Groundwater Compliance Monitoring Plan Cadet Manufacturing Company and Swan Manufacturing Company Portions, Vancouver Port of Nustar Cadet Swan Site

Prepared for
Port of Vancouver

Port of Vancouver USA

March 2024

Parametrix

Groundwater Compliance Monitoring Plan
Cadet Manufacturing Company and Swan Manufacturing Company Portions, Vancouver Port of Nustar Cadet Swan Site

Prepared for

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Certification

The technical material and data contained in this document were prepared under the supervision and direction of the undersigned whose seal is affixed below.

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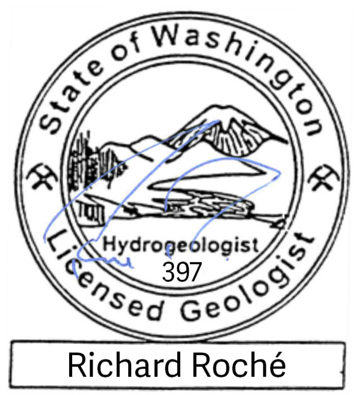

3/29/2024

Contents

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Acronyms and Abbreviations

µg/L	micrograms per liter
AO	agreed order
Cadet	Cadet Manufacturing Company
CAP	cleanup action plan
CC	Carol Curtis
COC	contaminant of concern
COV	City of Vancouver
COV3	City of Vancouver water station WS-3
CPU	Clark Public Utilities
Ecology	Washington State Department of Ecology
GCMP	groundwater compliance monitoring plan
GWM	Great Western Malting
MNA	monitored natural attenuation
msl	mean sea level
MTCA	Model Toxics Control Act
P&T	groundwater pump and treat interim action
PAA	Pleistocene alluvial aquifer
PCE	tetrachloroethylene
POC	point of compliance
PSA	point of standards application
SMC	Swan Manufacturing Company
TCE	trichloroethylene
USA	unconsolidated sedimentary aquifer
VLL	Vancouver Lake Lowland
VOC	volatile organic compound

1. Introduction

This Groundwater Compliance Monitoring Plan (GCMP) has been developed as a requirement for implementation of the Cleanup Action Plan (CAP) associated with the Cadet Manufacturing Company (Cadet) and former Swan Manufacturing Company (SMC) sites located in Vancouver, Washington. The Cadet and former SMC sites are part of a larger cleanup site referred to in the Washington State Department of Ecology (Ecology) database as the “Vancouver Port of NuStar Cadet Swan” site (the “Site” or “Site area”). Figure 1-1 shows the area of the Site identified by Agreed Order (AO) DE 18152 based on the historical maximum extent of volatile organic compound (VOC) contamination. Figure 1-1 also shows the location and areas associated with SMC, Cadet, NuStar, and Kinder Morgan portions of the Site. The CAP for the SMC and Cadet portions of the Site was issued by Ecology in September 2023 (Ecology 2023a). AO DE 21295, effective August 12, 2023 (Ecology 2023b), provides for implementation of the CAP.

This GCMP presents the groundwater monitoring plan that will be used to demonstrate that the cleanup action, specifically monitored natural attenuation (MNA), is progressing as expected.

1.1 Purpose

Compliance groundwater monitoring is a primary aspect of the selected remedy and will comply with the Model Toxics Control Act (MTCA) as defined in Washington Administrative Code (WAC) 173-340-410 and pursuant to requirements established in AO DE 21295 between Ecology and the Port of Vancouver, USA. In the context of this cleanup project, the compliance monitoring is considered protection monitoring under WAC 173-340-410. Since the cleanup action for the dispersed residual concentrations is MNA and includes shutting down the groundwater pump and treat interim action (the P&T system), a component of protection monitoring will be the implementation of a contingency plan if MNA is not occurring as expected.

Monitoring of the SMC and Cadet sites was initiated in 1998 and previously included soil gas, indoor air, and outdoor air. As documented in annual environmental monitoring reports, interim treatment actions completed at and in the vicinity of the SMC and Cadet sites have significantly reduced VOC concentrations in all media. Based on these results and Ecology approvals, monitoring of the SMC and Cadet sites since 2012 has been limited to groundwater. The pre-CAP groundwater monitoring program had been optimized over time as contaminant issues and risks were reduced or eliminated.

The Feasibility Study (FS) report (Parametrix 2023) detailed the proposed final remedy(s) to address residual dissolved trichloroethylene (TCE), tetrachloroethylene (PCE), and associated compounds from the Cadet and SMC sites. Ecology approved the FS and issued the CAP in September 2023 (Ecology 2023a). The approved cleanup action consists of MNA, which includes natural processes to reduce contaminants of concern (COC) levels to acceptable concentrations. These processes include natural biodegradation, dispersion, dilution, sorption, volatilization, and chemical and biological stabilization, transformation, or destruction of hazardous substances. Monitoring is used to verify that these processes are actively reducing hazardous substance concentrations.

The approved MNA alternative was developed to support shutdown of the existing groundwater P&T system to achieve remedial action objectives. The P&T system, located at the SMC site, began operation in June 2009 to capture and treat the commingled dissolved VOC plumes sourced from the SMC and Cadet sites and to reduce the concentrations of VOCs in groundwater in the Site.

A numeric flow and transport groundwater model was used to simulate groundwater movement and evaluate the effectiveness of cleanup action alternatives for the FS. Findings from the model using recent groundwater monitoring results and simulations with the P&T system shutdown were used during development of this GCMP.

1.2 Monitoring Plan Design Basis

This GCMP was designed to collect sufficient data to demonstrate that the cleanup action, specifically MNA, is progressing as expected. The following information was used to develop the GCMP:

1. Current (2022) groundwater conditions as documented in annual environmental monitoring reports focusing on current conditions with consideration of changes (concentration trends) that have occurred over time.
2. Results of groundwater flow and transport modeling completed to evaluate contaminant distribution in the absence of P&T system operation.

These factors are briefly described below and detailed further in the CAP and FS documents.

1.2.1 Groundwater Conditions

Evaluation of VOCs in groundwater in the Site is primarily based on the use of concentration trends and isoconcentration maps for each monitoring zone (e.g., shallow, intermediate, and deep). These monitoring zones were adopted during the SMC, Cadet, and NuStar Remedial Investigation (RI) efforts to evaluate and describe groundwater quality at the Site. In the vicinity of the SMC and Cadet areas, the shallow unconsolidated sedimentary aquifer (USA) monitoring zone extends from ground surface to -10 feet mean sea level (msl; approximately 40 feet below ground surface) and corresponds to alluvial deposits. The intermediate USA monitoring zone extends from -10 feet msl to -100 feet msl and corresponds with catastrophic flood sand and gravel deposits. The deep zone extends below -100 feet msl down to the top of the Troutdale formation, which varies in elevation in the Site area. The deep zone corresponds with channel fill deposits and reworked Troutdale formation material. In the vicinity of the Site, the USA is also referred to as the Pleistocene alluvial aquifer (PAA). The existing groundwater monitoring networks in and adjacent to the Site area are shown on Figure 1-2.

Defining the distribution of VOCs in groundwater at the Site is based on the presence of TCE and PCE. These two compounds have the highest frequency of detection, are the primary contaminants released at the known source areas, are the focus of cleanup actions, and are the primary COCs in groundwater (i.e., indicator hazardous substances). TCE and PCE are also currently the only VOCs detected above the MTCA Method B groundwater cleanup levels. The concentrations of TCE and PCE detected in monitoring well samples collected during 2022 are shown on Figures 4-1 through 4-10, included in Appendix A. The TCE plume is defined by a 4 micrograms per liter (μg/L) contour representing the MTCA Method B cleanup level for TCE. The PCE plume is defined by a 5 μg/L contour representing the applicable state and federal drinking water standard (maximum contaminant level) as the MTCA Method B cleanup level is higher.

Groundwater monitoring results from 2022 indicate:

- The overall extent of the SMC and Cadet dissolved VOC plume continues to decrease.
- Completed remedial actions have significantly reduced source area contamination with the extent of shallow groundwater containing VOCs above MTCA Method B cleanup levels primarily limited to Port property.
- Shallow Zone – VOC concentrations in SMC and Cadet shallow groundwater monitoring wells continue to show an overall declining trend. TCE and PCE concentrations in shallow zone wells are below the cleanup level in SMC and Cadet wells, except for six wells located at the former SMC site and one well at the Cadet facility.
- Intermediate Zone – VOC concentrations in SMC and Cadet intermediate USA zone wells continue to decline and are below cleanup levels in SMC and Cadet wells except for TCE at SMC site MW-05i, Cadet well CM-MW-23i, CM-MW-28USA-120.5, and southeastern area wells MW-15i and MW-37i. PCE concentrations in intermediate SMC and Cadet wells are below cleanup levels.
- Deep Zone – VOC concentrations in the SMC and Cadet deep USA zone wells have been declining slowly over the last several years. PCE concentrations in the deep zone wells are below the cleanup level.

1.2.2 Groundwater Model

The Port developed a three-dimensional, finite difference groundwater flow and contaminant transport model for the SMC portion of the Site in 2002 as part of the RI. Development of a groundwater model was proposed early in the RI effort to describe groundwater flow conditions and the fate and transport processes in the vicinity of SMC. Activities at that point of the RI determined characterization of groundwater flow beneath the SMC site was complicated by the influence of river stage elevations, tidal fluctuations, and water supply well pumping; concluding that water level contour maps based on manual water level measurements represented over-generalizations and potentially misrepresentation of actual groundwater flow conditions. The combination of small-scale and local variations in groundwater flow direction associated with local recharge characteristics, along with very low horizontal gradients, resulted in complicated water level interpretations. The distribution of the contaminant plume suggested that the flow of groundwater was heavily influenced by production well pumping. Thus, a groundwater flow model was developed to help with interpretation of groundwater flow in the project area.

Refinement, evaluation, and confirmation of the model has been completed over time and facilitated through ongoing collection of hydrogeologic data in the project and active model areas during the RI effort. In 2006, the Port and Clark Public Utilities (CPU) agreed to conduct further model calibration and validation to confirm that the model was an appropriate tool to evaluate remedial alternatives for the dispersed plume originating from the SMC, Cadet, and NuStar sites and to evaluate those alternatives with respect to proposed water supply development in the Columbia River Lowlands. CPU had developed a similar flow model to assist in its evaluation of potential water supply wellfield sites in the Vancouver Lake Lowlands area. The Port and CPU worked collaboratively to reassess groundwater flow in the vicinity of the Site, resulting in the Vancouver Lake Lowland (VLL) Groundwater Flow Model (Parametrix et al. 2008), which was approved by Ecology for the SMC and Cadet cleanup site (Ecology 2008).

Hydrogeologic-related modifications to the model for the NuStar site area were made in 2011 to reflect understanding of the Site's historical river channel setting. These modifications were used in

2011 modeling associated with evaluation of the Port's P&T system (Parametrix 2011). Other than modification of the NuStar site area to capture the historical river channel setting, no additional modifications were made to the VLL groundwater flow model.

The model was used in 2021 during preparation of the FS to evaluate the effectiveness of the P&T interim action and predict contaminant distribution after shutdown of the P&T system. As part of this analysis, the model was used to assess whether the low concentrations of residual contamination in the vicinity of the SMC and Cadet sites posed potential unacceptable risk to water supply wells operated by CPU, the City of Vancouver (COV), the Port, and Port tenants. Completed model simulations used 2020 TCE concentrations and assumed that the P&T system was turned off. Regional production well pumping rates (CPU, COV, the Port, and Great Western Malting [GWM]) were based on information provided by those entities. The findings of the 2021 model assessment for the FS were detailed in a technical memorandum included in the FS (Pacific Groundwater Group 2021) and are summarized below.

Modeled groundwater flow directions have the strongest influence on contamination transport pathways. Simulations predict that following shutdown of the P&T system, groundwater flow in the Site area is from the Columbia River to the north. This predicted flow direction is in response to high production pumping occurring at COV water station WS-3 (COV3) and scheduled pumping from the PAA at the CPU Carol Curtis (CC) wellfield. The COV3 water station and the CC wellfield are located approximately 1.4 miles northeast and 1.7 miles north, respectively, of the SMC source area as shown on Figure 1-3.

Figure 1-4 shows the predicted progression of the dissolved VOC plume area (representing TCE) over time by advective flow alone (flow simulation) and fate/transport simulation. Advective flow is shown by the purple particle trace lines while contaminant fate/transport is shown by the plume area colors. Note that the plume area shown on Figure 1-4 is an infinite source (a constant source concentration that does not reduce over time) simulation rather than a finite source simulation (a depleting source that reduces over time). As such, the simulated plume development shown on Figure 1-4 represents a highly conservative source assumption that provides an upper limit on predicted transport concentrations associated with currently observed source concentrations. The model predicts that northward migration of the dissolved plume away from the remnant SMC source area occurs between the area that can be delineated by two lines: one extending from the SMC source area to COV3 and another extending from the SMC source area to the CC as shown on Figure 1-3. As shown on Figure 1-4, the advective flow path turns to COV3 at a point approximately between COV3 and CC, while the fate/transport plume is pulled toward both the COV3 and CC north of the Site. The model predicts that very low TCE concentrations (significantly below the standard detection limit of 0.5 μg/L and cleanup level of 4.0 μg/L) could occur in production wells at both wellfields and that trace concentrations of TCE could arrive at the two wellfields about 15 years after the P&T system is turned off. As previously stated, this analysis is very conservative as it assumes an infinite source. Groundwater monitoring during the past 25 years has demonstrated the source is depleting.

2. Groundwater Monitoring System Design

The GCMP is based on the FS model findings and 2021 VOC contaminant data and is designed to validate model-predicted behavior following shutdown of the P&T operation. Groundwater modeling completed in 2021 as part of the FS suggests the remaining very low concentrations of contaminants from the SMC site (generally below cleanup levels) will migrate to the northeast following shutdown of P&T operation in response to COV3 and future CC wellfield pumping, but at concentrations significantly below the standard detection limit of 0.5 µg/L and cleanup level of 4.0 µg/L. The most conservative scenario modeled (infinite source) predicts that very low TCE concentrations could migrate to COV3 and CC wellfields. Therefore, the focus of compliance monitoring is to:

1. Demonstrate that the cleanup action, specifically MNA, is progressing as expected.
2. Confirm contaminant concentrations are at or below levels predicted by the FS model.

Table 2-1 lists existing monitoring wells associated with the Cadet and SMC groundwater monitoring well network. Locations of the listed wells are shown on Figure 1-2. Table 2-1 identifies wells that will be monitored as part of this GCMP and:

- Water quality zone associated with each monitoring well.
- Well screen depth.
- Current VOC levels.
- Wells currently monitored in accordance with the September 20, 2017, Performance Groundwater Monitoring Plan (2017 performance plan).
- New wells to be installed as part of this GCMP.

Table 2-1 also identifies the following well monitoring designations:

- Attenuation monitoring wells
- SMC source area monitoring wells
- Non-SMC/Cadet source monitoring wells
- Deep zone monitoring wells
- Port/GWM wellfield monitoring wells
- Inactive monitoring point wells

Table 2-2 summarizes the proposed sample schedule and purpose of monitoring wells included in the GCMP. Monitoring frequency as presented in Table 2-2 will be applied for the first 5 years following shutdown of the P&T system. The GCMP will then be reviewed and optimized appropriately with an anticipated reduction of monitoring over time if data are consistent with model-predicted results and indicate that natural attenuation is proceeding as anticipated. Additional information for the well monitoring designation groups is provided below.

2.1 Attenuation Monitoring Wells

Groundwater monitoring is planned in the area where the model predicts contaminants will migrate to following P&T system shutdown. The model indicates that remnant contaminant transport following P&T system shutdown will occur between the lines running from the SMC source to COV3 and to the CC wellfield. Figure 2-2 shows the 80-year model-predicted advection and dispersion area presented on Figure 1-4 with existing monitoring well locations added. Monitoring will also include wells located outside of the projected plume area where VOCs are currently or have previously been detected to verify that natural attenuation is continuing to occur at these locations north of the SMC site. Monitoring wells included in the attenuation monitoring group consist of shallow and intermediate wells. Deep wells located in the area north of SMC are included in the deep zone group.

Attenuation monitoring will be completed north of Lower River Road/Fourth Plain Boulevard. The following inner and outer attenuation monitoring locations north of SMC site have been identified.

Inner well locations are situated south of West 31st Street representing the area that could be captured by restarting the P&T system, if needed. As indicated on Table 2-2, six monitoring wells, consisting of three shallow and three intermediate wells, are identified as inner attenuation monitoring wells. Existing wells CM-MW-23s and -23i are located within 200 feet of the predicted flow path (the particle trace path shown on Figure 2-2). The highest TCE and PCE concentrations north of Lower River Road/Fourth Plain Boulevard are currently detected in CM-MW-23i. Based on model prediction, higher concentrations may be occurring east of the CM-MW-23i. Multi-port well CM-MW-29USA is located just outside the east side of the predicted flow path.

Outer well locations are situated north of West 31st Street representing the area that cannot be captured by restarting the P&T system, if needed. As indicated on Table 2-2, eight monitoring wells, consisting of intermediate wells, are identified as outer attenuation monitoring wells. Currently, there are no groundwater monitoring points in the northern outer area of the FS model migration pathway area that could serve as an outer compliance location situated in the predicted contaminant migration pathway. This area is where La Frambois Road and West 34th Street intersect with Fruit Valley Road. Existing multi-port well CM-MW-27USA is nonfunctional.

Monitoring data suggest that contaminant migration may currently be occurring farther to the northwest rather than to the northeast as predicted by the model. Data also indicate that contaminants are more dispersed north of the SMC source area than was predicted by the model. Therefore, several compliance monitoring points west of the CPU CC wellfield line shown on Figure 2-2 will be used.

Attenuation monitoring north of the SMC site will focus on the intermediate zone but will also include select shallow and deep zone wells to provide data to compare with model-predicted results. Deep zone attenuation monitoring will include wells located throughout the site area as described in Section 2.4, Deep Zone Monitoring Wells.

The attenuation monitoring group wells will be monitored annually during March, consistent with the 2017 performance plan schedule.

2.2 SMC Source Area Monitoring Wells

Monitoring at the SMC source area wells will be completed to confirm source decline assumptions. Monitoring of the SMC source area will focus on the shallow zone but will also include intermediate wells MW-5i and MW-2i to provide data on intermediate zone contaminant levels beneath the SMC source area site and in the historical contaminant migration pathway just east of the SMC source area site, respectively. Figure 2-4 identifies the SMC source area site monitoring well locations.

The SMC source area monitoring wells will be sampled semi-annually (March and August), consistent with the 2017 performance monitoring schedule. An exception is MW-2i, which will be sampled annually during March. East well MW-2i will be sampled bi-annually due to the low VOC concentrations detected at this well and model results that indicate groundwater flow at the SMC source area is toward the north following shutdown of P&T system.

2.3 Non-SMC/Cadet Source Monitoring Wells

Monitoring will be completed at shallow well MW-E and intermediate wells MW-31i, MW-32i, and MW-33i that are located north of the NuStar facility. These wells will be used to monitor natural attenuation north of the NuStar facility to determine if natural attenuation is occurring in this area and when resulting groundwater quality compliance occurs. Figure 2-5 shows the location of non-SMC/Cadet source monitoring wells. Groundwater modeling indicates that groundwater flow in this area, primarily in the intermediate zone, is toward the north from the river in response to pumping.

Non-SMC/Cadet source monitoring wells will be sampled annually during March. An exception is MW-33i, which will be sampled bi-annually (every other year) during March due to low levels of VOCs detected at this most northern well.

2.4 Deep Zone Monitoring Wells

All deep wells where VOCs are regularly detected will be sampled to confirm that natural attenuation is occurring. An exception is multi-port wells CM-MW-01d and CM-MW-3d where only the deepest port is scheduled to be sampled. The deepest port at these two multi-port wells is where the highest VOC concentrations in the deep zone have been detected. Deep zone wells where VOCs are not detected are not included the deep zone monitoring well group. Figure 2-6 shows the locations of active deep zone monitoring wells listed in Table 2-2 and non-active deep wells that are also included in Table 2-1.

The deep zone monitoring well group will be sampled bi-annually during March. A bi-annual monitoring frequency is conducted due to the slow changes in VOC concentrations observed in deep wells.

2.5 Port/GWM Wellfield Area Monitoring Wells

Specific wells near Port and GWM production wells will be sampled, including intermediate wells MW-15i and MW-37i located north of the Port of Vancouver/GWM wellfield. Monitoring of these wells will be completed to evaluate natural attenuation. Figure 2-5 shows the location of the Port/GWM wellfield area monitoring wells with active wells, as listed on Table 2-2, highlighted. These wells will be sampled annually during March.

3. Cleanup Levels and Points of Compliance

The CAP describes the development of cleanup standards and points of compliance (POCs) for various media at the Site. Cleanup standards were developed in accordance with WAC 173-340-720 through WAC 173-340-760. In accordance with WAC 173-340-700(3), cleanup standards were developed for hazardous substances identified at the Site and the specific areas or exposure pathways where humans or the environment could potentially become exposed to these substances.

Per WAC 173-340-720(8)(b), the standard POC is throughout the Site and throughout the saturated zone. This POC corresponds to the drinking water pathway cleanup level. The saturated zone is defined as all groundwater beneath the Site within the USA zone (i.e., shallow, intermediate, and deep zones).

3.1 Cleanup Levels

As described in the CAP, cleanup standards used to protect groundwater were developed in accordance with WAC 173-340-720. For groundwater, Method B was used to develop the groundwater cleanup levels. Groundwater cleanup levels must be established based on the highest beneficial use of groundwater, which was assumed to be drinking water. Groundwater in the project area, including the Site, is classified as a drinking water resource and will likely continue to be classified as a drinking water resource in the future. Groundwater at the Site is therefore considered potable and includes all groundwater within the USA [a.k.a., the PAA] zone (i.e., shallow, intermediate, and deep zones).

MTCA requires groundwater cleanup levels to be based on the reasonable maximum exposure expected to occur under both current and future Site conditions. For potable groundwater, this means that the cleanup level must be set for COCs at concentrations that allow the water to be safely used as a source of drinking water. PCE and TCE are present at the Site at concentrations above the MTCA cleanup levels. PCE and TCE are also the primary contaminants in groundwater at the Site and have been the drivers of past interim action efforts and remedial action alternatives described in the FS.

Cleanup levels for the groundwater at the Site are:

- PCE: 5 μg/L
- TCE: 4 μg/L

3.2 Points of Compliance

Demonstrating compliance with cleanup standards involves specifying where on the Site the cleanup levels must be met (POC) and how long it will take for a site to meet cleanup levels (restoration time frame). Groundwater cleanup levels need to be attained in all groundwater from the POC to the outer boundary of the contaminant plume. Monitoring is conducted to demonstrate that cleanup standards have been met and will continue to be met in the future.

The CAP references the standard POC which is established throughout the Site from the uppermost level of the saturated zone extending vertically to the lowest-most depth which could potentially be affected by the Site. At the Site, the saturated zone is defined as all groundwater within the USA that consists of Site-defined shallow, intermediate, and deep zones.

