. If the certifying authority issues a water quality certification for the proposed discharge, the permittee must submit a copy of the certification to the district engineer. The discharge is not authorized by an NWP until the district engineer has notified the permittee that the water quality certification requirement has been satisfied by the issuance of a water quality certification or a waiver.

(c) The district engineer or certifying authority may require additional water quality management measures to ensure that the authorized activity does not result in more than minimal degradation of water quality.

26. Coastal Zone Management. In coastal states where an NWP has not previously received a state coastal zone management consistency concurrence, an individual state coastal zone management consistency concurrence must be obtained, or a presumption of concurrence must occur (see 33 CFR 330.4(d)). If the permittee cannot comply with all of the conditions of a coastal zone management consistency concurrence previously issued by the state, then the permittee must obtain an individual

coastal zone management consistency concurrence or presumption of concurrence in order for the activity to be authorized by an NWP. The district engineer or a state may require additional measures to ensure that the authorized activity is consistent with state coastal zone management requirements.

27. Regional and Case-By-Case Conditions. The activity must comply with any regional conditions that may have been added by the Division Engineer (see 33 CFR 330.4(e)) and with any case specific conditions added by the Corps or by the state, Indian Tribe, or U.S. EPA in its CWA section 401 Water Quality Certification, or by the state in its Coastal Zone Management Act consistency determination.

28. Use of Multiple Nationwide Permits. The use of more than one NWP for a single and complete project is authorized, subject to the following restrictions:
(a) If only one of the NWPs used to authorize the single and complete project has a specified acreage limit, the acreage loss of waters of the United States cannot exceed the acreage limit of the NWP with the highest specified acreage limit. For example, if a road crossing over tidal waters is constructed under NWP 14, with associated bank stabilization authorized by NWP 13, the maximum acreage loss of waters of the United States for the total project cannot exceed 1⁄3-acre.
(b) If one or more of the NWPs used to authorize the single and complete project has specified acreage limits, the acreage loss of waters of the United States authorized by those NWPs cannot exceed their respective specified acreage limits. For example, if a commercial development is constructed under NWP 39, and the single and complete project includes the filling of an upland ditch authorized by NWP 46, the maximum acreage loss of waters of the United States for the commercial development under NWP 39 cannot exceed 1/2-acre, and the total acreage loss of waters of United States due to the NWP 39 and 46 activities cannot exceed 1 acre.

29. Transfer of Nationwide Permit Verifications. If the permittee sells the property associated with a nationwide permit verification, the permittee may transfer the nationwide permit verification to the new owner by submitting a letter to the appropriate Corps district office to validate the transfer. A copy of the nationwide permit verification must be attached to the letter, and the letter must contain the following statement and signature:

"When the structures or work authorized by this nationwide permit are still in existence at the time the property is transferred, the terms and conditions of this nationwide permit, including any special conditions, will continue to be binding on the new owner(s) of the property. To validate the transfer of this nationwide permit and the associated liabilities associated with compliance with its terms and conditions, have the transferee sign and date below."

____
(Transferee)

____
(Date)

30. Compliance Certification. Each permittee who receives an NWP verification letter from the Corps must provide a signed certification documenting completion of the authorized activity and implementation of any required compensatory mitigation. The success of any required permittee-responsible mitigation, including the achievement of ecological performance standards, will be addressed separately by the district engineer. The Corps will provide the permittee the certification document with the NWP verification letter. The certification document will include:

(a) A statement that the authorized activity was done in accordance with the NWP authorization, including any general, regional, or activity-specific conditions;

(b) A statement that the implementation of any required compensatory mitigation was completed in accordance with the permit conditions. If credits from a mitigation bank or in-lieu fee program are used to satisfy the compensatory mitigation requirements, the certification must include the documentation required by 33 CFR 332.3(l)(3) to confirm that the permittee secured the appropriate number and resource type of credits; and

(c) The signature of the permittee certifying the completion of the activity and mitigation.

The completed certification document must be submitted to the district engineer within 30 days of completion of the authorized activity or the implementation of any required compensatory mitigation, whichever occurs later.

31. Activities Affecting Structures or Works Built by the United States. If an NWP activity also requires review by, or permission from, the Corps pursuant to 33 U.S.C. 408 because it will alter or temporarily or permanently occupy or use a U.S. Army Corps of Engineers (USACE) federally authorized Civil Works project (a "USACE project"), the prospective permittee must submit a pre-construction notification. See paragraph (b)(10) of general condition 32. An activity that requires section 408 permission and/or review is not authorized by an NWP until the appropriate Corps office issues the section 408 permission or completes its review to alter, occupy, or use the USACE project, and the district engineer issues a written NWP verification.

32. Pre-Construction Notification. (a) *Timing*. Where required by the terms of the NWP, the prospective permittee must notify the district engineer by submitting a pre-construction notification (PCN) as early as possible. The district engineer must determine if the PCN is complete within 30 calendar days of the date of receipt and, if the PCN is determined to be incomplete, notify the prospective permittee within that 30 day period to request the additional information necessary to make the PCN complete. The request must specify the information needed to make the PCN complete. As a general rule, district engineers will request additional information necessary to make the PCN complete only once. However, if the prospective permittee does not provide all of the requested information, then the district engineer will notify the prospective permittee that the PCN is still incomplete and the PCN review process will not commence until all of the requested information has been received by the district engineer. The prospective permittee shall not begin the activity until either:

(1) He or she is notified in writing by the district engineer that the activity may proceed under the NWP with any special conditions imposed by the district or division engineer; or

(2) 45 calendar days have passed from the district engineer's receipt of the complete PCN and the prospective permittee has not received written notice from the district or division engineer. However, if the permittee was required to notify the Corps pursuant to general condition 18 that listed species or critical habitat might be affected or are in the vicinity of the activity, or to notify the Corps pursuant to general condition 20 that the activity might have the potential to cause effects to historic properties, the permittee cannot begin the activity until receiving written notification from the Corps that there is "no effect" on listed species or "no potential to cause effects" on historic properties, or that any consultation required under Section 7 of the Endangered Species Act (see 33 CFR 330.4(f)) and/or section 106 of the National Historic Preservation Act (see 33 CFR 330.4(g)) has been completed. If the proposed activity requires a written waiver to exceed specified limits of an NWP, the permittee may not begin the activity until the district engineer issues the waiver. If the district or division engineer notifies the permittee in writing that an individual permit is required within 45 calendar days of receipt of a complete PCN, the permittee cannot begin the activity until an individual permit has been obtained. Subsequently, the permittee's right to proceed under the NWP may be modified, suspended, or revoked only in accordance with the procedure set forth in 33 CFR 330.5(d)(2).

(b) *Contents of Pre-Construction Notification*: The PCN must be in writing and include the following information:

(1) Name, address and telephone numbers of the prospective permittee;

(2) Location of the proposed activity;

(3) Identify the specific NWP or NWP(s) the prospective permittee wants to use to authorize the proposed activity;

(4) (i) A description of the proposed activity; the activity's purpose; direct and indirect adverse environmental effects the activity would cause, including the anticipated amount of loss of wetlands, other special aquatic sites, and other waters expected to result from the NWP activity, in acres, linear feet, or other appropriate unit of measure; a description of any proposed mitigation measures intended to reduce the adverse environmental effects caused by the proposed activity; and any other NWP(s), regional general permit(s), or individual permit(s) used or intended to be used to authorize any part of the proposed project or any related activity, including other separate and distant crossings for linear projects that require Department of the Army authorization but do not require pre-construction notification. The description of the proposed activity and any proposed mitigation measures should be sufficiently detailed to allow the district engineer to determine that the adverse environmental effects of the activity will be no more than minimal and to determine the need for compensatory mitigation or other mitigation measures.

(ii) For linear projects where one or more single and complete crossings require pre-construction notification, the PCN must include the quantity of anticipated losses of wetlands, other special aquatic sites, and other waters for each single and complete crossing of those wetlands, other special aquatic sites, and other waters (including those single and complete crossings authorized by an NWP but do not require PCNs). This information will be used by the district engineer to evaluate the cumulative adverse environmental effects of the proposed linear project, and does not change those non-PCN NWP activities into NWP PCNs.

(iii) Sketches should be provided when necessary to show that the activity complies with the terms of the NWP. (Sketches usually clarify the activity and when provided results in a quicker decision. Sketches should contain sufficient detail to provide an illustrative description of the proposed activity (e.g., a conceptual plan), but do not need to be detailed engineering plans);

(5) The PCN must include a delineation of wetlands, other special aquatic sites, and other waters, such as lakes and ponds, and perennial and intermittent streams, on the project site. Wetland delineations must be prepared in accordance with the current method required by the Corps. The permittee may ask the Corps to delineate the special aquatic sites and other waters on the project site, but there may be a delay if the Corps does the delineation, especially if the project site is large or contains many wetlands, other special aquatic sites, and other waters. Furthermore, the 45-day period will not start until the delineation has been submitted to or completed by the Corps, as appropriate;

(6) If the proposed activity will result in the loss of greater than 1/10-acre of wetlands or 3/100-acre of stream bed and a PCN is required, the prospective permittee must submit a statement describing how the mitigation requirement will be satisfied, or explaining why the adverse environmental effects are no more than minimal and why compensatory mitigation should not be required. As an alternative, the prospective permittee may submit a conceptual or detailed mitigation plan.

