Natural Attenuation and Restoration Timeframe Evaluation

Alexander Avenue Petroleum Facilities Site
Tacoma, Washington
Ecology Facility Site No. 1377/Cleanup Site No. 743

AGENCY REVIEW DRAFT

Prepared for the Washington State Department of Ecology

May 16, 2017

Port of Tacoma

Table of Contents

1 Introduction 1

2 Background 3

2.1 Indicator Hazardous Substances & Screening Levels 3

2.2 Summary of Post RI Groundwater Sampling Results 4

3 Methods 5

3.1 Contaminant Time Series Analysis 5

3.1.1 Plume Stability 6

3.1.2 Attenuation Rates (k_{point}) 6

3.1.3 Half-life Calculation ($t_{1/2}$ attenuation) 6

3.1.4 Restoration Timeframe Calculation 6

3.2 Geochemical Evaluation 6

3.3 Concentration versus Distance Analysis 7

4 Results & Discussion 8

4.1 Delineating the Plume – Attenuation Zones 8

4.2 Contaminant Time Series Analysis 8

4.2.1 Plume Stability 9

4.2.2 Attenuation Rate (k_{point}) and Half-life results ($t_{1/2}$) 10

4.2.3 Restoration Timeframe 12

4.3 Geochemical Evaluation 14

4.4 Concentration versus Distance Analysis 14

4.4.1 Benzene 14

4.4.2 Gas-range TPH 16

4.4.3 Diesel & Oil-Range TPH with silica gel cleanup 16

4.4.4 Diesel & Oil-Range TPH without silica gel cleanup 17

5 Conclusions 19

6 References 21

Figures

Figure 2-1 - Groundwater Sampling Locations - 15 Foot Zone
Figure 2-2 - Groundwater Sampling Locations - 25 Foot Zone
Figure 2-3 - Benzene in Groundwater - 15 Foot Zone
Figure 2-4 - Benzene in Groundwater - 25 Foot Zone
Figure 2-5 - Gasoline-Range TPH in Groundwater - 15 Foot Zone
Figure 2-6 - Diesel & Oil-Range TPH with Silica Gel Cleanup in Groundwater - 15 Foot Zone
Figure 2-7 - Diesel & Oil-Range TPH without Silica Gel Cleanup in Groundwater - 15 Foot Zone
Figure 2-8a - Benzene Time Series - 15 Foot Zone
Figure 2-8b - Benzene Time Series - 25 Foot Zone
Figure 2-9a - Gasoline-Range TPH Time Series - 15 Foot Zone
Figure 2-9b - Gasoline-Range TPH Time Series - 25 Foot Zone
Figure 2-10a - Diesel & Oil-Range TPH Time Series - 15 Foot Zone
Figure 2-10b - Diesel & Oil-Range TPH Time Series - 25 Foot Zone

Figure 4-1 - Natural Attenuation Zones - 15 Foot Zone
Figure 4-2 - Natural Attenuation Zones - 25 Foot Zone
Figure 4-3 - Benzene Restoration Timeframe - 15 Foot Zone
Figure 4-4 - Benzene Restoration Timeframe - 25 Foot Zone
Figure 4-5 - Gasoline-Range TPH Restoration Timeframe - 15 Foot Zone
Figure 4-6 - Diesel & Oil-Range TPH Restoration Timeframe - 15 Foot Zone
Figure 4-7 - Geochemical Indicators in Groundwater
Figure 4-8 - Benzene - Concentration vs Distance
Figure 4-9 - Gasoline-Range TPH - Concentration vs Distance
Figure 4-10 - Diesel & Oil-Range TPH - Concentration vs Distance
Figure 4-11 - Diesel & Oil-Range TPH without Silica Gel Cleanup - Concentration vs Distance

Tables

Table 4-1 - Benzene Time Series Analysis

Table 4-2 - Gasoline-Range TPH Time Series Analysis

Table 4-3 - Diesel and Oil-Range TPH Time Series Analysis

Table 4-4 - Literature Review – Biodegradation Rates

Table 4-5 - Benzene - Concentration vs Distance Analysis

Table 4-6 - Gasoline-Range TPH - Concentration vs Distance Analysis

Table 4-7 - Diesel and Oil-Range TPH - Concentration vs Distance Analysis

Table 4-8 - Diesel and Oil-Range TPH without SGC - Concentration vs Distance Analysis

Appendix A: Data Tables

Table A1 - Groundwater Results - 15 Foot Zone

Table A2 - Groundwater Results - 25 Foot Zone

Table A3 - Seep Results

Table A4 - Groundwater Elevations

Table A5 - LNAPL Measurements

Table A7 - Historical Groundwater Data - 15 Foot Zone

Table A8 - Historical Groundwater Data - 25 Foot Zone

1 Introduction

The purpose of the memorandum is to provide supporting technical analysis for natural attenuation's inclusion as an alternative component with other remedial technologies at the Alexander Avenue Petroleum Facilities Site (Site). Site soil and groundwater are impacted by historical petroleum hydrocarbon releases. Analyses include quantifying the natural attenuation rate of benzene, gasoline-range total petroleum hydrocarbon (TPH), and diesel-range TPH, and estimating restoration timeframes for the fore stated contaminants. These estimates will be used in the upcoming Feasibility Study (FS) to evaluate which remedies may provide a reasonable restoration timeframe as required under the Model Toxics Control Act (MTCA).

Natural attenuation is defined by MTCA as the combination of physical (dispersion, dilution, volatilization), chemical (sorption and chemical degradation), and biological (biodegradation) processes that reduce the mass, toxicity, mobility, volume, or concentration of hazardous substances in the environment [WAC 170-143-200]. Natural attenuation, alone or combined with other clean up actions, can be an effective remedy for petroleum contaminated groundwater.

The Department of Ecology's (Ecology) guidance document, *Guidance on Remediation of Petroleum-Contaminated Groundwater by Natural Attenuation* (2005), outlines five factors that should be considered and evaluated when determining if natural attenuation is a feasible cleanup action alternative (Section 3.2.1) and meets the requirements set forth in WAC 173-340-360(2)[1] and WAC 173-340-370(7)[2]:

1. What is the status of the ground water plume at the site? Is the plume stable or shrinking?
2. Is chemical or biological degradation a substantial mechanism of natural attenuation at the site?
3. What is the estimated restoration time frame?
4. Will the use of natural attenuation be protective of human health and the environment during the estimated restoration timeframe?
5. Has source control been conducted to the maximum extent practicable?

This memorandum addresses requirements one through four (above) for the purpose of characterizing the role of natural attenuation in contaminant mass reduction and providing a tool for quantitative estimates of restoration timeframes. Methods from Ecology's Guidance were applied to evaluate the attenuation of benzene, gasoline-range petroleum, and diesel-range petroleum, which are Indicator Hazardous Substances at the Site.

This memorandum is organized as follows:

[1] WAC 173-340-360(2) – Minimum requirement for cleanup actions.
[2] WAC 173-340-370(7) – Ecology expectations for appropriate use of natural attenuation of hazardous substances as a cleanup action alternative.

Background (Section 2) – Summarizes the Site indicator hazardous substances presented in the remedial investigation (RI) and reevaluates select screening levels. presents the results of post RI groundwater and seep sampling that was conducted to support this work.

Methods (Section 3) – Presents the analytical techniques applied in the evaluation and references applicable guidance documents.

Results and Discussion (Section 4) – Presents the results of the analyses described in the methods section: plume stability, attenuation rates, contaminant half-life values, restoration timeframe estimates, secondary geochemical indicators of biodegradation, and concentration versus distance analysis. Published half-life values for benzene and diesel-range TPH are also presented for comparison to Site results.

Conclusions (Section 5) – Summarizes the Site restoration timeframes at the standard point of compliance in the upland, as well as the time necessary to reach screening criteria at the tideline under natural attenuation only remedial action.

References (Section 6) – References used for developing this memorandum.

2 Background

This section summarizes the Site indicator hazardous substances presented in the RI and reevaluates select screening levels, and presents the post RI groundwater and seep sampling that was conducted to support this work.

2.1 Indicator Hazardous Substances & Screening Levels

The RI Report (RI; Aspect, 2016), presents the chemical specific screening levels by particular media and exposure pathway that are determined to be protective of human health and the environment. The chemical concentrations detected in Site media were compared to those screening levels to determine chemicals of concern (COCs) and indicator hazardous substances (IHSs). The Site qualifies as an industrial property under MTCA, and human consumption of Site groundwater is not a complete exposure pathway because Site groundwater is considered non-potable in accordance with MTCA (WAC 173-340-720(2)). Groundwater screening levels were considered for discharge to marine surface water (ecological and human health exposures for each groundwater zone including seeps), and vapor intrusion (human health exposure for the 15-foot shallow groundwater zone but not applied to seeps). Soil screening levels were considered for direct contact (human health) under industrial land use; and protection of groundwater (human health and ecological receptors) applying marine surface water and vapor intrusion receptors but adjusted to appropriate modifying factors including natural background and practical quantitation limits. Site COCs were identified based on detections above screening levels with several chemicals not retained due to both low frequency and magnitude of exceedances, or a correlation to the 709 embankment fill area and elevated pH plume associated with the neighboring Occidental Chemical Corporation (OCC) site.

IHSs were identified based on the frequency and magnitude of exceedance of COCs in each medium at the Site and were presented in the RI to illustrate the extent of contamination and to define the scope of remedial actions. The Site IHSs included benzene, gasoline-range TPH, diesel-range plus heavy-oil-range TPH, and tetrachloroethene (PCE), trichloroethene (TCE), and vinyl chloride (VC). Other chemicals were only sporadically detected or are correlated to IHSs but cover a smaller footprint and have lower exceedance of screening levels include 1,1-dichloroethene, ethylbenzene, 1,2,4-trimethlybenzene, xylenes, and naphthalene. This analysis of monitored natural attenuation focuses on the IHS's benzene, gasoline-range TPH and diesel and oil-range TPH. The attenuation potential of other IHSs are not evaluated as these chlorinated volatile organic compounds are generally on the north end of the Site and will be addressed by OCCs future cleanup actions (GHD 2017).

On November 15, 2016 EPA made a decision which included a partial approval and partial disapproval of Washington State's surface water quality standards (WAC 173-201A) to ensure that state adopted criteria are set at levels to adequately protect fish consumers in Washington from exposure to toxic pollutants. In light of this decision the screening levels for the IHSs presented in the RI are reexamined with regards to evaluating monitored natural attenuation.

- For benzene two screening levels were presented in the RI, 24 µg/L representing the vapor intrusion (VI) pathway and 58 µg/L representing groundwater discharge to marine surface water. Based on EPA's decision the human health criteria applied to groundwater discharge to marine surface water reduces the screening level from 58 µg/L to 1.6 µg/L.

- Gas-range and diesel-range TPH screening levels are based on MTCA Method A cleanup levels for groundwater, they are 800 µg/L and 500 µg/L respectively. Surface water quality criteria do not exist for gas or diesel. Because human consumption of Site groundwater is not a complete exposure pathway these screening criteria for gas-range and diesel-range TPH were considered highly conservative in the RI. The RI also evaluated the use of silica gel cleanup (SGC) in the groundwater analysis of TPH, citing recent studies that conclude the vast majority of polar organic compounds removed by SGC have low human health toxicity and do not increase aquatic toxicity of the groundwater.[3] The RI also concludes that comparing the non-SGC TPH data to groundwater TPH cleanup levels is conservative. EPA's recent decision does not directly affect the TPH screening levels. For the purpose of this MNA analysis the gas-range and diesel-range TPH screening levels are unchanged from the RI, but they are still considered highly conservative.

Preliminary cleanup levels, points of compliance, and potentially remediation levels for Site COCs will be considered in the FS. The FS will also evaluate the potential effect of OCCs proposed cleanup action at the neighboring property on potential cleanup actions at this Site. Regarding monitored natural attenuation this evaluation estimates restoration timeframes on a well by well basis consistent with MTCA's standard point of compliance approach. This evaluation also considers a pathway analysis (Sec. 4.4) that may be used in the FS to support the use of conditional points of compliance and/or remediation levels.

2.2 Summary of Post RI Groundwater Sampling Results

As described in the RI/FS Work Plan Addendum No. 1 (Aspect, 2015), at the close of the RI, the Port of Tacoma (Port), Mariana Properties, Inc. (Mariana), and the Washington State Department of Ecology (Ecology) decided additional data collection was necessary to complete the Remedial Investigation/Feasibility Study (RI/FS). The primary objective of the additional data collected was to support quantitative estimates of restoration time frames for achieving potential groundwater cleanup levels for Site COCs and at a potential conditional point of compliance for various remedial alternatives.

Wells selected for an additional year of quarterly sampling were chosen based on a record of historical data points and elevated COC concentrations. Eighteen wells were sampled in the 15-foot zone, five wells were sampled in the 25-foot zone, and three seeps were sampled.

The sampling network is presented in Figures 2-1 and 2-2. Wells were sampled in December 2015, February 2016, May 2016, and August 2016. Seeps were sampled in May 2016 and August 2016. The water level measurements from the four quarters as well as all historical concentration for the indicator constituent are included as summary tables in Appendix A. Concentrations for the indicator constituents for the last four quarters were averaged and concentration isopleths were prepared for benzene in the 15 and 25 foot aquifer, gasoline in the 15 foot aquifer, and diesel with and without silica gel cleanup in the 15 foot aquifer (See Figures 2-4, 2-5, 2-6 and 2-7). These are considered current conditions for use in estimating restoration time frames for the FS alternatives. Time series trends over the Site monitoring history are presented in Figures 2-8, 2-9, and 2-1

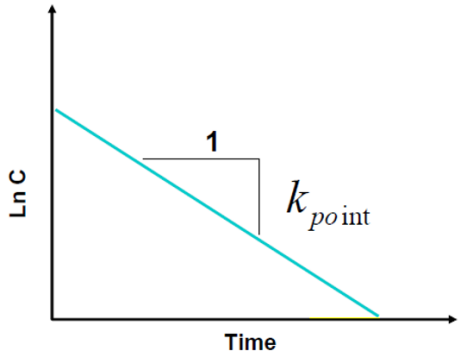
[3] Since the RI, an additional study has been published which found metabolites in groundwater in classes ranked as low toxicity to humans (Zemo et al. 2016).