For the Site, the POCs are the well locations identified on Figure 2-2 and listed in Table 3-1.

3.3 Restoration Time Frame

In addition to establishing POCs, demonstration of compliance with cleanup standards includes determining how long it will take for a site to meet cleanup levels, which is referred to as the restoration time frame. Determination of a reasonable restoration time frame for the Site includes consideration of the following factors:

- Potential risks posed by the Site to human health and the environment.
- Practicability of achieving a shorter restoration time frame.
- Current use of the Site, surrounding areas, and associated resources that are, or may be, affected by releases from the Site.
- Potential future use of the Site, surrounding areas, and associated resources that are, or may be, affected by releases from the Site.
- Ability to control and monitor the migration of hazardous substances from the Site.
- Toxicity of the hazardous substances at the Site.
- Natural processes that reduce concentrations of hazardous substances and have been documented to occur at the Site or under similar Site conditions.

A longer period of time can be used for the restoration time frame for a site to achieve cleanup levels at the POCs if the cleanup action selected has a greater degree of long-term effectiveness than on-site or off-site disposal, isolation, or containment options.

The FS report and the FS modeling effort informed determination of reasonable restoration time frame factors. The FS model predicts that following shutdown of the P&T system:

- TCE concentrations will slowly increase at the attenuation wells described in Section 2.1.
- TCE concentrations will increase fastest in monitoring wells that are north of and closest to the SMC source area such as CM-MW-20s/i and will peak below 6 µg/L in 3 years, then start declining.
- TCE concentrations will increase but remain below 4 µg/L in the following monitoring wells:
  - → Inner compliance area monitoring well CM-MW-23s/I and outer compliance area monitoring wells CM-MW-19s/i/d and CM-MW-29USA, then will start to decline after approximately 7 years.
  - → Outer compliance area monitoring well CM-MW-28USA then will start to decline after 10 years.
  - → Outer compliance area monitoring well CM-MW-28USA, located outside of the predicted contaminant migration pathway, will slightly increase before decreasing within 2 years.

4. Sampling and Analysis

Monitoring wells included in this GCMP are listed on Table 2-1 and shown on Figure 2-1. Table 2-2 presents the compliance groundwater monitoring schedule. All attenuation monitoring wells are scheduled to be sampled annually during March. The SMC source area wells are scheduled to be sampled semi-annually during March and August. Deep zone wells are scheduled to be sampled bi-annually (every other year).

Collected groundwater samples will be analyzed for VOCs by EPA Method 8260D. Due to occurrence of low concentrations, groundwater sample results have been reported down to the method detection limit since 2018. Results above the method detection limit but below the method reporting limit are qualified to indicate they represent an estimated concentration.

Groundwater sampling and analysis for VOCs will be completed consistent with procedures and methods currently in place and used during the RI/FS effort. Appendix B presents field methods detailing sampling and analysis procedures.

5. Reporting

Groundwater monitoring results will be presented in annual groundwater monitoring reports. The reports will present activities completed during a calendar year, groundwater sample analysis results, and a review of those results with respect to meeting groundwater cleanup levels at the POCs and former source area conditions.

6. References

Ecology (Washington State Department of Ecology). 2008. Ecology's site specific approval of the February 2008 Vancouver Lake Lowlands Groundwater Model Summary Report and the two groundwater flow model versions, Base Case and Alternate Case. Unpublished memorandum by Craig Rankine, Washington State Department of Ecology to Patty Boyden, Port of Vancouver, Vancouver, Washington.

Ecology. 2023a. Cleanup Action Plan.

Ecology. 2023b. Agreed Order DE 18152.

Pacific Groundwater Group. 2021. Vancouver Lake Lowland Long-Term Contaminant Transport Analysis, Technical Memorandum. October 5, 2021.

Parametrix. 2011. Draft Interim Action Summary Report, Groundwater Pump and Treatment System, SMC and Cadet Sites. Prepared for the Port of Vancouver, Vancouver, Washington. June 2011.

Parametrix. 2023. Feasibility Study, Cadet Manufacturing Company and Swan Manufacturing Company Portions, Vancouver Port of NuStar Swan Cadet Site. September 13, 2023.

Parametrix, S.S. Papadopulos and Associates, Pacific Groundwater Group, and Keta Waters, Inc. 2008. Vancouver Lake Lowlands Groundwater Model Summary Report. Prepared by Parametrix. Prepared for the Port of Vancouver and Clark Public Utilities. Vancouver, Washington. February 2008.

Figures

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Parametrix

Source: © Mapbox, © OpenStreetMap, Port of Vancouver

0 250 500 1,000 Feet

- Site - Historical Maximum Extent of HVOC Contamination
- Area of Site Included in Agreed Order 18152
- Cadet Facility
- Kinder Morgan Facility
- NuStar Facility
- Swan Site

Figure 1-1
Site Location Map

Groundwater Compliance Monitoring Plan
Swan and Cadet Sites
Port of Vancouver, WA

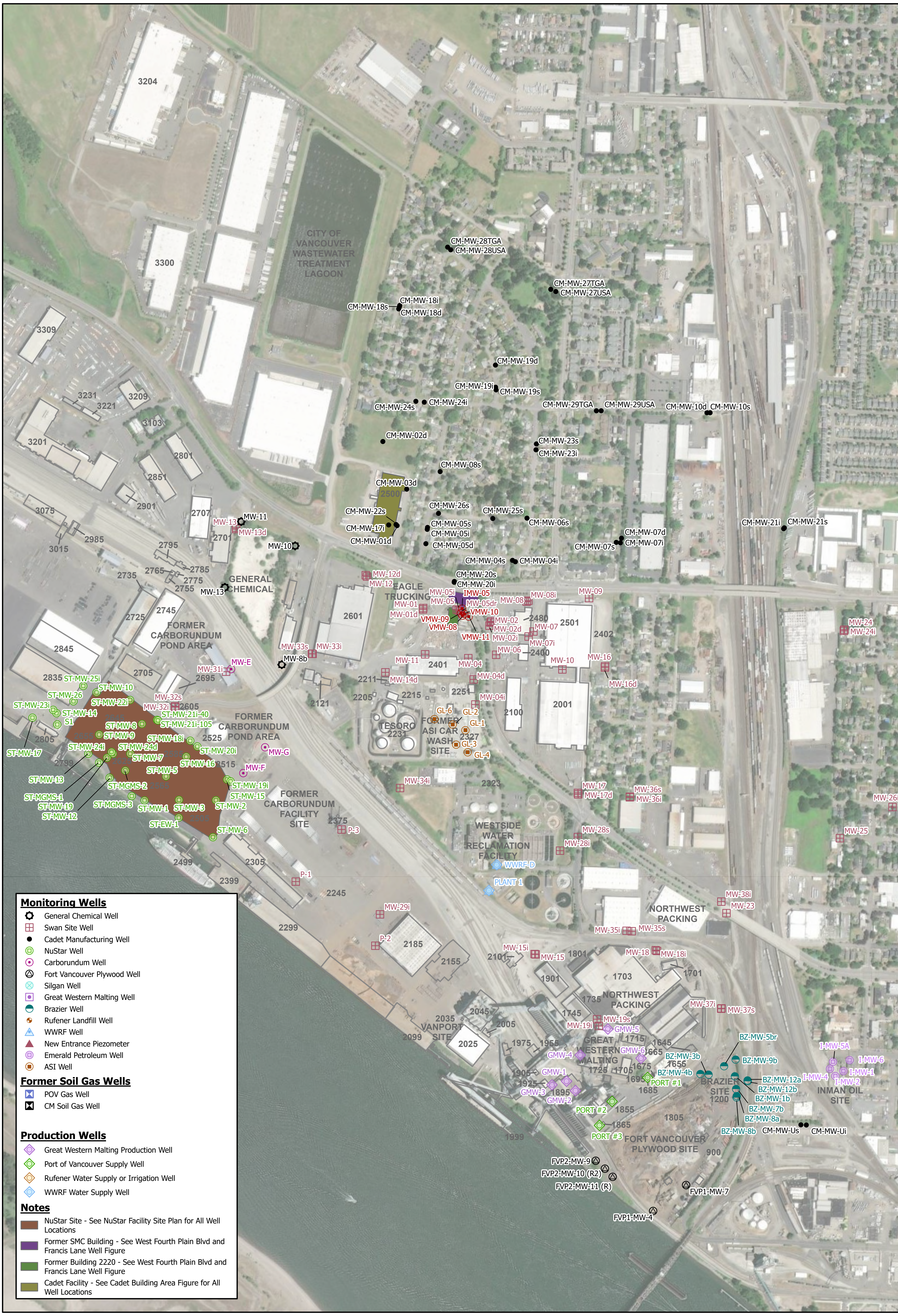

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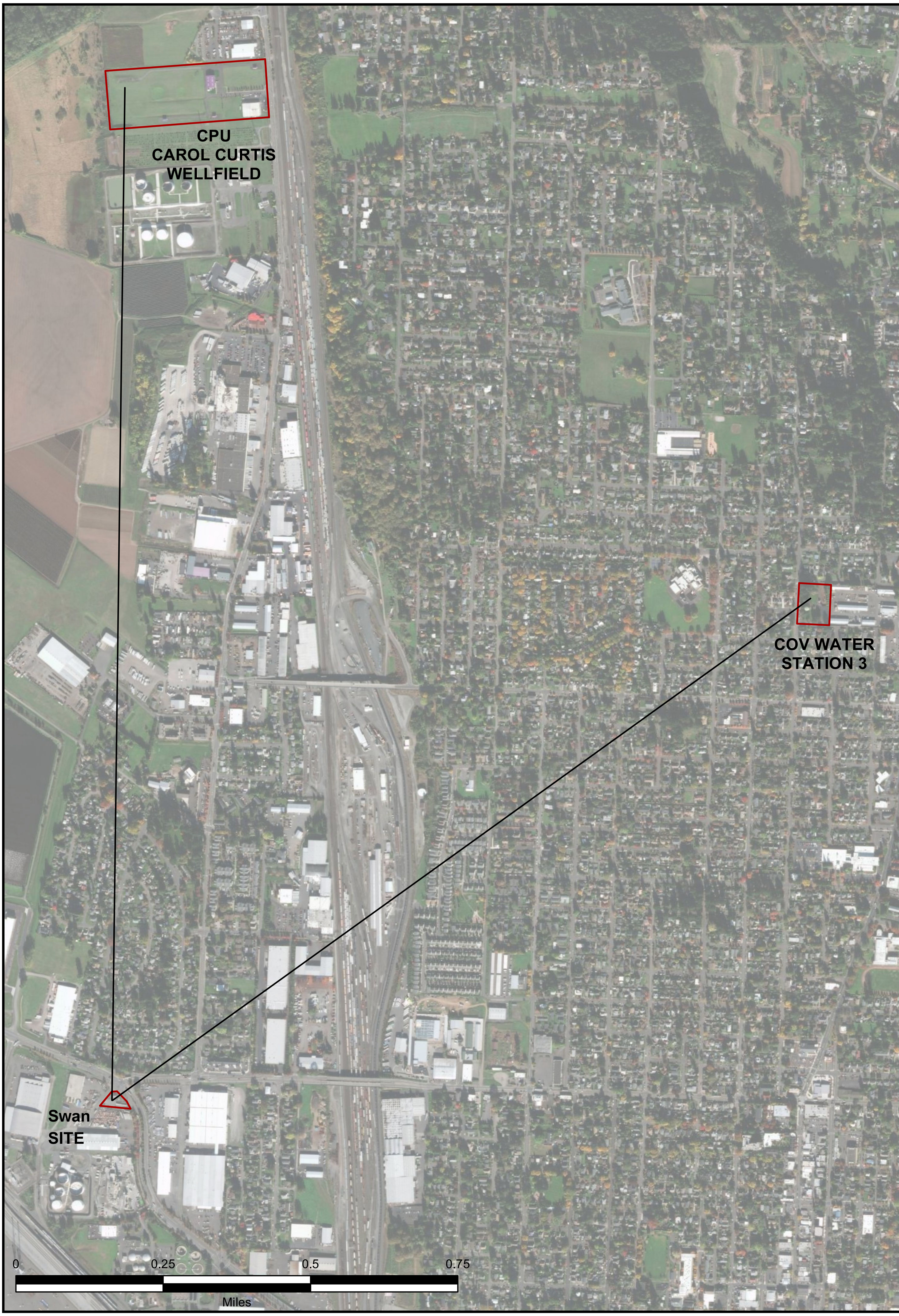
Figure 1-2:
Existing Site Area Well Networks

N

0 500 1,000

Scale in Feet

NuStar, Swan, and Cadet
Vancouver, WA



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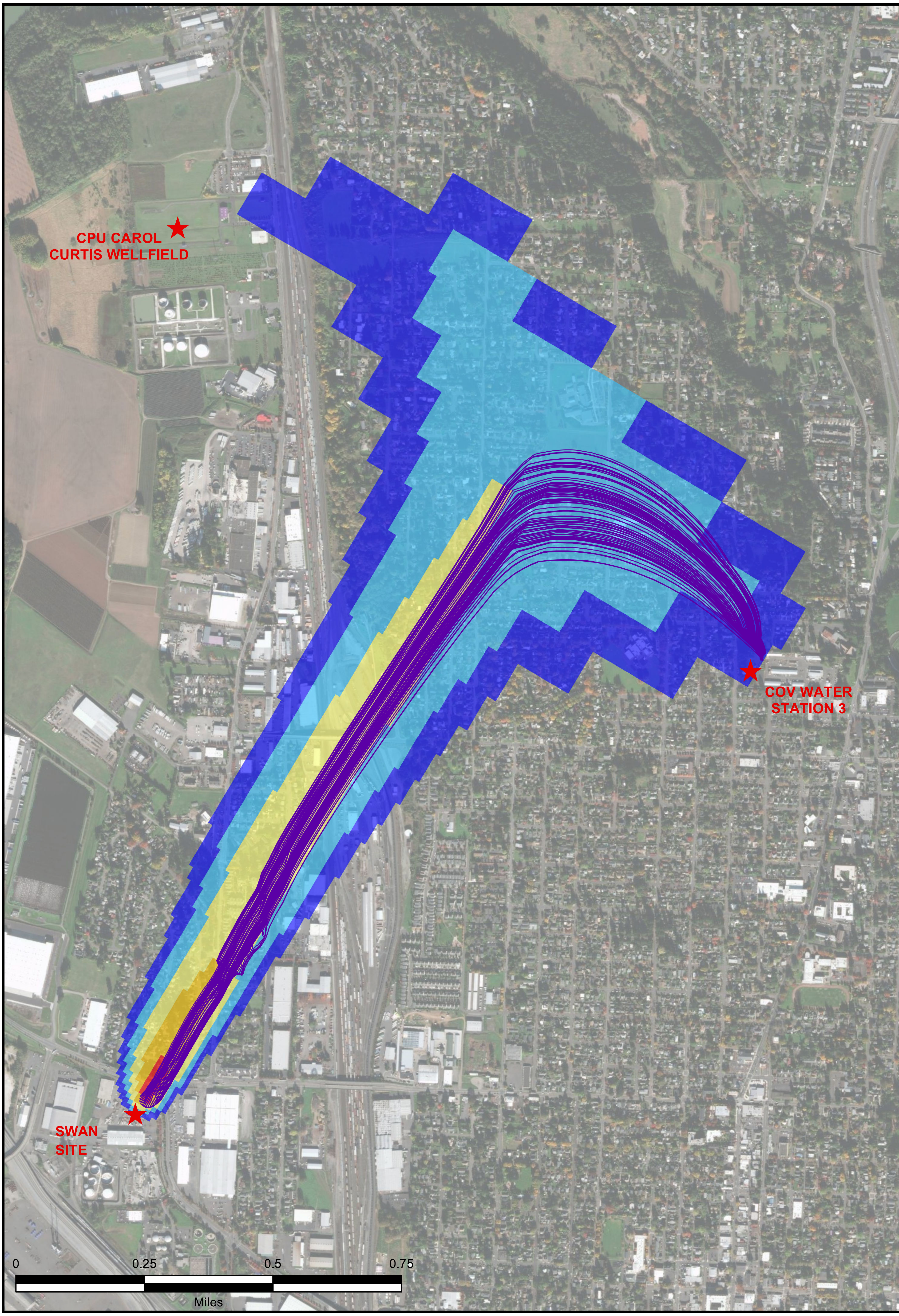
Straight lines from Swan Source

Area To CPU Curtis Wellfield:
located 1.6 miles to the north
To COV Water Station 3:
located 1.4 miles to the northeast.

Figure 1-3
Location of CPU Carol Curtis Wellfield, COV Water Station, and Swan Site

PORT OF VANCOUVER, WASHINGTON



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2021 FS Model Particle Trace Area

2021 FS Model Rate/Transport Plume Area

- 0.5 ug/L
- 2 ug/L
- 8 ug/L
- 32 ug/L
- 500 ug/L

N

Figure 1-4

Model Contaminant Transport Plume & Particle Trace

PORT OF VANCOUVER, WASHINGTON

Parametrix Date: 8/29/2023

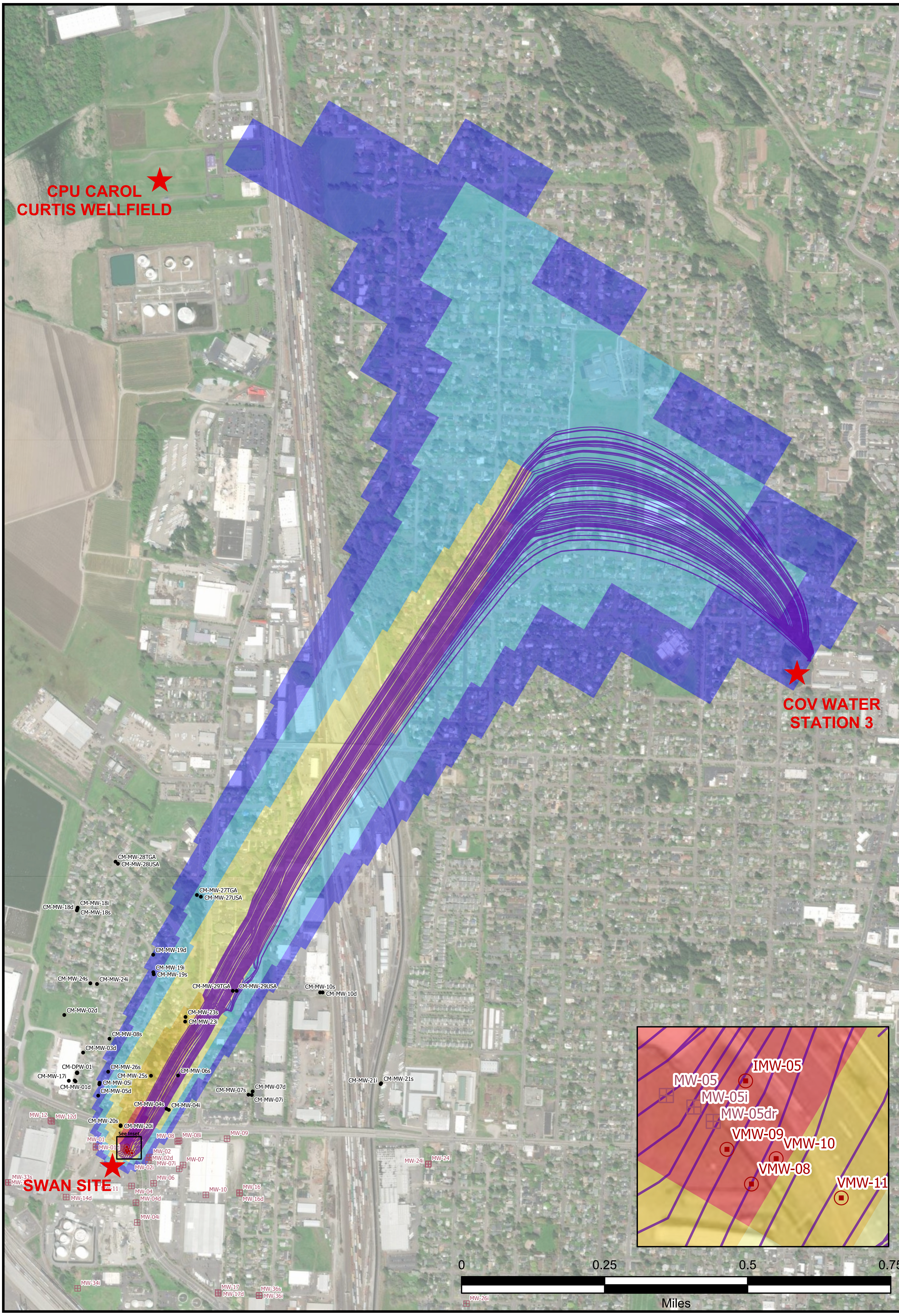
Figure 2-1: Groundwater Compliance Monitoring Wells

N

0 500 1,000

Scale in Feet

NUSTAR, SWAN, AND
CADER VANCOUVER, WA



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Parametrix Date: 9/1/2023

- 2021 FS Model Particle Trace Area
- Swan Site Well
- Cadet Manufacturing Well
- Swan Shallow Source Area Well