(7) For non-federal permittees, if any listed species (or species proposed for listing) or designated critical habitat (or critical habitat proposed for such designation) might be affected or is in the vicinity of the activity, or if the activity is located in designated critical habitat (or critical habitat proposed for such designation), the PCN must include the name(s) of those endangered or threatened species (or species proposed for listing) that might be affected by the proposed activity or utilize the designated critical habitat (or critical habitat proposed for such designation) that might be affected by the proposed activity. For NWP activities that require pre-construction notification, Federal permittees must provide documentation demonstrating compliance with the Endangered Species Act;

(8) For non-federal permittees, if the NWP activity might have the potential to cause effects to a historic property listed on, determined to be eligible for listing on, or potentially eligible for listing on, the National Register of Historic Places, the PCN must state which historic property might have the potential to be affected by the proposed activity or include a vicinity map indicating the location of the historic property. For NWP activities that require pre-construction notification, Federal permittees must provide documentation demonstrating compliance with section 106 of the National Historic Preservation Act;

(9) For an activity that will occur in a component of the National Wild and Scenic River System, or in a river officially designated by Congress as a “study river” for possible inclusion in the system while the river is in an official study status, the PCN must identify the Wild and Scenic River or the “study river” (see general condition 16); and

(10) For an NWP activity that requires permission from, or review by, the Corps pursuant to 33 U.S.C. 408 because it will alter or temporarily or permanently occupy or use a U.S. Army Corps of Engineers federally authorized civil works project, the pre-construction notification must include a statement confirming that the project proponent has submitted a written request for section 408 permission from, or review by, the Corps office having jurisdiction over that USACE project.

(c) *Form of Pre-Construction Notification*: The nationwide permit pre-construction notification form (Form ENG 6082) should be used for NWP PCNs. A letter containing the required information may also be used. Applicants may provide electronic files of PCNs and supporting materials if the district engineer has established tools and procedures for electronic submittals.

(d) *Agency Coordination*: (1) The district engineer will consider any comments from Federal and state agencies concerning the proposed activity’s compliance with the terms and conditions of the NWPs and the need for mitigation to reduce the activity’s adverse environmental effects so that they are no more than minimal.

(2) Agency coordination is required for: (i) all NWP activities that require pre-construction notification and result in the loss of greater than 1/2-acre of waters of the United States; (ii) NWP 13 activities in excess of 500 linear feet, fills greater than one cubic yard per running foot, or involve discharges of dredged or fill material into special aquatic sites; and (iii) NWP 54 activities in excess of 500 linear feet, or that extend into the waterbody more than 30 feet from the mean low water line in tidal waters or the ordinary high water mark in the Great Lakes.

(3) When agency coordination is required, the district engineer will immediately provide (e.g., via e-mail, facsimile transmission, overnight mail, or other expeditious manner) a copy of the complete PCN to the appropriate Federal or state offices (FWS, state natural resource or water quality agency, EPA, and, if appropriate, the NMFS). With the exception of NWP 37, these agencies will have 10 calendar days from the date the material is transmitted to notify the district engineer via telephone, facsimile transmission, or e-mail that they intend to provide substantive, site-specific comments. The comments must explain why the agency believes the adverse environmental effects will be more than minimal. If so contacted by an agency, the district engineer will wait an additional 15 calendar days before making a decision on the pre-construction notification. The district engineer will fully consider agency comments received within the specified time frame concerning the proposed activity’s compliance with the terms and conditions of the NWPs, including the need for mitigation to ensure that the net adverse environmental effects of the proposed activity are no more than minimal. The district engineer will provide no response to the resource agency, except as provided below. The district engineer will indicate in the administrative record associated with each pre-construction notification that the resource agencies’ concerns were considered. For NWP 37, the emergency watershed protection and rehabilitation activity may proceed immediately in cases where there is an unacceptable hazard to life or a significant loss of property or economic hardship will occur. The district engineer will consider any comments received to decide whether the NWP 37 authorization should be modified, suspended, or revoked in accordance with the procedures at 33 CFR 330.5.

(4) In cases of where the prospective permittee is not a Federal agency, the district engineer will provide a response to NMFS within 30 calendar days of receipt of any Essential Fish Habitat conservation recommendations, as required by section 305(b)(4)(B) of the Magnuson-Stevens Fishery Conservation and Management Act.

(5) Applicants are encouraged to provide the Corps with either electronic files or multiple copies of pre-construction notifications to expedite agency coordination.

C. SEATTLE DISTRICT REGIONAL GENERAL CONDITIONS: The following conditions apply to the 2021 NWPs - Final 41 NWPs for the Seattle District in Washington State, as applicable.

RGC 1, Project Drawings
Drawings must be submitted with pre-construction notification (PCN). Drawings must provide a clear understanding of the proposed project, and how waters of the United States will be affected. Drawings must be originals and not reduced copies of large-scale plans. Engineering drawings are not required. Existing and proposed site conditions (manmade and landscape features) must be drawn to scale.

RGC 2, Aquatic Resources Requiring Special Protection
A PCN is required for activities resulting in a loss of waters of the United States in wetlands in dunal systems along the Washington coast, mature forested wetlands, bogs and peatlands, aspen-dominated wetlands, alkali wetlands, vernal pools, camas prairie wetlands, estuarine wetlands, and wetlands in coastal lagoons.

RGC 3, New Bank Stabilization in Tidal Waters of Puget Sound
Activities involving new bank stabilization in tidal waters in Water Resource Inventory Areas (WRIAs) 8, 9, 10, 11 and 12 (within the areas identified on Figures 1a through 1e) cannot be authorized by NWP.

RGC 4, Commencement Bay
No permanent losses of wetlands or mudflats within the Commencement Bay Study Area may be authorized by any NWP (see Figure 2).

RGC 5, Bank Stabilization
All projects including new or maintenance bank stabilization activities in waters of the United States where salmonid species are present or could be present, requires PCN to the U.S. Army Corps of Engineers (Corps) (see NWP general condition 32).
For new bank stabilization projects only, the following must be submitted to the Corps:

a. The cause of the erosion and the distance of any existing structures from the area(s) being stabilized.
b. The type and length of existing bank stabilization within 300 feet of the proposed project.
c. A description of current conditions and expected post-project conditions in the waterbody.
d. A statement describing how the project incorporates elements avoiding and minimizing adverse environmental effects to the aquatic environment and nearshore riparian area, including vegetation impacts in the waterbody.

In addition to a. through d., the results from any relevant geotechnical investigations can be submitted with the PCN if it describes current or expected conditions in the waterbody.

RGC 6, Crossings of Waters of the United States
Any project including installing, replacing, or modifying crossings of waters of the United States, such as culverts or bridges, requires submittal of a PCN to the U.S. Army Corps of Engineers (see NWP general condition 32).
If a culvert is proposed to cross waters of the U.S. where salmonid species are present or could be present, the project must apply the stream simulation design method from the Washington Department of Fish and Wildlife located in the *Water Crossing Design Guidelines* (2013), or a design method which provides passage at all life stages at all flows where the salmonid species would naturally seek passage. If the stream simulation design method is not applied for a culvert where salmonid species are present or could be present, the project proponent must provide a rationale in the PCN sufficient to establish one of the following:

a. The existence of extraordinary site conditions.
b. How the proposed design will provide equivalent or better fish passage and fisheries habitat benefits than the stream simulation design method.

Culverts installed under emergency authorization that do not meet the above design criteria will be required to meet the above design criteria to receive an after-the-fact nationwide permit verification.

RGC 7, Stream Loss

A PCN is required for all activities that result in the loss of any linear feet of streams.

RGC 8, Construction Boundaries
Permittees must clearly mark all construction area boundaries within waters of the United States before beginning work on projects that involve grading or placement of fill. Boundary markers and/or construction fencing must be maintained and clearly visible for the duration of construction. Permittees should avoid and minimize removal of native vegetation (including submerged aquatic vegetation) to the maximum extent possible.

RGC 9, ESA Reporting to NMFS
For any nationwide permit that may affect threatened or endangered species;
Incidents where any individuals of fish species, marine mammals and/or sea turtles listed by National Oceanic and Atmospheric Administration Fisheries, National Marine Fisheries Service (NMFS) under the Endangered Species Act appear to be injured or killed as a result of discharges of dredged or fill material into waters of the U.S. or structures or work in navigable waters of the U.S. authorized by this Nationwide Permit verification shall be reported to NMFS, Office of Protected Resources at (301) 713-1401 and the Regulatory Office of the Seattle District of the U.S. Army Corps of Engineers at (206) 764-3495. The finder should leave the animal alone, make note of any circumstances likely causing the death or injury, note the location and number of individuals involved and, if possible, take photographs. Adult animals should not be disturbed unless circumstances arise where they are obviously injured or killed by discharge exposure or some unnatural cause. The finder may be asked to carry out instructions provided by the NMFS to collect specimens or take other measures to ensure that evidence intrinsic to the specimen is preserved.

D. SEATTLE DISTRICT REGIONAL SPECIFIC CONDITIONS FOR THIS NWP:

NWP 38 Specific Regional Condition:
1. Non-government project proponents must submit a copy of court ordered remedial plans or related settlements with the pre-construction notification.

E. 401 WATER QUALITY CERTIFICATION: Depending on the geographic region of the work authorized by this verification, the appropriate 401 certifying authority has made the following determinations:

Washington Department of Ecology (Ecology) (Projects in all areas except as described for the other certifying agencies listed below): General and Specific WQC Conditions

A. State General Conditions for all Nationwide Permits

In addition to all of the U.S. Army Corps of Engineers' (Corps) national and Seattle District'sregional permit conditions, the following state general Water Quality Certification (WQC) conditions **apply to all NWPs whether granted or granted with conditions** in Washington where Ecology is the certifying authority.

Due to the lack of site specific information on the discharge types, quantities, and specific locations, as well as the condition of receiving waters and the quantity of waters (including wetlands) that may be lost, Ecology may need to review the project if one of the following stategeneral conditions is triggered.

This case-by-case review may be required, and additional information regarding the project and associated discharges may be needed, to verify that the proposed project would comply with state water quality requirements and if an individual WQC is required or if the project meets this programmatic WQC.

1. **In-water construction activities**. Ecology WQC review is required for projects or activities authorized under NWPs where the project proponent has indicated on the Joint Aquatic Resource Permit Application (JARPA) question 9e that the project or activity will not meet State water quality standards, or has provided information indicating that the project or activity will cause, or

may be likely to cause or contributeto an exceedance of a State water quality standard (Chapter 173-201A WAC) or sediment management standard (Chapter 173-204 WAC).

Note: In-water activities include any activity within a jurisdictional wetland and/orwaters.