3 Methods

Methods described in this Section are presented in Ecology's guidance document, *Guidance on Remediation of Petroleum-Contaminated Groundwater by Natural Attenuation* (2005), and from the Environmental Protection Agency's guidance document, *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities* (2009). Time series analysis as described in Appendix F of Ecology's Guidance is used to assess plume stability, and calculate attenuation rates, restoration timeframes, and half-life values (Sec 3.1). In addition to time series analysis, groundwater geochemical parameters are used to qualitatively assess the role of biodegradation in attenuation of contaminant mass (Sec 3.2). Lastly, data is spatially analyzed by plotting concentration data over distance along the plume centerline as described in Appendix F of Ecology's Guidance to assess seep restoration timeframe.

3.1 Contaminant Time Series Analysis

Concentrations for the indicator constituents were natural log transformed and plotted versus time for each well location (Ecology 2005, Appendix F). The slope of the best-fit line of the linear regression analysis is an approximation of the attenuation rate at that point in the plume.



(Ecology, 2005, Figure F.1)

k_{point} = **Point decay rate constant: Slope of natural log ground water concentration (Ln C_t) vs. time plot at a well**

The slope of the line is then evaluated by the R^2 value and the application of a confidence interval. The R^2 value represents the fraction of the variance in Y (concentration data) that is explained by the simple linear regression model. A R^2 value of 1 indicates a perfect linear relationship, and zero indicates no linear relationship. A R^2 of zero does not necessarily mean that there is not a relationship between X and Y, but that there is no linear relationship within the historical sample of data that is being analyzed.

The statistical significance of the linear regression trend was determined using an 85% confidence interval and a 15% probability of error. An 85% confidence level is recommended by Ecology for statistical significance testing (Ecology, 2005). The level of confidence is the probability that the slope of the trend is significantly different from zero. The statistical trend test applied to the well data was selected based on the sample size. Linear regression trend tests require a sample size of at least 8. For wells with a sample size of 8 or greater a linear regression trend test was applied (EPA, 2009: Section 17.3.1). Wells trends with a sample size of less than 8 were tested for significance using the Mann Kendall trend test, a non-parametric method where the data do not need to be normal or follow a particular distribution (EPA, 2009: Section 17.3.2).

3.1.1 Plume Stability

For plume stability determinations Ecology recommends the following criteria: for a contaminant plume to be considered stable or shrinking, monitoring well concentrations should be stable or shrinking in at least 80% of the wells within the plume (Ecology 2005, Table 3.2). Time-series trends are declining (shrinking) if the sign of the slope of the line is negative. For the purposes of evaluating plume stability the statistical significance of the trends was not considered.

3.1.2 Attenuation Rates (k_{point})

As mentioned above (Sec 3.1), the slope of the best-fit line of the natural log transformed concentration data plotted versus time is an approximation of the attenuation rate, also referred to as the decay rate, at a particular well (k_{point}).

3.1.3 Half-life Calculation ($t_{1/2}$ attenuation)

Half-life ($t_{1/2}$) of the contaminants were calculated from the attenuation rate using the following equation from Ecology's Guidance (Eq. B.2):

$$t_{1/2} = \frac{\ln(2)}{(k_{point})}$$

Typically half-life values are calculated with a biodegradation rate (λ) rather than an attenuation rate constant (k_{point}). Biodegradation rates can be estimated from the calibration of a groundwater solute transport model (for example, BIOSCREEN). We did not use model calibration to assess the fraction of attenuation that can be attributed to biodegradation at the Site, this technique may be applied during FS development.

3.1.4 Restoration Timeframe Calculation

Restoration timeframes were calculated using the following equation (Ecology, 2005, Eqn F.2):

$$t = \frac{\ln\left(\frac{SL}{C_{current}}\right)}{-k_{point}}$$

Where t is the time it will take for the contaminant concentration to reach the screening level criteria; SL is the screening criteria; $C_{current}$ is the current contaminant concentration; and $-k_{point}$ is the attenuation rate (decay rate constant).

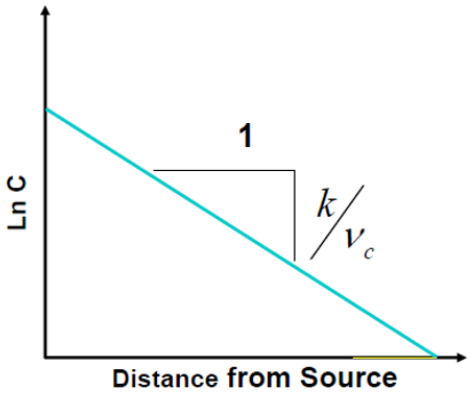
3.2 Geochemical Evaluation

Biodegradation of contaminant mass involves the degradation of hydrocarbons into other compounds by indigenous microbes through aerobic and/or anaerobic respiration. During respiration electrons are transferred from an electron donor (petroleum hydrocarbons) to an electron acceptors. In the process electron acceptors are reduced. Naturally abundant electron acceptors in an aquifer are dissolved oxygen (DO), nitrate (NO_3^-), manganese (Mn^{4+}) ferric iron (Fe^{3+}), sulfate (SO_4^{2-}), and finally carbon dioxide (CO_2). The metabolic byproduct of the reduced species, respectively, are carbon dioxide (CO_2), nitrogen gas (N_2), manganese (Mn^{2+}), ferrous iron (Fe^{2+}), hydrogen sulfide (H_2S), and methane (CH_4).

As part of the RI monitoring select wells were analyzed for geochemical indicators of biodegradation (Aspect, 2016). Groundwater samples were analyzed for electron acceptors (dissolved oxygen, nitrate, nitrite, and sulfate) and products of biodegradation (dissolved manganese, methane, and alkalinity).

3.3 Concentration versus Distance Analysis

Concentration versus distance analysis was applied to estimate the necessary reductions in concentrations at the shoreline to arrive at seep contaminant concentrations that meet the screening criteria. Natural-log transformed concentration data from monitoring wells positioned along the center line of the plume(s) were plotted versus distance.



(Ecology, 2005, Figure F.2)

k/v_c = Slope of natural log concentration (Ln C_x) vs. distance plot.

k = Bulk Attenuation rate: Slope * Contaminant Velocity (V_c)

To estimate plume length the trend line can be projected forward to the screening criteria. Alternatively, the distance the contamination would have to travel down-gradient from the source to reach the screening criteria can be calculated using the following equation (Ecology, 2005, Eq. F.5):

$$x = -ln\left(\frac{C_{SL}}{C_{start}}\right) * \frac{v_c}{k}$$

Where x is the travel distance; C_{SL} is the screening criteria; C_{start} is the concentration at the up-gradient monitoring well; v_c is contaminant velocity; and k is the bulk attenuation rate. Equation F.5 can be rearranged to solve for the C_{start} concentration in the upgradient source area well necessary for the concentration at the corresponding downgradient shoreline well to meet the screening criteria.

$$C_{start} = \frac{C_{SL}}{e^{x*\frac{k}{v_c}}}$$

Where x is the distance between the two wells, and k/v_c is the slope of the natural log transformed concentration versus distance trendline.

4 Results & Discussion

Results are presented in the same sequence as outlined in the Methods section. First the results of the time series analysis will be presented, then the geochemical evaluation, and finally the outcome of the concentration versus distance analysis. This section will present the results and preliminary interpretations.

4.1 Delineating the Plume – Attenuation Zones

Before applying the natural attenuation analyses we recognized that the Site can be defined by three zones: the source zone (SZ), the attenuation zone (AZ), and the groundwater to surface water transition zone (TZ; Figure 4-1 and 4-2). The source zone is defined by the area of the well network where light non-aqueous phase liquid (LNAPL) was detected during the RI (Aspect 2016, Figure 6.2-2) [4]. LNAPL forensic testing indicates a mixture of weathered gasoline- and middle-distillate diesel-range TPH, with the majority of product in the diesel range (Aspect 2016). Surrounding the source zone is the attenuation zone, the area where contaminants (benzene, gas-range TPH, and diesel-range TPH with SGC) were detected above screening criteria during the RI. The transition zone designation is intended to describe the area near the shoreline where groundwater is mixing with seawater due to tidal fluctuation and where geochemical conditions change relative to the attenuation zone that enhance biodegradation processes. Measurement of geochemical indicators at select wells found elevated sulfate in shoreline wells, likely indicating seawater influence (Sec 4.3). The transition zone is defined at the area from the mean higher high water line to 50 feet inland, however tidal fluctuations have been observed as far upland as 200 ft.

Contaminant attenuation rates may be depressed in the source zone where LNAPL is still present, and accelerated in the transition zone where mixing with seawater dilutes contaminant mass and the addition of electron acceptors accelerates biodegradation.

4.2 Contaminant Time Series Analysis

Concentration data for the indicator constituents are presented in summary tables in Appendix A. The results of the time series analysis for benzene, gas-range TPH, and diesel-range TPH are presented Tables 4-1, 4-2, and 4-3, respectively. Data and results presented in the Tables are organized into sections, *Well data*, *Linear Trend Analysis, Significance, Half-Life, Restoration Timeframe,* and *Summary by natural attenuation zone*.

Basic well data is presented in *Well data,* included the contaminant concentration at the time of the initial sampling event (dates vary across well locations), current contaminant concentration (the average over the last four quarterly sampling events), the sample size (i.e. number of sampling events at the well location), and record length. The screening level for each groundwater zone is presented in the *SL (ppb)* block above the *Well data.* The results of the linear trend analysis are presented in *Linear Trend Analysis*, including attenuation rate (the slope of the linear regression), and the R^2 value. The *Significance* column presents the results of the statistical significance testing. The *Restoration Timeframe* section presents both the restoration timeframe (in years) calculated from the well specific attenuation rate constant and

[4] NAPL was either directly observed, or trace NAPL was observed in the form of sheen and a strong TPH odor.

from the "average" attenuation rate constant. The "average" attenuation rate constant is determined by a selecting the most reliable values at individual wells based on the R^2 value and the statistical significance test results and averaging them as a way to give more weight to the more reliable trends and exclude less reliable trends, additional details are presented in section 4.2.2. These values are summarized under the *Summary by natural attenuation zone* header. And lastly, the *Half-Life* column presents the results of the attenuation half-life values calculated at each well location. Wells data is color-coded by attenuation zone: red for source zone wells; yellow for attenuation zone wells; and green for transition zone wells.

4.2.1 Plume Stability

The results of the plume stability assessment for benzene, gas-range TPH, and diesel-range TPH are presented below.

4.2.1.1 Benzene

The Benzene plume in the 15 foot zone is shrinking. Of the 18 wells monitored in the 15-ft zone, 17 (94%) have declining trends (negative slopes; Figure 2-8 and Table 4-1). Five wells in the 25-ft zone were analyzed, four (80%) have declining trends. The Benzene plume in the 25-ft zone is also shrinking.

4.2.1.2 Gas-Range TPH

Six wells (33%) have declining trends and 12 wells (67%) have increasing trends (positive slopes; Figure 2-9 and Table 4-2). Of the five wells in the 25-ft zone, there have been only a few detections. One well has consistently had gas detections above the MDL (MW-104-25). The trend line for the data is nearly flat and all detections have been below the Site Screening Level (800 ug/L).

Increasing trends in the 15-ft zone were unexpected. It is unlikely that that gas plume could be expanding due to the age of the release. The gas analysis may be skewed due to the relatively short time frame over which groundwater has been analyzed at the Site. Most wells have been analyzed for gas-range petroleum since only 2012. Four wells have pre-2012 gas-range data: 721-MW3 (1995 and 2008); 721-MW2 (2008); 709-MW11-15 (2004); 709-MW17-15 (2004). Of the four listed wells, three have decreasing trends. The historical monitoring data is insufficient to effectively characterize the stability of the gas plume. Over the short term the concentration trends may be masked by water table fluctuations, precipitation, sampling variability, and/or analytical uncertainly.

4.2.1.3 Diesel & Oil-Range TPH

Ten wells (56%) have decreasing trends, and 8 (44%) have increasing trends (Table 4-3). Diesel trends in the 25-ft zone were not analyzed because all groundwater monitoring results were below the Site screening level (500 ug/L).

The 15-ft diesel plume does not meet the Ecology's recommended 80% of stable of shrinking wells in the contaminated plume to consider the plume to be stable or shrinking. However the majority of wells do have declining trends. Similar to the gas analysis, this diesel analysis may be skewed due to the relatively short time frame that groundwater has been monitored at the site, with most well samples only analyzed for diesel-range petroleum since 2012. In addition, the footprint of the diesel-plume without SGC is much larger than the footprint of the diesel-plume with SGC, which now occupies an area centered around the source area. This greater extent of the diesel-plume without SGC may indicate ongoing production of polar compounds from biodegradation of TPH, and the higher solubility and subsequently greater mobility of polar compounds (Aspect 2016). On average, concentration results

with SGC are 1/10th of the concentration from analysis without silica gel cleanup. The 15-ft diesel plume is shrinking, and there is no diesel plume in the 25-ft zone.

4.2.2 Attenuation Rate (k_{point}) and Half-life results ($t_{1/2}$)

Attenuation rate and half-life results for benzene, gas-range TPH, and diesel-range TPH are presented in Table 4-1, 4-2, and 4-3 under the *Linear Trend Analysis* and *Half-Life* columns. The results of the statistical significance testing and R^2 values were used to calculate an average attenuation rate and half-life value for wells in the source zone, attenuation zone and transition zone (as previously described in Section 4.2). The estimated attenuation rate and half-life value ($t_{1/2}$ attenuation) is a function of source decay, advection, dispersion, sorption, and dissolved phase biodegradation.

Typically half-life values are calculated for the biodegradation rate (λ) rather than attenuation rate constant (k_{point}). To roughly estimate the biodegradation half-life ($t_{1/2}$ biodegradation) values at the Site we applied a mixing model developed for Terminal 30 at the Port of Seattle. Terminal 30 is similar to the Alexander Avenue Petroleum Facilities Site: a petroleum release to a shallow, tidally influence aquifer in dredge fill and native tideflats. The natural attenuation study conducted at Terminal 30 developed a mixing model to estimate the physical process of attenuation (tidal mixing, dispersion and diffusion). By subtracting the physical attenuation rate from the gross attenuation rate they were able to estimate the ratio of attenuation attributable to biodegradation. The study found that on average about 65% of the observed attenuation was due to biodegradation (RETEC, 2006).

To compare Site specific half-life values to literature half-life values we've made the assumption that biodegradation rate at the Site is similar to biodegradation rates at Terminal 30 and accounts for roughly 50% of contaminant attenuation. Both attenuation rate half-life values and biodegradation half-life values are presented below.

4.2.2.1 Benzene

Eleven (11) wells had decreasing trends significantly different from zero across all three natural attenuation zones (Table 4-1). A summary is presented below.