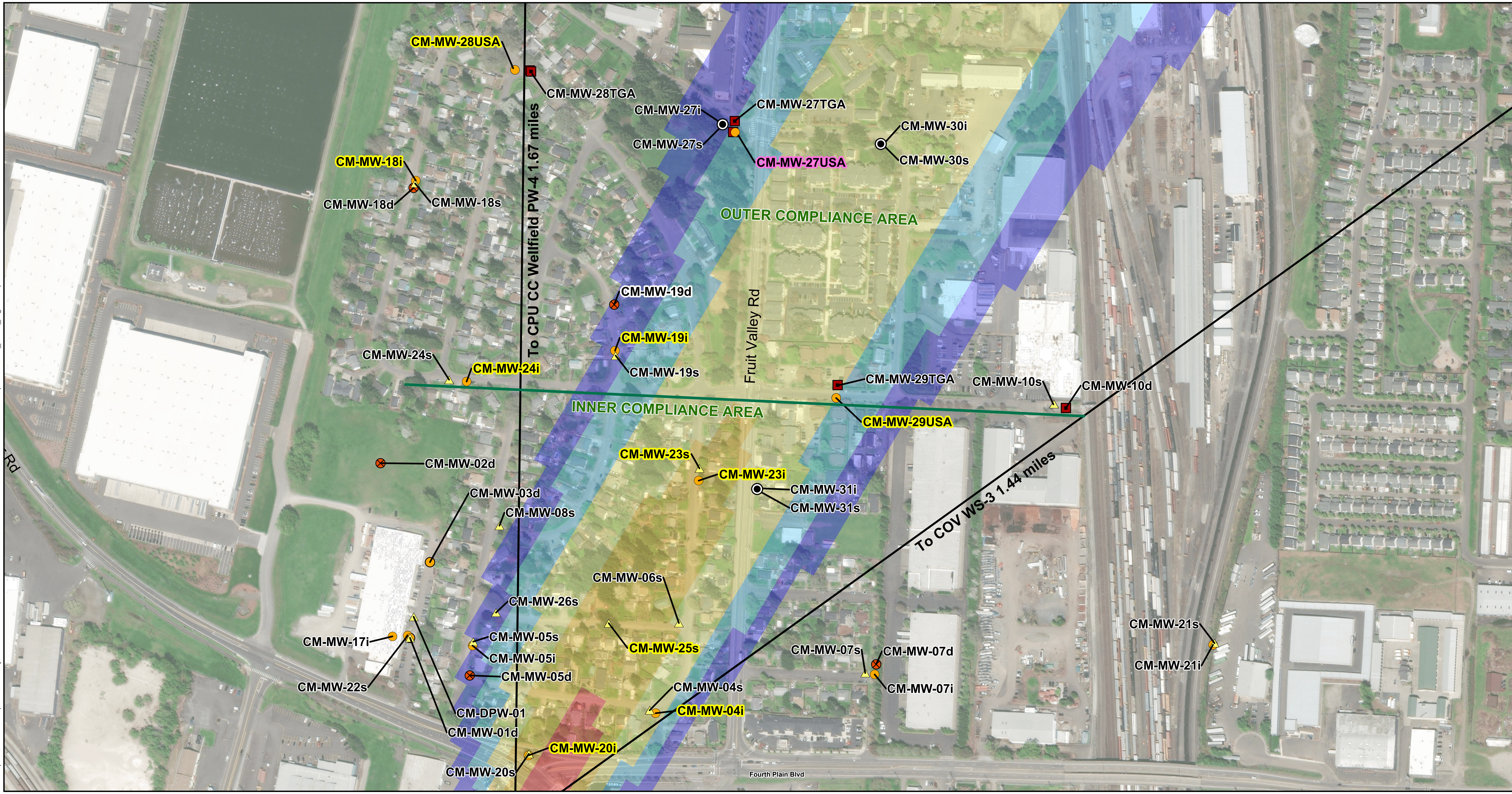
2021 FS Model Rate/Transport Plume Area

- 0.5 ug/L
- 2 ug/L
- 8 ug/L
- 32 ug/L
- 500 ug/L

Figure 2-2
Model Predicted Transport Area and Existing Monitoring Wells

N

PORT OF VANCOUVER, WASHINGTON



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Parametrix Date: 9/1/2023

CM-04 (pink)	Multi-port Well Inoperable
◉	Potential New Compliance Well Location
CM-04 (yellow)	Proposed Compliance Well
△	Shallow USA Groundwater Monitoring Well
● (orange)	Intermediate USA Groundwater Monitoring Well
⊗	Deep USA Groundwater Monitoring Well
■	TGA Monitoring Well

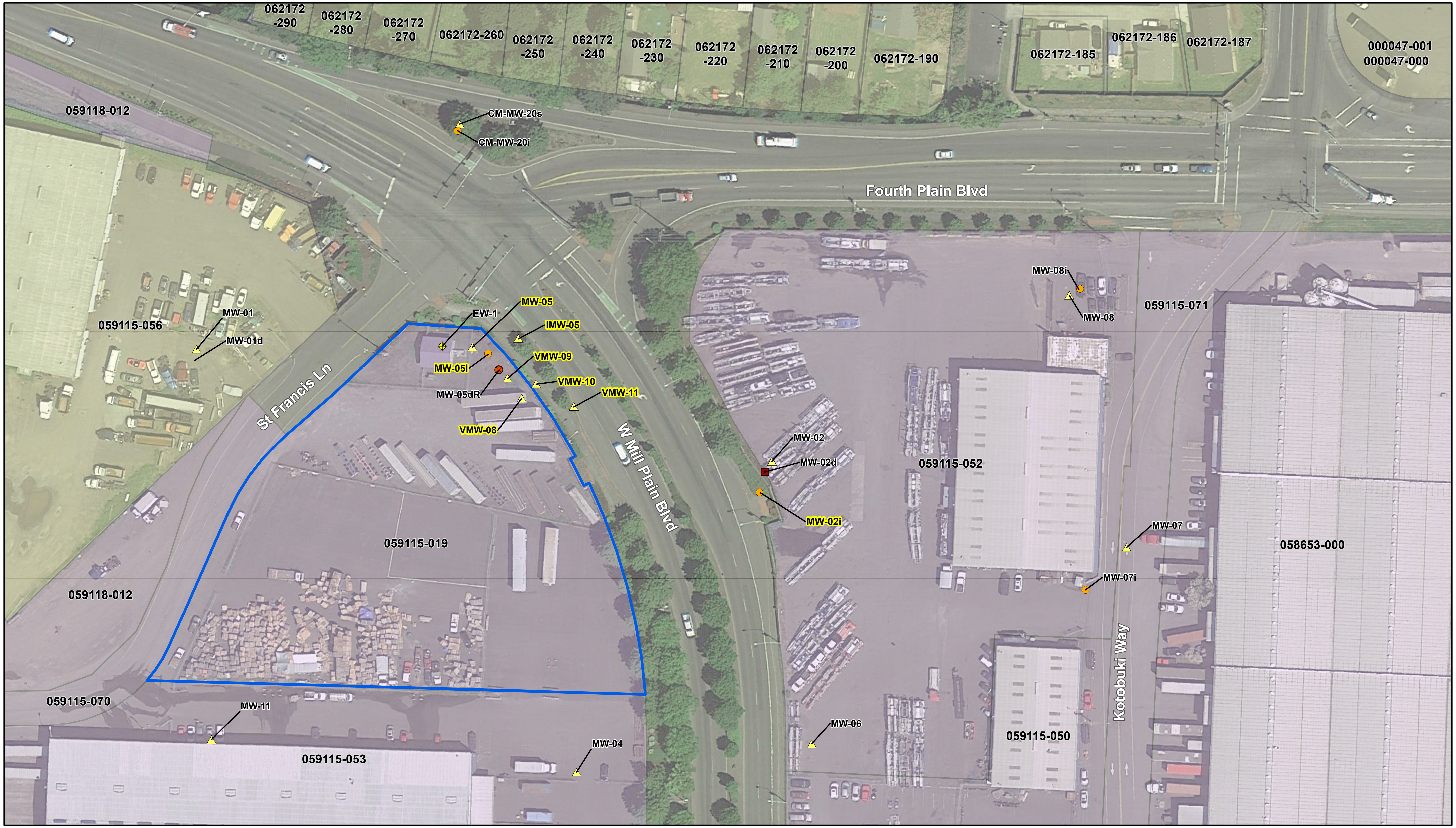
2021 FS Model Rate/Transport Plume Area
- 0.5 ug/L
- 2 ug/L
- 8 ug/L
- 32 ug/L
- 500 ug/L

N

Feet: 0 125 250 500

Figure 2-3
Attenuation Monitoring Well Locations

Groundwater Compliance Monitoring Plan
Port of Vancouver, WA



Parametrix Date: 9/1/2023

N

Source: Clark County, Google Earth (Aerial May 2017)

0 80 160

Feet

Swan Source Area Monitoring Wells

Swan Site Property Boundary

Ownership

Port of Vancouver

Private

City of Vancouver ROW (No Fill)

Shallow USA Groundwater Monitoring Well

Intermediate USA Groundwater Monitoring Well

Deep USA Groundwater Monitoring Well

TGA Monitoring Well

GPTIA Extraction Well

Figure 2-4
Swan Source Area Monitoring Wells

Groundwater Compliance Monitoring Plan
Port of Vancouver, WA

Parametrix Date: 9/1/2023

Port/GWM Wellfield Area Monitoring Wells

Non-Swan/Cadet Source Monitoring Wells

N

0 500 1,000

Scale in Feet

Figure 2-5: Non-Swan/Cadet Source and Port/GWM Wellfield Area Monitoring Wells

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Parametrix Date: 9/1/2023

Figure 2-6: Deep Zone Monitoring Wells

USA Deep Zone Monitoring Wells

GROUNWATER COMPLIANCE MONITORING PLAN
VANCOUVER, WA

N

0 500 1,000

Scale in Feet

Tables

Table 2-1 Groundwater Monitoring Well Network
Groundwater Compliance Monitoring Plan
Swan and Cadet Portions, Vancouver Port of NuStar Cadet Swan Site

Well ID	Water Quality Zone	Well Depth (ft bgs)	Top of Screen (ft bgs)	Bottom of Screen (ft bgs)	Well Location	Comments	Well Monitoring Designation	Sample Schedule
MW-01	shallow	25	15	25	Located 9 ft north of MW-01d.	Well located west of SMC source area. VOCs not detected.	Inactive monitoring point.	Inactive well
MW-01d	deep	221	211	220.7	Located next to MW-01 in Eagle Trucking (truck repair) compound.	Well located west of SMC source area. TCE concentrations above cleanup level.	Deep zone monitoring well	Bi-Annual
MW-02	shallow	30	20	30	~6 ft east of west side soundwall in United Auto compound.	Well located east of the SMC source area. VOC concentrations below cleanup levels.	Inactive monitoring point.	Inactive well
MW-02i	intermediate	49.53	39.5	49.5	Located east side of Mill Plain Blvd between sidewalk and sound wall north side of former bus stop platform.	Well located east of the SMC source area. VOC concentrations below cleanup levels.	Inner attenuation monitoring well	Semi-Annual
MW-02d	TGA	217	207	216.7	~15 ft northeast of MW-02.	Well located east of the SMC source area. VOCs not detected.	Inactive monitoring point.	Inactive well
MW-04	shallow	25	15	25	Located in loading area northeast of bldg 2401.	Well located south of SMC source area. Trace VOC levels detected.	Inactive monitoring point.	Inactive well
MW-04i	intermediate	100	90	99.7	Located east side of concrete batch plant. Well is off to the east side of the main facility access road.	Well located south of SMC source area. Trace VOC levels detected.	Inactive monitoring point.	Inactive well
MW-04d	deep	232.3	222	232	Located in northeast corner of concrete batch plant in isolated asphalt area, fire lane behind building 2401.	Well located south of SMC source area. VOCs not detected.	Inactive monitoring point.	Inactive well
MW-05	shallow	30	20	30	East of EW-1 well house; just east of fence.	Shallow well located in SMC source area. TCE and PCE above cleanup levels detected.	SMC source area monitoring well	Semi-Annual
MW-05i	intermediate	100	90	99.7	Well east of MW-05.	Shallow well located in SMC source area. TCE above cleanup levels detected.	SMC source area monitoring well	Semi-Annual
MW-05dR	deep	227.5	217.3	227.3	Southeast of MW-5i.	Deep well located in the SMC source area. TCE above cleanup levels.	Deep zone monitoring well	Bi-Annual
MW-06	shallow	29	216	226	Located in southern area of United Auto compound. Well located ~30 ft east of chain-link fence.	Well located southeast of SMC source area. VOC concentrations below cleanup levels.	Inactive monitoring point.	Inactive well
MW-07	shallow	30	19	29	In the middle of Kotobuki Way.	Well located east of SMC source area. VOC concentrations below cleanup levels.	Inactive monitoring point.	Inactive well
MW-07i	intermediate	90	80	90	Well located just inside fence of United auto compound next to gate.	Well located east of SMC source area. VOC concentrations below cleanup levels.	Inactive monitoring point.	Inactive well
MW-08	shallow	30	20	30	In parking lot front of United auto tranport office.	Well located east of SMC source area. VOC concentrations below cleanup levels.	Inactive monitoring point.	Inactive well
MW-08i	deep	130	120	129.7	~12 feet northeast of MW-08.	Well located east of SMC source area. VOC not detected.	Inactive monitoring point.	Inactive well
MW-09	shallow	32	22	32	Located near propane storage tank near northeast corner of building.	Well located east of SMC source area. VOC concentrations below cleanup levels.	Inactive monitoring point.	Inactive well
MW-10	shallow	31.5	21	31	Well historically covered by materials requiring fork lift to access.	Well located east of SMC source area. VOC concentrations below cleanup levels.	Inactive monitoring point.	Inactive well
MW-11	shallow	26	16	26	Located in parking area adjacent to western end north side of bldg 2401 south of smc source area.	Well located south of SMC source area. VOCs not detected.	Inactive monitoring point.	Inactive well
MW-12	shallow	31	21	31	Located 12 feet west of MW-12d.	Well located west of SMC source area. VOCs not detected.	Inactive monitoring point.	Inactive well
MW-12d	deep	216.3	206	216	Located near northeast corner of bldg 2601 parking lot.	Well located west of SMC source area. TCE concentrations above cleanup level.	Deep zone monitoring well	Bi-Annual
MW-13	shallow	29	19	29	Located next to MW-13d. Perched groundwater zone.	Well located west of SMC source area. VOCs not detected.	Inactive monitoring point.	Inactive well
MW-13d	TGA	262	252	261.7	Located in untraveled gravel area between bldg 2701 and west side of former alum pond.	Well located west of SMC source area. VOCs not detected.	Inactive monitoring point.	Inactive well
MW-14d	deep	221	211	220.7	Located in paved area just north of Tesoro tank farm.	Well located southwest of SMC source area. VOC cocentrations below cleanup levels.	Deep zone monitoring well	Bi-Annual
MW-15	shallow	33	23	33	Located in parking lot west of bldg 1901. Located 8' west of MW-15i.	Well located west of Port/GWM wellfield. VOCs not detected.	Inactive monitoring point.	Inactive well
MW-15i	intermediate	139	129	139	Located in gravel parking lot west of bldg 1901. Approximately 50 ft west of paved road center line. MW-15s located 8 ft slightly north of of 15i.	Well located west of Port/GWM wellfield. TCE above cleanup levels.	Port/GWM wellfield area monitoring point	Annual
MW-16	shallow	36	26	36	Located in southeast corner of gravel/grass lot east of building. North above ground monument.	Well located east of SMC source area. VOC concentrations below cleanup levels.	Inactive monitoring point.	Inactive well
MW-16d	TGA	230	220	229.7	Located adjacent to MW-16.	Well located east of SMC source area. VOCs not detected.	Inactive monitoring point.	Inactive well
MW-17	shallow	31	21	31	Located in back middle section southeast corner of bldg 2001 parking lot. ~10 feet south of MW-17d.	Well located southeast of SMC source area. VOCs not detected.	Inactive monitoring point.	Inactive well
MW-17d	TGA	195	185	195	Located in back secrtion of southeast corner of bldg 2001 parking lot. ~12 ft south of MW-17.	Well located southeast of SMC source area. VOCs not detected.	Inactive monitoring point.	Inactive well
MW-18	shallow	38	28	38	Located ~9 feet west of MW-18i.	Well located north of Port/GWM wellfield. VOCs not detected.	Inactive monitoring point.	Inactive well
MW-18i	intermediate	130	120	130	Located just north of former truck weight station north just south of access road.	Well located north of Port/GWM wellfield. VOCs concentrations below cleanup levels.	Inactive monitoring point.	Inactive well
MW-19s	shallow	33	120	130	Located north side of access road next to gate fence, north of MW-19i.	Well located north of Port/GWM wellfield. VOCs not detected.	Inactive monitoring point.	Inactive well
MW-19i	intermediate	130	23	33	Well is located ~7 ft east of a raised construction trailer (near entry stairs) on north side of GWM building.	Well located north of Port/GWM wellfield. VOCs detected at trace levels.	Inactive monitoring point.	Inactive well
MW-23	shallow	45	35	45	Located under west end of Mill Plain Blvd bridge overpass of rail lines.	Well located northeast of Port/GWM wellfield. VOCs not detected.	Inactive monitoring point.	Inactive well
MW-24	shallow	62	52	62	Located at dead end of W 25th Street. 8 ft north of MW-24i.	Well located east of SMC site and east of the railroad corridor. VOCs not detected.	Inactive monitoring point.	Inactive well

Well ID	Water Quality Zone	Well Depth (ft bgs)	Top of Screen (ft bgs)	Bottom of Screen (ft bgs)	Well Location	Comments	Well Monitoring Designation	Sample Schedule
MW-24i	intermediate	123	113	123	Located at dead end of W 25th Street.	Well located east of SMC site and east of the railroad corridor. VOCs not detected.	Inactive monitoring point.	Inactive well
MW-25	shallow	85	75	85	Located at dead end of W 19th Street.	Well located southeast of SMC site and east of the railroad corridor. VOCs not detected.	Inactive monitoring point.	Inactive well
MW-26i	intermediate	113	103	113	Located in front yard south side of W 20th Street between Lincoln Avenue and Markle Avenue. Well is located 3 ft south of 1107 mailbox in lawn.	Well located southeast of SMC site and east of the railroad corridor. VOCs not detected.	Inactive monitoring point.	Inactive well
MW-28s	shallow	29	19	29	Located in grass median on east side of Thompson Avenue south of Mill Plain Blvd. Located 8 ft from east side of Thompson asphalt.	Well located southeast of SMC source area. VOCs not detected.	Inactive monitoring point.	Inactive well
MW-28i	intermediate	85	75	85	Located in grass area in the City of Vancouver wastewater treatment plant compound eastern side 9 ft east of concrete/asphalt pile.	Well located southeast of SMC source area. VOCs concentrations at trace levels.	Inactive monitoring point.	Inactive well
MW-29i	intermediate	125	115	125	Located in Terminal 2 lay down area west of eastern terminal building 2185 just south of light pole #21.	Well located west of Port/GWM wellfield. Trace TCE concentrations detected.	Inactive monitoring point.	Inactive well
MW-31i	intermediate	85.5	75	85.5	Well is located inside of bldg 2685 under a 13.5 inch flush floor lid marked OPW. Monument is located ~3 ft east and at south end red vehicle lift. May need to coordinate accessing well when shop is in use.	Well located with of NuStar facility site. PCE concentrations above cleanup levels.	Non-Cadet/SMC source monitoring	Annual
MW-32s	shallow	33	23	33	Well is located 5 feet west of MW-32i.	Well located with of NuStar facility site. VOCs not detected.	Inactive monitoring point.	Inactive well
MW-32i	intermediate	70	60	70	Well is located in security parking lot just southwest of main POV gatehouse.	Well located with of NuStar facility site. TCE and PCE concentrations above cleanup levels.	Non-Cadet/SMC source monitoring	Annual
MW-33s	shallow	31	21	31	Located 5 feet east of MW-33i.	Well located southwest of SMC source area. VOCs not detected.	Inactive monitoring point.	Inactive well
MW-33i	intermediate	85.5	75	85	Located near southwest corner of building near west end of St Francis Lane. No access issues.	Well located southwest of SMC source area. Trace VOC concentrations detected.	Non-Cadet/SMC source monitoring	Bi-Annual
MW-34i	intermediate	105.5	95	105	Located in grass field west of City wastewater treament plant compound. Pink well monument located west end of grass area.	Well located south of SMC source area. Trace TCE levels detected.	Inactive monitoring point.	Inactive well
MW-35s	shallow	32.5	22.5	32.5	Located ~30 feet east of MW-35i.	Well located north of Port/GWM wellfield. VOCs not detected.	Inactive monitoring point.	Inactive well
MW-35i	intermediate	122.5	112	122	Located near southeast corner of building that is north of bldg 1703. Well is between building and fence.	Well located north of Port/GWM wellfield. VOCs concentrations below cleanup levels.	Inactive monitoring point.	Inactive well
MW-36s	shallow	34	24	34	Located 3 feet north of MW-36i in sidewalk landscaping.	Well located southeast of SMC source area. VOCs not detected.	Inactive monitoring point.	Inactive well
MW-36i	intermediate	105	95	105	Located in sidewalk south of W 20th Street and north of buidling.	Well located southeast of SMC source area. PCE and TCE trace levels detected.	Inactive monitoring point.	Inactive well
MW-37i	intermediate	125	115	125	Well is located 7 feet east of eastern most rail just north of rail switch.	Well located east of Port/GWM wellfield. TCE detected above cleanup levels.	Non-Cadet/SMC source monitoring	Annual
MW-38i	intermediate	155.5	145	155	Located in southeastern corner of Columbia Cascade parking lot.	Well located northeast of Port/GWM wellfield. VOC concentration below cleanup levels.	Non-Cadet/SMC source monitoring	Annual
MW-E	shallow	34.1	23.7	33.7	Located adjacent to north side of bldg 2685 on asphalt access road under a sewer manhole cover marked with an S.	Well located with of NuStar facility site. TCE and PCE concentrations above cleanup levels.	Non-Cadet/SMC source monitoring	Annual
MW-F	shallow	37.3	26.9	36.9	Located adjacent to the northside of NW Harborside Drive near T-intersection.	Well located with of NuStar facility site. VOCs not detected.	Inactive monitoring point.	Inactive well
MW-G	shallow	37.7	27.3	37.3	Located in gravel area north of MW-F. Well is ~60 feet from base of tank berm and ~75 feet from paved road edge.	Well located with of NuStar facility site. Trace cis-1,2-DCE detected.	Inactive monitoring point.	Inactive well
IMW-05	shallow	25.9	20	30	Located in planter strip NE of EW-1 cinder block wall; between side walk and Mill Plain Blvd.	Shallow SMC source area monitoring well. TCE at cleanup level.	SMC source area monitoring well	Semi-Annual
VMW-08	shallow	29.4	15	25	East of EW-1 well house and west of wall. South of VMW-9.	Shallow SMC source area monitoring well. TCE and PCE above cleanup levels.	SMC source area monitoring well	Semi-Annual
VMW-09	shallow	28.1	16	26	East of EW-1 well house and west of wall. North of VMW-8.	Shallow SMC source area monitoring well. TCE and PCE above cleanup levels.	SMC source area monitoring well	Semi-Annual
VMW-10	shallow	29.5	18	28	Well is located adjacent to east side of wall on sidewalk near planter.	Shallow SMC source area monitoring well. TCE and PCE above cleanup levels.	SMC source area monitoring well	Semi-Annual
VMW-11	shallow	27.7	18	28	Well is located in the north corner of bus stop pull in next to curb.	Shallow SMC source area monitoring well. TCE and PCE above cleanup levels.	SMC source area monitoring well	Semi-Annual
Piezo P-1	shallow				Located in rail corridor. 9' from north rail and 15 feet west of end paved section between rails.	Well/piezometer located east of NuStar site. Not sampled.	Inactive monitoring point.	Inactive well
Piezo P-2	shallow				Located 4.5' west and 3.5' north of yellow guard rails.	Well/piezometer located east of NuStar site. Not sampled.	Inactive monitoring point.	Inactive well
Piezo P-3	shallow				Located 16' west of T-2 bioswale west fence.	Well/piezometer located east of NuStar site. Not sampled.	Inactive monitoring point.	Inactive well
CM-MW-01d-040	shallow	226	39.75	40.25	Mutli-port well located in a large utility vault. Well is located in Cadet parking lot.	VOC concentrations below cleanup levels.	Inactive monitoring point.	Inactive well
CM-MW-01d-121	intermediate	226	120.25	120.75		VOC concentrations below cleanup levels.	Inactive monitoring point.	Inactive well
CM-MW-01d-161	deep	226	160.75	161.25		VOC concentrations just above or below cleanup levels.	Inactive monitoring point.	Inactive well
CM-MW-01d-194	deep	226	193.25	193.75		TCE concentratrions above cleanup level.	Inactive monitoring point.	Inactive well
CM-MW-01d-224	deep	226	223.75	224.25		TCE concentrations above cleanup level.	Deep zone monitoring well	Bi-Annual
CM-MW-02d	deep	230.7	220	230	Located in field north of Cadet building.	TCE concentrations above cleanup level.	Deep zone monitoring well	Bi-Annual
CM-MW-03d-060	intermediate	227.8	15	25	Mulit-port well located in a large utility vault. Well located in Cadet parking lot.	TCE concentrations above cleanup level.	Inactive monitoring point.	Inactive well
CM-MW-03d-100	intermediate	227.8	59.2	59.7		VOC concentrations below cleanup levels.	Inactive monitoring point.	Inactive well
CM-MW-03d-141	deep	227.8	99.7	100.2		TCE concentrations above cleanup level.	Inactive monitoring point.	Inactive well