2. **Projects or Activities Discharging to Impaired Waters**. Ecology WQC review is required for projects or activities that will occur in a 303(d) listed segment of a waterbody or upstream of a listed segment and may result in further exceedances of the specific listedparameter to determine if the project meets this programmatic WQC or will require individual WQC.

To determine if your project or activity is in a 303(d) listed segment of a waterbody, visitEcology's Water Quality Assessment webpage for maps and search tools.

3. **Aquatic resources requiring special protection**. Certain aquatic resources are unique and difficult-to-replace components of the aquatic environment in Washington. Activities that would affect these resources must be avoided to the greatest extent practicable. Compensating for adverse impacts to high value aquatic resources is typically difficult, prohibitively expensive, and may not be possible in some landscapesettings.

Ecology WQC review is required for projects or activities in areas identified below to determine if the project meets this programmatic WQC or will require individual WQC.

a. Activities in or affecting the following aquatic resources:
   i. Wetlands with special characteristics (as defined in the Washington State Wetland Rating Systems for western and eastern Washington, Ecology Publications #14-06-029 and #14-06-030):
      - Estuarine wetlands.
      - Wetlands of High Conservation Value.
      - Bogs.
      - Old-growth forested wetlands and mature forested wetlands.
      - Wetlands in coastal lagoons.
      - Wetlands in dunal systems along the Washington coast.
      - Vernal pools.
      - Alkali wetlands.

   ii. Fens, aspen-dominated wetlands, camas prairie wetlands.

   iii. Category I wetlands.

   iv. Category II wetlands with a habitat score ≥ 8 points.

b. Activities in or resulting in a loss of eelgrass (Zostera marina) beds.

This state general condition does not apply to the following NWPs:
NWP 20 – Response Operations for Oil and Hazardous Substances
NWP 32 – Completed Enforcement Actions
NWP 48 – Commercial Shellfish Mariculture Activities

4. Loss of More than 300 Linear Feet of Streambed. For any project that results in the lossof more than 300 linear feet of streambed Ecology WQC review is required to determineif the project meets this programmatic WQC or will require individual WQC.

5. Temporary Fills. For any project or activity with temporary fill in wetlands or other waters for more than six months Ecology WQC review is required to determine if theproject meets this programmatic WQC or will require individual WQC.

6. **Mitigation.** Project proponents are required to show that they have followed the mitigation sequence and have first avoided and minimized impacts to aquatic resourceswherever practicable. For projects requiring Ecology WQC review or an individual WQC with unavoidable impacts to aquatics resources, a mitigation plan must be provided.

    a. Wetland mitigation plans submitted for Ecology review and approval shall be based on the most current guidance provided in Wetland Mitigation in Washington State, Parts 1 and 2 (available on Ecology's website) and shall, at aminimum, include the following:

        i. A description of the measures taken to avoid and minimize impacts to wetlands and other waters of the U.S.

        ii. The nature of the proposed impacts (i.e., acreage of wetlands and functions lost or degraded).

        iii. The rationale for the mitigation site that was selected.

        iv. The goals and objectives of the compensatory mitigation project.

        v. How the mitigation project will be accomplished, including construction sequencing, best management practices to protect water quality, proposed performance standards for measuring success and the proposed buffer widths.

        vi. How it will be maintained and monitored to assess progress toward goals and objectives. Monitoring will generally be required for a minimum of five years. For forested and scrub-shrub wetlands, 10 years of monitoring will often be necessary.

        vii. How the compensatory mitigation site will be legally protected for the long term.

Refer to Wetland Mitigation in Washington State – Part 2: Developing Mitigation Plans (Ecology Publication #06-06-011b) and Selecting Wetland Mitigation Sites Using a Watershed Approach (Ecology Publications #09-06-032 (Western Washington) and #10-06-007 (Eastern Washington)) for guidance on selecting suitable mitigation sites and developing mitigation plans.

Ecology encourages the use of alternative mitigation approaches, includingcredit/debit methodology, advance mitigation, and other programmatic approaches such as mitigation banks and in-lieu fee programs. If you are interested in proposing use of an alternative mitigation approach, consult with the appropriate Ecology regional staff person. Information on alternative mitigation approaches is available on Ecology's website.

    b. Mitigation for other aquatic resource impacts will be determined on a case-by-case basis.

7. **Stormwater Pollution Prevention**. All projects involving land disturbance or impervious surfaces must implement stormwater pollution prevention or control measures to avoiddischarge of pollutants in stormwater runoff to waters.

    a. For land disturbances during construction, the applicant must obtain and implement permits (e.g., Construction Stormwater General Permit) where required and follow Ecology's current stormwater manual.

b. Following construction, prevention or treatment of on-going stormwater runofffrom impervious surfaces shall be provided.

Ecology's Stormwater Management and Design Manuals and stormwater permitinformation are available on Ecology's website.

8. **Application**. For projects or activities that will require Ecology WQC review, or anindividual WQC, project proponents must provide Ecology with a JARPA or the equivalent information, along with the documentation provided to the Corps, as described in national general condition 32, Pre-Construction Notification (PCN), including, where applicable:

    a. A description of the project, including site plans, project purpose, direct and indirect adverse environmental effects the project discharge(s) would cause, best management practices (BMPs), and proposed means to monitor the discharge(s).

    b. List of all federal, state or local agency authorizations required to be used for anypart of the proposed project or any related activity.

    c. Drawings indicating the OHWM, delineation of special aquatic sites, and other waters of the state. Wetland delineations must be prepared in accordance with thecurrent method required by the Corps and shall include Ecology's Wetland Rating form. Wetland Rating forms are subject to review and verification by Ecology staff.

    Guidance for determining the OHWM is available on Ecology's website.

    d. A statement describing how the mitigation requirement will be satisfied. A conceptual or detailed mitigation or restoration plan may be submitted. See stategeneral condition 5.

    e. Other applicable requirements of Corps NWP general condition 32, Corps regional conditions, or notification conditions of the applicable NWP.

Ecology **grants with conditions Water Quality Certification** (WQC) for this NWP provided that Ecology individual WQC review is not required per the state general conditions (see above) and the following conditions:

Ecology Section 401 Water Quality Certification – Granted with conditions. Ecology individual WQC is required for projects or activities authorized under this NWP if:

The project or activity is not authorized though a Model Toxics Control Act (MTCA) order or a Comprehensive Environmental Response, Compensation and Liability Act(CERCLA) order

Environmental Protection Agency (EPA) (on Tribal Lands where Tribes Do Not Have Treatment in a Similar Manner as a State and Lands with Exclusive Federal Jurisdiction in Washington):

On behalf of the 28 tribes that do not have treatment in a similar manner as a state and for exclusive federal jurisdiction lands located within the state of Washington, EPA Region 10 has determined that CWA Section 401 WQC for the following proposed NWPs is granted with conditions. EPA Region 10 has determined that any discharge authorized under the following proposed NWPs will comply with water quality requirements, as defined at 40 C.F.R. § 121.1(n), subject to the following conditions pursuant to CWA Section 401(d).

General Conditions:

EPA General Condition 1 – Aquatic Resources of Special Concern
Activities resulting in a point source discharge in the following types of aquatic resources of special concern shall request an individual project-specific CWA Section 401 WQC: mature forested wetlands; bogs, fens and other peatlands; vernal pools; aspen-dominated wetlands; alkali wetlands; camas prairie wetlands; wetlands in dunal systems along the Oregon or Washington Coast; riffle-pool complexes of streams; marine or estuarine mud-flats; salt marshes; marine waters with native eelgrass or kelp beds; or marine nearshore forage fish habitat. To identify whether a project would occur in any of these aquatic resources of special concern, project proponents shall use existing and available information to identify the location and type of resources, including using the U.S. Fish and Wildlife Service's online digital National Wetland Inventory maps, identifying project location on topographical maps, and/or providing on-site determinations as required by the Corps. When a project requires a Pre-Construction Notification (PCN) to the Corps, project proponents shall work with the Corps to identify whether the project is in any of these specific aquatic resources of special concern.

EPA General Condition 2 – Soil Erosion and Sediment Controls

Turbidity shall not exceed background turbidity by more than 50 Nephelometric Turbidity Units (NTU) above background instantaneously or more than 25 NTU above background for more than ten consecutive days.[8] Projects or activities that are expected to exceed these levels require an individual project-specific CWA Section 401 WQC.

The turbidity standard shall be met at the following distances from the discharge:

Wetted Stream Width at Discharge Point	**Approximate Downstream Point to Sample to Determine Compliance**
Up to 30 feet	50 feet
>30 to 100 feet	100 feet
>100 feet to 200 feet	200 feet
>200 feet	300 feet
Lake, Pond, Reservoir	Lesser of 100 feet or maximum surface distance

For Marine Water	**Point of Compliance for Temporary Area of Mixing**
Estuaries or Marine Waters	Radius of 150 feet from the activity causing the turbidity exceedance

Measures to prevent and/or reduce turbidity shall be implemented and monitored prior to, during, and after construction. Turbidity monitoring shall be done at the point of compliance within 24 hours of a precipitation event of 0.25 inches or greater. During monitoring and maintenance, if turbidity limits are exceeded or if measures are identified as ineffective, then additional measures shall be taken to come into compliance and EPA shall be notified within 48 hours of the exceedance or measure failure.

EPA General Condition 3 - Compliance with Stormwater Pollution Prevention and the National Pollutant Discharge Elimination System Permit Provisions
For land disturbances during construction that 1) disturb one or more acres of land, or 2) will disturb less than one acre of land but are part of a common plan of development or sale that will ultimately disturb one or more acres of land, the permittee shall obtain and implement Construction Stormwater General Permit requirements,[9] including:

1. The permittee shall develop a Stormwater Pollution Prevention Plan (SWPPP)[10] and submit it to EPA Region 10 and appropriate Corps District; and
2. Following construction, prevention or treatment of ongoing stormwater runoff from impervious surfaces that includes soil infiltration shall be implemented.