Natural Attenuation Zone	*Wells with significant trends*	*Average attenuation rate (k_{point})*	*Average $t_{1/2}$ - attenuation*	*Average $t_{1/2}$ - biodegradation*
SZ	709-MW-09-15, 721-MW15-15, 721-MW2, 721-MW8-15	-3.16×10^{-4}	6	12
AZ – 15 foot	709-MW-11-15, 709-MW-17-15, MW-130-15	-9.50×10^{-4}	2	4
AZ – 25 foot	MW-110-25 and MW-137-25	-2.47×10^{-3}	1	2
TZ	721-MW9-15 and 95-15	-6.60×10^{-4}	3	6

The SZ attenuation rate (-3.16×10^{-4}) is the lowest rate across natural attenuation zones, followed by the TZ (-6.60×10^{-4}), and the highest rates of attenuation is in the AZ (-9.50×10^{-4} and -2.47×10^{-3}). Based on the

results of this analysis our hypothesis in Sec. 4.1 that attenuation would be accelerated in the TZ relative to the AZ zone does not appear to be true for benzene.

Literature values for dissolved benzene half-life from in-situ field studies are between 0.2 to 0.7 under aerobic biodegradation and 0.6 years for anaerobic degradation (Lawrence, 2006). In comparison, Site anaerobic biodegradation half-life values in the attenuation and transition zone are roughly 2 to 6 years, 10 times greater than literature values. A summary of table of literature values is presented in Table 4-4.

4.2.2.2 Gasoline-Range TPH

There are no statistically significant decreasing gas trends, a criteria of R^2 greater than 0.1 was used to calculated average half-life values for the source zone and attenuation zone (Table 4-2). A summary table is presented below.

Natural Attenuation Zone	*Wells with $R^2 > 0.1$*	*Average attenuation rate (k_{point})*	*Average $t_{1/2}$ - attenuation*	*Average $t_{1/2}$ - biodegradation*
SZ	709-MW-09-15 and MW-109-15	-3.22×10^{-4}	6	12
AZ – 15 foot	709-MW-11-15	-3.78×10^{-4}	5	10
AZ – 25 foot	MW-110-25 and MW-137-25	-1.75×10^{-3}	1	2
TZ	-- no wells meet statistical criteria --	--	--	--

The SZ attenuation rate is (-3.22×10^{-4}) the lowest rate across natural attenuation zones, followed by AZ (-3.78×10^{-4} and -1.75×10^{-3}). An average rate for the TZ was not calculated because none of the wells met the statistical screening criteria of R^2 greater than 0.1. Site anaerobic biodegradation half-lifes for dissolved gas-range TPH in the attenuation zone are 2 to 10 years.

4.2.2.3 Diesel & Oil-Range TPH

There is one well with a statistically significant decreasing trend for diesel, attenuation zone well 721-MW3 (Table 4-3). A criteria of R2 greater than 0.1 was used to calculated average half-life values for the source zone and attenuation zone. A summary table is presented below.

Natural Attenuation Zone	*Wells with $R^2 > 0.1$*	*Average attenuation rate (k_{point})*	*Average $t_{1/2}$ - attenuation*	*Average $t_{1/2}$ - biodegradation*
SZ	709-MW-09-15, 721-MW12-15, 721-MW14-15, and 721-MW6-15	-2.17×10^{-4}	9	18
AZ – 15 foot	721-MW3	-3.98×10^{-4}	5	10
AZ – 25 foot	-- no diesel plume in the 25-ft zone --	--	--	--

TZ	-- no wells meet statistical criteria --	--	--	--

The SZ attenuation rate (-2.17×10^{-4}) is the lowest rate across natural attenuation zones, followed by AZ (-3.98×10^{-4}). Results are not shown for the AZ – 25-foot zone because time-series analysis was not applied to diesel and oil-range TPH the 25-foot zone. Results from the TZ are not shown because none of the wells met the statistical screening criteria of R^2 greater than 0.1. Literature values for diesel half-life from in-situ field studies range from 2.5 to 15 years and as short as 0.06 years under aerobic conditions (Table 4-2; PGG, 2016, and Cunningham, 2004). In comparison, the Site anaerobic biodegradation half-life in the attenuation zone is roughly 5 years.

In summary, for all three contaminants the SZ attenuation rate is lower than the AZ attenuation rate. This is likely due to the presence of LNAPL in in the source zone. Half-life values for benzene in the AZ are roughly 10 times that of reported literature values, literature biodegradation rates for gas-range TPH are not available, and biodegradation half-life values for diesel and oil-range TPH in the AZ are within the range of reporting literature values.

4.2.3 Restoration Timeframe

Restoration timeframes were calculated from the well specific attenuation rate constants. If the trend at the well had a positive slope a restoration timeframe could not be calculated from well specific data, in this case the average attenuation rate constant for either the source zone or the attenuation zone (Sec. 4.2.2) was applied to the current concentration to calculate the restoration timeframe (Tables 4-1, 4-2, and 4-3). A restoration timeframe of zero indicates that the current concentration at the well is below screening criteria. As discussed in section 4.2, the results of the time series linear regression analysis have varying levels of certainty across the well network. Greater confidence is put in future concentration projections for wells with decreasing trends that are significantly different from zero and, or, have a R^2 values greater than 0.1.

4.2.3.1 Benzene

For benzene, the restoration timeframe in the source zone ranges from 9 to 156 years, and from 5 to 67 years in the attenuation zone/transition zone. In the 25-foot attenuation zone the restoration timeframes ranges from 2 to 152 years (Figure 4-3 and 4-4).

Of the 10 wells in the source zone, the two wells along the northeast boundary have concentrations below the screening criteria, 709-MW9-15 and 721-MW8-15. The longest restoration time is in the western source zone at well 721-MW2, 156 years. The remaining 7 source zone wells will be restored between 9 and 44 years. The disproportionately long restoration timeframe at well 721-MW2 is likely due to the presence of measureable LNAPL at this location.

Of the eight wells in the attenuation zone and transition zone, three have concentrations below the screening criteria, the two wells to the west of the source zone will be restored in 9 to 15 years (MW-130-15 and HC-N11-6, respectively). The wells with the longest restoration timeframes are 721-MW3 and MW-104-15. Well 721-MW3 is immediately adjacent to the source zone and has a restoration timeframe of 52 years. Well MW-104-15 is in the transition zone and has a restoration timeframe of 67 years. Well MW-104-15 has a very short sampling history (it was installed in October 2014) and does not

have a linear trend that is significantly different from zero and the R^2 value is less than 0.1. The historical monitoring data is insufficient to effectively characterize the long-term trend. If the average attenuation rate constant for wells with statistically significant trends in the attenuation zone is applied to the current concentration at well MW-104-15 (368 µg/L), the restoration timeframe is 18 years.

In the 25-foot attenuation zone, wells 721-MW-10-25 and MW-105-25, do not have statistically significant trends and have R^2 value is less than 0.1 Both wells have long restoration timeframes applying their individual decay rate constants, 119 and 152 years. If the average decay rate constant for wells with statistically significant trends in the 25-foot attenuation zone is applied to current well concentrations (111 and 140 µg/L, respectively), the restoration timeframe is reduced to 5 years at both wells.

4.2.3.2 Gas-range TPH

For gas, the restoration timeframe in the source zone ranges from 4 to 124 years, and from 3 to 80 years in the attenuation zone (Figure 4-5). In the 25-foot zone concentrations are below the screening criteria.

Of the 10 wells in the source zone, well 721-MW2 has the longest restoration timeframe at 124 years, historically concentrations have stayed relatively flat for at this location, likely due to the presence on LNAPL. If the average attenuation rate from wells 709-MW-9-15 and MW-109-15 is applied to the current concentration at 721-MW2, the restoration timeframe is reduced from 124 year to 13 years. The remaining source zone wells are projected to be restored in 4 to 34 years.

Of the eight wells in the attenuation zone and transition zone well 721-MW3 has the longest restoration timeframe at 80 years, the well is immediately adjacent to the source zone. The remaining six wells will be restored in 3 to 11 years. As previously mentioned in section 4.2.1.2 the gas analysis is likely skewed due to the relatively short time frame over which groundwater has been analyzed at the Site. No wells were found to have decreasing trends that were significantly different than zero, two decreasing trend in the source zone had R^2 values greater than 0.10, 709-MW-9-15 and MW-109-15, and one decreasing trend in the attenuation zone had a R^2 values greater than 0.10, 709-MW-11-15. In the gas dataset these three wells have the most reliable attenuation rates. If the attenuation rate at well 709-MW-11-15 is applied to well 721-MW3, the well reaches the screening criteria in 5 years instead of 80 years.

4.2.3.3 Diesel & Oil-Range TPH

For diesel with SGC, the restoration timeframe in the source zone ranges from 1 to 42 years, and from 2 to 12 years in the attenuation zone (Figure 4-6). In the 25-foot zone concentrations are below the screening criteria.

Of the 10 wells in the source zone, the six wells on the eastern half are already below screening criteria or will meet it within the next year. The four wells on the western half of the source zone have the longest restoration timeframes, ranging from 20 to 42 years. Well 721-MW2 has the longest restoration timeframe, at 42 years. Well 721-MW2 does not have a significant trend and the R^2 value is 0.06, historically concentrations have stayed relatively flat for at this location. If the average attenuation rate from source zone wells with R^2 value greater than 0.10 is applied to well 721-MW2 the restoration timeframe is reduced from 42 years to 13 years.

Of the eight wells in the attenuation zone and transition zone, five have concentrations below the screening criteria, the two wells to the north of the source zone will be restored in 12 to 14 years (709-

MW-17-15 and 709-MW11-15), and the well to the east of the source zone will be restored in 2 years (HC-N11-15).

Restoration timeframes cannot be estimated for diesel without SGC with available site data.

4.3 Geochemical Evaluation

Electron acceptors nitrate, nitrite, and sulfate are depleted in the petroleum impacted area and the bi-product of biodegradation, methane, is elevated in the source zone relative to the attenuation zone (Figure 4-7). Further subtleties in the relationships between geochemical indicators and contaminant presence are difficult to assess due to the absence of background data from outside the boundaries of the petroleum plumes. Generally, reactants (nitrate, nitrite, dissolved oxygen and sulfate) are depleted in areas of petroleum impact relative to metabolic by-products (alkalinity, dissolved manganese, and methane), an indication that biodegradation is actively destroying contaminant mass.

High concentrations of sulfate, likely from seawater intrusion, were observed in shoreline wells. The contribution of sulfate from seawater intrusion enhances biodegradation of petroleum via sulfate-reducing metabolic processes and is a likely contributor to the natural attenuation of petroleum hydrocarbons close to the shoreline.

4.4 Concentration versus Distance Analysis

Concentration versus distance analysis was applied used to estimate the potential reductions in source zone concentrations needed to meet screening criteria at the shoreline. Concentration versus distance analyses were conducted for Site plumes in the 15-ft aquifer including benzene, gas-range TPH, diesel-range TPH with and without silica gel cleanup. Separate analyses were completed for each side of the groundwater divide. The eastern transect includes wells four source zone wells (MW-106-15, MW-109-15, 721-MW6-15, and 721-MW11-15), one transition zone well (MW-104-15), and seep SP-103. Due to differing attenuation rates in the source and attenuation zones (SZ/AZ) and the transition zone (TZ), a regression analysis was applied separately to each zone. The SZ/AZ transect is from well MW-106-15 to MW-104-15, and the TZ transect is from well MW-104-15 to SP-103. The western transect includes wells two source zone wells (721-MW15-15 and 721-MW2) and two attenuation zone wells (HC-N11-6 and MW-130-15). The SZ/AZ transect is from well 721-MW-15-15 to MW-130-15. The western transect does not have a shoreline well or seep data.

4.4.1 Benzene

Table 4-5 and Figure 4-8 present the results of the concentration versus distance analysis for benzene. The table and figure present the average concentrations along with the linear regression of the natural log transformed data and statistical tests that support the concentration versus distance analysis. The results are presented below by transect.

4.4.1.1 Eastern Transect

Along the eastern transect the downgradient source zone well (721-MW11-15) has an average concentration of 570 µg/L, the downgradient shoreline well (MW-104-15) has an average concentration of 368 µg/L, and the seep (SP-103) has an average concentration of 14 µg/L. The SP-103 seep concentration exceeded the screening criteria of 1.6 µg/L in August 2016 with benzene reported at 27

µg/L, the May 2016 result was non-detect at 0.2 µg/L. Benzene results were non-detect at locations SP-101 and SP-102 during both May and August 2016.

The concentration versus distance analysis results indicate the slope of the source zone and attenuation zone regression is -1.03×10^{-3} with an R^2 value of 0.18. This regression is not statistically significant. The slope of the transition zone regression is -5.69×10^{-2}. With only two data points the statistical tests are not relevant.

By applying the concentration versus distance regressions we can estimate the amount of mass reduction needed to lower the seep concentration below the surface water screening criteria of 1.6 µg/L. Using the TZ regression, the concentration at the upgradient shoreline well (MW-104-15) would need to be reduced from 368 µg/L to 43 µg/L, a reduction of 88%. Based on the current benzene attenuation rate at well MW-104-15 it would take 26 years to achieve this reduction.

Using the SZ/AZ regression, to achieve the target concentration of 43 µg/L at the shoreline well, the concentration at the upgradient source zone well (721-MW-11-15) must be reduced from 570 to 411 µg/L, a reduction of 28%. Based on the current benzene attenuation rate at this well it will take 2 years to achieve this reduction.

The shoreline well (MW-104-15) has surprisingly high concentrations of benzene considering its location, roughly 340 feet from the source zone and within the transition zone where attenuation is thought to be accelerated due to mixing of groundwater with seawater. The concentration at MW-104-15 could be elevated as a remnant of historically higher source zone concentrations paired with a preferential pathway, accelerating the benzene plume migration towards MW-104-15 and seep SP-103.

4.4.1.2 Western Transect

The western transect does not have a shoreline well or seeps samples. The two source zone wells, 721-MW15-15 and 721-MW2 have average concentrations of 1350 µg/L and 908 µg/L, respectively. The attenuation wells HC-N11-6 and MW-130-15 have average concentrations of 256 µg/L and 94 µg/L, respectively. Monitoring well MW-130-15, the most downgradient transect well is ~400 feet from the Blair Waterway. With the change in benzene's screening criteria to 1.6 µg/L described in Section 2.1, the extent of benzene on the western side of the site is no longer fully delineated in either the 15-foot or 25-foot aquifers.