Table 2-1 Groundwater Monitoring Well Network
Groundwater Compliance Monitoring Plan
Swan and Cadet Portions, Vancouver Port of NuStar Cadet Swan Site

Well ID	Water Quality Zone	Well Depth (ft bgs)	Top of Screen (ft bgs)	Bottom of Screen (ft bgs)	Well Location	Comments	Well Monitoring Designation	Sample Schedule
CM-MW-03d-181	deep	227.8	140.2	140.7	parking lot.	TCE concentrations above cleanup level.	Inactive monitoring point.	Inactive well
CM-MW-03d-227	deep	227.8	180.7	181.2		TCE concentrations above cleanup level.	Deep zone monitoring well	Bi-Annual
CM-MW-04s	shallow	30	15	30	Located in southwest corner where W 27th Street meets Unander Ave.	Well located east of Cadet site. VOC concentrations below cleanup levels.	Inactive monitoring point.	Inactive well
CM-MW-04i	intermediate	95	85	95	Located in southwest corner where W 27th Street meets Unander Ave. CM-MW-04i 22 feet east of CM-MW-4s.	Well located east of Cadet site. VOC concentrations below cleanup levels.	Inner attenuation monitoring well	Annual
CM-MW-05s	shallow	25	15	25	Located on east side of Weigel Avenue east of Cadet building between W 27th and W 28th Streets.	Well located east of Cadet site. VOC concentrations below cleanup levels.	Inactive monitoring point.	Inactive well
CM-MW-05i	intermediate	95	85	95	Located on east side of Weigel Avenue east of Cadet building between W 27th and W 28th Streets.	Well located east of Cadet Site. VOC concentrations below cleanup levels.	Inactive monitoring point.	Inactive well
CM-MW-05d	deep	217	206.5	216.5	Located on east side of Weigel Avenue east of Cadet building between W 27th and W 28th Streets.	Well located east of Cadet site. TCE concentrations above cleanup level.	Deep zone monitoring well	Bi-Annual
CM-MW-06s	shallow	34.5	19	34	Located on west side of W 28th Street where it meets Unander Avenue. Gas lid not a monitoring well lid.	Well located east of Cadet Site. VOC concentrations below cleanup levels.	Inactive monitoring point.	Inactive well
CM-MW-07s	shallow	44.5	24	44	Located on north side of W 27th Street, next to parking, where it meets Thompson Avenue.	Well located east of Cadet Site. VOC concentrations below cleanup levels.	Inactive monitoring point.	Inactive well
CM-MW-07i	intermediate	109	99	109	Located on north side of W 27th Street where it meets Thompson Avenue. Well is ~17 feet east of CM-MW-07s.	Well located east of Cadet Site. VOC concentrations below cleanup levels.	Inactive monitoring point.	Inactive well
CM-MW-07d	deep	225	215	225	Located on east side of Thompson Ave near W 27th Street.	Well located east of Cadet site. VOC concentrations at trace levels.	Inactive monitoring point.	Inactive well
CM-MW-08s	shallow	24.5	14	24	Located on north side of Van Allman Avenue where it meets Weigel Avenue.	Well located northeast of the Cadet site. VOCS not detected.	Inactive monitoring point.	Inactive well
CM-MW-10s	shallow	23	7.5	22.5	Located on north side of eastern end of W 31st Street in gravel area. MW-10s marked on mon rim.	Well located northeast of Cadet site. Trace PCE concentrations detected.	Inactive monitoring point.	Inactive well
CM-MW-10d	TGA	59	220	230	Located on near CM-MW-10s in gravel area. Located 18 feet due east of CM-MW-10s.	Well located northeast of Cadet site. VOCs not detected.	Inactive monitoring point.	Inactive well
CM-MW-17i	intermediate	230	85	95	Located inside of Cadet facility.	Well located at Cadet site. VOC concentrations below cleanup levels.	Inactive monitoring point.	Inactive well
CM-MW-18s	shallow	29.5	14	29	Located between CM-MW-18i and -18d.	Well located north of Cadet site. VOCs not detected.	Inactive monitoring point.	Inactive well
CM-MW-18i	intermediate	98	88	98	Located in the mid-section of Yeoman Avenue on east side of street ~15 feet north of CM-MW-18s.	Well located north of Cadet site. Trace TCE concentrations detected.	Outer attenuation monitoring well	Annual
CM-MW-18d	deep	198.5	188.5	198	Located ~18 feet south of CM-MW-18s.	Well located at Cadet site. VOC concentrations below cleanup levels.	Deep zone monitoring well	Bi-Annual
CM-MW-19s	shallow	34.5	19	34	Located just south of CM-MW-19i.	Well located northeast of the Cadet site. VOCS not detected.	Inactive monitoring point.	Inactive well
CM-MW-19i	intermediate	94	84	94	Located on west side of Van Allman Avenue south of W 31st Street.	Well located northeast of the Cadet site. Trace PCE and TCE concentrations detected.	Outer attenuation monitoring well	Annual
CM-MW-19d	deep	178.5	168	178	Located on east side of Van Allman Avenue ~ 100 feet north of CM-MW-19i and -19s.	Well located northeast of the Cadet site. TCE concentrations above cleanup levels.	Deep zone monitoring well	Bi-Annual
CM-MW-20s	shallow	35	20	35	Located in the median at W 4th Plain Blvd and Mill Plani Blvd intersection.	Well located between SMC and Cadet sites. VOC concentrations below cleanup levels.	Inactive monitoring point.	Inactive well
CM-MW-20i	intermediate	99.5	89	99	Located in the median at W 4th Plain Blvd and Mill Plani Blvd intersection.	Well located between SMC and Cadet sites. VOC concentrations below cleanup levels.	Inner attenuation monitoring well	Semi-Annual
CM-MW-21s	shallow	64	49	64	Located east of BN railroad tracks west of W 4th Plain Blvd. Well located ~15 ft west of fence above rail yard. Well located ~7 ft north of CM-MW-21i.	Well located east of Cadet site and east of railroad corridor. VOCs not detected.	Inactive monitoring point.	Inactive well
CM-MW-21i	intermediate	120.5	110	120	Located south of CM-MW-21s.	Well located east of Cadet site and east of railroad corridor. VOCs not detected.	Inactive monitoring point.	Inactive well
CM-MW-22s	intermediate	40.5	35	40	Located in east Cadet parking lot adjecent to CM-MW-01d.	Well located adjacent to east side of Cadet building. Low level TCE and PCE concentrations detected.	Inactive monitoring point.	Inactive well
CM-MW-23s	shallow	37	22	37	Located on east side of Unander Avenue south of W 31st Street. In front of 2913 Unander.	Well located northeast of the Cadet site. Low PCE and TCE concentrations detected.	Inner attenuation monitoring well	Annual
CM-MW-23i	intermediate	102	92	102	Located just south of CM-MW-23s.	Well located northeast of the Cadet site. VOC concentrations below cleanup levels.	Inner attenuation monitoring well	Annual
CM-MW-24s	shallow	35	20	35	Located west of CM-MW-24i.	Well located north of the Cadet site. VOCs not detected.	Inactive monitoring point.	Inactive well
CM-MW-24i	intermediate	98.5	88	98	Located on south side of W 31st Street just east of Xavier Avenue.	Well located north of the Cadet site. Trace PCE and TCE concentrations detected.	Outer attenuation monitoring well	Annual
CM-MW-25s	shallow	30	15	30	Located on north side of W 28th Street mid section of street.	Well located east of the Cadet site. Trace level PCE and TCE concentrations detected.	Inner attenuation monitoring well	Annual
CM-MW-26s	shallow	30	15	30	Located on south side of W 28th Street near Weigle Avenue.	Well located northeast of the Cadet site. TCE concentrations above cleanup levels.	Inactive monitoring point.	Inactive well
CM-MW-27TGA	TGA	170	159.5	169.5	Located in northeast corner of Fruit Valley park and south of CM-MW-27USA.	Well located northeast of Cadet site. VOCs not detected.	Inactive monitoring point.	Inactive well
CM-MW-27USA-049.5	shallow	129	49	49.5	Located in northeast corner of Fruit Valley park in grass area adjacent to La Frambois Road near Fruit Valley Road.	Trace levels of TCE detected.	Inactive monitoring point.	Inactive well
CM-MW-27USA-090	intermediate	129	89.5	90		Sample port not functional. Never sampled.	nonfunctioning monitoring point.	Inactive well
CM-MW-27USA-127	intermediate	129	126.6	127		Sample port not functional. Never sampled.	nonfunctioning monitoring point.	Inactive well
CM-MW-28TGA	TGA	210.5	200	210	Located on north side of Unander Road just east of Xavier Avenue.	Well located northeast of Cadet site. Only trace levels toluene detected.	Inactive monitoring point.	Inactive well
CM-MW-28USA-050	intermediate	180	49.5	50		Trace TCE levels detected.	Outer attenuation monitoring well	Annual

Table 2-1 Groundwater Monitoring Well Network
Groundwater Compliance Monitoring Plan
Swan and Cadet Portions, Vancouver Port of NuStar Cadet Swan Site

Well ID	Water Quality Zone	Well Depth (ft bgs)	Top of Screen (ft bgs)	Bottom of Screen (ft bgs)	Well Location	Comments	Well Monitoring Designation	Sample Schedule
CM-MW-28USA-120.5	intermediate	180	120	120.5	Located on west side of Xavier Avenue at intersection with Unander Avenue. Well located northeast of the Cadet site.	TCE concentrations just above/below cleanup level.	Outer attenuation monitoring well	Annual
CM-MW-28USA-180	deep	180	179.5	180		TCE concentrations above cleanup level.	Deep zone monitoring well	Annual
CM-MW-29TGA	TGA	160	150	160	Located on south side of W 31st Street 4 feet west of CM-MW-29USA.	Well located northeast of the Cadet site. TCE and PCE concentrations above cleanup levels.	Outer attenuation monitoring well	Annual
CM-MW-29USA-060.5	intermediate	140.5	60	60.5	Located on north side of W 31st Street between Fruit Valley Road and Thompson Avenue. Well located northeast of Cadet site.	Low levels of TCE and PCE detected.	Outer attenuation monitoring well	Annual
CM-MW-29USA-100	intermediate	140.5	99.5	100		Low levels of TCE and PCE detected.	Outer attenuation monitoring well	Annual
CM-MW-29USA-140.5	intermediate	140.5	140	140.5		Low levels of TCE and PCE detected.	Outer attenuation monitoring well	Annual
CM-DPW-01	shallow	28.4	8	28	Located in east Cadet parking lot adjacent to paint emissions drop out unit.	Well located adjacent to east side of Cadet building. TCE concentrations above cleanup level.	Inner attenuation monitoring well	Annual
CM-MW-Us	shallow	55	39.5	54.5	Located on north side of W 11th Street south of railroad station in off street parking area.	Well located east of Port/GWM wellfield and east of railroad corridor. TCE detected above cleanup levels. VOCs not detected.	Inactive monitoring point.	Inactive well
CM-MW-Ui	intermediate	130	110	129.5	Located on north side of W 11th Street south of railroad station in off street parking area. Located 11 ft east of CM-MW-Ui.	Well located east of Port/GWM wellfield and east of railroad corridor. TCE detected above cleanup levels.	Non-Cadet/SMC source monitoring	Annual

Notes.

CM-DPW-01	: Bold well identification indicates well is an active location per the updated 9/20/2017 performance groundwater monitoring plan schedule.
	: Indicates well is identified as Groundwater Compliance Monitoring Plan active location.

Only existing wells are listed. Wells that have been decommissioned are not listed.

Table 2-2 - Groundwater Compliance Monitoring Plan - Compliance Groundwater Monitoring Schedule
Swan & Cadet Groundwater Monitoring Well Network

Well Name	Water Quality Zone	Compliance Monitoring Function	Sample Schedule	Comments
Attenuation Monitoring Well		These wells are used to monitor natural attenuation in the area north of Forth Plain Blvd. This area was historically impacted by the former Cadet site source. Groundwater modeling indicates that groundwater flow is toward the northeast/north with P&T system off. These wells will be monitored to verify occurrence of natural attenuation and resulting groundwater quality compliance. Attenuation monitoring wells consist of inner and outer wells. Inner wells are located south of West 31st Street representing historic area of P&T capture. Outer wells are locates north of West 31st Street representing area beyond the historic P&T capture area.		
CM-DPW-01	shallow	Inner attenuation area monitoring well	Annual	Well is located adjacent to east side of Cadet facility where historically high VOC concentrations were detected. Well has longest continous sample record of former Cadet monitoring wells. Well to be used to confirm continuing attenuation at the Cadet facility shallow zone.
CM-MW-4i	intermediate	Inner attenuation area monitoring well	Annual	Well is located northeast of the SMC source area and in the groundwater model determined post-P&T operation contaminant migration pathway. VOC concentrations are currently below cleanup levels. Well will be used to verify concentrations continue to attenuate.
CM-MW-20i	intermediate	Inner attenuation area monitoring well	Semi-Annual	Well is located north of the SMC source area and in the groundwater model determined post-P&T operation contaminant migration pathway. VOC concentrations are currently below cleanup levels. Well will be used to verify concentrations continue to attenuate.
CM-MW-23s	shallow	Inner attenuation area monitoring well	Annual	Well is located northeast of the SMC source area and in the groundwater model determined post-P&T operation contaminant migration pathway. VOC concentrations are currently below cleanup levels. Well will be used to verify concentrations continue to attenuate.
CM-MW-23i	intermediate	Inner attenuation area monitoring well	Annual	Well is located northeast of the SMC source area, adjacent to shallow CM-MW-23s, and located in the groundwater model determined post-P&T operation contaminant migration pathway. VOC concentrations are currently below cleanup levels. Well will be used to verify concentrations continue to attenuate.
CM-MW-25s	shallow	Inner attenuation area monitoring well	Annual	Well is located northeast of the SMC source area and located in the groundwater model determined post-P&T operation contaminant migration pathway. VOC concentrations are currently below cleanup levels. Well will be used to verify concentrations continue to attenuate.
CM-MW-18i	intermediate	Outer attenuation area monitoring well	Annual	Well is located north of the Cadet facility. This area is outside the groundwater model determined post-P&T operation contaminant migration pathway. Well will be used to verify VOC concentrations continue to remain at trace levels.
CM-MW-19i	intermediate	Outer attentuation area monitoring well	Annual	Well is located northeast of the Cadet facility. This area is located on the side of the groundwater model determined post-P&T operation contaminant migration pathway. Well will be used to verify VOC concentrations continue to remain at trace levels.
CM-MW-24i	intermediate	Outer attentuation area monitoring well	Annual	Well is located north of the Cadet facility. This area is outside the groundwater model determined post-P&T operation contaminant migration pathway. Well will be used to verify VOC concentrations continue to remain at trace levels.
CM-MW-28USA-050	intermediate	Outer attentuation area monitoring well	Annual	This shallow multi-port is located at northern outer edge monitoring location north of Cadet facility. Trace levels of TCE and PCE currently detected. Sample point will provide a shallow zone monitoring point at the north outer edge of the monitoring network to verify occurrence of attenuation in this area.
CM-MW-28USA-120.5	intermediate	Outer attentuation area monitoring well	Annual	This intermediate multi-port is located at northern outer edge monitoring location north of Cadet facility. Low levels of TCE and PCE currently detected. Sample point will provide a shallow zone monitoring point at the north outer edge of the monitoring network to verify occurrence of attenuation in this area.
CM-MW-29USA-060.5	intermediate	Outer attentuation area monitoring well	Annual	This intermediate multi-port is located on the eastern side of the groundwater model determined post-P&T operation migration pathway. Low levels of TCE and PCE currently detected. Sample point will used to verify concentrations continue to attenuate.
CM-MW-29USA-100	intermediate	Outer attentuation area monitoring well	Annual	This intermediate multi-port is located on the eastern side of the groundwater model determined post-P&T operation migration pathway. Low levels of TCE and PCE currently detected. Sample point will used to verify concentrations continue to attenuate.
CM-MW-29USA-140.5	intermediate	Outer attentuation area monitoring well	Annual	This intermediate multi-port is located on the eastern side of the groundwater model determined post-P&T operation migration pathway. Low levels of TCE and PCE currently detected. Sample point will used to verify concentrations continue to attenuate.
Swan Source Area Monitoring Wells		These wells are used to monitor natural attenuation of the former Swan source area. These source area wells will be monitored to verify continued decline of the source area.		
MW-02i	intermediate	Source area monitoring well	Semi-Annual	Well is located east of the SMC source area site. This well will provide at monitoring point to confirm attenuation is continuing to occur just east of the former SMC source area. Historic groundwater flow was toward the east of the SMC site in response to historic GWM production well pumping. VOC concentrations are below cleanup levels.
IMW-05	shallow	Source area monitoring well	Semi-Annual	Well appears to be adjacent to the SMC residual source area. TCE concentrations at cleanup level.
MW-05	shallow	Source area monitoring well	Semi-Annual	MW-05 is the closest shallow well to P&T sytem extraction well EW-1. Historically the highest TCE concentrations were detected at MW-05. TCE and PCE concentrations are above cleanup levels.
MW-05i	intermediate	Source area monitoring well	Semi-Annual	VOCs detected in well understood to be from outlying areas pulled past MW-05i by extraction well EW-1 pumping. Prior to P&T pumping VOC concentrations were not detected or at trace level. Well will be used to verify attenuation in the intermediate zone beneath the SMC source area.
VMW-08	shallow	Source area monitoring well	Semi-Annual	Source area shallow monitoring well. TCE and PCE concentration above cleanup levels.
VMW-09	shallow	Source area monitoring well	Semi-Annual	Source area shallow monitoring well. TCE and PCE concentration above cleanup levels.
VMW-10	shallow	Source area monitoring well	Semi-Annual	Source area shallow monitoring well. TCE and PCE concentration above cleanup levels.
VMW-11	shallow	Source area monitoring well	Semi-Annual	Source area shallow monitoring well. TCE and PCE concentration above cleanup levels.
Non-Swan/Cadet Source Monitoring Wells		These wells are used to monitor natural attenuation north of the NuStar facility source area. These wells will be used to monitor contaminant concentrations north of the NuStar facility, to determine if natural attenuation is occurring, and when resulting groundwater quality compliance occurrs. Groundwater modeling indicates that groundwater flow primarily in the intermediate zone is toward the north from the NuStar facility in response to pumping.		
MW-E	shallow	Non-SMC/Cadet source monitoring	Annual	Well located north of the NuStar facility adjacent to the south side of the railroad corridor. VOC concentrations decreased initially following start of P&T operation. Since March 2013 detected concencentrations have varied with higher concentrations tyically detected in September samples. PCE concentrations at or below MTCA cleanup level.
MW-31i	intermediate	Non-SMC/Cadet source monitoring	Annual	Well is located south of the Port railroad corridor. PCE concentrations are detected at higher concentrations than TCE. PCE concentrations are typically above cleanup level while TCE concentrations are typically below cleanup level. Well will provide data on VOC concentration trends.
MW-32i	intermediate	Non-SMC/Cadet source monitoring	Annual	Well is located just north of the NuStar facility. PCE concentrations are detected at higher concentrations than TCE. TCE and PCE concentrations are above cleanup levels. Well will provide data on VOC concentration trends.
MW-33i	intermediate	Non-SMC/Cadet source monitoring	Bi-Annual	Well is located north of the Port railroad corridor. PCE concentrations are typically detected at slightly higher concentrations than TCE. TCE and PCE concentrations are typically below cleanup levels. Well will provide data on VOC concentration trends.
Deep Zone Monitoring Wells		These wells are used to monitor natural attenuation in the deep water quality zone of the USA. The deep zone is of limited areal extent in the project area and as a result shows muted influence to regional pumping and P&T pumping. These wells will be used to monitor contaminant concentrations in deep zone wells were VOCs are detected, determine if natural attenuation is occurring, and when resulting groundwater quality compliance occurrs.		
MW-01d	deep	Deep zone attenuation monitoring	Bi-Annual	Well is located west of the SMC source area. TCE concentrations are detected above cleanup levels. Well will provide data on VOC concentration trends.
CM-MW-02d	deep	Deep zone attenuation monitoring	Bi-Annual	Well is located north of the Cadet facility. TCE concentrations are detected above cleanup levels. Well will provide data on VOC concentration trends.
CM-MW-01d-224	deep	Deep zone attenuation monitoring	Bi-Annual	Mulit-port well is located on the east side of the Cadet facility. TCE concentrations are detected above cleanup levels. Well will provide data on VOC concentration trends.
CM-MW-03d-227	deep	Deep zone attenuation monitoring	Bi-Annual	Mulit-port well is located on the east side northern end of the Cadet facility. TCE concentrations are detected above cleanup levels. Well will provide data on VOC concentration trends.
MW-05dr	deep	Deep zone attenuation monitoring	Bi-Annual	Well is located at the SMC source area. TCE concentrations are detected above cleanup levels. Well will provide data on VOC concentration trends.
CM-MW-05d	deep	Deep zone attenuation monitoring	Bi-Annual	Well is located east of the Cadet facility. TCE concentrations are detected above cleanup levels. Well will provide data on VOC concentration trends.
MW-12d	deep	Deep zone attenuation monitoring	Bi-Annual	Well is located west of the SMC source area. TCE concentrations are detected above cleanup levels. Well will provide data on VOC concentration trends.
MW-14d	deep	Deep zone attenuation monitoring	Bi-Annual	Well is located southwest of the SMC source area. VOC concentrations are below cleanup levels. Well will provide data on VOC concentration trends.
CM-MW-18d	deep	Deep zone attenuation monitoring	Bi-Annual	Well is located north of the Cadet facility. VOC concentrations are below cleanup levels. Well will provide data on VOC concentration trends.
CM-MW-19d	deep	Deep zone attenuation monitoring	Bi-Annual	Well is located northeast of the Cadet facility. TCE concentrations are above the cleanup level. Well will provide data on VOC concentration trends.
CM-MW-28USA-180	deep	Deep zone attenuation monitoring	Bi-Annual	Mulit-port well is located on the north of the Cadet facility and is an outter edge of monitoring point. TCE concentrations are detected above cleanup levels. Well will provide data on VOC concentration trends.
Port/GWM Wellfield Area Monitoring Wells		These wells are used to monitor natural attenuation in the area near the Port and Great Western Malting production wells. TCE is almost exclusively detected in intermediate zone monitoring located in this area. These wells will be used to monitor contaminant concentrations in wells where VOCs are detected, determine if natural attenuation is occurring, and when resulting groundwater quality compliance occurrs.		
MW-15i	intermediate	Port/GWM wellfield area monitoring	Annual	Well is located northwest of the Port/GWM wellfield. Typically only TCE was detected at well. More recently trace levels of PCE and cis-1,2-DCE have been detected. Detected TCE concentrations are above cleanup levels. Well will provide data on VOC concentration trends.
MW-37i	intermediate	Port/GWM wellfield area monitoring	Annual	Well is located east of the Port/GWM wellfield. Only TCE is detected at well. Detected TCE concentrations are above cleanup levels. Well will provide data on VOC concentration trends.
MW-38i	intermediate	Port/GWM wellfield area monitoring	Annual	Well is located northeast of the Port/GWM wellfield. TCE and PCE is detected at well with TCE at higher concentrations. Detected TCE concentrations have dropped below cleanup levels. Well will provide data on VOC concentration trends.
CM-MW-Ui	intermediate	Port/GWM wellfield area monitoring	Annual	Well is located southeast of the Port/GWM wellfield and east of a portion of the BNSF rail corridor. Only TCE is detected at well. Detected TCE concentrations are above cleanup levels. Well will provide data on VOC concentration trends.