EPA General Condition 4 – Projects or Activities Discharging to Impaired Waters
Projects or activities are not authorized under the NWPs if the project will involve point source discharges into an active channel (e.g., flowing or open waters) of a water of the U.S. listed as impaired under CWA Section 303(d) and/or if the waterbody has an approved Total Maximum Daily Load (TMDL) and the discharge may result in further exceedance of a specific parameter (e.g., total suspended solids, dissolved oxygen, temperature) for which the waterbody is listed or has an approved TMDL. The current lists of impaired waters of the U.S. under CWA Section 303(d) and waters of the U.S. for which a TMDL has been approved are available on EPA Region 10's web site at: https://www.epa.gov/tmdl/impaired-waters-and-tmdls-region-10.

EPA General Condition 5 – Notice to EPA
All project proponents shall provide notice to EPA Region 10 prior to commencing construction activities authorized by a NWP. This will provide EPA Region 10 with the opportunity to inspect the activity for the purposes of determining whether any discharge from the proposed project will violate this CWA Section 401 WQC. Where the Corps requires a PCN for an applicable NWP, the project proponent shall also provide the PCN to EPA Region 10. EPA Region 10 will provide written notification to the project proponent if the proposed project will violate the water quality certification of the NWP.

EPA General Condition 6 – Unsuitable Materials
The project proponent shall not use wood products treated with leachable chemical components (e.g., copper, arsenic, zinc, creosote, chromium, chloride, fluoride, pentachlorophenol), which result in a discharge to waters of the U.S., unless the wood products meet the following criteria:

1. Wood preservatives and their application shall be in compliance with EPA label requirements and criteria of approved EPA Registration Documents under the Federal Insecticide, Fungicide, and Rodenticide Act;
2. Use of chemically treated wood products shall follow the Western Wood Preservatives Institute (WWPI) guidelines and BMPs to minimize the preservative migrating from treated wood into the aquatic environment;
3. For new or replacement wood structures, the wood shall be sealed with non-toxic products such as water-based silica or soy-based water repellants or sealers to prevent or limit leaching. Acceptable alternatives to chemically treated wood include untreated wood, steel (painted, unpainted or coated with epoxy petroleum compound or plastic), concrete and plastic lumber; and
4. All removal of chemically treated wood products (including pilings) shall follow the most recent "EPA Region 10 Best Management Practices for Piling Removal and Placement in Washington State."

Federally recognized tribes located within the state of Washington

EPA Region 10 cannot certify that the range of discharges from potential projects authorized under this NWP will comply with water quality requirements, as defined in 40 CFR 121.1(n). Therefore, CWA Section 401 water quality certification is denied for this NWP and applicants must request an individual water quality certification, consistent with 40 CFR 121.5.

Lands of Exclusive Federal Jurisdiction

EPA Region 10 cannot certify that the range of discharges from potential projects authorized under this NWP will comply with water quality requirements, as defined in 40 CFR 121.1(n). Therefore, CWA Section 401 water quality certification is denied for this NWP and applicants must request an individual water quality certification, consistent with 40 CFR 121.5.

Specific Tribes with Certifying Authority (Projects in Specific Tribal Areas):
WQC was issued by the Swinomish Indian Tribal Community. WQC was waived by the Confederated Tribes of the Chehalis Reservation and Colville Indian Reservation, Kalispel Tribe of Indians, Port Gamble S'Klallam Tribe, Quinault Indian Nation, and the Spokane Tribe of Indians. WQC was denied by the Lummi Nation, Makah Tribe, Puyallup Tribe of Indians, and the Tulalip Tribes; therefore, individual WQC is required from these tribes.

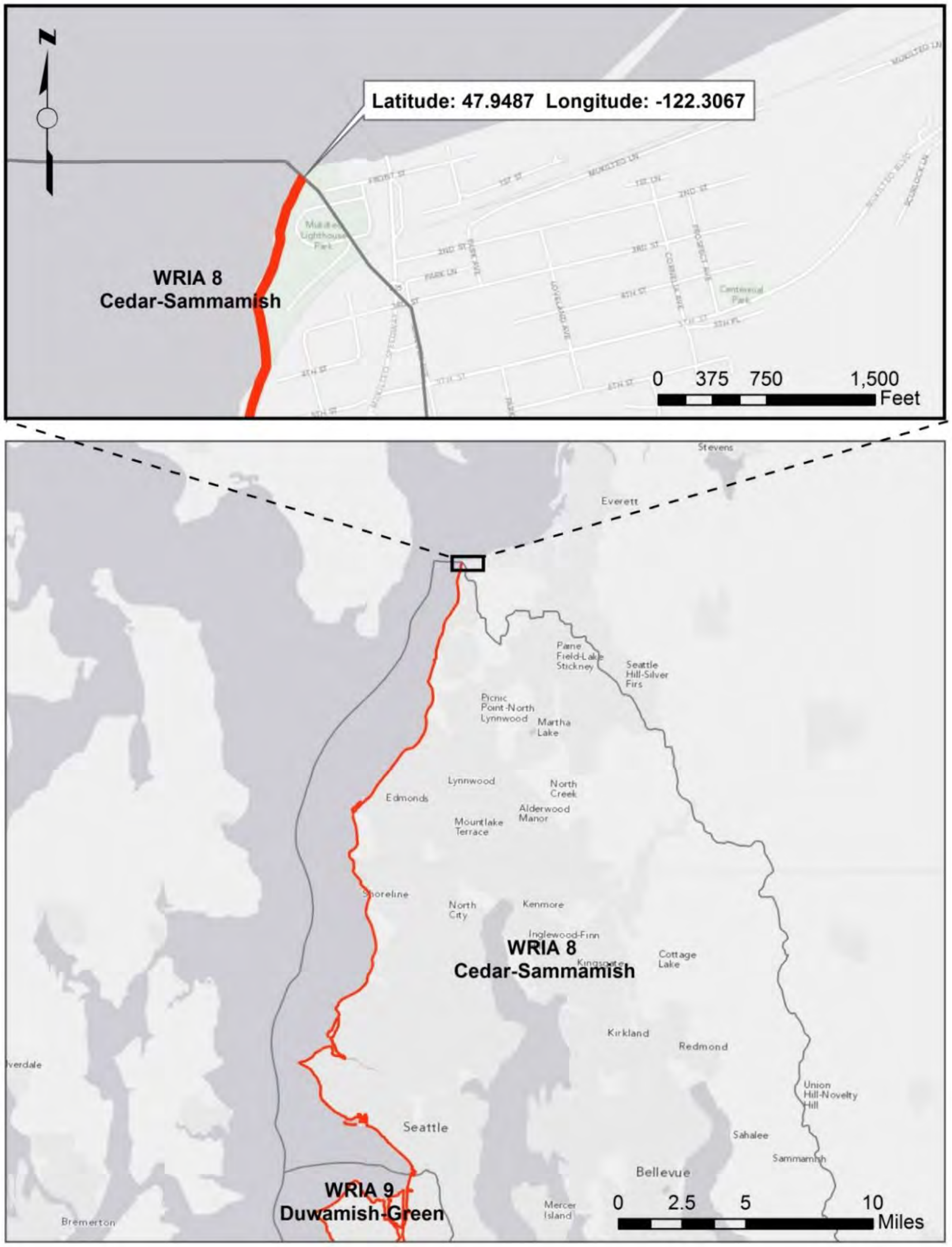
F. COASTAL ZONE MANAGEMENT ACT (CZMA) CONSISTENCY RESPONSE FOR THIS NWP:

Ecology's determination is that they concur with conditions that this NWP is consistent with CZMA.

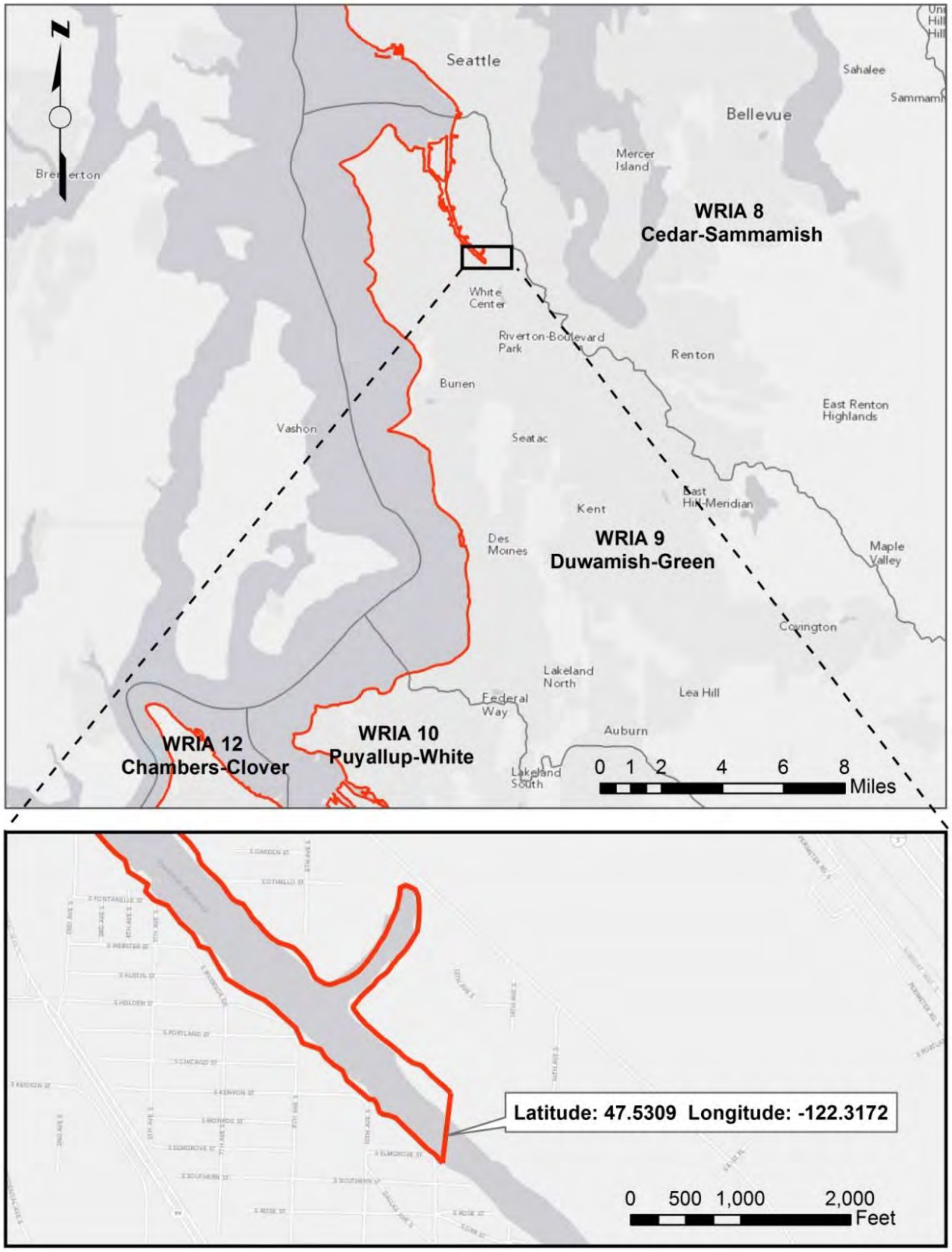
CZM Federal Consistency Response – Concur with Conditions.