The concentration versus distance analysis results indicate the slope of the SZ/AZ regression is -6.98×10^{-3} with an R^2 value of 0.995. This regression is statistically significant. While there is no regression available from the Western transition zone, if the eastern transition zone regression is applied, the concentration at a well 50 feet from the shoreline would need to be 28 µg/L or less to be protective of seeps in the Blair Waterway. This assumes the shoreline well is located approximately 50 feet in from the Blair Waterway and 344 feet from monitoring well MW-130-15. To achieve the target concentration of 28 µg/L at the shoreline well, the concentration at the up-gradient source zone well (MW-130-15) must be 303 µg/L or less, the current concentration at the up-gradient well is 94 µg/L, below the protective threshold.

The benzene concentration in the 25-foot aquifer shoreline well (MW-137-25) is 14 µg/L, well below the estimated upgradient concentration necessary at the shoreline to be protective of surface water. The

results indicate that no source mass reduction is needed to achieve the screening criteria of 1.6 µg/L at the western shoreline.

4.4.2 Gas-range TPH

Table 4-6 and Figure 4-9 present the results of the concentration versus distance analysis for gas-range TPH along the eastern and western transects.

4.4.2.1 Eastern Transect

On the eastern transect gas-range TPH concentrations did not exceed screening criteria (800 µg/L) at the seep locations (SP-101, SP-102, and SP-103) in May or August 2016. The current average concentration of 544 µg/L in the shoreline well (MW-104-15) is also below the screening criteria. The analytical results indicate that no source mass reduction is needed to achieve the screening criteria at the eastern shoreline.

The concentration versus distance analysis results indicate the slope of the SZ/AZ regression is -4.00×10^{-3} with an R^2 value of 0.95. This regression is statistically significant. The slope of the TZ regression is -5.31×10^{-2}, with only two data points the statistical tests are not relevant. This analysis may be valuable during the feasibility study for evaluating the response of gas-range TPH to potential remedial alternatives.

4.4.2.2 Western Transect

Along the western transection source zone wells (721-MW15-15 and 721-MW2) currently have average concentrations of 4,800 µg/L and 3,475 µg/L, while the downgradient attenuation zone well (MW130-15) has an average concentration of 2,025 µg/L. There are no shoreline wells or seeps sampled along the Western Transect.

The concentration versus distance analysis results indicate the slope of the SZ/AZ regression is -1.91×10^{-3} with an R^2 value of 0.86. This regression is statistically significant. While there is no regression available from the Western transition zone, if the eastern transition zone regression is applied, the concentration at a well 50 feet from the shoreline would need to be 11,378 µg/L or less to be protective of seeps in the Blair Waterway. This assumes the well is located approximately 50 feet in from the Blair Waterway and 344 feet from monitoring well MW-130-15. Using the SZ/AZ regression, to achieve the target concentration of 11,378 µg/L at the shoreline well, the concentration at the up-gradient source zone well (MW-130-15) must be 21,901 µg/L or less, the current concentration at the up-gradient well is 2,025 µg/L, below the protective threshold.

The gas-range TPH average concentration in the 25-foot aquifer shoreline well is 69 µg/L, below the screening criteria. This analysis indicates that no source mass reduction is needed to achieve the gas-range screening criteria at the western shoreline.

4.4.3 Diesel & Oil-Range TPH with silica gel cleanup

Table 4-7 and Figure 4-10 present the results of the concentration versus distance analysis for diesel-range TPH along the eastern and western transects.

4.4.3.1 Eastern Transect

Diesel-range TPH concentrations were below the detection limit of 100 µg/L at all three seep locations, SP-101, SP-102, and SP-103, in May and August 2016. The current concentration at the shoreline well MW-104-15 (68 µg/L) is also below the screening criteria (500 µg/L). Similarly, so are results from the shoreline wells 95-15 (248 µg/L) and 721-MW9-15 (63 µg/L). The analytical results indicate that no source mass reduction is needed to achieve the screening criteria at the eastern shoreline seep and shoreline wells.

The concentration versus distance analysis results indicate the slope of the SZ/AZ regression is -3.83×10^{-3} with an R^2 value of 0.84. This regression is not statistically significant. The slope of the TZ regression is -5.30×10^{-3}, with only two data points the statistical tests are not relevant. These analyses may be valuable during the feasibility study for evaluating the likely the response of diesel-range TPH to potential remedial alternatives.

4.4.3.2 Western Transect

Along the western transection the source zone wells (721-MW15-15 and 721-MW2) currently have average concentrations of 3,013 µg/L and 1,425 µg/L, while the downgradient attenuation zone well (MW130-15) has an average concentration of 83 µg/L, well below the diesel-range TPH screening criteria. The western transect does not have a shoreline well or seeps samples.

The concentration versus distance analysis results indicate the slope of the SZ/AZ regression is -8.89×10^{-3} with an R^2 value of 0.92. This regression is statistically significant. This analysis can be utilized during the feasibility study for evaluating the likely the response of diesel-range TPH to potential remedial alternatives.

4.4.4 Diesel & Oil-Range TPH without silica gel cleanup

Table 4-8 and Figure 4-11 present the results of the concentration versus distance analysis for diesel-range TPH without SGC along the eastern and western transects.

4.4.4.1 Eastern Transect

Along the eastern transect the downgradient source zone well (721-MW11-15) has an average concentration of 6,525 µg/L, the downgradient shoreline well (MW-104-15) has an average concentration of is 2,863 µg/L, and seep (SP-103) has an average concentration of 1,015 µg/L.

The concentration versus distance analysis results indicate the slope of the SZ/AZ regression is -2.01×10^{-3} with an R^2 value of 0.97. This regression is statistically significant. The slope of the TZ regression is -1.79×10^{-2}, but with only two data points the statistical tests are not relevant.

By applying the concentration versus distance regressions we can estimate the amount of mass reduction needed to lower the seep concentration below the surface water screening criteria of 500 µg/L. Using the TZ regression, the concentration at the upgradient shoreline well MW-104-15 would need to be reduced by 51% from 2,863 µg/L to 1,410 µg/L. Similarly the next upgradient well 721-MW11-15 would need to be reduced by 59% from 6,525 µg/L to 2,696 µg/L. Due to limited record lengths for non SGC diesel-range TPH, the restoration timeframe to achieve these reduction cannot be estimated.

4.4.4.2 Western Transect

Along the western transection the source zone wells (721-MW15-15 and 721-MW2) have an average concentrations of 12,300 µg/L and 10,275 µg/L, respectively. The downgradient attenuation zone well (MW130-15) has an average concentration of 4,325 µg/L. The western transect does not have a shoreline wells or seep samples.

The concentration versus distance analysis results indicate the slope of the SZ/AZ regression is -2.81×10^{-3} with an R^2 value of 0.95. This regression is statistically significant. While there is no regression available for the Western transition zone, if the eastern transition zone regression is applied, the concentration at a well 50 feet from the shoreline would need to be 1,222 µg/L or less to be protective of seeps in the Blair Waterway. This assumes the well is located approximately 50 feet in from the Blair Waterway and 344 feet from monitoring well MW-130-15. Using the SZ/AZ regression, to achieve the target concentration of 1,222 µg/L at the shoreline well, the concentration at the up-gradient source zone well (MW-130-15) must be 3,209 µg/L or less.The current concentration at the up-gradient well is 4,325 µg/L, below the protective threshold.

This analysis indicates that no source mass reduction is needed to achieve the diesel and oil-range screening criteria at a western shoreline seep.

5 Conclusions

In accordance with procedures outlined in Ecology's guidance document *Guidance on Remediation of Petroleum-Contaminated Groundwater by Natural Attenuation* (2005) we have established that natural attenuation of petroleum hydrocarbons is ongoing and that biodegradation is a significant component of the observed natural attenuation. This is based on multiple lines of evidence, including: generally declining concentration trends at individual wells; geochemical indicators that indicate biodegradation is occurring (depleted electron acceptors and increases in the products of biodegradation in sources areas); and a comparison of estimated half-life rates to half-life values available in the literature.

Restoration timeframes were estimated for benzene, gas-range TPH, and diesel and oil-range TPH at the standard point of compliance in absence of other remedial action.

- Benzene concentrations will reach the screening criteria (1.6 µg/L) in all source zone wells in 156 years, and at all attenuation zone wells in 67 years. The benzene plume in the 25-foot zone will meet the screening criteria (1.6 µg/L) in 152 years. Benzene is above the screening criteria in the nearshore/transition zone and in the seeps on the Hylebos Waterway. Concentrations in the eastern shoreline wells need to be reduced to 43 µg/L to be protective of seeps, this could take as long as 26 years.
- Gas concentrations will reach the screening criteria (800 µg/L) at all locations in the source zone in 124 years, and at all locations in the attenuation zone in 80 years. Gas is above the screening criteria in the nearshore/transition zone, and below the screening criteria in the seeps.
- Diesel concentrations will reach the screening criteria (500 µg/L) at all locations in the source zone in 42 years, and at all locations in the attenuation zone in 12 years. Diesel is below screening criteria in the nearshore/transition zone wells, and non-detect in the seeps.

Our comparison of Site contaminant half-life values to literature values found the Site specific values to be high, particularly for benzene. It is possible that actual half-life rates are lower and that the result of our analysis are conservative, meaning Site benzene may degrade more quickly than estimated, reducing restoration timeframes.

Based on the results of this analysis, remedy selection should first consider actions that will address benzene concentrations at the tideline (seeps) in the Hylebos Waterway. As a secondary priority, the remedy selection should consider actions that will reduce upland benzene, gas-range TPH and diesel and oil-range TPH concentrations in groundwater and soil to site screening criteria. The site is capped by asphalt, current VI concerns have been addressed (Port and Aspect 2016 & Ecology 2016), and it has been established that site groundwater is not, and will not be, used as a drinking water resource (i.e. all upland exposure pathways are incomplete, Aspect 2016). Therefore, once benzene concentrations in seeps have been addressed, monitored natural attenuation could be an appropriate Site remedy.

Diesel-range TPH without silica gel cleanup is not considered a driver for remedy selection for the following reasons:

1. A screening criteria of 500 µg/L is already highly conservative for Site conditions (no drinking water use) and was developed for diesel-range TPH with silica gel cleanup. MTCA cleanup levels have not been developed for diesel analysis without silica gel cleanup.

2. Silica gel cleanup serves to screen out biodegradation metabolites prior to TPH analysis. When silica gel cleanup is not applied detection of metabolites are combined with diesel-range results.
3. Risk analysis of metabolites found that 90% of identified metabolites in had a low toxicity profile, and 10% had a low-to-moderate toxicity profile (Zemo et al., 2016).
4. Any implementation of a remedial action that addresses benzene, gas-range TPH and diesel-range TPH at the site would also address TPH's biodegraded metabolites. Metabolites are biodegradable and will completely attenuate (mineralization to carbon dioxide) with time (Zemo, 2016).

Remedy alternatives will be explored in detail in the FS, along with preliminary cleanup levels, points of compliance, and potentially remediation levels for Site COCs. The FS will also evaluate the potential effect of OCCs proposed cleanup action at the neighboring property on potential cleanup actions at this Site. Based on the variability in predicted timeframes and the inherent uncertainty of the analysis we plan to use the estimated restoration timeframes as a relative tool (i.e., determining the relative effect on restoration timeframe from different potential remedies) to support the FS and selection of Site remedial action.

6 References

Aspect Consulting (Aspect), 2014, Work Plan for Remedial Investigation/Feasibility Study, Alexander Avenue Petroleum Tank Facilities Site, Tacoma, Washington, June 2014.

Aspect Consulting (Aspect), 2015, Remedial Investigation Data and Memorandum and Groundwater Monitoring Plan, Alexander Avenue Petroleum Tank Facilities Site, Tacoma, Washington, March 2015.

Aspect Consulting (Aspect), 2016, Draft Remedial Investigation, Alexander Avenue Petroleum Tank Facilities Site, Tacoma, Washington, December 2016.

Boopathy, R., 2004. Anaerobic biodegradation of no. 2 diesel fuel in soil: a soil column study, Bioresource Technology 94, 143-151, February 13, 2004.

Cross, K., K. W. Biggar, K. Semple, J. Foght, S. E. Guigard, and J. E. Armstrong, 2011, Intrinsic Bioremediation of Diesel-contaminated cold groundwater in bedrock, Journal of Environmental Engineering and Science 5(1):13-27, February 2011.

Cunningham, R., 2004, Biodegradation Rates of Weathered Hydrocarbons in Controlled Laboratory Microcosms and Soil Columns Simulation Natural Attenuation Field Conditions, A Master's Thesis Presented to the Faculty of California poly technic State University San Luis Obispo, October 2004.

EPA, 2016, EPA's Partial Approval/Partial Disapproval of Washington's Human Health Water Quality Criteria and Implementation Tools, *to* Maia Bellon, Director, Department of Ecology, *from* Daniel Opalski, Director, Office of Water and Watersheds, Environmental Protection Agency, November 15.

GHD (Glenn Springs Holdings, Inc.), 2017, Feasibility Study Report, Occidental Chemical Corporation, 605 Alexander Avenue, Tacoma, Washington, January 25, 2017.

Lawrence, S.J., 2006, *Description, Properties, and Degradation of Selected Volatile Organic Compounds Detected in Ground Water – A Review of Selected Literature*: Atlanta, Georgia, U.S. Geological Survey, Open-File Report 2006-1338, 62 p., a Web-only publication at *http://pubs.usgs.gov/ofr/2006/1338/*.

Port of Tacoma (Port) and Aspect Consulting (Aspect), 2016, Technical Memorandum: Vapor Intrusions Assessment, Alexander Avenue Petroleum Tank Facilities Site, Ecology Facilities Site No. 1377/Cleanup Site No. 743, December 16, 2016.

Pacific Groundwater Group (PGG), 2016, Port of Seattle Terminal 30 Revised 2013 Remedial Investigation/Feasibility Study, Seattle Washington, January 11, 2016.

RETEC Group Inc., 2006, *Supplemental Data Report, Revision 1, Terminal 30, Port of Seattle, Seattle, Washington,* Prepared for Port of Seattle, January 30.