Sample Schedule Note:

Annual scheduled wells will be sampled during March representing first quarter sampling event.
Semi-Annual scheduled wells will be sampled during March and August (representing third quarter event).
Bi-Annual scheduled wells will be sampled every other year during March. First Bi-Annual event will be during March 2024.

Table 3-1 - Groundwater Points of Compliance Monitoring Wells
Groundwater Compliance Monitoring Plan
Swan & Cadet Groundwater Monitoring Well Network

Well Name	Water Quality Zone	Compliance Monitoring Function	Sample Schedule	Comments
Attenuation Monitoring Well		These wells are used to monitor natural attenuation in the area north of Forth Plain Blvd. This area was historically impacted by the former Cadet site source. Groundwater modeling indicates that groundwater flow is toward the northeast/north with P&T system off. These wells will be monitored to verify occurrence of natural attenuation and resulting groundwater quality compliance. Attenuation monitoring wells consist of inner and outer wells. Inner wells are located south of West 31st Street representing historic area of P&T capture. Outer wells are locates north of West 31st Street representing area beyond the historic P&T capture area.		
CM-DPW-01	shallow	Inner attenuation area monitoring well	Annual	Well is located adjacent to east side of Cadet facility where historically high VOC concentrations were detected. Well has longest continous sample record of former Cadet monitoring wells. Well to be used to confirm continuing attenuation at the Cadet facility shallow zone.
CM-MW-4i	intermediate	Inner attenuation area monitoring well	Annual	Well is located northeast of the SMC source area and in the groundwater model determined post-P&T operation contaminant migration pathway. VOC concentrations are currently below cleanup levels. Well will be used to verify concentrations continue to attenuate.
CM-MW-20i	intermediate	Inner attenuation area monitoring well	Annual	Well is located north of the SMC source area and in the groundwater model determined post-P&T operation contaminant migration pathway. VOC concentrations are currently below cleanup levels. Well will be used to verify concentrations continue to attenuate.
CM-MW-23s	shallow	Inner attenuation area monitoring well	Annual	Well is located northeast of the SMC source area and in the groundwater model determined post-P&T operation contaminant migration pathway. VOC concentrations are currently below cleanup levels. Well will be used to verify concentrations continue to attenuate.
CM-MW-23i	intermediate	Inner attenuation area monitoring well	Annual	Well is located northeast of the SMC source area, adjacent to shallow CM-MW-23s, and located in the groundwater model determined post-P&T operation contaminant migration pathway. VOC concentrations are currently below cleanup levels. Well will be used to verify concentrations continue to attenuate.
CM-MW-25s	shallow	Inner attenuation area monitoring well	Annual	Well is located northeast of the SMC source area and located in the groundwater model determined post-P&T operation contaminant migration pathway. VOC concentrations are currently below cleanup levels. Well will be used to verify concentrations continue to attenuate.
CM-MW-18i	intermediate	Outer attenuation area monitoring well	Annual	Well is located north of the Cadet facility. This area is outside the groundwater model determined post-P&T operation contaminant migration pathway. Well will be used to verify VOC concentrations continue to remain at trace levels.
CM-MW-19i	intermediate	Outer attentuation area monitoring well	Annual	Well is located northeast of the Cadet facility. This area is located on the side of the groundwater model determined post-P&T operation contaminant migration pathway. Well will be used to verify VOC concentrations continue to remain at trace levels.
CM-MW-24i	intermediate	Outer attentuation area monitoring well	Annual	Well is located north of the Cadet facility. This area is outside the groundwater model determined post-P&T operation contaminant migration pathway. Well will be used to verify VOC concentrations continue to remain at trace levels.
CM-MW-28USA-050	intermediate	Outer attentuation area monitoring well	Annual	This shallow multi-port is located at northern outer edge monitoring location north of Cadet facility. Trace levels of TCE and PCE currently detected. Sample point will provide a shallow zone monitoring point at the north outer edge of the monitoring network to verify occurrence of attenuation in this area.
CM-MW-28USA-120.5	intermediate	Outer attentuation area monitoring well	Annual	This intermediate multi-port is located at northern outer edge monitoring location north of Cadet facility. Low levels of TCE and PCE currently detected. Sample point will provide a shallow zone monitoring point at the north outer edge of the monitoring network to verify occurrence of attenuation in this area.
CM-MW-29USA-060.5	intermediate	Outer attentuation area monitoring well	Annual	This intermediate multi-port is located on the eastern side of the groundwater model determined post-P&T operation migration pathway. Low levels of TCE and PCE currently detected. Sample point will used to verify concentrations continue to attenuate.
CM-MW-29USA-100	intermediate	Outer attentuation area monitoring well	Annual	This intermediate multi-port is located on the eastern side of the groundwater model determined post-P&T operation migration pathway. Low levels of TCE and PCE currently detected. Sample point will used to verify concentrations continue to attenuate.
CM-MW-29USA-140.5	intermediate	Outer attentuation area monitoring well	Annual	This intermediate multi-port is located on the eastern side of the groundwater model determined post-P&T operation migration pathway. Low levels of TCE and PCE currently detected. Sample point will used to verify concentrations continue to attenuate.
Swan Source Area Monitoring Wells		These wells are used to monitor natural attenuation of the former Swan source area. These source area wells will be monitored to verify continued decline of the source area.		
MW-02i	intermediate	Source area monitoring well	Semi-Annual	Well is located east of the SMC source area site. This well will provide at monitoring point to confirm attenuation is continuing to occur just east of the former SMC source area. Historic groundwater flow was toward the east of the SMC site in response to historic GWM production well pumping. VOC concentrations are below cleanup levels.
IMW-05	shallow	Source area monitoring well	Semi-Annual	Well appears to be adjacent to the SMC residual source area. TCE concentrations at cleanup level.
MW-05	shallow	Source area monitoring well	Semi-Annual	MW-05 is the closest shallow well to P&T sytem extraction well EW-1. Historically the highest TCE concentrations were detected at MW-05. TCE and PCE concentrations are above cleanup levels.
MW-05i	intermediate	Source area monitoring well	Semi-Annual	VOCs detected in well understood to be from outlying areas pulled past MW-05i by extraction well EW-1 pumping. Prior to P&T pumping VOC concentrations were not detected or at trace level. Well will be used to verify attenuation in the intermediate zone beneath the SMC source area.
VMW-08	shallow	Source area monitoring well	Semi-Annual	Source area shallow monitoring well. TCE and PCE concentration above cleanup levels.
VMW-09	shallow	Source area monitoring well	Semi-Annual	Source area shallow monitoring well. TCE and PCE concentration above cleanup levels.
VMW-10	shallow	Source area monitoring well	Semi-Annual	Source area shallow monitoring well. TCE and PCE concentration above cleanup levels.
VMW-11	shallow	Source area monitoring well	Semi-Annual	Source area shallow monitoring well. TCE and PCE concentration above cleanup levels.
Deep Zone Monitoring Wells		These wells are used to monitor natural attenuation in the deep water quality zone of the USA. The deep zone is of limited areal extent in the project area and as a result shows muted influence to regional pumping and P&T pumping. These wells will be used to monitor contaminant concentrations in deep zone wells were VOCs are detected, determine if natural attenuation is occurring, and when resulting groundwater quality compliance occurrs.		
MW-01d	deep	Deep zone attenuation monitoring	Bi-Annual	Well is located west of the SMC source area. TCE concentrations are detected above cleanup levels. Well will provide data on VOC concentration trends.
CM-MW-02d	deep	Deep zone attenuation monitoring	Bi-Annual	Well is located north of the Cadet facility. TCE concentrations are detected above cleanup levels. Well will provide data on VOC concentration trends.
CM-MW-01d-224	deep	Deep zone attenuation monitoring	Bi-Annual	Mulit-port well is located on the east side of the Cadet facility. TCE concentrations are detected above cleanup levels. Well will provide data on VOC concentration trends.
CM-MW-03d-227	deep	Deep zone attenuation monitoring	Bi-Annual	Mulit-port well is located on the east side northern end of the Cadet facility. TCE concentrations are detected above cleanup levels. Well will provide data on VOC concentration trends.
MW-05dr	deep	Deep zone attenuation monitoring	Bi-Annual	Well is located at the SMC source area. TCE concentrations are detected above cleanup levels. Well will provide data on VOC concentration trends.
CM-MW-05d	deep	Deep zone attenuation monitoring	Bi-Annual	Well is located east of the Cadet facility. TCE concentrations are detected above cleanup levels. Well will provide data on VOC concentration trends.
MW-12d	deep	Deep zone attenuation monitoring	Bi-Annual	Well is located west of the SMC source area. TCE concentrations are detected above cleanup levels. Well will provide data on VOC concentration trends.
MW-14d	deep	Deep zone attenuation monitoring	Bi-Annual	Well is located southwest of the SMC source area. VOC concentrations are below cleanup levels. Well will provide data on VOC concentration trends.
CM-MW-18d	deep	Deep zone attenuation monitoring	Bi-Annual	Well is located north of the Cadet facility. VOC concentrations are below cleanup levels. Well will provide data on VOC concentration trends.
CM-MW-19d	deep	Deep zone attenuation monitoring	Bi-Annual	Well is located northeast of the Cadet facility. TCE concentrations are above the cleanup level. Well will provide data on VOC concentration trends.
CM-MW-28USA-180	deep	Deep zone attenuation monitoring	Bi-Annual	Mulit-port well is located on the north of the Cadet facility and is an outter edge of monitoring point. TCE concentrations are detected above cleanup levels. Well will provide data on VOC concentration trends.

Sample Schedule Note:

Annual scheduled wells will be sampled during March representing first quarter sampling event.
Semi-Annual scheduled wells will be sampled during March and August (representing third quarter event).
Bi-Annual scheduled wells will be sampled every other year during March. First Bi-Annual event will be during March 2024.

Appendix A

2022 TCE and PCE Isoconcentration Figures

Parametrix Date: 4/27/2022 Path: \\parametrix.com\pmx\Port\Projects\Clients\1940-Port of Vancouver\275-1940-006-POV TCE\99Svcs\GIS\POV\MXD_PDF\AEMR_2022\Draft\Mapdocs\Fig_4-1_POV_Isoconcentrations_TCE_Shallow4_Q1_2022.mxd

N

0 250 500 750

Scale in Feet

MW-10 — Well Location Name

23 — March 2022 Sample Result (µg/L)

ND = Non-Detect

NS = Not sampled

IA = Inactive Sampling Location

> 4 µg/L

> 25 µg/L

> 50 µg/L

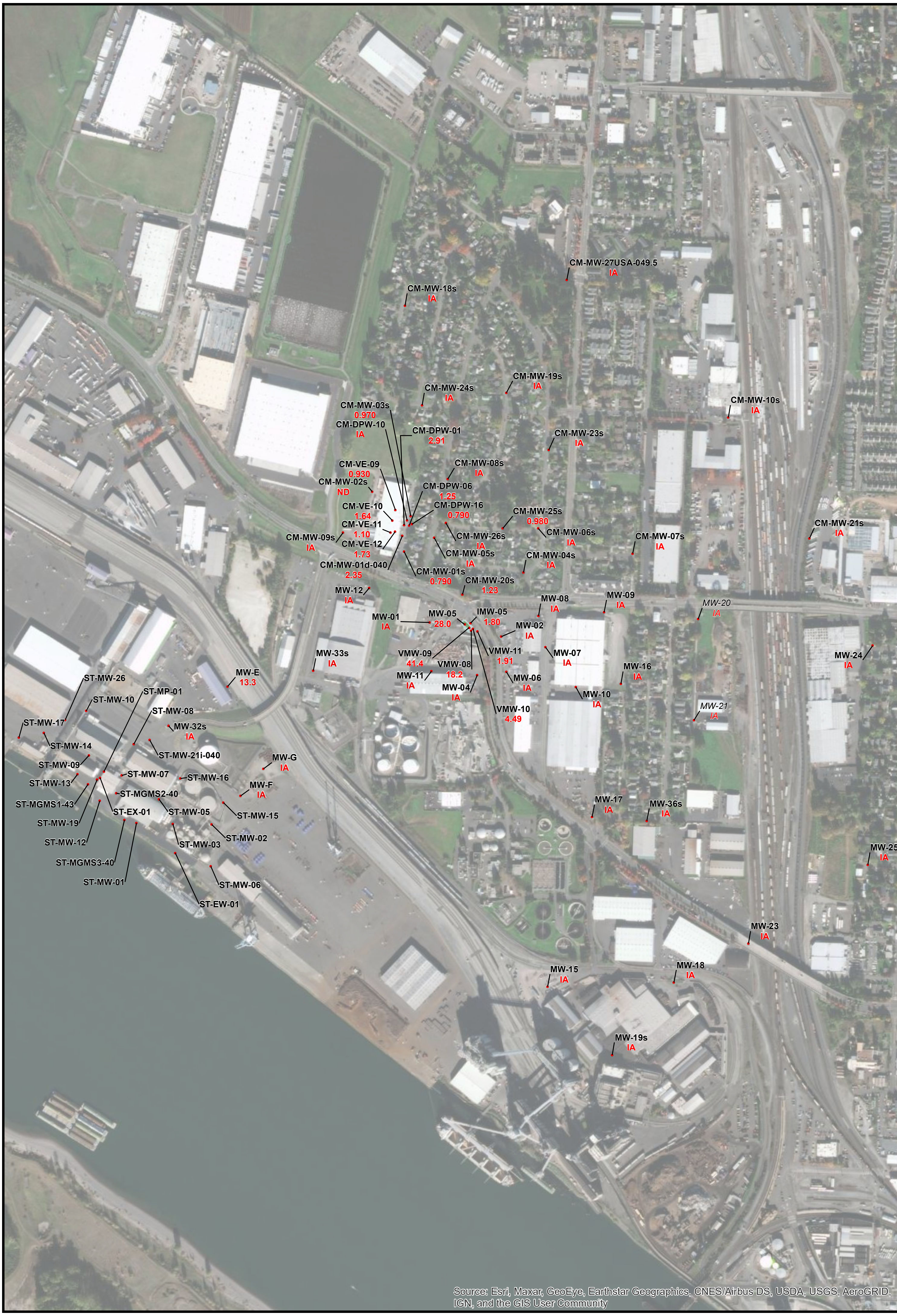
> 100 µg/L

Note: Wells shown in italics have been decommissioned.

*Isoconcentrations are based on March 2022 Results.

Figure 4-1
TCE Isoconcentrations in Shallow USA Zone Groundwater

2022 ANNUAL ENVIRONMENTAL MONITORING REPORT
SMC AND CADET SITES
PORT OF VANCOUVER, WASHINGTON



Parametrix Date: 4/27/2022 Path: \\parametrix.com\pmx\Port\Projects\Clients\1940-Port of Vancouver\275-1940-006-POV TCE\99Svcs\GIS\POV\MXD_PDF\AEMR_2022\Draft\Mapdocs\Fig_4-2_POV_Isoconcentrations_PCE_Shallow5_Q1_2022.mxd

N

0 250 500 750

Scale in Feet

MW-10 — Well Location Name
23 — March 2022 Sample Result (µg/L)

ND = Non-Detect
NS = Not sampled
IA = Inactive Sampling Location

> 5 µg/L
> 25 µg/L

Note: Wells shown in italics have been decommissioned.
*Isoconcentrations are based on March 2022 results.

Figure 4-2
PCE Isoconcentrations in Shallow USA Zone Groundwater

2022 ANNUAL ENVIRONMENTAL MONITORING REPORT
SMC AND CADET SITES
PORT OF VANCOUVER, WASHINGTON

Parametrix Date: 1/25/2023 Path: U:\Port\Projects\Clients\1940-Port of Vancouver\275-1940-006-POV TCE\99Svcs\GIS\POV\MXD_PDF\AEMR_2022\Draft\Mapdocs\Fig_4-3_POV_Isoconcentrations_TCE_Intermediate4_Q1_2022.mxd

N

0 250 500 750

Scale in Feet

MW-10 — Well Location Name

23 — March 2022 Sample Result (µg/L)

ND = Non-Detect
NS = Not sampled
IA = Inactive Sampling Location

> 4 µg/L
> 25 µg/L

Note: Wells shown in italics have been decommissioned.
*Isoconcentrations are based on March 2022 results.

Figure 4-3
TCE Isoconcentrations in Intermediate USA Zone Groundwater

2022 ANNUAL ENVIRONMENTAL MONITORING REPORT
SMC AND CADET SITES
PORT OF VANCOUVER, WASHINGTON

Parametrix Date: 1/25/2023 Path: U:\Port\Projects\Clients\1940-Port of Vancouver\275-1940-006-POV TCE\99Svcs\GIS\POV\MXD_PDF\AEMR_2022\Draft\Mapdocs\Fig_4-4_POV_Isoconcentrations_PCE_Intermediate5_Q1_2022.mxd

N

0 250 500 750

Scale in Feet

MW-10 — Well Location Name

23 — March 2022 Sample Result (µg/L)

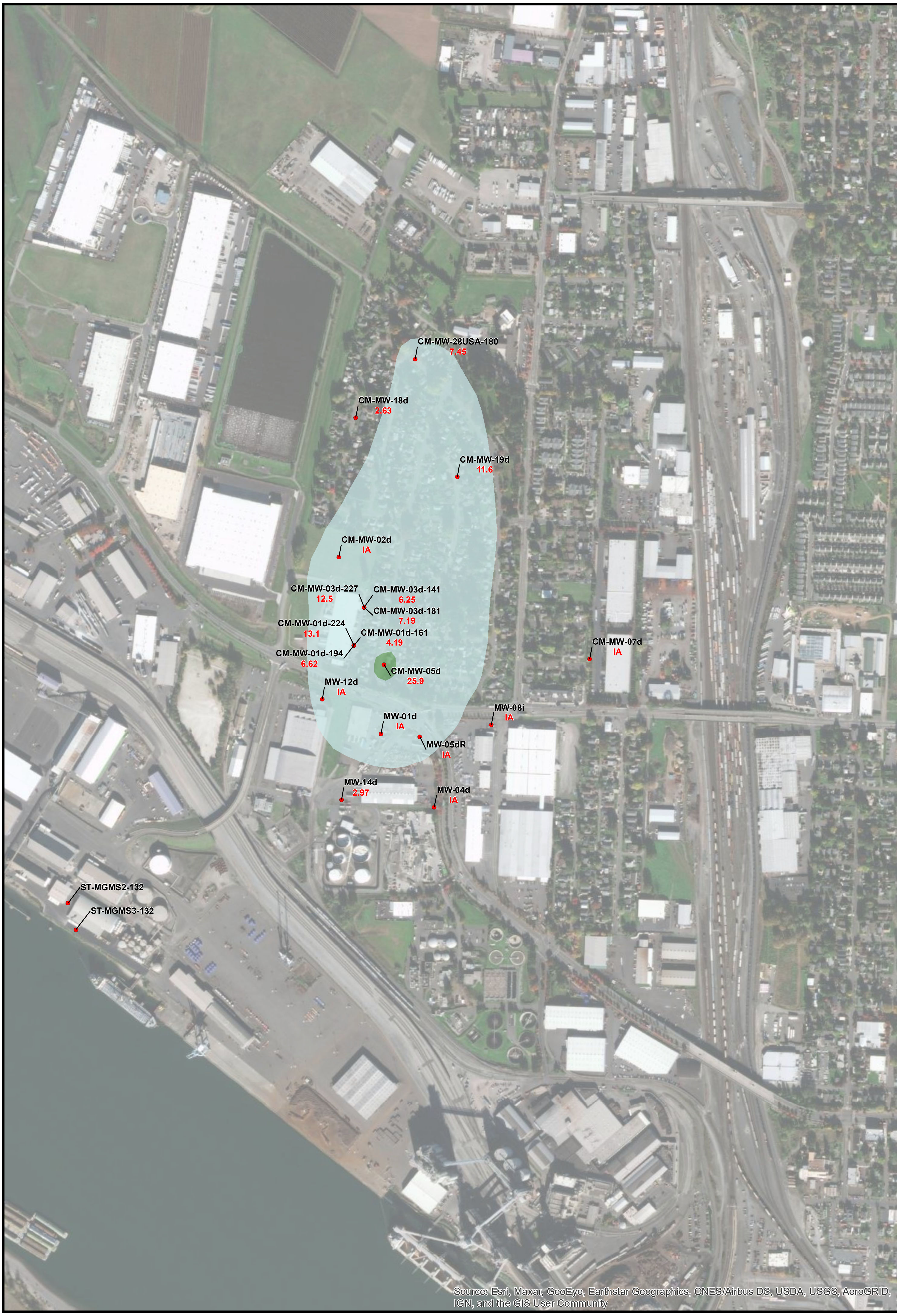
ND = Non-Detect
NS = Not sampled
IA = Inactive Sampling Location

> 5 µg/L
> 25 µg/L

Note: Wells shown in italics have been decommissioned.
*Isoconcentrations are based on March 2022 results.