1. A CZM Federal Consistency Decision is required for projects or activities under this NWP if a State 401 Water Quality Certification is required.

Seattle District Regional General Conditions - Figures
Figure 1: RGC 3 - WRIAs 8, 9, 10, 11, and 12
a. WRIA 8



b. WRIA 9



N
Seattle
Bellevue
Sahalee
Mercer Island
Bremerton
WRIA 8
Cedar-Sammamish
White Center
Riverton-Boulevard Park
Renton
Burien
East Renton Highlands
Vashon
Seatac
East Hill-Meridian
Kent
WRIA 9
Duwamish-Green
Des Moines
Maple Valley
Covington
Lakeland North
Lea Hill
Federal Way
Auburn
WRIA 12
Chambers-Clover
WRIA 10
Puyallup-White
Lakeland South
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Miles
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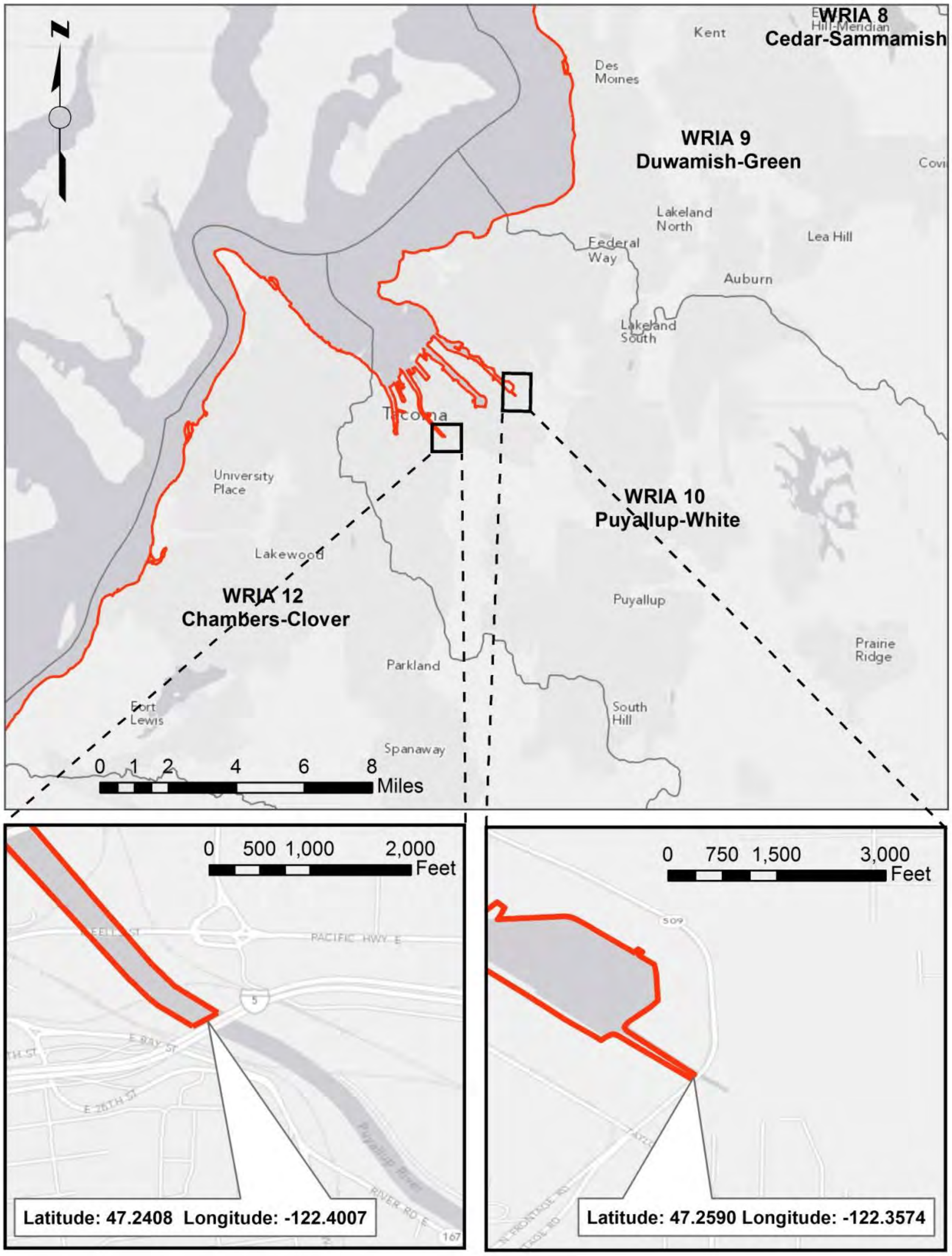
0 500 1,000 2,000
Feet

c. WRIA 10


WRIA 8
Cedar-Sammamish
Kent
Des Moines
WRIA 9
Duwamish-Green
Lakeland North
Federal Way
Lea Hill
Auburn
Lakeland South
Tacoma
University Place
WRIA 10
Puyallup-White
Lakewood
WRIA 12
Chambers-Clover
Puyallup
Prairie Ridge
Parkland
Fort Lewis
South Hill
Spanaway
0 1 2 4 6 8
Miles
0 500 1,000 2,000
Feet
PACIFIC HWY E
E BAY ST
E 26TH ST
Puyallup River
RIVER RD E
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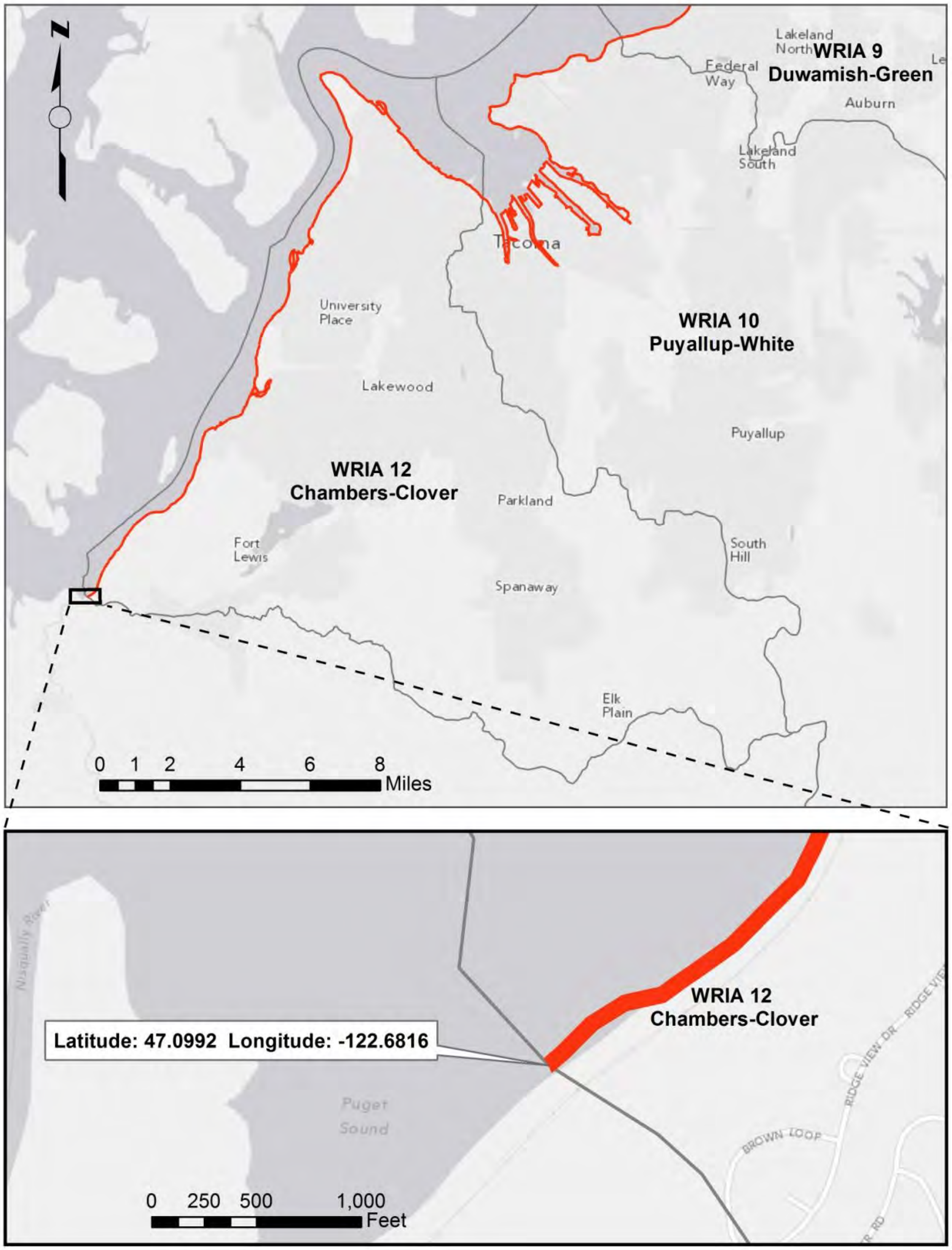
0 750 1,500 3,000
Feet
509
Latitude: 47.2590 Longitude: -122.3574