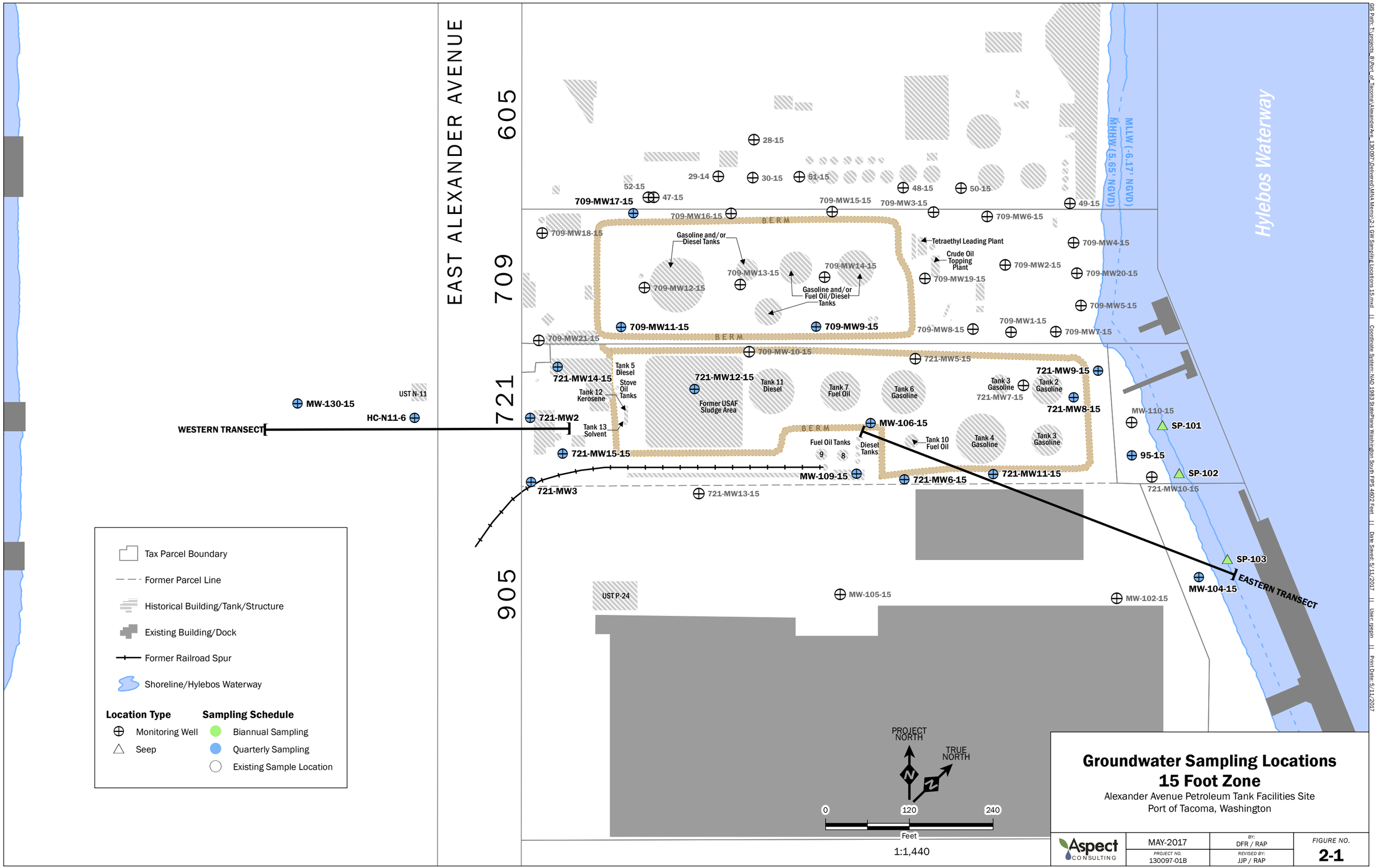
Washington State Department of Ecology (Ecology), 2016, "Re: Alexander Avenue VI memo," Message *to* Sarah Weeks, Port, *from* Joyce Mercuri, Ecology. December 28.

Washington State Department of Ecology (Ecology), 2005, Guidance on Remediation of Petroleum-Contaminated Ground Water by Natural Attenuation, Publication No. 05-09-09, July 2005.

Wisconsin State Department of Natural Resources (Wisconsin DNR), 2014, Guidance on Natural Attenuation for Petroleum Releases, Publication No. RR-614, January 2014.

United States Environmental Protection Agency (EPA), 2009, Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Unified Guidance, Publication No. EPA 530/R-09-007, March 2009.

FIGURES



Groundwater Sampling Locations 15 Foot Zone

Alexander Avenue Petroleum Tank Facilities Site
Port of Tacoma, Washington

Aspect Consulting	MAY-2017	BY: DFR / RAP	FIGURE NO. 2-1
	PROJECT NO. 130097-01B	REVISED BY: JJP / RAP	

GIS Path: T:\projects_8\Port_of_Tacoma\Alexander Ave_130097\Delivered\MXA Memo\2-1 GW Sampling Locations 15.mxd || Coordinate System: NAD 1983 StatePlane Washington South FIPS 4602 Feet || Date Saved: 5/11/2017 || User: mepin || Print Date: 5/11/2017

EAST ALEXANDER AVENUE

605

709

721

905

92C-25
88C-25
18-25
17C-25
9-25
3-25
MLLW (-6.17' NGVD)
MHHW (5.65' NGVD)
Hylebos Waterway
709-MW16-25
709-MW15A-25
709-MW6-25
709-MW18-25
B E R M
Gasoline and/or Diesel Tanks
Tetraethyl Leading Plant
Crude Oil Topping Plant
709-MW20-25
Gasoline and/or Fuel Oil/Diesel Tanks
709-MW11-25
709-MW9-25
709-MW21-25
721-MW14-25
721-MW5-25
721-MW9-25
Tank 5 Diesel
Stove Oil Tanks
Tank 12 Kerosene
721-MW12-25
Former USAF Sludge Area
Tank 11 Diesel
Tank 7 Fuel Oil
Tank 6 Gasoline
Tank 3 Gasoline
Tank 2 Gasoline
UST N-11
WESTERN TRANSECT
Tank 13 Solvent
MW-110-25
Fuel Oil Tanks
9
8
Diesel Tanks
Tank 10 Fuel Oil
Tank 4 Gasoline
Tank 3 Gasoline
95C-25
721-MW15-25
721-MW11-25
721-MW10-25
721-MW6-25
721-MW13-25
MW-137-25
EASTERN TRANSECT
MW-104-25
UST P-24
93C-25
MW-105-25
MW-102-25

Tax Parcel Boundary
Former Parcel Line
Historical Building/Tank/Structure
Existing Building/Dock
Former Railroad Spur
Shoreline/Hylebos Waterway
Monitoring Well - Quarterly Sampling
Existing Monitoring Well

PROJECT NORTH
TRUE NORTH
N
0
120
240
Feet
1:1,440

Groundwater Sampling Locations 25 Foot Zone

Alexander Avenue Petroleum Tank Facilities Site
Port of Tacoma, Washington

Aspect Consulting	MAY-2017	BY: DFR / RAP	FIGURE NO. 2-2
	PROJECT NO. 130097-01B	REVISED BY: JJP / RAP	

GIS Path: T:\projects_8\Port_of_Tacoma\Alexander Ave_130097\Delivered\MXD\Memo\2-2 GW Sampling Locations 25.mxd || Coordinate System: NAD 1983 StatePlane Washington South FIPS 4602 Feet || Date Saved: 5/5/2017 || User: rpeplin || Print Date: 5/11/2017

Benzene in Groundwater

> 58 µg/L Isoconcentration Line
previous screening level, based on surface water protection

> 24 µg/L Isoconcentration Line
screening level based on vapor intrusion

> 1.6 µg/L Isoconcentration Line
screening level based on surface water protection

Location Type	Sample Result
Monitoring Well	Above Screening Level 24 µg/L
Seep	Above Screening Level 1.6 µg/L
	Detected, No Screening Level Exceedance
	Non-Detect
	No Result

EAST ALEXANDER AVENUE

605

709

721

905

Hylebos Waterway

MLLW (-6.17' NGVD)
MHHW (5.65' NGVD)

709-MW17-15 0.4
47-15
52-15
28-15
29-14
30-15
31-15
48-15
50-15
49-15
709-MW15-15
709-MW3-15
709-MW6-15
709-MW16-15
709-MW18-15
B E R M
Gasoline and/or Diesel Tanks
Tetraethyl Leading Plant
Crude Oil Topping Plant
709-MW4-15
709-MW2-15
709-MW20-15
709-MW19-15
709-MW14-15
709-MW13-15
709-MW12-15
Gasoline and/or Fuel Oil/Diesel Tanks
709-MW5-15
709-MW11-15 1.1
709-MW9-15 11
709-MW8-15
709-MW1-15
709-MW7-15
709-MW21-15
721-MW14-15 58
709-MW-10-15
B E R M
721-MW5-15
721-MW9-15 0.4
Tank 5 Diesel
Stove Oil Tanks
721-MW12-15 295
Tank 11 Diesel
Tank 7 Fuel Oil
Tank 6 Gasoline
Tank 3 Gasoline
721-MW7-15
Tank 2 Gasoline
721-MW8-15 3.3
Tank 12 Kerosene
Former USAF Sludge Area
MW-110-15
SP-101 0.2
UST N-11
MW-130-15 94
HC-N11-6 256
721-MW2 908
Tank 13 Solvent
MW-106-15 323
B E R M
Fuel Oil Tanks
9
8
Diesel Tanks
Tank 10 Fuel Oil
Tank 4 Gasoline
Tank 3 Gasoline
95-15 9.4
721-MW10-15
SP-102 0.2
WESTERN TRANSECT
721-MW15-15 1350
MW-109-15 1223
721-MW11-15 570
721-MW3 283
721-MW13-15
721-MW6-15 623
SP-103 14
EASTERN TRANSECT
MW-104-15 368
UST P-24
MW-105-15
MW-102-15

- Tax Parcel Boundary
- Former Parcel Line
- Historical Building/Tank/Structure
- Existing Building/Dock
- Former Railroad Spur
- Shoreline/Hylebos Waterway

PROJECT NORTH
TRUE NORTH

0 120 240
Feet

1:1,440

Note: Isoconcentration contours are based on the average concentration over the most recent 4 quarters of data (December 2015, February 2016, May 2016, and August 2016, seeps were sampled in May and August only) and RI data where needed. For the purpose of calculating an average non-detect values were approximated by dividing the reporting limit by two (2).

Benzene in Groundwater
15 Foot Zone

Alexander Avenue Petroleum Tank Facilities Site
Port of Tacoma, Washington

Aspect Consulting			
	MAY-2017	BY: DFR / RAP	FIGURE NO. 2-3
	PROJECT NO. 130097-01B	REVISED BY: JJP / RAP	

GIS Path: T:\projects_8\Port_of_Tacoma\Alexander Ave_130097\Delivered\MNA Memo\2-3 Benzene in GW-15.mxd | | Coordinate System: NAD 1983 StatePlane Washington South FIPS 4602 Feet | | Date Saved: 5/11/2017 | | User: mpjin | | Print Date: 5/16/2017

Benzene in Groundwater

- > 58 µg/L Isoconcentration Line
  previous screening level, based on surface water protection
- > 1.6 µg/L Isoconcentration Line
  screening level based on surface water protection

Location Type	Sample Result
⊕ Monitoring Well	Above Screening Level 24 µg/L
△ Seep	Above Screening Level 1.6 µg/L
	Detected, No Screening Level Exceedance
	Non-Detect
	No Result

EAST ALEXANDER AVENUE

605

709

721

905

Hylebos Waterway

MLLW (-6.17' NGVD)
MHHW (5.65' NGVD)

18-25
17C-25
9-25
3-25
709-MW16-25
709-MW15A-25
709-MW6-25
709-MW18-25
709-MW20-25
709-MW11-25
709-MW9-25
709-MW21-25
721-MW5-25
721-MW14-25
721-MW9-25
721-MW12-25
721-MW15-25
721-MW13-25
721-MW6-25
721-MW11-25
MW-110-25
2
95C-25
721-MW10-25
111
MW-137-25
14
MW-105-25
145
MW-104-25
180
93C-25
MW-102-25

B E R M

Gasoline and/or Diesel Tanks
Tetraethyl Leading Plant
Crude Oil Topping Plant
Gasoline and/or Fuel Oil/Diesel Tanks
Tank 5 Diesel
Stove Oil Tanks
Tank 12 Kerosene
Former USAF Sludge Area
Tank 11 Diesel
Tank 7 Fuel Oil
Tank 6 Gasoline
Tank 3 Gasoline
Tank 2 Gasoline
Tank 13 Solvent
Fuel Oil Tanks
9
8
Diesel Tanks
Tank 10 Fuel Oil
Tank 4 Gasoline
Tank 3 Gasoline

WESTERN TRANSECT
EASTERN TRANSECT

UST N-11
UST P-24

- Tax Parcel Boundary
- Former Parcel Line
- Historical Building/Tank/Structure
- Existing Building/Dock
- Former Railroad Spur
- Shoreline/Hylebos Waterway

Note: Isoconcentration contours are based on the average concentration over the most recent 4 quarters of data (December 2015, February 2016, May 2016, and August 2016, seeps were sampled in May and August only) and RI data where needed. For the purpose of calculating an average non-detect values were approximated by dividing the reporting limit by two (2).

PROJECT NORTH
TRUE NORTH

0 120 240
Feet
1:1,440

Benzene in Groundwater
25 Foot Zone

Alexander Avenue Petroleum Tank Facilities Site
Port of Tacoma, Washington

Aspect Consulting	MAY-2017	BY: DFR / RAP	FIGURE NO. 2-4
	PROJECT NO. 130097-01B	REVISED BY: JJP / RAP	

Gasoline-Range TPH in Groundwater

> 800 µg/L Isoconcentration Line
screening level based on MTCA Method A for unrestricted land use

Location Type	Sample Result
⊕ Monitoring Well	Above Screening Level 800 µg/L
△ Seep	Detected, No Screening Level Exceedance
	Non-Detect
	No Result

EAST ALEXANDER AVENUE

605

709

721

905

Hylebos Waterway

MLLW (-6.17' NGVD)
MHHW (5.65' NGVD)

28-15
29-15
30-15
51-15
52-15
47-15
48-15
50-15
49-15
709-MW15-15
709-MW3-15
709-MW6-15
709-MW4-15
709-MW2-15
709-MW20-15
709-MW5-15
709-MW1-15
709-MW7-15
709-MW8-15
709-MW19-15
709-MW14-15
709-MW16-15
709-MW17-15 1850
709-MW18-15
709-MW13-15
709-MW12-15
709-MW11-15 1355
709-MW9-15 5725
709-MW21-15
709-MW10-15
721-MW5-15
721-MW9-15 1275
721-MW14-15 5050
721-MW12-15 5200
721-MW2 3475
721-MW15-15 4800
721-MW3 1675
721-MW13-15
MW-109-15 3750
721-MW6-15 3825
721-MW8-15 1350
721-MW11-15 2925
MW-106-15 4450
MW-110-15
95-15 1906
721-MW10-15
MW-130-15 2025
HC-N11-6 3475
UST N-11
UST P-24
MW-105-15
MW-102-15
MW-104-15 544

BERM

Gasoline and/or Diesel Tanks
Tetraethyl Leading Plant
Crude Oil Topping Plant
Gasoline and/or Fuel Oil/Diesel Tanks
Tank 5 Diesel
Stove Oil Tanks
Tank 12 Kerosene
Tank 13 Solvent
Former USAF Sludge Area
Tank 11 Diesel
Tank 7 Fuel Oil
Tank 6 Gasoline
Tank 3 Gasoline
Tank 2 Gasoline
Fuel Oil Tanks
Diesel Tanks
Tank 10 Fuel Oil
Tank 4 Gasoline
Tank 3 Gasoline
9
8

SP-101 325
SP-102 210
SP-103 100U

WESTERN TRANSECT
EASTERN TRANSECT

Tax Parcel Boundary
Former Parcel Line
Historical Building/Tank/Structure
Existing Building/Dock
Former Railroad Spur
Shoreline/Hylebos Waterway

Note: Isoconcentration contours are based on the average concentration over the most recent 4 quarters of data (December 2015, February 2016, May 2016, and August 2016, seeps were sampled in May and August only) and RI data where needed. For the purpose of calculating an average non-detect values were approximated by dividing the reporting limit by two (2). If all results were non-detect, the average reporting limit is presented with the qualifier 'U'.