Figure 4-4
PCE Isoconcentrations in Intermediate USA Zone Groundwater

2022 ANNUAL ENVIRONMENTAL MONITORING REPORT - DRAFT
SMC AND CADET SITES
PORT OF VANCOUVER, WASHINGTON



Parametrix Date: 4/20/2022 Path: U:\Port\Projects\Clients\1940-Port of Vancouver\275-1940-006-POV TCE\99Svcs\GIS\POV\MXD_PDF\AEMR_2022\Draft\Mapdocs\Fig_4-5_POV_Isoconcentrations_TCE_Deep4_Q1_2021.mxd

N

0 250 500 750

Scale in Feet

MW-10 — Well Location Name

23 — March 2022 Sample Result (µg/L)

ND = Non-Detect

NS = Not sampled

IA = Inactive Sampling Location

> 4 µg/L

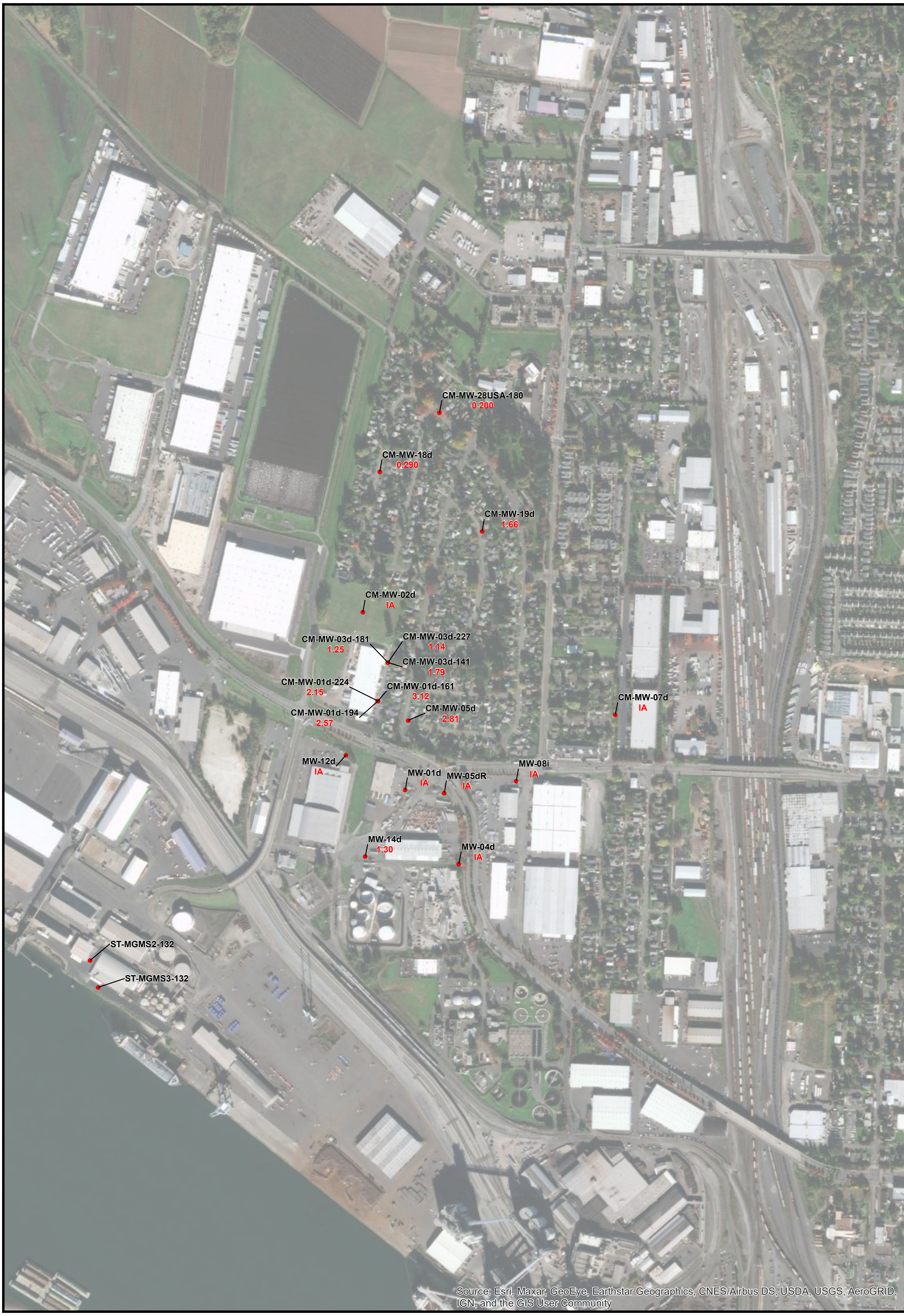
> 25 µg/L

Note: Wells shown in italics have been decommissioned.

Figure 4-5

TCE Isoconcentrations in Deep USA Zone Groundwater

2022 ANNUAL ENVIRONMENTAL MONITORING REPORT
SMC AND CADET SITES
PORT OF VANCOUVER, WASHINGTON



Parametrix Date: 4/20/2022 Path: U:\Port\Projects\Clients\1940-Port of Vancouver\275-1940-006-POV TCE\99Svcs\GIS\POV\MXD_PDF\AEMR_2022\Draft\Mapdocs\Fig_4-6_POV_Isoconcentrations_PCE_Deep5_Q1_2022.mxd

N

0 250 500 750

Scale in Feet

MW-10 — Well Location Name

23 — March 2022 Result (µg/L)

ND = Non-Detect

NS = Not sampled

IA = Inactive Sampling Location

> 5 µg/L

Figure 4-6
PCE Isoconcentrations in Deep USA Zone Groundwater

2022 ANNUAL ENVIRONMENTAL MONITORING REPORT
SMC AND CADET SITES
PORT OF VANCOUVER, WASHINGTON

Parametrix Date: 12/21/2022 Path: U:\Port\Projects\Clients\1940-Port of Vancouver\275-1940-006-POV TCE\99Svcs\GIS\POV\MXD_PDF\AEMR_2022\Draft\Mapdocs\Fig_4-7_FormerSMCSiteArea_TCE_Q1_2022.mxd

Source: Clark County Google Earth (Aerial May 2017)

N

0 80 160 Feet

MW-10 — Well Location Name
23 — March 2022 Result (µg/L)
15 — August 2022 Result (µg/L)
Indicates shallow zone result

ND = Non-Detect
NS = Not sampled
IA = Inactive Sampling Location

4 ug/L
25 ug/L
100 ug/L

SMC Site Property Boundary

Ownership

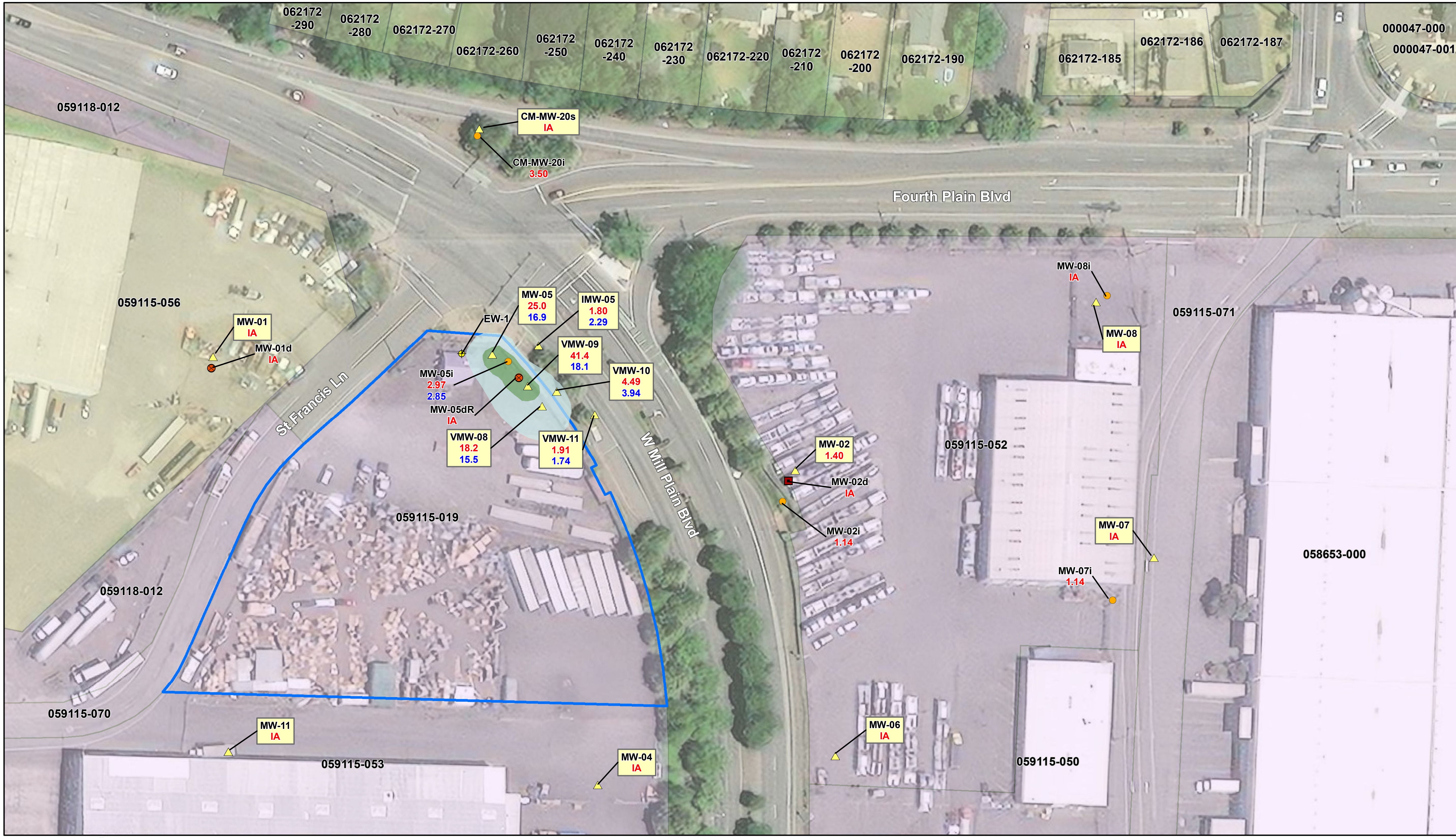
City of Vancouver ROW (No Fill)
Port of Vancouver
Private

Shallow USA Groundwater Monitoring Well
Intermediate USA Groundwater Monitoring Well
Deep USA Groundwater Monitoring Well
TGA Monitoring Well
GPTIA Extraction Well

Figure 4-7
Former SMC Site Area
TCE Concentrations in Groundwater

2022 Annual Environmental Monitoring Report
SMC and Cadet Sites
Port of Vancouver, WA

Note: Isoconcentrations are based on March 2022 shallow zone well results.



Parametrix Date: 12/21/2022 Path: U:\Port\Projects\Clients\1940-Port of Vancouver\275-1940-006-POV TCE\99Svcs\GIS\POV\MXD_PDF\AEMR_2022\Draft\Mapdocs\Fig_4-8_FormerSMCSiteArea_PCE_Q1_2022.mxd

Source: Clark County

N

0 80 160
Feet

MW-10 — Well Location Name
23 — March 2022 Result (µg/L)
15 — August 2022 Result (µg/L)

Indicates shallow zone result

ND = Non-Detect
NS = Not sampled
IA = Inactive Sampling Location

> 5 µg/L
> 25 µg/L

SMC Site Property Boundary

Ownership
- City of Vancouver ROW (No Fill)
- Port of Vancouver
- Private

- Shallow USA Groundwater Monitoring Well
- Intermediate USA Groundwater Monitoring Well
- Deep USA Groundwater Monitoring Well
- TGA Monitoring Well
- GPTIA Extraction Well

Figure 4-8
Former SMC Site Area
PCE Concentrations in Groundwater

2022 Annual Environmental Monitoring Report
SMC and Cadet Sites
Port of Vancouver, WA

Note: Isoconcentrations are based on March 2022 shallow zone well results.

Date: 12/21/2022 Path: U:\PortProjects\Clients\1940-Port of Vancouver\275-1940-006-POV TCE\99Svcs\GIS\POV\MXD_PDF\AEMR_2022\Draft\Mapdocs\Fig_4-9_Cadet_Site_Area_PCE.mxd

Parametrix

MW-10 — Well Location Name
23 — March 2022 Result (µg/L)
15 — August 2022 Result (µg/L)

ND = Non-Detect
NS = Not sampled
IA = Inactive Sampling Location

N

Feet
0 25 50 100

Cadet Site Property Boundary
City of Vancouver (ROW)
Private
Port of Vancouver
Indicates Shallow Zone Result

Shallow USA Groundwater Monitoring Well
Intermediate USA Groundwater Monitoring Well
Deep USA Groundwater Monitoring Well
TGA Monitoring Well

Note: Wells shown in italics have been decommissioned.

Figure 4-9
Cadet Site Area
PCE Concentrations in Groundwater

2022 Annual Environmental Monitoring Report
SMC and Cadet Sites
Port of Vancouver, WA

Parametrix

MW-10 — Well Location Name
23 — March 2022 Result (µg/L)
15 — August 2022 Result (µg/L)

ND = Non-Detect
NS = Not sampled
IA = Inactive Sampling Location

N

Feet
0 25 50 100

>4 ug/L

- Cadet Site Property Boundary
- City of Vancouver (ROW)
- Private
- Port of Vancouver
- Indicates Shallow Zone Result

- Shallow USA Groundwater
- Intermediate USA Groundwater
- Deep USA Groundwater
- TGA Monitoring

Note: Wells shown in italics have been decommissioned.

Figure 4-10
Cadet Site Area
TCE Concentrations in Groundwater

2022 Annual Environmental Monitoring Report
SMC and Cadet Sites
Port of Vancouver, WA

Appendix B

Field Methods

APPENDIX B: FIELD METHODS

1. INTRODUCTION

This appendix presents sample collection methods to be employed during monitoring events completed under the Groundwater Compliance Monitoring Plan for the SMC and Cadet sites, Port of Vancouver. These field methods were originally presented in the Work Plan for Remedial Investigation and Feasibility Study for the SMC site (Parametrix 1999) and have been revised as necessary to include any changes to sampling methods and/or protocols that have occurred since preparation of the work plan. Site groundwater sampling methods apply low-flow purging techniques using dedicated submersible bladder pumps or a peristaltic pump to collect groundwater samples. The standard operating procedures for groundwater sampling, personnel and equipment decontamination, and investigation-derived waste (IDW) handling are presented below.

2. LOW-FLOW GROUNDWATER SAMPLING WITH DEDICATED SUBMERSIBLE BLADDER PUMP

2.1 PURPOSE AND SCOPE

The objective of this section is to describe the method used to collect groundwater samples from monitoring wells with dedicated submersible bladder pumps. Low flow purging is used to reduce stress on the water column and minimize drawdown inside the well in order to limit alterations to the water chemistry and the mobilization of solids. Low stress purge rates should be from 0.2 to 0.5 liters per minute (L/min), with an overall drawdown of less than 0.1 meter (0.33 feet). Sampling should occur when the water column and other parameter measurements (based on the criteria listed below) have stabilized.

2.2 MATERIALS

The following materials are used during low stress groundwater sampling:

- Groundwater sampling field data sheets
- Water level meter
- Bladder pump controller
- High density polyethylene tubing
- Air compressor or nitrogen tank and regulator
- Power source (generator or field vehicle power outlet)
- Two graduated 5-gallon plastic buckets
- YSI multi-parameter water quality meter (pH, dissolved oxygen (DO), oxidation-reduction potential (ORP), specific conductance and temperature)
- Flow through cell for water quality meter
- Sample containers
- Sample labels

- Personal Protective Equipment (PPE)
- Decontamination supplies

2.3 SAMPLING PROCEDURE

- Open monitoring well monument, remove the protective plug from the well cap, and allow groundwater to stabilize by monitoring the groundwater level with the water level meter (groundwater has stabilized when fluctuations in the groundwater level are no longer observed). Once groundwater has stabilized, use the water level meter to measure and record depth to groundwater to the nearest 0.01 feet from the surveyed measuring point (typically a notch or ink mark on the north rim of the top of well casing).
- Calibrate all field meters according to manufacturers' specifications and record results on the field data sheet.
- Connect the air compressor (connected to power source) or nitrogen tank to the pump controller and the controller to the pump connection on the wellhead.
- Connect polyethylene tubing to the pump effluent line on the wellhead. Run the tubing from the effluent line to the flow through cell containing the water quality probes. Direct overflow from the flow through cell into the graduated 5-gallon bucket.
- Start compressor or open nitrogen tank control valve and begin purging; control flow via the pump controller.
- Adjust pump controller to achieve minimum drawdown (less than 0.33 feet) and optimum groundwater flow rate (0.2 to 0.5 L/min). Record depth to groundwater measurements on the field data sheet every 2 to 4 minutes.
- Collect and record water quality indicator parameters every 2 to 4 minutes. The water quality indicators include: dissolved oxygen, specific conductance, pH, oxidation-reduction potential, and temperature. Groundwater is considered stable and representative of groundwater in the formation when three consecutive water-quality indicator readings are within the following criteria:

Groundwater Quality Parameters	**Stabilization Criteria**
pH	+/- 0.1 pH units
Specific conductance	+/- 3% S/cm
Oxidation-reduction potential	+/- 10 millivolts
Dissolved oxygen	+/- 0.05 mg/L for values < 1 mg/L +/- 0.2 mg/L for values > 1 mg/L

- Once the groundwater quality parameter stabilization criteria are met, sample collection can take place. Collect sample from the effluent line of the wellhead, not from the discharge of the flow-through cell. If necessary, collect duplicate sample immediately after primary sample collection is complete, following the same procedures for both samples.
- After sampling is complete, disconnect the air compressor or nitrogen tank from the pump controller and the pump controller from the well. The polyethylene tubing connecting the pump effluent line on the wellhead should also be removed and

discarded or decontaminated, unless dedicated to the well. Tubing dedicated to the well will be left in place. Reinstall protective plug in the well cap and replace monument cover.

- Record on the sample label the sample date and time, client name, sample identification (ID), and requested analysis, and attach the label to the sample container. The sample IDs should be consistent with previous sampling events and as they are reported on the tables included in annual monitoring reports. For example, well CM-MW-01d-060.5 should be labeled as such on the sample container; do not use "shortcut" labeling such as eliminating the .5 at the end of the ID. POV wells should be labeled MW-01, MW-02, etc. Also, trip blank labels and duplicate labels should be consistent between samplers. For example, trip blanks should be labeled as TB-01, TB-02, TB-03, etc. Duplicates should be labeled as POV-FD-mmddyy for SMC wells and CM-FD-mmddyy for Cadet wells (e.g. POV-FD-092715 or CM-FD-092415).
- Record on the field data sheet the project name and number, sample ID, sample date and time, weather conditions, personnel on site, any problems or corrective actions, and any other information that will allow reconstruction of pertinent field activities. Field data sheets should clearly indicate which samples include duplicates.
- Record the sample ID exactly as it is listed on the sample container, date, time, and desired analysis on the chain-of-custody form. Duplicate sample times should be recorded as 0000 on the chain-of-custody as well as on the sample label.
- Place the samples into a cooler with ice, along with the completed chain-of-custody form (place the custody form in a plastic bag for protection against melt water). Place packing materials around the samples if needed to ensure that breakage will not occur during shipping. A commercial carrier (e.g., FedEx, UPS, etc.) or a courier from the project laboratory will pick up and transport the cooler to the project analytical laboratory under chain-of-custody procedures.

3. LOW-FLOW GROUNDWATER SAMPLING WITH PERISTALTIC PUMP

3.1 PURPOSE AND SCOPE

The objective of this section is to describe the method used to collect groundwater samples from monitoring wells with a peristaltic pump. Low flow purging is used to reduce stress on the water column and minimize drawdown inside the well in order to limit alterations to the water chemistry and the mobilization of solids. Low stress purge rates should be from 0.2 to 0.5 liters per minute (L/min), with an overall drawdown of less than 0.1 meter (0.33 feet). Sampling should occur when the water column and other parameter measurements (based on the criteria listed below) have stabilized.

3.2 MATERIALS

The following materials are used during low stress groundwater sampling:

- Groundwater field data sheet
- Water level meter
- Peristaltic pump

- 0.25-inch (OD) polyethylene tubing
- Generator or other power source for pump
- Two graduated 5-gallon plastic buckets
- YSI multi-parameter water quality meter (pH, dissolved oxygen (DO), oxidation-reduction potential (ORP), specific conductance and temperature)
- Flow through cell for water quality meter
- Sample containers
- Sample labels
- PPE
- Decontamination supplies

3.3 SAMPLING PROCEDURES

- Open monitoring well monument, remove the protective plug from the well cap, and allow groundwater to stabilize by monitoring the groundwater level with the water level meter (groundwater has stabilized when fluctuations in the groundwater level are no longer observed). Once groundwater has stabilized, use the water level meter to measure and record depth to groundwater to the nearest 0.01 feet from the surveyed measuring point (typically a notch or ink mark on the north rim of the top of well casing).
- Calibrate all field meters according to manufacturers' specifications and record results on the field data sheet.
- Connect the peristaltic pump to the generator or other power source.
- Connect polyethylene tubing to the flexible tubing which is placed in the pumphead. Run the effluent end of the tubing to the flow through cell containing the water quality probes. Direct overflow from the flow through cell into the graduated 5-gallon bucket.
- Start generator or activate power source and begin purging.
- Adjust flow control knob on the pump to achieve minimum drawdown (less than 0.33 feet) and optimum groundwater flow rate (0.2 to 0.5 L/min). Record depth to groundwater measurements on the field data sheet every 2 to 4 minutes.
- Collect and record water quality indicator parameters every 2 to 4 minutes. The water quality indicators include: dissolved oxygen, specific conductance, pH, oxidation-reduction potential, and temperature. Groundwater is considered stable and representative of groundwater in the formation when three consecutive water-quality indicator readings are within the following criteria:

Groundwater Quality Parameters	**Stabilization Criteria**
pH	+/- 0.1 pH units
Specific conductance	+/- 3% S/cm
Oxidation-reduction potential	+/- 10 millivolts
Dissolved oxygen	+/- 0.05 mg/L for values < 1 mg/L +/- 0.2 mg/L for values > 1 mg/L

- Once the groundwater quality parameter stabilization criteria are met, sample collection can take place. Collect sample from the tubing routed through the peristaltic pump, not from the discharge of the flow-through cell. Reduce flow rate before sampling to minimize possibility of volatilization of dissolved VOCs before sampling. If necessary, collect duplicate sample immediately after primary sample collection is complete, following the same procedures for both samples.
- After sampling is completed, disconnect the generator or other power source from the pump and remove the tubing (if not dedicated) from the well and discard. Tubing dedicated to the well should be stored in a plastic bag for future use. The polyethylene tubing connecting the pump effluent line on the wellhead should also be removed and discarded. Reinstall protective plug in the well cap and replace monument cover.
- Record on the sample label the sample date and time, client name, sample ID, and requested analysis, and attach the label to the sample container. The sample IDs should be consistent with previous sampling events and as they are reported on the tables included in annual monitoring reports. For example, well CM-MW-01d-060.5 should be labeled as such on the sample container; do not use “shortcut” labeling such as eliminating the .5 at the end of the ID. POV wells should be labeled MW-01, MW-02, etc. Also, trip blank labels and duplicate labels should be consistent between samplers. For example, trip blanks should be labeled as TB-01, TB-02, TB-03, etc. Duplicates should be labeled as POV-FD-mmddyy for SMC wells and CM-FD-mmddyy for Cadet wells (e.g. POV-FD-092715 or CM-FD-092415).
- Record on the field data sheet the project name and number, sample ID, sample date and time, weather conditions, personnel on site, any problems or corrective actions, and any other information that will allow reconstruction of pertinent field activities. Field data sheets should clearly indicate which samples include duplicates.
- Record the sample ID exactly as it is listed on the sample container, date, time, and desired analysis on the chain-of-custody form. Duplicate sample times should be recorded as 0000 on the chain-of-custody as well as on the sample label.
- Place the samples into a cooler with ice, along with the completed chain-of-custody form (place the custody form in a plastic bag for protection against melt water). Place packing materials around the samples if needed to ensure that breakage will not occur during shipping. A commercial carrier (e.g., FedEx, UPS, etc.) or courier from the project laboratory will pick up and transport the cooler to the project analytical laboratory under chain-of-custody procedures.