d. WRIA 12


Lakeland North
WRIA 9
Duwamish-Green
Federal Way
Auburn
Lakeland South
Tacoma
University Place
WRIA 10
Puyallup-White
Lakewood
Puyallup
WRIA 12
Chambers-Clover
Parkland
Fort Lewis
South Hill
Spanaway
Elk Plain
0 1 2 4 6 8
Miles
Nisqually River
WRIA 12
Chambers-Clover
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Puget Sound
BROWN LOOP
RIDGE VIEW DR
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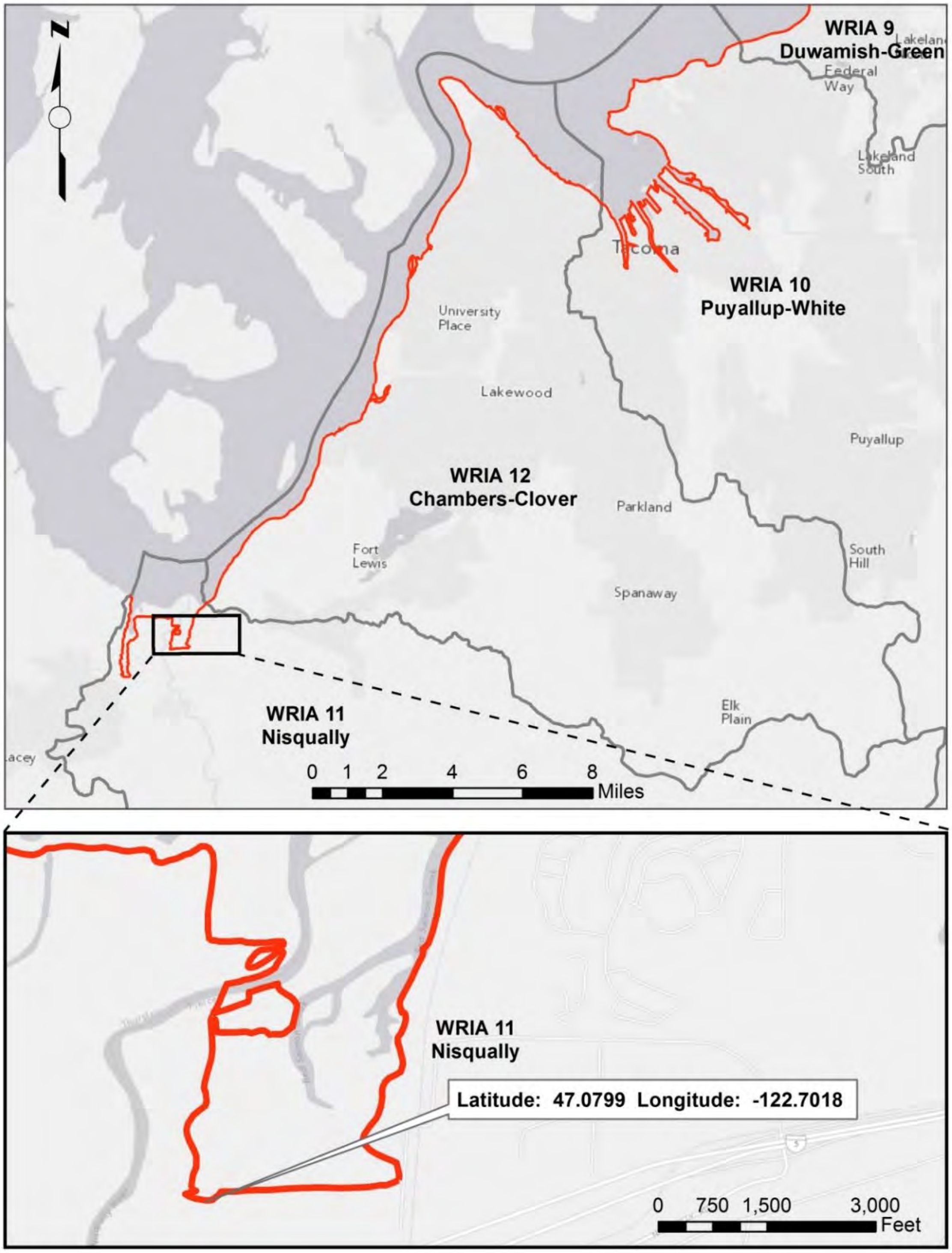
Feet

e. WRIA 11



WRIA 9
Duwamish-Green
Federal Way
Lakeland South
Tacoma
WRIA 10
Puyallup-White
University Place
Lakewood
Puyallup
WRIA 12
Chambers-Clover
Parkland
Fort Lewis
South Hill
Spanaway
Elk Plain
WRIA 11
Nisqually
0 1 2 4 6 8
Miles
WRIA 11
Nisqually
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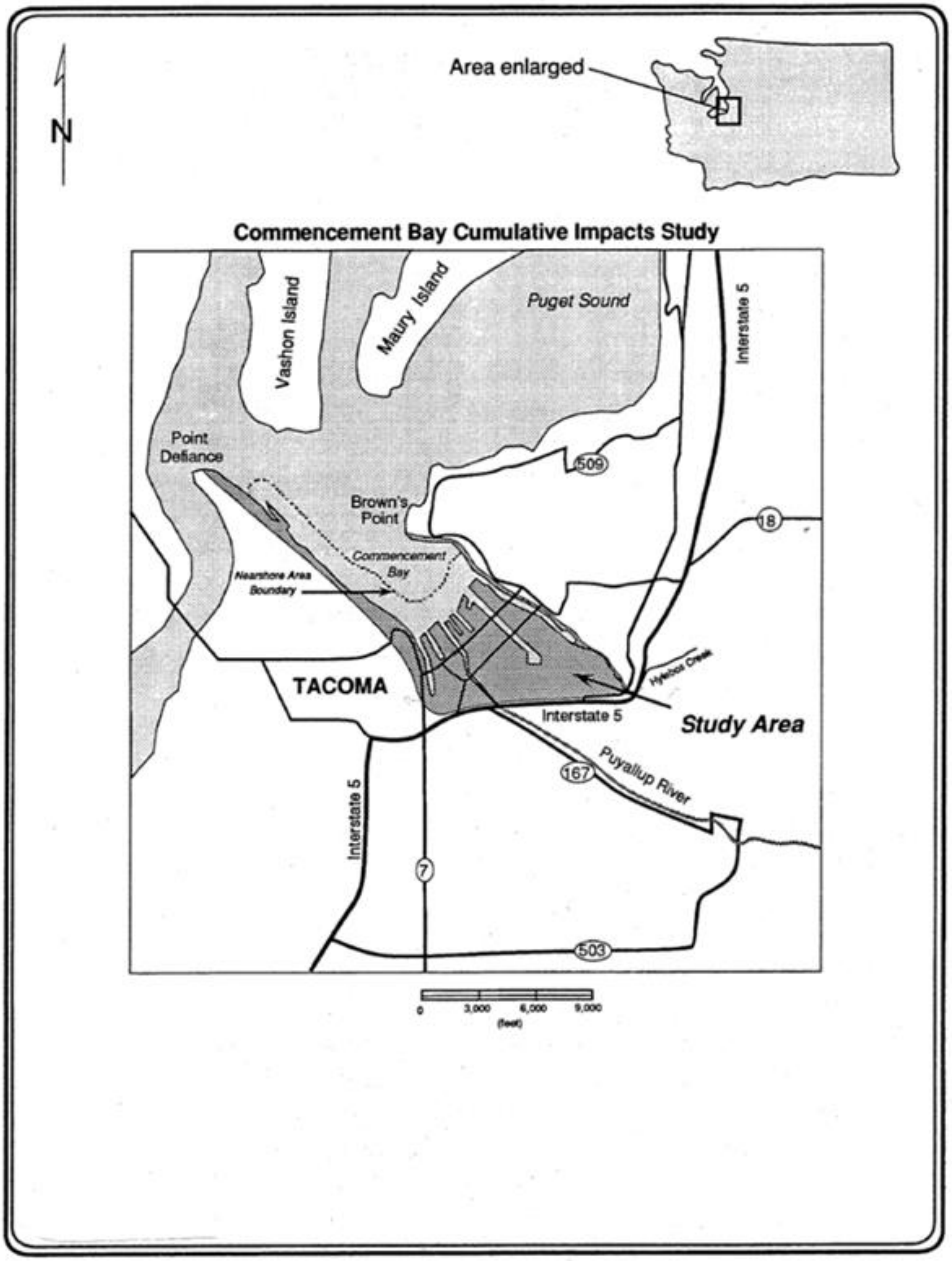
0 750 1,500 3,000
Feet

Figure 2. RGC 4 - Commencement Bay Study Area



US Army Corps of Engineers ®
Seattle District

CERTIFICATE OF COMPLIANCE WITH DEPARTMENT OF THE ARMY PERMIT

Permit Number: NWS-______________________________

Name of Permittee: ______________________________

Date of Issuance: ______________________________

Upon completion of the activity authorized by this permit, please check the applicable boxes below, date and sign this certification, and return it to the following email or mailing address:

NWS.Compliance@usace.army.mil

OR

Department of the Army
U.S. Army Corps of Engineers Seattle District, Regulatory Branch
4735 E. Marginal Way S, Bldg 1202
Seattle, Washington 98134-2388

Please note that your permitted activity is subject to a compliance inspection by a U.S. Army Corps of Engineers representative. If you fail to comply with the terms and conditions of your authorization, your permit may be subject to suspension, modification, or revocation.