PROJECT NORTH
TRUE NORTH

0 120 240
Feet

1:1,440

Gasoline-Range TPH in Groundwater
15 Foot Zone

Alexander Avenue Petroleum Tank Facilities Site
Port of Tacoma, Washington

Aspect Consulting	MAY-2017	BY: DFR / RAP	FIGURE NO. 2-5
	PROJECT NO. 130097-01B	REVISED BY: JJP / RAP	

Diesel & Oil-Range TPH with Silica Gel Cleanup in Groundwater

> 500 µg/L Isoconcentration Line
screening level based on MTCA Method A for unrestricted land use

Location Type
- Monitoring Well
- Seep

Sample Result
- Above Screening Level 500 µg/L
- Detected, No Screening Level Exceedance
- Non-Detect
- No Result

EAST ALEXANDER AVENUE

605

709

721

905

Hylebos Waterway

MLLW (-6.17' NGVD)
MHHW (5.65' NGVD)

28-15
29-15
30-15
51-15
52-15
47-15
48-15
50-15
49-15
709-MW15-15
709-MW17-15
2850
709-MW16-15
B E R M
709-MW3-15
709-MW6-15
709-MW18-15
Gasoline and/or Diesel Tanks
Tetraethyl Leading Plant
709-MW4-15
Crude Oil Topping Plant
709-MW2-15
709-MW20-15
709-MW12-15
709-MW13-15
709-MW14-15
709-MW19-15
709-MW11-15
2220
Gasoline and/or Fuel Oil/Diesel Tanks
709-MW5-15
709-MW9-15
523
709-MW8-15
709-MW1-15
709-MW7-15
709-MW21-15
B E R M
709-MW10-15
B E R M
721-MW14-15
1158
721-MW5-15
721-MW9-15
63
Tank 5 Diesel
721-MW12-15
1300
Tank 11 Diesel
Tank 7 Fuel Oil
Tank 6 Gasoline
Tank 3 Gasoline
721-MW7-15
Tank 2 Gasoline
721-MW8-15
100
MW-110-15
SP-101
100U
MW-130-15
83
UST N-11
HC-N11-6
638
721-MW2
1425
Tank 12 Kerosene
Stove Oil Tanks
Former USAF Sludge Area
MW-106-15
568
Tank 13 Solvent
B E R M
Fuel Oil Tanks
9
8
Diesel Tanks
Tank 10 Fuel Oil
Tank 4 Gasoline
Tank 3 Gasoline
95-15
248
WESTERN TRANSECT
721-MW15-15
3225
MW-109-15
450
721-MW11-15
540
721-MW10-15
SP-102
75
721-MW6-15
390
721-MW13-15
721-MW3
205
SP-103
100U
EASTERN TRANSECT
MW-104-15
68
MW-105-15
MW-102-15
UST P-24

PROJECT NORTH
TRUE NORTH
0
120
240
Feet
1:1,440

- Tax Parcel Boundary
- Former Parcel Line
- Historical Building/Tank/Structure
- Existing Building/Dock
- Former Railroad Spur
- Shoreline/Hylebos Waterway

Note: Isoconcentration contours are based on the average concentration over the most recent 4 quarters of data (December 2015, February 2016, May 2016, and August 2016, seeps were sampled in May and August only) and RI data where needed. For the purpose of calculating an average non-detect values were approximated by dividing the reporting limit by two (2). If all results were non-detect, the average reporting limit is presented with the qualifier 'U'.

Diesel & Oil-Range TPH with Silica Gel Cleanup in Groundwater 15 Foot Zone

Alexander Avenue Petroleum Tank Facilities Site
Port of Tacoma, Washington

Aspect Consulting	MAY-2017	BY: DFR / RAP	FIGURE NO. 2-6
	PROJECT NO. 130097-01B	REVISED BY: JJP / RAP	

Diesel & Oil-Range TPH without Silica Gel Cleanup in Groundwater

> 500 µg/L Isoconcentration Line
screening level based on MTCA Method A for unrestricted land use

Location Type

- Monitoring Well
- Seep

Sample Result

- Above Screening Level 500 µg/L
- Detected, No Screening Level Exceedance
- Non-Detect
- No Result

- Tax Parcel Boundary
- Former Parcel Line
- Historical Building/Tank/Structure
- Existing Building/Dock
- Former Railroad Spur
- Shoreline/Hylebos Waterway

Note: Isoconcentration contours are based on the average concentration over the most recent 4 quarters of data (December 2015, February 2016, May 2016, and August 2016, seeps were sampled in May and August only) and RI data where needed. For the purpose of calculating an average non-detect values were approximated by dividing the reporting limit by two (2).

EAST ALEXANDER AVENUE

605

709

721

905

Hylebos Waterway

MLLW (-6.17' NGVD)
MHHW (5.65' NGVD)

28-15
29-15
30-15
51-15
52-15
47-15
48-15
50-15
49-15
709-MW15-15
709-MW3-15
709-MW6-15
709-MW17-15 23250
709-MW16-15
B E R M
709-MW18-15
Gasoline and/or Diesel Tanks
Tetraethyl Leading Plant
Crude Oil Topping Plant
709-MW4-15
709-MW2-15
709-MW20-15
709-MW13-15
709-MW14-15
709-MW19-15
709-MW12-15
Gasoline and/or Fuel Oil/Diesel Tanks
709-MW11-15 9350
709-MW9-15 11475
709-MW5-15
709-MW8-15
709-MW1-15
709-MW7-15
709-MW21-15
B E R M
709-MW10-15
721-MW14-15 12225
721-MW5-15
721-MW9-15 1545
721-MW12-15 7775
Tank 5 Diesel
Stove Oil Tanks
Tank 12 Kerosene
Tank 11 Diesel
Tank 7 Fuel Oil
Tank 6 Gasoline
Tank 3 Gasoline
721-MW7-15
Tank 2 Gasoline
Former USAF Sludge Area
721-MW2 10275
MW-106-15 8000
721-MW8-15 812.5
MW-110-15
SP-101 1250
Tank 13 Solvent
B E R M
Fuel Oil Tanks
9
8
Diesel Tanks
Tank 10 Fuel Oil
Tank 4 Gasoline
Tank 3 Gasoline
95-15 2875
721-MW15-15 12300
MW-109-15 8125
721-MW11-15 6525
721-MW10-15
SP-102 820
721-MW3 8475
721-MW13-15
721-MW6-15 6900
SP-103 1015
MW-104-15 2863
EASTERN TRANSECT
MW-130-15 4325
UST N-11
HC-N11-6 5400
WESTERN TRANSECT
UST P-24
MW-105-15
MW-102-15

PROJECT NORTH
TRUE NORTH
0
120
240
Feet
1:1,440

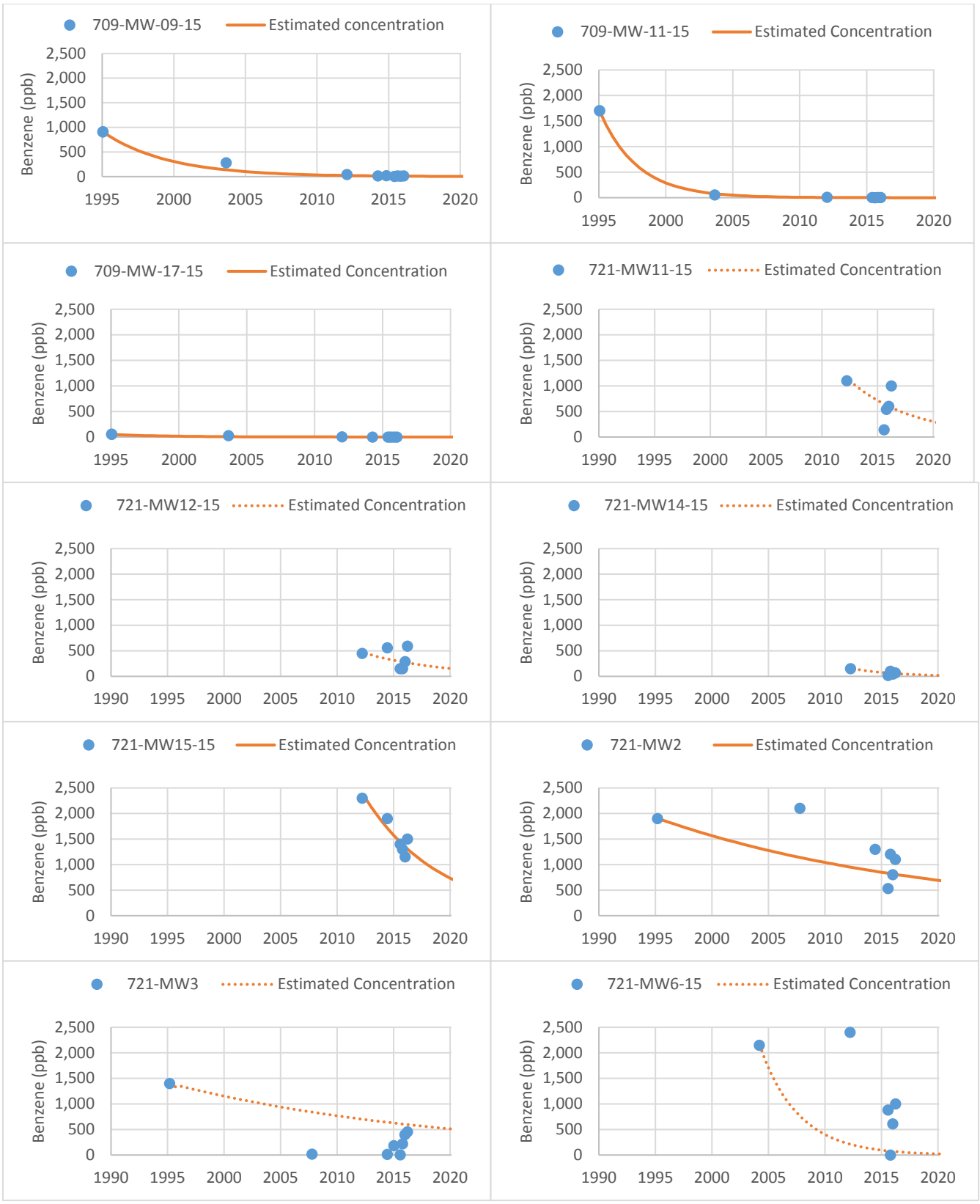
Diesel & Oil-Range TPH without Silica Gel Cleanup in Groundwater 15 Foot Zone

Alexander Avenue Petroleum Tank Facilities Site
Port of Tacoma, Washington

Aspect Consulting	MAY-2017	BY: DFR / RAP	FIGURE NO. 2-7
	PROJECT NO. 130097-01B	REVISED BY: JJP / RAP	

Figure 2-8a
Benzene Time Series - 15 Foot Zone

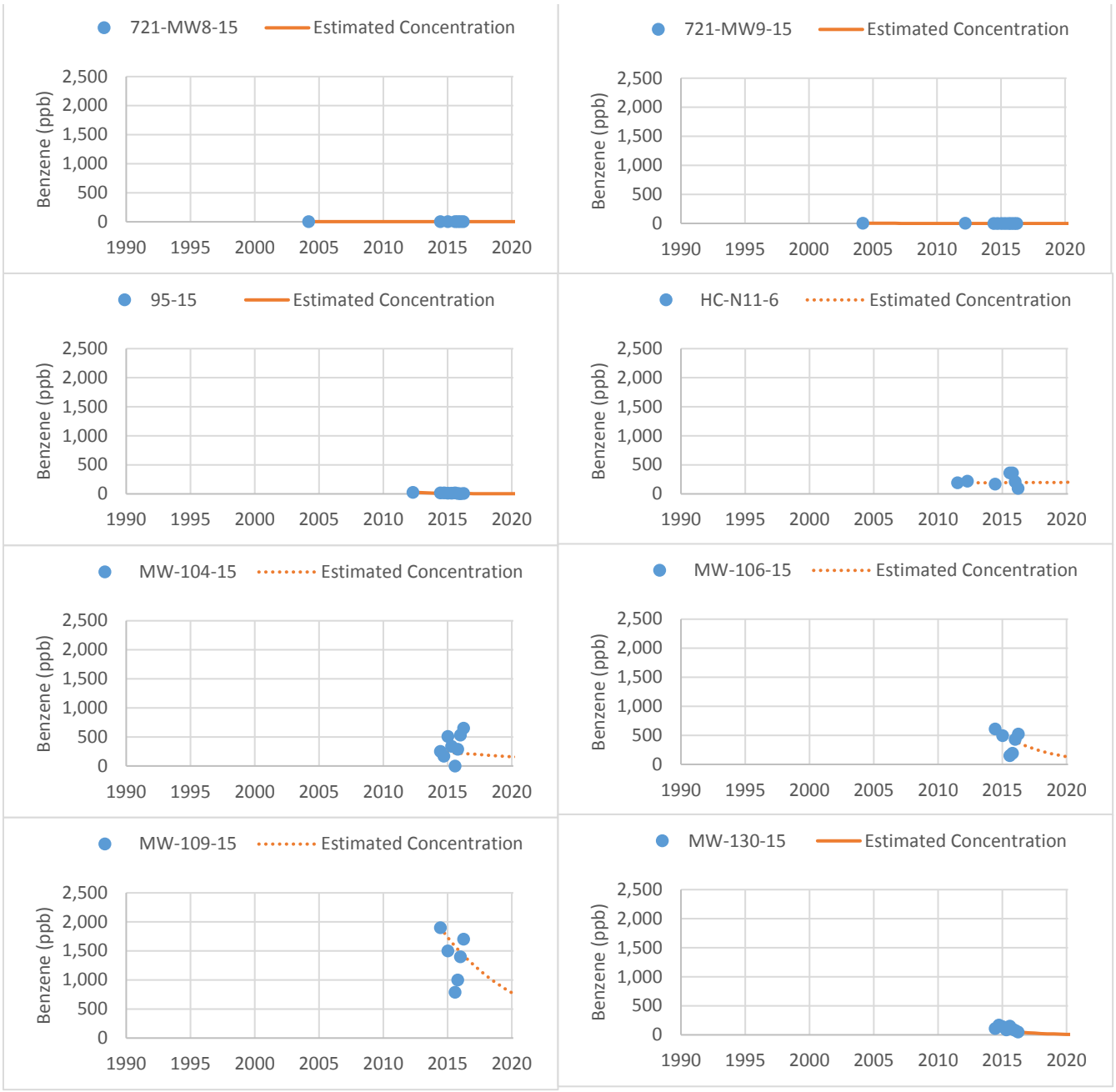
DRAFT



S:\Facility\Environmental\Remediation\RemediationProjects\Parcel 2 - Alexander Ave\Working-Draft\FS 2015-2016\MNA\Final draft_2017_05_15\Analysis_2017_05_15.xlsx