4. DECONTAMINATION

4.1 PURPOSE

This section provides personnel and equipment decontamination procedures that are to be followed during field activities.

4.2 SCOPE

Decontamination is the process of removing or neutralizing contaminants that have accumulated on personnel and/or equipment at hazardous waste sites. Decontamination is required to protect personnel from the potential effects of hazardous substances and to minimize the spread of those substances. Decontamination methods include physical removal of contaminants, detoxification, and disinfection/sterilization.

This section describes decontamination responsibilities and procedures to be implemented at hazardous and non-hazardous waste sites. The procedures outlined are to be followed by all personnel who participate in site activities in areas that may contain hazardous or non-hazardous substances. The scenarios of decontamination procedures presented here will not necessarily be appropriate for a given site. As part of the Site-Specific Health and Safety Plan (HSP), project procedures may be prepared that focus on site-specific conditions that incorporate the appropriate procedures.

These procedures apply in their entirety to all Parametrix projects unless the Corporate Health and Safety Manager (CHSO) grants a variance. Modifications to these procedures may be appropriate on a project-specific basis.

4.3 RESPONSIBILITIES

There are specific responsibilities for Parametrix personnel to comply with the required decontamination procedures, depending on an individual's role within the company or on a given project. These responsibilities are outlined below:

- **Site-Specific Health and Safety Officer:** The Site-Specific Health and Safety Officer (SHSO) is responsible for maintaining and enforcing the project decontamination program. HSP decontamination procedures for all projects shall be reviewed and authorized by the CHSO. All modifications and/or changes must be noted in the field logbook, documented as HSP revisions, and initiated by all field personnel.
- **Site Manager:** The Site Manager is responsible for assuring that all site personnel become familiar with and follow the decontamination procedures described in this document or in the Site-Specific HSP.

4.4 PERSONNEL DECONTAMINATION PROCEDURES

Contamination avoidance is the best way to prevent the spread of contaminants. Minimize direct contact with contaminants by not leaning against objects, and not kneeling or sitting on the ground; through the use of remote sample-handling and container-opening techniques, wherever appropriate; and through the use of disposable equipment, wherever appropriate.

4.4.1 Decontamination Program Planning

The SHSO shall research the background information on a particular site when planning decontamination procedures for the fieldwork at that site. The physical, chemical, toxicological, and pathogenic properties (if any), as well as the amounts and concentrations of each contaminant present at the site, are the determining factors in selecting the levels of protection for personnel and the extent of decontamination required. Sources of information for the characterization of hazardous or non-hazardous waste sites include site records, state and federal agency files, and interviews with knowledgeable people. Hazardous and toxicological references, industrial process references, and manufacturers' handbooks are also good sources of information. Topography, local meteorological conditions (most probable wind direction, rainfall, etc.), and other site-specific features, are factors to consider in defining decontamination measures.

4.4.2 Decontamination Station Layout

When site conditions require, a dedicated area shall be established as a decontamination station. The decontamination station shall be located upwind of the Exclusion Zone. This is especially important when airborne contaminants are detected at above-background levels, or when such a potential exists. This is to prevent the airborne contamination of the Contamination Reduction Zone (CRZ) and the Support Zone. Exclusion, CRZ, and Support zones are defined as follows:

- **Exclusion Zone:** The zone encompassing the contaminated area that must be large enough to prevent the spread of contaminants beyond its boundaries. The extent of the Exclusion Zone will depend on:
  - Toxicity of the contaminants.
  - Physical form of the contaminants (solid, liquid, or gas).
  - Amounts and concentrations of the contaminants.
  - Fire and explosive potential of contamination.
  - Site-specific conditions such as topography and meteorology, and potential and active migration pathways to air, water, and soil.
- **Contamination Reduction Zone:** The area between the Exclusion and Support Zones where contamination is controlled and/or removed. A contamination reduction corridor is an area within the CRZ that is the point of entry and exit for personnel to and from the Exclusion Zone.
- **Support Area:** The Support Area is separated from the CRZ by the contamination control line (CCL). The Support Area must be free from all contamination at all times.

The boundaries of the decontamination station should be clearly visible to all field personnel. The decontamination line should be set up along a straight line to facilitate identification of each station in the decontamination process. Movements to and from the exclusion zone will only be via the decontamination corridor.

Site-specific conditions to consider when locating the decontamination station are the location(s) of field investigation activities, accessibility to site personnel, and site terrain and safety. The decontamination station should be moved if site investigation activities are moved significantly.

The SHSO will determine if gross contamination has spread beyond the Exclusion Zone if wind direction changes (when airborne contaminants are suspected), inclement weather develops, or other site-specific factors arise.

Multiple decontamination stations may be deemed necessary by the SHSO, depending on the particular project.

Decontamination equipment, materials, and supplies are generally selected on the basis of availability and compatibility with contaminants encountered. Other considerations include ease of equipment decontamination, disposability, and site-specific requirements. Recommended equipment for a decontamination station includes the following:

- Plastic sheeting, or other suitable materials, on which the decontamination tubs, clean equipment, and contaminated equipment can be set down.
- Long-handled, soft-bristled wire or other scrub brushes to help scrub off contaminants.
- Large plastic or steel tubs or other suitable tubs. These should be large enough for a worker to step in.
- Paper towels for drying protective clothing and equipment.
- DOT-approved drums with lids for contaminated wash and rinse solutions, for contaminated disposal items, and for trash cans.
- Washcloths, soap, and towels for hand rinse.
- Pressurized spray cans for deionized/distilled water.
- Portable shower facilities for full-body wash (if needed).
- Folding chairs and tables.
- Pocketknife.
- Stakes and rope for marking the hot zone limits.
- First aid kit.
- Decontamination solutions and detergents.
- Distilled and deionized water. Potable tap water for decontamination.

4.4.3 Decontamination Solutions

Personnel will generally use household soap and water. The detergents Alconox® or Liqui-Nox® and water are the preferred surfactants for most decontamination procedures relating to equipment. Selection of specific solvents and decontamination solutions are to be defined in the site work plan.

The effectiveness of decontamination solutions will be continuously verified. Visual observations of discoloration, stains, and arid substances adhering to objects, are indications that the decontamination solution is not effective in removing contamination. Decontamination solutions must be replenished frequently with use to ensure their continued effectiveness.

The quality of rinse water used in the decontamination process shall be verified. A distilled/deionized rinse is the final step in the decontamination of equipment and in removing all traces of contaminants.

4.4.4 Personnel Decontamination

Personnel decontamination procedures depend on the level of personal protection worn by the field crew, as required by the Site-Specific Health and Safety Plan, and upon the degree of contamination the crew members experience. The objective of personal decontamination is to protect the health of all crewmembers and to prevent the spread of contamination from the site. Therefore, the following procedures should be extended and modified by the SHSO until all field personnel are satisfied that complete decontamination has been accomplished. In the event of an emergency, the SHSO may decide to curtail these decontamination procedures to evacuate the site or initiate first aid.

- **Level B Decontamination:** Level B personal protection equipment (PPE) includes chemical-resistant disposable coveralls, self-contained breathing apparatus (SCBA), hardhat, steel-toe/shank boots, boot covers, and inner and outer gloves. Level B decontamination procedures also can be divided into four sublevels: (1) highly-contaminated personnel exiting the Exclusion Zone, (2) minimally-contaminated personnel exiting the Exclusion Zone, (3) highly-contaminated personnel crossing the hot line to exchange SCBA tanks, and (4) minimally-contaminated personnel crossing the hot line to exchange SCBA tanks. These distinctions are noted in the decontamination station descriptions below.
    - Station 1 – Segregated Equipment Drop (All Sublevels): Before crossing the hot line, personnel returning from the field must deposit all equipment and/or sample bottles in segregated areas on plastic sheeting. Highly contaminated equipment, such as samplers and sample containers, are kept separate from minimally contaminated and difficult-to-clean equipment, such as air monitoring equipment.
    - Station 2 – Boot Cover and Outer Glove Wash, Rinse, and Removal: Personnel must step into a washtub containing a detergent solution. Boot covers and outer gloves are scrubbed with a long-handled, soft-bristled brush. All surfaces of the boots and gloves are washed, including boot soles and duct tape used to seal covers and gloves to coverall. Boot covers, including soles and outer gloves, are rinsed with a long-handled, soft-bristled brush. Tape is removed from boot covers and outer gloves and deposited into a plastic-lined disposal drum. Boot covers and outer gloves are removed and deposited into a plastic-lined disposal drum. A knife may be used to aid in the removal of tight fitting boot covers.
    - Station 3 – Coverall, SCBA, and Safety Boot Wash and Rinse: At this station, all exposed surfaces of PPE are washed with the detergent solution. Personnel must step into a washtub containing a detergent solution. All gear is scrubbed with a long-handled, soft-bristled brush. All surfaces of gear should be scrubbed, including boot soles, until visible contamination is removed. All exposed surfaces of PPE are rinsed to remove detergent.
    - Personnel must step into a washtub containing tap water. All gear is rinsed with a long-handled, soft-bristled brush. Pressure sprayers containing tap water may be used to aid in rinsing.
    - Station 4 – Safety Boot, SCBA Backpack and Chemically Resistant Overall Removal: Boots must be removed and set on plastic sheeting. While still wearing the face-piece, the SCBA backpack is removed and set on a chair or

table. The air supply hose is disconnected from the regulator valve. Chemically resistant overalls are removed and disposed to a plastic-lined disposal drum.

- Station 5 – Inner Glove Wash and Rinse and SCBA Face Piece Removal: Inner gloves are scrubbed by rubbing hands together with a detergent solution then rinsed in tap water. The SCBA face-piece is removed without touching inner gloves to face, and then deposited on plastic sheeting.
- Station 6 – Inner Glove Removal: Inner gloves are removed and disposed to a plastic-lined disposal drum.
- Station 7 – Field Wash/Field Shower: Hands and face are washed with hand soap, then rinsed and dried with paper towels. If highly toxic, skin-corrosive, or skin-absorbable materials are at the site, shower entire body.

- **Level C Decontamination:** Level C personal protection includes chemical-resistant disposable coverall, APR, hardhat, steel toe/shank boots, boot covers, and inner and outer gloves. Depending on exposure hazards, boot covers and outer gloves may not be required, and Tyvek® coveralls may be substituted for chemical-resistant coveralls. Station decontamination activities include the following:
  - Station 1 – Segregated Equipment Drop: Before crossing the hot line, personnel returning from the field must deposit all equipment and/or sample bottles in segregated areas on plastic sheeting. Highly contaminated equipment, such as samplers and sample containers, are kept separate from minimally contaminated and difficult-to-clean equipment, such as air monitoring equipment.
  - Station 2 – Boot Covers and Outer Glove Wash, Rinse, and Removal: Personnel must step into a washtub containing a detergent solution. Boot covers and outer gloves are scrubbed with a long-handled, soft-bristled brush. All surfaces of the boots and gloves are washed including boot soles and duct tape used to seal covers and gloves to coveralls.
  - Personnel must step into a washtub containing tap water. Boot covers, including bottoms and outer gloves, are rinsed with long-handled, soft-bristled brush. Tape that seals boot covers and outer gloves is removed and deposited into a plastic-lined disposal drum. Boot covers and outer gloves are removed and deposited into a plastic-lined disposal drum. A knife may be used to aid in the removal of tight fitting boot covers.
  - Station 3 – Safety Boots and Coverall Wash, Rinse, and Removal: Personnel must step into washtub containing detergent solution. Boots are scrubbed with a long-handled, soft-bristled brush. If leather safety boots are worn, the soles are scrubbed and the upper surfaces are wiped with a paper towel dipped in detergent solution. If waterproof coveralls are worn, they are scrubbed also. All surfaces of gear, including boot soles, are scrubbed until visible contamination is removed.
  - Personnel must step into washtub containing tap water. Boots and coveralls are rinsed with a long-handled, soft-bristled brush. Boots are removed and set on plastic sheeting. Coveralls are removed and disposed to a plastic-lined disposal drum.
  - Station 4 – Inner Glove Wash and Rinse: Inner gloves are scrubbed by rubbing hands together with a detergent solution. Finish with a rinse in tap water.

  - Station 5 – APR and Inner Glove Removal: The APR is removed without touching inner gloves to face, and then deposited on plastic sheeting. Inner gloves are removed and disposed to a plastic-lined disposal drum.

- **Level D Decontamination:** Level D is the lowest level of personal protection and is worn when exposure to contaminants is not expected. Level D personal protection includes hardhat and steel toe/shank leather boots. Depending on the anticipated activities, Level D may also include Tyvek® coveralls and gloves. Station decontamination activities include the following:
  - Station 1 – Segregated Equipment Drop: Personnel returning from the field must deposit all equipment and/or sample bottles in segregated areas on plastic sheeting. Highly contaminated equipment, such as samplers and sample containers, are kept separate from minimally contaminated and difficult-to-clean equipment, such as air-monitoring meters.
  - Station 2 – Safety Boot Wash, Rinse, and Removal: Boot soles must be scrubbed with a long-handled, soft-bristled brush. All surfaces of gear, including boot soles, must be scrubbed until visible contamination is removed. Boot soles are rinsed with tap water using a long-handled, soft-bristled brush. Boots are removed and placed on plastic sheeting.
  - Station 3 – Coveralls Removal (if needed): If worn, remove coveralls and dispose to a plastic-lined disposal drum.
  - Station 4 – Glove Wash, Rinse, and Removal (if needed): If worn, inner gloves are scrubbed by rubbing hands together with a detergent solution. Finish with a rinse in tap water. Gloves are removed and disposed to a plastic-lined disposal drum.

4.4.4.1 Priorities of Worker Decontamination

The following members of the work team returning from the Exclusion Zone shall have priority over others when being decontaminated.

- A worker who is in need of first aid, or is in physical discomfort.
- A worker who is low on air or whose SCBA is malfunctioning.
- A worker who has been highly contaminated.
- A worker who did the major part of physical activity required on site.

It is the responsibility of the SHSO to decide which workers receive priority.

4.4.4.2 Emergency Decontamination

In an emergency, the primary concern shall be to prevent the loss of life or severe injury to personnel. If immediate administration of medical treatment is required to prevent further deterioration of health, then decontamination may be eliminated, modified, or performed later when the worker's condition is stabilized. The SHSO and the team leader must weigh the consequences of delaying, modifying, or eliminating decontamination against the consequences of delaying treatment, before making a decision on a case-by-case basis.

First aid equipment shall be readily available in the Support Area and as specified in the Site-Specific HSP. At least one response team member shall be trained in first aid and CPR.

Arrangements shall be made to advise medical personnel on the nature of contaminants to which the patient was exposed and the extent of decontamination. In some cases, the SHSO will need to contact nearby emergency response medical facilities in advance to alert them of the possibility of a problem. This will help the medical facility to prepare for the specific sort of health care that may be required in an emergency.

4.4.4.3 Cold Weather Decontamination

In freezing temperatures, a small quantity of ethanol can be added to the washtubs containing decontamination and tap water to prevent freezing. Deionized water and distilled water containers shall be kept warm in the heated van or car for use when needed. Orchard sprayers shall also be kept in a warm place when not in use.

4.5 EQUIPMENT DECONTAMINATION PROCEDURES

4.5.1 Protection of Monitoring Equipment

All equipment and monitoring instruments shall be protected from contamination while in use by wrapping them in clean plastic bags and sealing them with tape.

4.5.2 Heavy Equipment

Heavy equipment like bulldozers, trucks, and drilling equipment are difficult to decontaminate. Decontamination shall consist of either steam cleaning or washing with suitable detergent solutions and then with water under high pressure. Decontamination equipment that may be needed include long-handled brushes, pressurized sprayers, curtains and enclosures to contain splashes from pressurized sprayers, and wire brushes. A decontamination pad lined with heavy-duty plastic sheeting may be needed for the decontamination of heavy equipment.

4.5.3 Tools/Sampling Equipment

Disposable tools shall be used wherever possible. Typically, decontamination of tools will include brushing with decontamination solution followed by tap water. This procedure shall be followed by spraying with distilled water and then deionized water. The tools shall be segregated and wrapped in clean plastic bags and taped securely.

Decontamination of sampling equipment such as split spoons, stainless steel buckets, and filtration transfer vessels shall be in accordance with the following steps:

- Set up clean tubs or buckets to collect wash and rinse solutions.
- Scrub item with Alconox or Liquinox and water until visually clean. Use Liquinox when phosphate is an analytical parameter.
- Rinse with tap water.
- Rinse with distilled or deionized water, the variety that can be found in any grocery store. A garden sprayer or squirt bottle may be used.

4.6 LEVEL OF PROTECTION OF DECONTAMINATION TEAM

Decontamination workers who initially come into contact with personnel and equipment returning from the Exclusion Zone shall be required to wear the same level of protection as the returning team, or one level lower. The level of protection for decontamination workers can be progressively decreased, without compromising worker safety, the farther away the stations are located from the hot line. The SHSO shall determine the level of protection required for the decontamination team.

4.7 INVESTIGATION-DERIVED WASTE

SOP HS-006 contains more details on disposal of decontamination solutions and other decontaminated items such as paper towels and Tyvek. Typically, the washtubs containing decontamination solution and rinse water shall be emptied into DOT-approved drums. The washtubs shall be sprayed with decontamination solution and tap water, and then also emptied into the drums. All solid waste shall be double-bagged and disposed of in drums. The drums shall be securely fastened and labeled as “decontamination water” or “solid waste.” Include the name of the site, the date, the company name, and the level of fullness on the drum label. The Port of Vancouver is responsible for the final disposal of investigation-derived waste at the project site.

5. REFERENCES

Parametrix. 1999. Work Plan for Remedial Investigation and Feasibility Study, Former Building 2220 Site (a.k.a. Swan Manufacturing Company Site), prepared for Port of Vancouver. June 1999.

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Appendix C

Quality Assurance Plan

APPENDIX C: QUALITY ASSURANCE PLAN

1. INTRODUCTION

1.1 PURPOSE

The purpose of the Quality Assurance Plan (QAP) is to establish a system of quality and performance checks pertaining to collection of groundwater samples; laboratory analysis of samples; and reporting of results for groundwater at the SMC and Cadet sites during all 2022 sampling events. A previous version of the QAP was included in the Work Plan for Remedial Investigation and Feasibility Study for the SMC site (Parametrix 1999), and its procedures have been followed for groundwater sampling conducted at the SMC and Cadet sites.

1.2 DATA QUALITY OBJECTIVES

Established before data collection, data quality objectives (DQOs) specify the quality of the data required to meet the stated goals of the project and to ensure collection of representative data of known and documentable quality. All investigation activities will be conducted and documented in accordance with the specified DQOs to ensure that sufficient data of known quality are collected. DQOs for precision, representativeness, accuracy, completeness, and comparability of the data to be collected and analyzed are described in Section 3.

An important project DQO for groundwater monitoring is to obtain appropriate quantitation limits so that the data generated can be compared to applicable quality standards. This QAP also presents procedures for handling samples, sample chain-of-custody procedures, instrument/ equipment preventative maintenance analytical methods for sample analysis, internal quality control, corrective actions, and data assessment.

2. ANALYTICAL DATA QUALITY LEVELS

The United States Environmental Protection Agency (EPA) has defined five levels of analytical data quality (USEPA 1987). This project will use Level III analytical support. Analyses performed using Level III techniques are designed to confirm the identification and quantification of organic and inorganic compounds in water samples; provide sufficient data for site characterization, environmental monitoring, and confirmation of field data; and support engineering studies and, if needed, risk assessment. Level III data will be sufficient for most samples, with the following requirements:

1. The project laboratories must follow the mandatory and recommended QA/QC procedures outlined for the specified methods. Where numerical method detection limits, precision, accuracy, and completeness DQOs are specified in this QAP, these limits will supersede method-specific requirements, unless method-specific requirements are more stringent.
2. The project laboratories must receive and implement the QAP. The Project Manager will request written correspondence from the laboratories acknowledging this fact. All analytical data must be archived for at least 10 years.

3. The project laboratories will complete case files containing all raw data (chromatograms, strip charts, or computer printouts). For data retained on compact disk (CD) or hard drives, results must be traceable to the case and the samples for future verification, should this information be required at a later date.

3. QUALITY ASSURANCE OBJECTIVES FOR PARCC MEASUREMENT

This section describes DQOs for precision, accuracy, representativeness, completeness, and comparability (PARCC) of the project data. Documentation from the project laboratories will be used to determine if the PARCC parameters are being met. This documentation includes reports on sample results, surrogate recoveries, spike recoveries, laboratory instrument calibrations, and copies of the actual gas chromatograph results. The documentation of PARCC allows validation of results against previous investigations and identifies data uses and/ or limitations prior to the actual data use.

Specific requirements for sample handling, sample custody, calibration, analytical procedures, data reporting, internal quality control, preventative maintenance, data assessment procedures, and corrective actions will be discussed in the following sections of this QAP.

3.1 PRECISION AND ACCURACY

Precision is a measure of mutual agreement among individual measurements of the same property under prescribed similar conditions. It is expressed in terms of standard deviation or relative percent difference (RPD). Accuracy is the degree of agreement of a measurement (or an average of measurements of the same property), X, with either an accepted reference or true value, T. Accuracy can be expressed as the difference between two values, X-T, or the difference as a percentage of the reference or true value, (X-T)/T x 100, or as a ratio, X/T. Accuracy is a measure of the bias in a system and will be expressed as the percent recovery of the samples.

Accuracy and precision are determined through quality control parameters such as surrogate recoveries, matrix spikes, matrix spike duplicates, laboratory control samples (LCS), LCS duplicates (LCSD), quality control (QC) check samples, and field duplicates. The project DQOs for the evaluation of these parameters are based on those given in SW-846 (USEPA 1986), the Contract Laboratory Program (CLP) statements of work (SOW) (USEPA 1993a, 1993b), functional guidelines outlined by the EPA for evaluating organic analyses (USEPA 1994a, 1994b), or statistical information provided by the project laboratories and pre-approved by the QA officer.