☐ The work authorized by the above-referenced permit has been completed in accordance with the terms and conditions of this permit.

Date work complete: ______________________________

☐ Photographs and as-built drawings of the authorized work (OPTIONAL, unless required as a Special Condition of the permit).

☐ If applicable, the mitigation required (e.g., construction and plantings) in the above-referenced permit has been completed in accordance with the terms and conditions of this permit (not including future monitoring).

Date work complete: ______________________________ ☐N/A

☐ Photographs and as-built drawings of the mitigation (OPTIONAL, unless required as a Special Condition of the permit).

☐ Provide phone number/email for scheduling site visits (must have legal authority to grant property access).

Printed Name: ______________________________

Phone Number: ____________________ Email: ______________________________

Printed Name: ______________________________

Signature: ______________________________

Date: ____________

Tacoma - Pierce County
Health Department
Healthy People in Healthy Communities
www.tpchd.org

No. 2637

WASTE DISPOSAL AUTHORIZATION

(XX **)** Non-Asbestos **(XX) New**

( ) Asbestos ( ) Renewal

A. Generator Name: Port of Tacoma – Parcel 15 Log yard

B. Generator Address: 667 Alexander Ave E, Tacoma, WA 98421

C. Transporter Name: TBD

D. Technical Contact: Stanley Sasser Phone: 253-383-9439

E. Waste Description: Arsenic from smelter slag contaminated fill soils

( ) Sludge **(XX) Solid** ( ) PCS ( ) Other

F. Approved Quantity: **2000 Tons**

G. **Actual Quantity (Filled in upon disposal):** __________

H. Multiple Loads: (**XX**) Yes ( ) No

I. Dates of Disposal: April 15, 2022 through April 15, 2023

J. Testing: Arsenic Total Metals

K. Reviewed by Department of Ecology: ( ) Yes (**XX**) No

L. Disposal/Transportation Requirements: **A copy of this WDA must be transported with EACH load of waste and presented to the LRI Landfill Scalehouse Operator**. Soils demonstrating excessive odors are not suitable for use as daily cover and shall be directly buried (disposed of) in the landfill. Loads shall be covered during transport to the landfill to prevent fugitive emissions. Load sizes shall comply with conditional-use and solid waste permit criteria.

M. Facility: (**XX**) **LRI Landfill (304th Street LF), 30919 Meridian Street, Eatonville, WA**

CERTIFICATION

Use of this document to deliver waste to the landfill noted above, certifies that the generator and/or applicant;

- Agree that the information submitted is true, accurate and complete to the best of their knowledge and that all known and suspected hazards have been disclosed.
- Agree that the generator and/or transporter will abide by all conditions specified in line (L) or any attachments.
  If the generator and/or applicant do not agree to the above certification, this authorization is null and void.

AUTHORIZED BY:

Keith Johnston

Keith Johnston, TPCHD (253) 405-8604

Cc: LRI LF Scalehouse via email

APPROVED

April 15, 2022

TACOMA-PIERCE COUNTY HEALTH DEPARTMENT
ENVIRONMENTAL HEALTH DIVISION

For Official Use Only

City of Tacoma
Environmental Services Department

Environmental Compliance: (253) 502-2222
Operations: (253) 591-5595
Email: sad@cityoftacoma.org

SPECIAL APPROVED DISCHARGE AUTHORIZATION
TO THE CITY OF TACOMA'S SANITARY SEWER SYSTEM
Tacoma Municipal Code, Chapter 12.08B.250 and 12.08C.360

The Special Approved Discharge (SAD) Authorization is issued solely to the Authorized Discharger named in the Authorization and is subject to the conditions set forth in this authorization for discharge to the City of Tacoma's Sanitary Sewer System.

I. GENERAL INFORMATION

SAD # 22-007	Effective Date: May 19, 2022	Expiration Date: May 18 2023
Authorized Discharger: Port of Tacoma		
Company Representative: Anita Fichthorn		
Address of Company: P.O Box 1837		
City: Tacoma	State: WA	Zip: 98401
Phone #: 253-830-5379	Email: afichthorn@nwseaportalliance.com	
Name of Property Owner: Port of Tacoma		
Address of Property Owner: Same as above		
City:	State:	Zip:
Phone #:	Email:	

II. PROJECT INFORMATION

Project Name: Parcel 15 (Portac) Clean-up Phase I

Discharge Type: Contaminated contact stormwater and groundwater.

Flow rate (Gallons Per Minute): 75

Discharge Location: Private line that discharges into MH 6772702

Address of Discharge Location: 4215 SR 509

Project Narrative: The Port of Tacoma (Authorized Discharger) is doing a soil remediation at an old log yard site containing contaminated soil. Contaminated groundwater and or stormwater may be encountered during the project. This authorization allows the discharge of contaminated water to the City of Tacoma's Municipal sanitary sewer following Control Authorities approval. This is a for Fee Authorization.

III. AUTHORIZATION GENERAL CONDITIONS

1. Duty to Comply
The Authorized Discharger shall comply with TMC 12.08B and 12.08C, Authorization Terms and Conditions, and the Special Approved Discharge Authorization Policy.

2. Dilution Prohibition
The Authorized Discharger shall not, in any way, dilute a discharge as a substitute to achieve compliance with the Special Approved Discharge Authorization.

3. Calibration and Maintenance of Equipment
The Authorized Discharger shall provide, calibrate, inspect, and maintain all flow measuring, discharge, sampling, monitoring, and pretreatment equipment accurately and reliably.

Authorized Dischargers shall not interfere with to cause damage or make unauthorized alterations to any monitoring or pretreatment equipment.

Records of maintenance and calibration shall be maintained.

4. Flow Measurement
The Authorized Discharger shall use approved flow measurement devices and methods and meter all discharge flows, unless other authorization has been granted by the Control Authority.

The Authorized Discharger shall control and monitor the flow of water in the upstream and downstream system to ensure that the capacity of the City of Tacoma's Municipal Sewer System is not exceeded as a result of the additional flow caused by the discharge.

The Authorized Discharger may be required to reduce the flow rate of the discharge, or cease discharging during heavy rain events which may overburden the sanitary sewer system.

5. Discharge Parameters
The Authorized Discharger shall meet prescribed discharge parameters as outlined in section IV of the Special Approved Discharge Authorization in order to discharge to the City of Tacoma's Municipal Sewer System.

6. Discharge Contingencies
The Authorized Discharger shall cease discharge when a violation of the Special Approved Discharge Authorization General Conditions is suspected or detected; or when directed by the City of Tacoma.

The Authorized Discharger shall observe and monitor the discharge for unusual color, odor, and/or sheen. If any of these conditions are observed, the discharge shall be ceased and the Control Authority shall be notified.

7. Access
The Authorized Discharger shall provide access at reasonable times to the Control Authority for the purposes of inspection to evaluate compliance with the Special Approved Discharge Authorization.

8. Authorization Duration
Special Approved Discharge Authorizations shall be issued for no longer than one (1) year. Conditions of the Authorization may be subject to change by the Director at any time during the life of the Authorization.

9. Project Completion Notification
The Authorized Discharger shall submit notification in writing to the Control Authority upon completion of the project.

10. Authorization Transfer
A Special Approved Discharge Authorization may not be transferred, reassigned, or sold.

11. Severability
If any provision of the Special Approved Discharge Authorization, TMC 12.08B and 12.08C, or the application thereof to any person or circumstance is held invalid, the remainder of the Special Approved Discharge Authorization or TMC 12.08B and 12.08C, or the application of such provision to other persons or circumstances, shall not be affected thereby.

12. Property Rights
The issuance of the Special Approved Discharge Authorization does not convey to the Authorized Discharger any property rights, either real or personal or convey any exclusive privileges. Nor does such issuance authorize any injury to private property, any invasion of personal rights, or any violation of federal, state or local laws.

13. Authorization Termination
The Director may terminate the Special Approved Discharge Authorization for violation of the Authorization's terms and conditions or for violation of TMC, Chapter 12.08B and 12.08C provisions.

IV. DISCHARGE PARAMETERS

Parameter	Discharge Limit		Approved Analytical Method EPA	Approved Analytical Method Standard
Mercury	0.033	mg/L	245.1; 245.2	
Molybdenum	0.55	mg/L	200.7, 200.8	
Nickel	1.12	mg/L	200.7, 200.8	
pH	5.0-11.0	Units		4500HB-2000
Selenium	0.14	mg/L	200.7, 200.8	
Silver	0.64	mg/L	200.7, 200.8	
Temperature	100	ºF		
Zinc	2.44	mg/L	200.7, 200.8	
BTEX	0.750	mg/L	624	
Flow	80	gpm		
TTO - SVOA,VOA	2.13	mg/L	624/625	
SGT-HEM	50	mg/L	1664A; 1664B (measured as silica gel treated, hexane extractable materials (SGT-HEM)	
Arsenic	0.23	mg/L	200.7, 200.8	
Benzene	0.050	mg/L	624	
Cadmium	0.103	mg/L	200.7, 200.8	
Chromium	4.74	mg/L	200.7, 200.8	
Copper	1.46	mg/L	200.7, 200.8	
Lead	0.427	mg/L	200.7, 200.8	
TSS	225	mg/L		2540D-1997

V. DISCHARGE REQUEST

Discharging to the municipal sewer system without prior permission from the Control Authority is prohibited.

Batch Dischargers
For discharges that occur by batch, the Authorized Discharger shall submit a Batch Discharge Request form. A copy of the analytical results from a certified laboratory and a chain of custody shall be attached and emailed to: SAD@cityoftacoma.org. Once reviewed, the Control Authority will return the approved email and the Authorized Discharger may commence the discharge between the hours of 7:30 a.m. and 5:00 p.m.

Continuous Dischargers
For discharges that occur on a continuous basis, the Authorized Discharger shall submit a copy of analytical data results from a certified laboratory and chain of custody to email: SAD@cityoftacoma.org. Once reviewed, the Control Authority will return the approved email and the Authorized Discharger may commence the discharge.