Figure 2-8a
Benzene Time Series - 15 Foot Zone

DRAFT



Note:
Projected concentration estimates calculated from Ecology (2005) Eqn F.1.
Solid trend lines indicates that the natural log transformed trend was found to be statistically significant from zero using the methods outlined in section 3.1

Figure 2-8b
Benzene Time Series - 25 Foot Zone

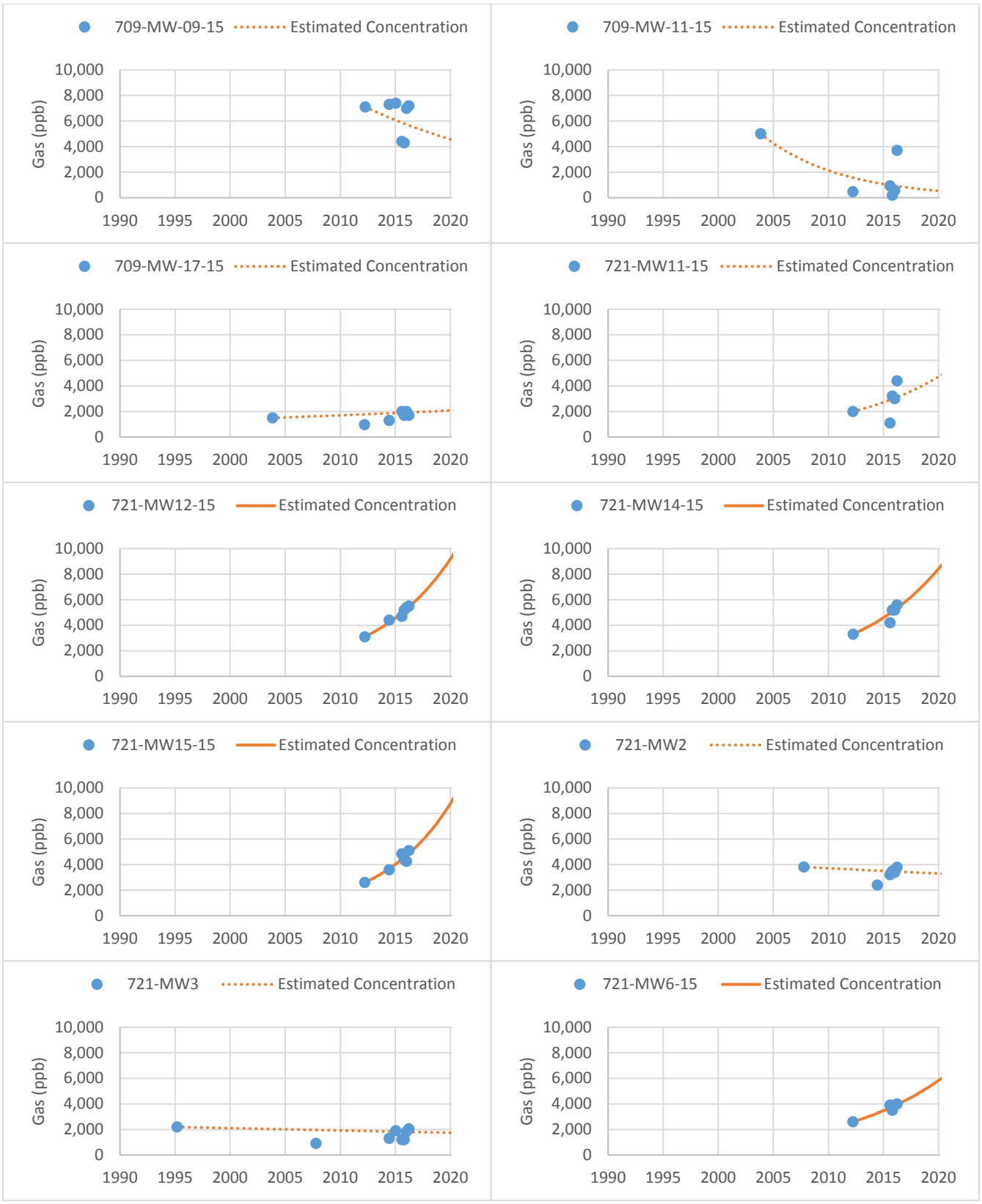
DRAFT

Note:
Projected concentration estimates calculated from Ecology (2005) Eqn F.1.
Solid trend lines indicates that the natural log transformed trend was found to be statistically significant from zero using the methods outlined in section 3.1

Figure 2-9a

DRAFT

Gasoline-Range TPH Time Series - 15 Foot Zone

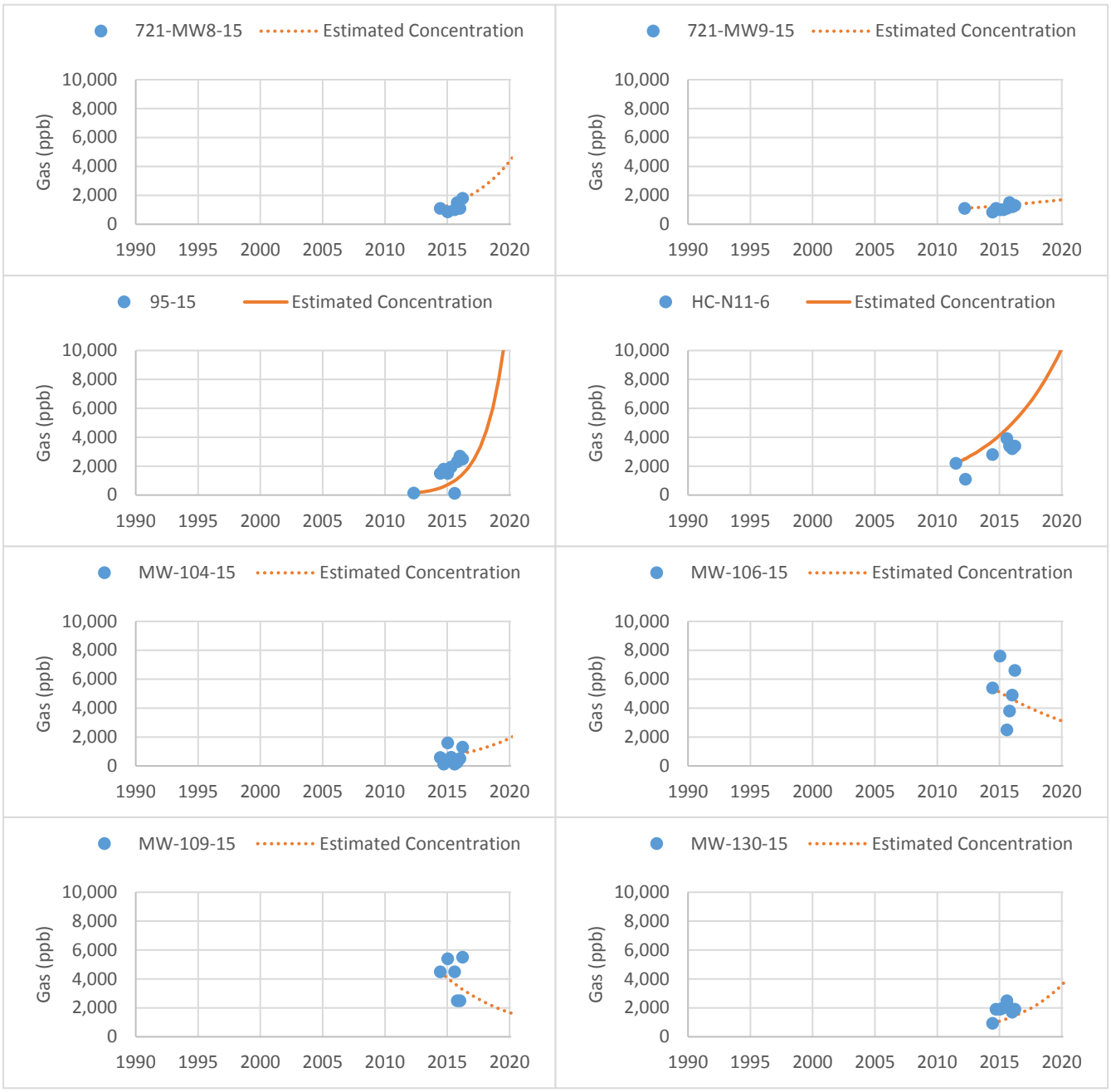


5/16/2017

S:\Facility\Environmental\Remediation\RemediationProjects\Parcel 2 - Alexander Ave\Working-Draft\FS 2015-2016\MNA\Final draft_2017_05_15\Analysis_2017_05_15.xlsx

Figure 2-9a
Gasoline-Range TPH Time Series - 15 Foot Zone

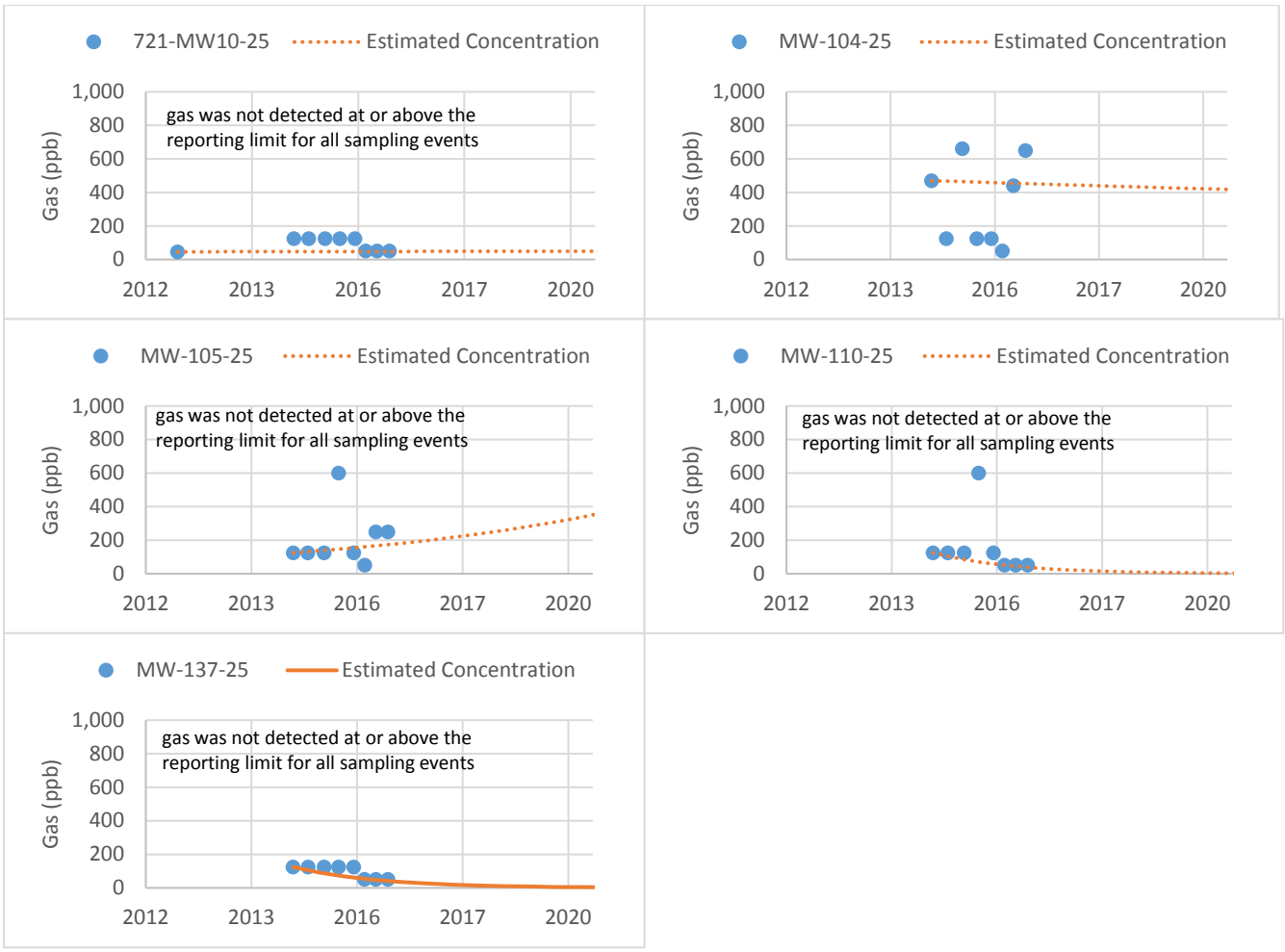
DRAFT



Note:
Projected concentration estimates calculated from Ecology (2005) Eqn F.1.