QC objectives (control limits expressed as percent) for surrogate recoveries, and percent recovery and RPD for matrix spikes, matrix spike duplicates, and laboratory duplicates for this project, will be those currently established by the testing laboratories. If the required QC objectives are not met after a corrective action is performed, the laboratory will notify the QA officer before data submittal. The QA officer will determine if additional corrective action should be performed, such as re-analysis, if applicable.

Field duplicate samples will be analyzed as QC samples for verification of precision and accuracy. If the results of the field duplicates are outside the control limits, corrective action and/ or data qualification will be determined after review by the QA officer or QA designee.

Field duplication can be of poor quality because of sample heterogeneity. Therefore, corrective action will be determined by the QA officer and discussed in the data QA report.

3.2 REPRESENTATIVENESS

Representativeness expresses the degree to which sampling data accurately and precisely represent a characteristic of a population. Sample locations and field sampling procedures have been chosen to maximize representativeness. Representativeness will be assessed from the review of sampling records and a QA audit of field activities.

3.3 COMPLETENESS

Completeness is a measure of the amount of valid data obtained from a measurement system compared to the total data collected. The QA objective for completeness during this project is 90 percent.

3.4 COMPARABILITY

Comparability expresses the confidence with which one data set can be compared to another. All measurements will be made so that results are comparable with other measurement data for similar samples and sample conditions, and with relevant action levels, criteria, or standards. The samples will be collected and analyzed using standard techniques, and analytical results will be reported in units consistent with EPA guidelines. Method detection limits and units to be reported are described in Section 6.

4. SAMPLING PROCEDURES

4.1 SAMPLE COLLECTION

Groundwater samples will be collected from each groundwater monitoring well in accordance with approved methods (ie low-flow purging technique).

4.2 QA/QC SAMPLES

Field and laboratory QA/ QC sample guidelines are summarized in Table 1.

Table 1. Guidelines For Minimum QA/ QC Samples For Field Sampling And Laboratory Analysis

Media	Field	Laboratory				
	Field Duplicate	Trip Blank[1]	Matrix Spike	Matrix Spike Duplicate[2]	Method Blank	Laboratory Control Sample
Groundwater	1 in 20	1 per cooler	1 in 20	1 in 20	1 in 20	1 in 20

1 Trip blank prepared by laboratory and analyzed for volatile organic compounds only.

2 Matrix spike duplicate analyzed for organic compounds.

4.3 SAMPLE CONTAINERS, PREPARATION, PRESERVATIVES, AND HOLDING TIMES

Specifications for containers, holding times, preservation, and handling are shown in Table 2.

Table 2. Sample Containers, Preparation, Preservatives, and Holding Times for Groundwater Samples

Analysis	Method	Sample Container	Container Size	Preservation and Handling	Holding Times[1,2,3]
VOCs	EPA 8260D	Glass vial; Teflon-lined silicon septum cap	40ml x 3	Fill bottles leaving NO AIR SPACE. Keep in dark, cool to 4°C; HCL to pH < 2	7 days; 14 days if preserved
Nitrate-Nitrogen	EPA 300.0	Polyethylene bottle	250ml x 1	Cool to 4°C	48 hours
Ammonia	SM 4500	Polyethylene bottle	500ml x 1	Cool to 4°C; H2SO4 to pH < 2	28 days
Metals (total and dissolved)[4]	EPA 6020	Polyethylene bottle	250ml x 1	Cool to 4°C; HNO3 to pH < 2	180 days
Total Suspended Solids	SM 2540D	Polyethylene bottle	500ml x 1	Cool to 4°C	7 days

1 USEPA 1983. Methods for Chemical Analysis of Water and Wastes.

2 USEPA 1986. Test Methods for Evaluating Solid Waste (SW-846), 3rd Edition.

3 APHA - AWWA - WPCF 1989. Standard Methods for the Examination of Waste and Wastewater, 17th Edition.

4 Dissolved aliquot is collected in the field through a 40 micron disposable in-line filter.

4.4 DOCUMENTATION

Sample collection and handling will be documented through the use of daily field logs and other forms, as indicated in Table 3.

Table 3. Sample Collection and Handling Records

Record	Use	Responsibility/Requirements
Field Notebook	Records significant events and observations.	Maintained by field sampler; all entries must be factual, detailed, objective; entries must be signed and dated.
Sampling Field Data Sheet	Provides a record of each sample collected.	Completed, dated, and signed by sampler; maintained in project file.
Exploratory Boring Log	Records geologic and groundwater data during field exploration; used to develop final logs of borings and well logs.	Completed by field geologist or engineer; maintained in project files.
Sample Label	Accompanies sample; contains specific sample identification information.	Completed and attached to sample container by sampler.
Chain-of-Custody Record	Documents chain-of-custody for sample handling.	Documented by sample number. Original accompanies sample. A copy is retained by QA Officer.

4.4.1 Daily Field Logs

A field notebook will be maintained to provide daily records of significant events and observations that occur during field investigations. All entries are to be made in waterproof ink, signed, and dated. Corrections will be made according to the procedures given at the end of this section.

Field notebooks are intended to provide sufficient data and observations to enable participants to reconstruct events that occurred during the project and to refresh the memory of the field personnel if called upon to give testimony during legal proceedings. The field notebook entries should be factual, detailed, and objective.

All field logs and field data sheets will be retained by the project field coordinator and secured in a safe place.

4.4.2 Corrections to Documents

Pages of the field notebook are not to be removed, destroyed, or thrown away. To correct all errors in the notebook, a single line will be drawn through the original entry (so that the original entry can still be read), and the corrected entry will be written alongside. The correction will be initialed and dated. Most corrected errors will require a footnote explaining the correction.

If an error made on a document is assigned to one person, that individual may make corrections simply by crossing out the error and entering the correct information. The erroneous information should not be obliterated. The person who made the entry should correct any error discovered in a document.

4.4.3 Photographs

All photographs taken of field activities will be documented with the following information noted on a photo log:

- Date, time, and subject or location of photograph taken
- Photographer
- Weather conditions
- Description of photograph taken
- Reasons photograph was taken
- Sequential number of the photograph
- Viewing direction

The photographer will review the photographs or slides and compare them to the log, to assure that the log and the photographs match.

5. SAMPLE CUSTODY

5.1 CUSTODY PROCEDURES

This section describes sample custody and the chain-of-custody procedures to be used for this project. These procedures ensure that the quality and integrity of the samples are maintained during their collection, transportation, storage, and analysis.

Sample documents will be carefully prepared so that sample identification and chain-of-custody can be maintained, and sample disposition controlled. Sample identification documents will include:

- Field notebooks
- Sample field data sheets
- Sample labels
- Chain-of-custody records

5.1.1 Chain-of-Custody

The chain-of-custody procedures used for this project provide an accurate written or computerized record that can be used to trace the possession of each sample from the time the sample is collected until the completion of all required analyses. A sample is in custody if it is in any of the following places:

- In someone's physical possession
- In someone's view
- In a secured container

- In a designated secure area

The following information will be provided on the laboratory-supplied chain-of-custody form:

- Project name and number
- Sample identification numbers
- Matrix type for each sample
- Analytical methods to be performed for each sample
- Number of containers for each sample
- Sampling date and time for each sample
- Turnaround time for analysis
- Names of all sampling personnel
- Signature and dates indicating the transfer of sample custody

5.1.2 Field Custody Procedures

The following field custody procedures will be followed:

- As few people as possible will handle the samples.
- The sample collector will be responsible for the care and custody of the samples collected until the samples are transferred or dispatched properly.
- The sample collector will record sample data on the sample collection form.
- The field coordinator will determine whether proper custody procedures were followed during the fieldwork and will decide if additional samples are required.

5.2 TRANSFER OF CUSTODY AND SHIPMENT

When samples are transferred, the person relinquishing the samples will sign the chain-of-custody form and record the date and time of transfer. The sample collector will sign the form in the first signature space.

The QA officer for the project will verify sample custody documentation during regular review of the data validation package.

The following transfer of custody and shipment procedures will be followed:

- A chain-of-custody form must accompany each cooler and shipping container in which samples are packed. When transferring samples, the individuals relinquishing and receiving them must sign, date, and note the time on the chain-of-custody form to document sample custody transfer.
- When coolers and shipping containers are shipped to the labs via a third party, the sample coolers and shipping containers will be sealed with custody seals prior to shipment. The method of shipment, name of courier, and other pertinent information will be entered in the “Remarks” section of the chain-of-custody form and traffic report.

- The chain-of-custody form will accompany all shipments, identifying their contents. The original form will accompany the shipment. The other copies will be distributed as appropriate to the QA officer and project manager.

5.3 SAMPLE IDENTIFICATION

Each sample will be labeled, chemically preserved (if required), and sealed immediately after collection. The labels will be supplied by the laboratory and filled out using waterproof ink and will be firmly affixed to the sample containers and tags.

The following information will be given on each sample label:

- Project name and number
- Name of sampler
- Date and time of sample collection
- Sample station
- Sample number
- Analysis required
- Preservation

5.4 SAMPLE PACKAGING

The samples will be transported and handled in a manner that not only protects the integrity of the sample, but also prevents any detrimental effects due to the possible hazardous nature of the samples.

6. ANALYTICAL PROCEDURES

As defined by Ecology (1995), the method detection limit (MDL) is the minimum concentration of a compound that can be measured and reported with 99 percent confidence that the analyte concentration is greater than zero. The Method Reporting Level (MRL) is the concentration that can be reliably measured within specified limits during routine laboratory operating conditions using Washington State Department of Ecology (Ecology)-approved methods. During data review, laboratory-specific MDLs and MRLs for water, soil gas, and indoor and outdoor air are compared with the regulatory standards specified in the project DQOs.

Where appropriate, these procedures may be modified, based on anticipated data uses and with recognition of validation requirements, to incorporate techniques familiar to the project laboratory. The laboratory will notify the QA officer of any proposed procedural changes and document these changes in the cover letter included with the data reports.

Matrix interferences may make achievement of the desired detection limits and associated quality control criteria impossible. In such instances, the project laboratories must report to the QA officer the reason for elevated detection limits or noncompliance with quality control criteria.

7. DATA REDUCTION, VALIDATION, AND REPORTING

7.1 DATA REDUCTION

Raw data (including instrument calibrations, chromatograms, and mass spectra), procedural logs for each instrument, sample extraction and preparation logs, and standard preparation logs will be kept on file at the project laboratories. Sample and QC results will be stored in a database maintained by the analytical laboratories.

7.2 DATA VALIDATION

All data packages provided by the project laboratories must provide a summary of QA results adequate to enable reviewers to validate or evaluate the quality of the data. The project QA officer is responsible for conducting checks for internal consistency, transmittal errors, and adherence to the quality control elements specified in the QAP.

For each data package, the project QA officer will conduct a review of the quality control results. Data will be qualified using guidance provided in the CLP functional guidelines for assessing data (USEPA 1994a, 1994b). The QA officer will review the following quality control data results for all samples:

- Chain-of-custody documentation
- Holding times
- Trip blanks
- Rinsate blanks
- Transfer blanks
- Duplicates
- Method blanks

A limited review (minimum 10%) of the following quality control data results will be conducted:

- Laboratory matrix spike/ matrix spike duplicate and/ or matrix duplicate results
- Laboratory surrogate recoveries
- Laboratory check samples

Further evaluations will be conducted, if, based on this limited review, the quality control data results indicate potential data quality problems.

The QA officer will prepare a quality assurance memorandum for each data package describing the results of the data validation and describing any qualifiers that are added to the data.

7.3 DATA REPORTING

All laboratory report data packages will contain the following information:

- Cover letter

- Chain-of-custody forms
- Summary of sample results
- Summary of QC results

The information provided in the cover letter will include:

- Laboratory name, address and telephone number
- Date(s) of sample receipt and number of samples received
- Detailed description of any problems encountered with QC, analysis, shipment or handling procedures
- Identification of possible reasons for any QC criteria falling outside acceptance limits
- Signature of laboratory representative and date certifying data results

The minimum information to be presented on each sample for each parameter or parameter group is:

- Client sample number and laboratory sample number
- Sample matrix
- Date of extraction/preparation and date/time of analysis
- Dilution factors
- Sample weights/volumes used in sample preparation/analysis
- Identification of analytical instrument
- Analytical method
- Detection/quantitation limits

The minimum QC summary information to be presented on each sample for each analyte or analyte group will include:

- Surrogate standard recovery results
- Matrix QC results (matrix spike/ matrix spike duplicate, duplicate)
- Method blank results
- Laboratory check standard results
- Definitions of any data qualifiers used

8. INTERNAL QUALITY CONTROL

Quality control checks consist of measurements performed in the field and laboratory. The analytical methods referenced in Section 10 specify routine methods required to evaluate data precision and accuracy, and to determine whether the data are within the quality control limits. Guidelines for minimum samples for field QA/ QC sampling and laboratory analysis were summarized in Table 1.

8.1 FIELD METHODS

The following quality control samples will be evaluated to verify accuracy and precision of laboratory results for this project: trip blank, equipment rinsate blank, and field duplicate. The frequency of quality control sample evaluation is also indicated by sample type, but may be adjusted when the final sampling schedule is determined. The frequencies of quality control sample evaluation described here should be considered a minimum.

8.1.1 Trip Blank

A minimum of one trip blank for each matrix (groundwater, soil gas, and air) will be analyzed per cooler or shipment of VOC samples. The trip blanks used for groundwater samples will be prepared by the laboratory using deionized (DI)/ distilled water. The trip blanks will be transported to and from the field, and then returned to the laboratories for analysis, unopened and unaltered.

8.1.2 Equipment Rinsate Blank

A minimum of one equipment rinsate blank will be collected per sampling event if sample collection involves the use of non-dedicated equipment (e.g., during low-flow purging with non-dedicated tubing). Equipment rinsate samples will be collected following equipment decontamination to assess the effectiveness of the decontamination process. Rinsate samples will consist of laboratory-supplied DI/ distilled water poured onto the non-dedicated sampling equipment and collected directly into appropriate sample containers. Currently, groundwater sampling and soil gas and indoor and outdoor air sampling use dedicated equipment and, thus, rinsate blanks will not be required.

8.1.3 Field Duplicate

In order to verify the precision of laboratory and/ or sampling methodology, a minimum of one blind field duplicate for each matrix will be analyzed per 20 samples, or one per sampling event if there are fewer than 20 samples in a sampling event. The field duplicates for water and soil gas samples will be collected sequentially. Field duplicates for indoor and outdoor air samples will be collected concurrently. The samples will be coded so the project laboratories cannot discern which samples are field duplicates.

8.2 LABORATORY METHODS

Specific procedures and frequencies for laboratory quality control are detailed by analytical method in the laboratory QA Plan. General descriptions of the types of required laboratory QC samples are provided in the following sections.

8.2.1 Method Blanks

To assess possible laboratory contamination, a minimum of one laboratory method blank will be analyzed per 20 samples, or one per sampling event if there are fewer than 20 samples in a sampling event. Method blanks will contain all reagents and undergo all procedural steps used for analysis.

8.2.2 Control Samples

A minimum of one laboratory control sample (LCS) and one LCS duplicate (LCSD) per 20 samples, or one per sampling event if there are fewer than 20 samples in a sampling event, will be analyzed for inorganics to verify the precision of laboratory equipment. The LCS will be a concentration within the calibration range at a different concentration than the standards used to establish the calibration curve. LCS/ LCSD analysis will follow EPA LCS/ LCSD guidelines established in SW-846 (USEPA 1986).

8.2.3 Matrix Spike

A minimum of one laboratory matrix spike (MS) per 20 groundwater samples, or one per sampling event if there are fewer than 20 samples in a sampling event, will be analyzed for VOCs in order to monitor recoveries and ensure that extraction and concentration levels are acceptable for QA/ QC review. MS preparation is not possible in Summa™ canisters containing soil gas or indoor and outdoor air samples. The laboratory matrix spike will be analyzed using a separate groundwater sample collected from one of the wells. The laboratory matrix spike will follow the matrix spike guidelines specified in the CLP SOWs (USEPA 1993a, 1993b).

8.2.4 Matrix Spike Duplicate

A minimum of one laboratory matrix spike duplicate (MSD) per 20 groundwater samples, or one per sampling event if there are fewer than 20 samples in a sampling event, will be analyzed for VOCs in order to provide information on the precision of chemical analysis. MSD preparation is not possible in Summa™ canisters containing soil gas or indoor and outdoor air samples. The MSD will be analyzed using a separate groundwater sample collected at the same well from which the matrix spike sample is collected. MSDs (rather than matrix duplicates) apply to organic analyses because of the potentially large number of undetected compounds to be reported. Comparing the MS and MSD provides better information on the quality of the data. The laboratory MSD will follow EPA matrix spike duplicate guidelines specified in SW-846 (USEPA 1986).

9. PREVENTIVE MAINTENANCE

9.1 FIELD INSTRUMENTS

The field coordinator will arrange for field instrumentation preventive maintenance. Qualified field technicians will perform preventive maintenance on field instruments following the manufacturer's instructions and maintenance schedules. Maintenance will be documented in instrument logbooks along with the date and initials of the individual performing the maintenance.

The field coordinator will routinely review and compare instrument calibration results against the preventive maintenance records to verify the effectiveness of the preventive maintenance program. The field coordinator will track scheduling of preventive maintenance required by the manufacturer.

9.2 LABORATORY INSTRUMENTS

The analytical project laboratory managers are ultimately responsible for the care of the laboratory instruments. They may delegate the responsibility to senior supervising chemists or technicians qualified to perform routine maintenance, after demonstrating that such personnel are trained in maintenance procedures for that laboratory section (e.g., wet chemistry, metals, and organics). Training of laboratory personnel on the routine care of laboratory equipment will be provided, at a minimum, during the initial installation of the equipment and, for new analysts, before initial use of the equipment.

Maintenance and other appropriate details will be documented in daily maintenance logbooks. The individual performing the maintenance procedures will date and sign each entry. At a minimum, the preventive maintenance schedules contained in the EPA methods and in the equipment manufacturer's instructions will be followed.

10. DATA ASSESSMENT PROCEDURES

The project laboratory QA officers will review analytical data to assure that the QA/ QC objectives for precision, accuracy, and completeness are met. These reviews will identify the occurrence of deficiencies in time to take corrective actions. This section describes routine procedures for assessing project data.

10.1 PRECISION

Precision measures the mutual agreement among individual measurements of the same property, usually under prescribed similar conditions. QA/ QC sample types that measure precision include field duplicates, matrix spike duplicates, and matrix duplicates. The estimate of precision of duplicate measurements is expressed as a relative percent difference (RPD):

$$RPD = (D1 - D2)/((D1 + D2)/2) \times 100$$

Where D1 = First sample value
D2 = Second sample value

The RPDs will be routinely calculated and compared with DQOs. Control limits are established by determining the standard deviation of a series of replicate measurements.

10.2 ACCURACY

Accuracy is assessed using the results of standard reference material, linear check samples, and matrix spike analyses. It is routinely expressed as a percent recovery, which is calculated:

$$\%\ Recovery = \frac{(Total\ Analyte\ Found - Analyte\ Originally\ Present) \times 100}{Analyte\ Added}$$

The percent recovery will be routinely calculated and checked against DQOs.

10.3 COMPLETENESS

The amount of valid data produced will be compared with the total analyses performed to assess the percent of completeness. Completeness will be routinely calculated and compared with the data quality objectives.

10.4 REPRESENTATIVENESS

Sample locations and sampling procedures will have been chosen to maximize representativeness. A qualitative assessment (based on professional experience and judgment) will be made of sample data representativeness based on review of sampling records and QA audit of field activities.

Corrective actions may be needed for two categories of nonconformance:

- Deviations from the methods or QA requirements established in Sampling and Analysis Plans (SAPs) or this QAP
- Equipment or analytical malfunctions

During field operations and sampling procedures, the project field coordinator will be responsible for taking and reporting required corrective actions. A description of any such action taken will be entered in the field notebook. The QA officer will be consulted immediately if field conditions are such that conformance with the SAP or QAP is not possible. Any corrective action or field condition resulting in a major revision of the QAP will be communicated to the project manager for review and concurrence. Whenever possible, this communication will be made before changes in field procedures are implemented.

During laboratory analysis, the project laboratory QA officers will be responsible for taking required corrective actions in response to equipment malfunctions. If an analysis does not meet data quality goals outlined in the QAP, corrective action will follow the guidelines in SW-846 (USEPA 1986). This includes, at a minimum, the following considerations:

- Calibration-check compounds must be within performance criteria specified in SW-846 (USEPA 1986), or corrective action must be taken before sample analysis begins.
- Before processing any samples, the analysts will demonstrate by analysis of a reagent blank that interferences from the analytical system, glassware, and reagents are within acceptable limits. Each time a set of samples is extracted or there is a change in reagents, reagent water blank will be processed as a safeguard against chronic laboratory contamination. The blank samples will be carried through all sample preparation and measurement steps.
- Surrogate spike analysis must be within the contract-required recovery limits, or corrective action must be taken and documented.

If analytical conditions do not conform to this QAP, the project QA officer will be notified as soon as possible so that additional corrective actions can be taken. Corrective Action Reports will document responses to any reported nonconformances. These reports may be generated from internal or external audits or from informal reviews of project activities. Corrective Action Reports will be reviewed for appropriateness of recommendations and actions by the project QA officer for QA matters, and by the project manager for matters of technical approach.

11. QUALITY ASSURANCE REPORTS

A QA data validation report will accompany all data packages submitted to Ecology. This QA report will summarize all relevant data quality information. The QA Officer will be responsible for data quality assessments and associated QA reports. Final task or investigative reports will contain a separate QA section summarizing data quality information.

12. REFERENCES

Ecology (Washington State Department of Ecology). 1995. Guidance on sampling and data analysis methods. Publication No. 94-49. Washington State Department of Ecology. Olympia, Washington. 1995.

Parametrix. 1999. Work Plan for Remedial Investigation and Feasibility Study, Former Building 2220 Site (a.k.a. Swan Manufacturing Company Site), prepared for Port of Vancouver. June 1999.

USEPA. 1986. Test methods for evaluating solid waste, 3rd edition. U.S. Environmental Protection Agency, Washington, D.C. 1986.

USEPA. 1987. Data Quality Objectives for Remedial Response Activities. U.S. Environmental Protection Agency, Washington, D.C. 1987.

USEPA. 1993a. Statement of work for inorganic analysis, multi-media, multi-concentration. U.S. EPA Contract Laboratory Program. (ILM03.0) U.S. Environmental Protection Agency, Washington, D.C. 1993.

USEPA. 1993b. Statement of work for organic analysis, multi-media, multi-concentration. U.S. EPA Contract Laboratory Program. (OLM01.5) U.S. Environmental Protection Agency, Washington, D.C. 1993.

USEPA. 1994a. USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review. Office of Emergency and Remedial Response. USEPA, Washington, D.C. 1994.

USEPA. 1994b. USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review. Office of Emergency and Remedial Response. USEPA, Washington, D.C. 1994.