VI. DISCHARGE RECORDS

The Authorized Discharger shall submit discharge records for the previous month, including no discharge notification to the Control Authority by the 15th of each month.

1. The Authorized Discharger shall notify the Control Authority within twenty-four (24) hours of any changes to the site contact.
2. The Authorized Discharger shall notify the Control Authority within twenty-four (24) hours of any significant change to the quality or volume of the discharge or changes that affect the potential for slug load to the Municipal Sewer System.
3. The Authorized Discharger shall submit a formal written notification to the Control Authority within five (5) days of the occurrence describing the following:

    a. What was discharged
    b. Volume of the discharge
    c. Circumstances of the discharge
    d. Duration of the discharge including beginning and end times and dates
    e. Corrective actions to prevent reoccurrence

4. The Authorized Discharger shall notify the Control Authority within twenty-four (24) hours of becoming aware of any of the following violations:

    a. Discharges prohibited by Tacoma Municipal Code, Chapter 12.08B and 12.08C, except where authorized by the Special Approved Discharge Authorization
    b. Exceedance of wastewater discharge limits as established in the Special Approved Discharge Authorization
    c. Failure to perform any Best Management Practices included in the Special Approved Discharge Authorization
    d. Bypass of any part of a required pretreatment system.

5. The Authorized Discharger shall submit a formal written report to the Control Authority within five (5) days after becoming aware of the violation. The report shall include the following information:

    a. Description of the violation, including the cause, date and time of the violation
    b. Date and time the discharge was stopped
    c. Measures taken to correct the violation
    d. Measures taken to prevent future violations

BILLING INFORMATION

The Authorized Discharger must pay the applicable fees and maintain payments as provided in Tacoma Municipal Code, Chapter 12.08B.250. The Authorized Discharger, from which material in violation of Chapter 12.08C is discharged into the City of Tacoma's Municipal Sewer System shall be liable to pay any supplemental charges the City of Tacoma incurs to respond to such violation as referenced in 12.08B.500.

ENFORCEMENT PROVISION

Violations of this Authorization or Tacoma Municipal Code, Chapter 12.08B and 12.08C may result in termination of the Special Approved Discharge Authorization and/or enforcement action in accordance with the policies and procedures contained in Tacoma's Enforcement Response Plan for wastewater, or Tacoma's Stormwater Compliance Policy for stormwater.

Date: ________________ By: ____________________________________
Kurt Fremont
Business Operations Division Manager
Environmental Services

Date: ________________ By: ____________________________________
Authorized Representative

Adam Griffin

To: Gilbert, Norman; Sasser, Stanley
Cc: Fichthorn, Anita
Subject: RE: PRE22-0142 Parcel 15 MTCA Cleanup comments

From: Gilbert, Norman <ngilbert@portoftacoma.com>
Sent: Wednesday, May 18, 2022 1:28 PM
To: Sasser, Stanley <ssasser@portoftacoma.com>; Adam Griffin <agriffin@aspectconsulting.com>
Cc: Fichthorn, Anita <afichthorn@nwseaportalliance.com>
Subject: FW: PRE22-0142 Parcel 15 MTCA Cleanup comments

All,

I think this concludes the comments from the City on substantive requirements.

Regards,

Norman Gilbert, PE
Project Manager II
PORT OF TACOMA
O: 253.383.9406
www.portoftacoma.com

From: noreply@cityoftacoma.org <noreply@cityoftacoma.org>
Sent: Wednesday, May 18, 2022 12:49 PM
To: Gilbert, Norman <ngilbert@portoftacoma.com>
Cc: shirley.schultz@cityoftacoma.org
Subject: PRE22-0142 Parcel 15 MTCA Cleanup comments

Hi, Norm -

I didn't put together a formal comment memo - the comments from staff are below. Thanks for giving us some time to review this for substantive compliance with code.

If you need something more formal, let me know.

Shirley Schultz, AICP (she/her)

City of Tacoma | Development Services

c: 253-345-0879

shirley.schultz@cityoftacoma.org

www.tacomapermits.org

Land use / zoning / shoreline – S Schultz

As a MTCA action this project is exempt from procedural permitting requirements. However, in order to meet substantive permitting requirements the project shall incorporate the comments from A Cook and M Hoppin.

Document any unexpected work and impacts. Additional permitting - if work falls outside the scope of the MTCA action - may be required.

CRITICAL AREA REVIEW - COMMENTS PROVIDED

Allison Cook

5/17/2022

Wapato creek is a fish bearing stream, and at this location is tidally inundated. In order to prevent trapping any fish, the silt fence on the plans should be placed above the limits of an extreme high tide so it is not overtopped by the tide and causes a fish trap.

It is preferred that the outfall pads are replaced with the least impacting substrate. If possible, rounded rock is preferred to quarry spall, etc.

The project area is considered a critical area under 13.11 of the Tacoma Municipal code. If vegetation is removed within the stream buffer, it is highly suggested that the area be restored with native plantings and that there is minimal clearing as possible to achieve the project.

Mieke Hoppin, Environmental Services

Projects shall comply with the requirements in TMC 12.08 which may include complying with Minimum Requirements contained in the City of Tacoma Stormwater Management Manual. Based upon the information provided, it appears this project may be exempt from the Minimum Requirements of the SWMM as it appears to be a maintenance project but this is unclear from the information provided - additional analysis is needed to determine which, if any, Minimum Requirements apply to this project.

Per the Interlocal Agreement By and Between the Port of Tacoma and the City of Tacoma for Mutual Cooperation and Support Regarding Agency Stormwater Management, the City of Tacoma will provide one courtesy stormwater review in conjunction with other required projects reviews for Port projects that discharge to the Port-owned MS4 at no cost to the Port. Additional reviews will be charged if requested per the ILA.

Port of Tacoma People. Partnership. Performance.

From:	Sasser, Stanley
To:	Penk, Miles A (DFW)
Cc:	Adam Griffin; Gilbert, Norman; Healy, Rob; Warfield, Tony
Subject:	RE: Port of Tacoma Parcel 15 (Portac) Cleanup Phase I
Date:	Tuesday, May 17, 2022 11:23:20 AM

Miles,

Thanks for the quick review and response.

-Stanley

From: Penk, Miles A (DFW) <Miles.Penk@dfw.wa.gov>
Sent: Tuesday, May 17, 2022 11:16 AM
To: Sasser, Stanley <ssasser@portoftacoma.com>
Cc: Adam Griffin <agriffin@aspectconsulting.com>; Gilbert, Norman <ngilbert@portoftacoma.com>; Healy, Rob <rhealy@portoftacoma.com>; Warfield, Tony <twarfield@portoftacoma.com>
Subject: RE: Port of Tacoma Parcel 15 (Portac) Cleanup Phase I

Hi Stanley,

I've reviewed all shared materials for the maintenance and repair of the two stormwater outfalls on Wapato Creek and have the following comments to provide:

- The angular rock dissipation designs look acceptable based on existing conditions and am pleased with the addition of check valves at OF-2 and OF-3.
- Construction methods and minimization measures all look consistent with what we'd prescribe to protect fish life.
- An In-water work window of **July 16 through December 31 and January 1 through February of any year is recommended** for the protection of juvenile salmonids and would be consistent with previous HPAs issued in this area.

Thank you for the opportunity to review this project and please let me know if there's anything else you need from me on this.

Miles Penk | Habitat Biologist
Washington Department of Fish and Wildlife
Region 6, Puyallup Watershed
Cell: (360) 480-2908
Email: Miles.Penk@dfw.wa.gov

From: Penk, Miles A (DFW)
Sent: Monday, May 16, 2022 5:05 PM
To: Sasser, Stanley <ssasser@portoftacoma.com>
Cc: Adam Griffin <agriffin@aspectconsulting.com>; Gilbert, Norman <ngilbert@portoftacoma.com>; Healy, Rob <rhealy@portoftacoma.com>; Warfield, Tony <twarfield@portoftacoma.com>
Subject: RE: Port of Tacoma Parcel 15 (Portac) Cleanup Phase I

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- Construction methods and minimization measures all look consistent with what we'd prescribe to protect fish life.
- An In-water work window of July 16 – September 30 appears acceptable for the protection of juvenile salmonids and would be consistent with previous HPAs issued in this area.

Thank you for the opportunity to review this project and please let me know if there's anything else you need from me on this.

Miles Penk | Habitat Biologist
Washington Department of Fish and Wildlife
Region 6, Puyallup Watershed
Cell: (360) 480-2908
Email: Miles.Penk@dfw.wa.gov

From: Sasser, Stanley <ssasser@portoftacoma.com>
Sent: Friday, May 6, 2022 2:04 PM
To: Penk, Miles A (DFW) <Miles.Penk@dfw.wa.gov>
Cc: Adam Griffin <agriffin@aspectconsulting.com>; Gilbert, Norman <ngilbert@portoftacoma.com>; Healy, Rob <rhealy@portoftacoma.com>; Warfield, Tony <twarfield@portoftacoma.com>
Subject: Port of Tacoma Parcel 15 (Portac) Cleanup Phase I

External Email

Good Afternoon Miles,

The Port of Tacoma is providing the following information to the Washington Department of Fish and Wildlife (WDFW) to solicit substantive comments under the Model Toxic Control Act for the Parcel 15 (Portac) Cleanup Phase I project. The Port of Tacoma entered Agreed Order No. DE 15816 (Agreed Order) with Washington State Department of Ecology on June 23, 2021, requiring implementation of the cleanup work defined in the Cleanup Action Plan (CAP), which includes maintenance and repair of two stormwater outfalls located below the high tide line (HTL) of Wapato Creek. In addition, site stormwater lines need to be restored with cast in place pipe lining. Both the Agreed Order and CAP have been through the public review process.

Please find attached the cover letter the Port sent to USACE along with the JARPA application and associated drawings for your review. We look forward to hearing from you and working with you on this important remediation project.

Cheers,

Stanley H. Sasser
Environmental and Planning Program Manager
PORT OF TACOMA
O: 253-383-9439 | C: 253-441-5644
www.portoftacoma.com