Figure 2-9b
Gasoline-Range TPH Time Series - 25 Foot Zone

DRAFT

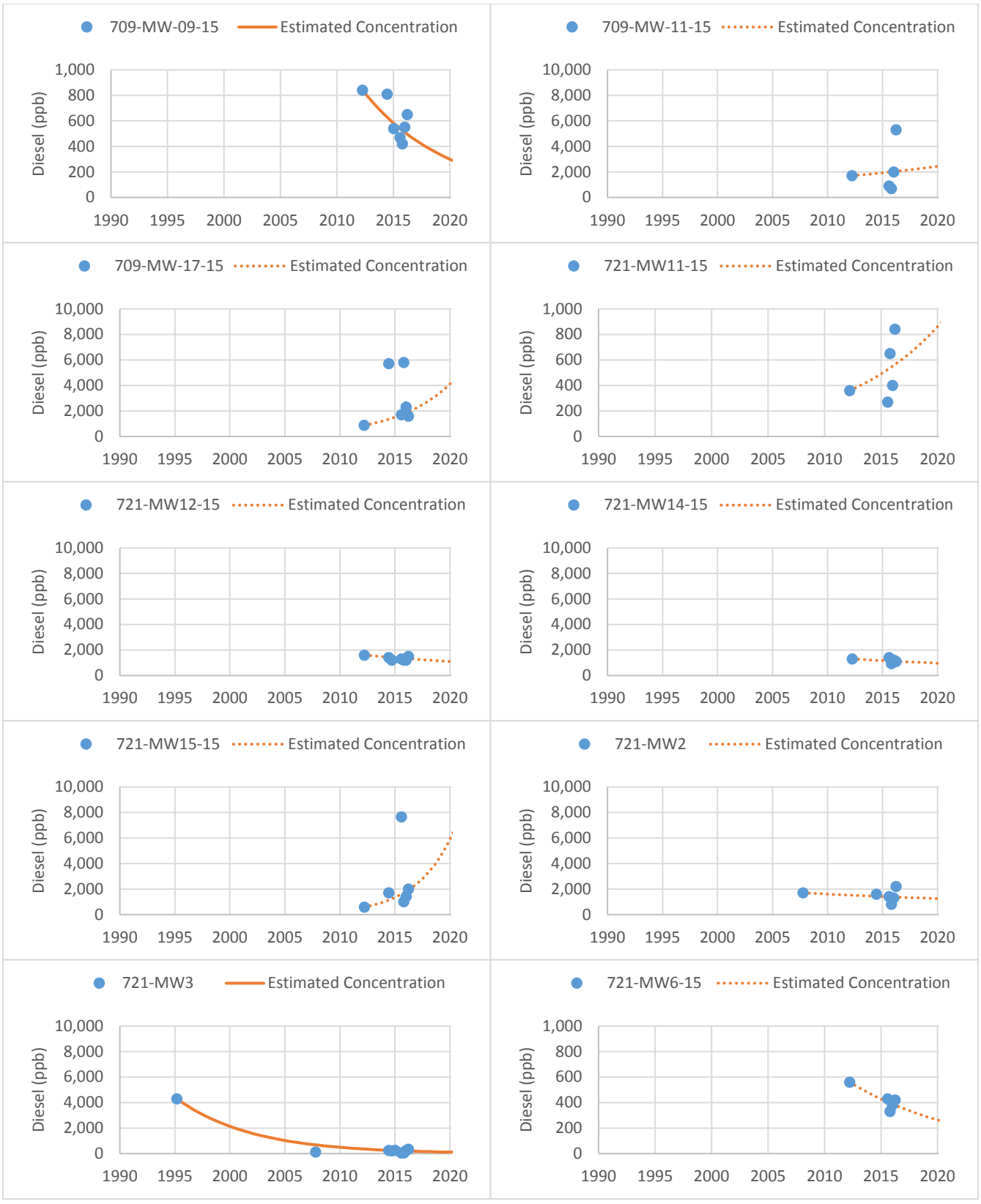


Note:
Projected concentration estimates calculated from Ecology (2005) Eqn F.1.
Solid trend lines indicates that the natural log transformed trend was found to be statistically significant from zero using the methods outlined in section 3.1

Figure 2-10a

DRAFT

Diesel Oil-Range TPH Time Series - 15 Foot Zone

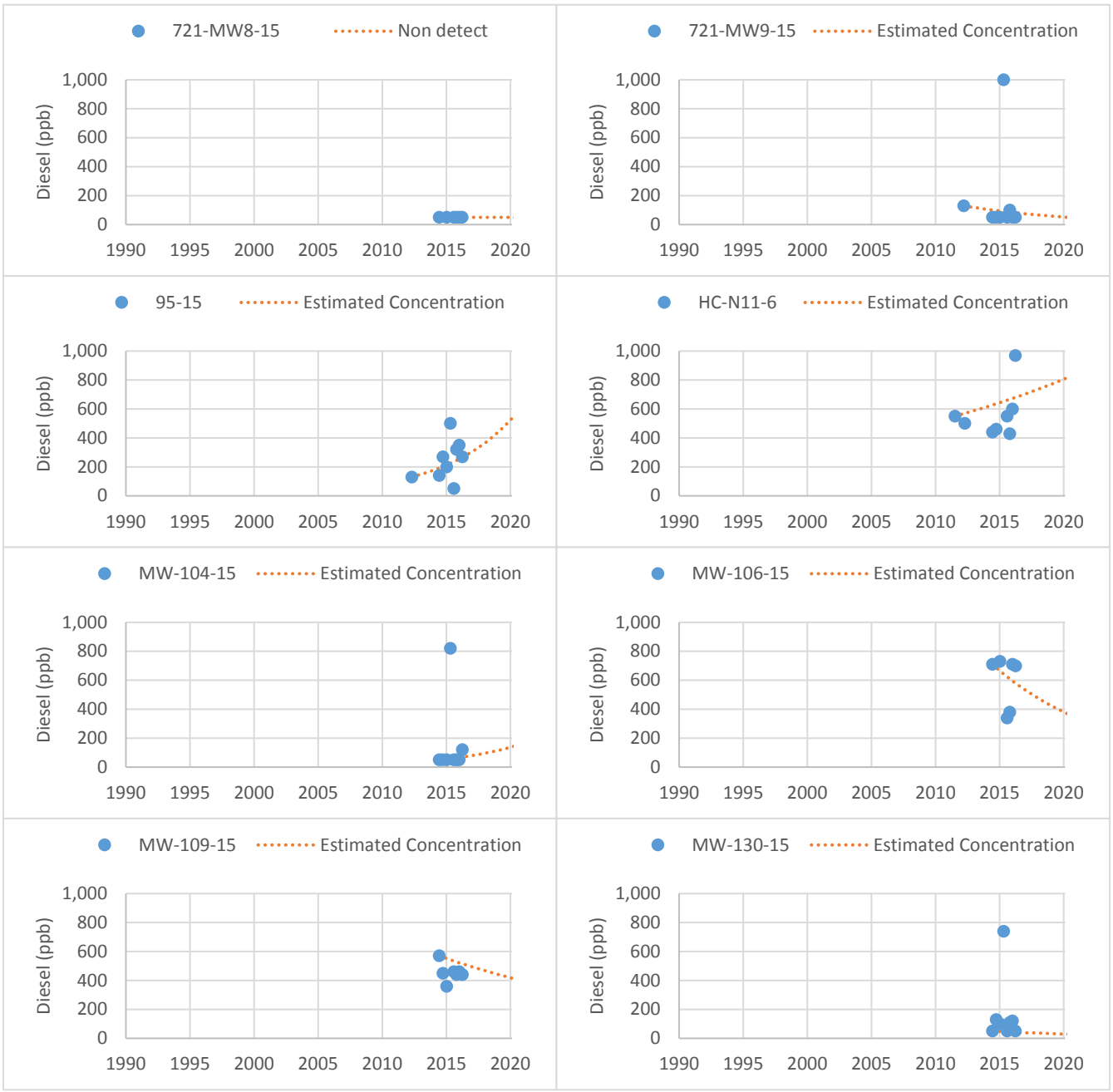


5/16/2017

S:\Facility\Environmental\Remediation\RemediationProjects\Parcel 2 - Alexander Ave\Working-Draft\FS 2015-2016\MNA\Final draft_2017_05_15\Analysis_2017_05_15.xlsx

Figure 2-10a
Diesel Oil-Range TPH Time Series - 15 Foot Zone

DRAFT



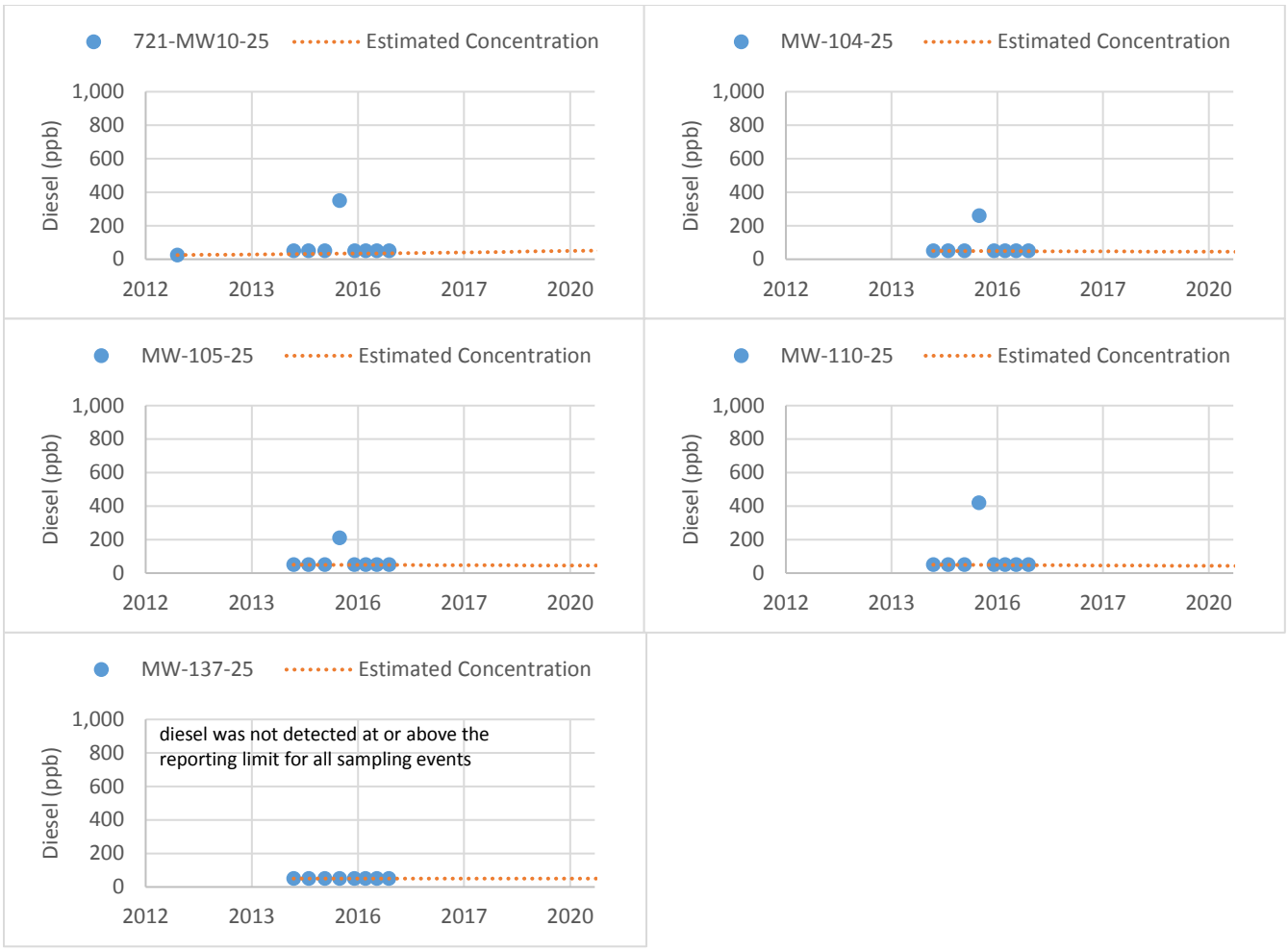
Note:
Projected concentration estimates calculated from Ecology (2005) Eqn F.1.
Solid trend lines indicates that the natural log transformed trend was found to be statistically significant from
Solid trend lines indicates that the natural log transformed trend was found to be statistically significant from

5/16/2017

Figure 2-10b

DRAFT

Diesel Oil-Range TPH Time Series - 25 Foot Zone



Note:
Projected concentration estimates calculated from Ecology (2005) Eqn F.1.
Statistical tests were not applied to diesel-range TPH data in the 25-foot zone.

Natural Attenuation Zones

Source Zone	*Wells where NAPL, or trace NAPL, was measured in October 2014 (RI Fig. 6.2-2)*
Attenuation Zone	*Wells where contaminants (benzene, gas-range TPH, and diesel & oil-range TPH) were detected above the screening criteria during the RI.*
Transition Zone	*Area of enhanced chemical attenuation within the tidally influenced groundwater to surface water transition zone.*

EAST ALEXANDER AVENUE

605

709

721

905

Hylebos Waterway

MLLW (-6.17' NGVD)
MHHW (5.65' NGVD)

28-15
29-14
30-15
51-15
48-15
50-15
52-15
47-15
49-15
709-MW15-15
709-MW3-15
709-MW6-15
709-MW17-15
709-MW16-15
709-MW18-15
709-MW4-15
709-MW2-15
709-MW20-15
709-MW19-15
709-MW13-15
709-MW14-15
709-MW12-15
709-MW5-15
709-MW11-15
709-MW9-15
709-MW8-15
709-MW1-15
709-MW7-15
709-MW21-15
709-MW-10-15
721-MW14-15
721-MW5-15
721-MW9-15
721-MW12-15
721-MW7-15
721-MW8-15
MW-130-15
UST N-11
HC-N11-6
721-MW2
721-MW15-15
MW-109-15
721-MW3
721-MW13-15
MW-106-15
721-MW6-15
721-MW11-15
721-MW10-15
95-15
MW-110-15
SP-101
SP-102
SP-103
MW-104-15
MW-105-15
MW-102-15
UST P-24

BERM

Gasoline and/or Diesel Tanks
Gasoline and/or Fuel Oil/Diesel Tanks
Tetraethyl Leading Plant
Crude Oil Topping Plant
Tank 5 Diesel
Stove Oil Tanks
Tank 12 Kerosene
Tank 13 Solvent
Former USAF Sludge Area
Tank 11 Diesel
Tank 7 Fuel Oil
Tank 6 Gasoline
Tank 3 Gasoline
Tank 2 Gasoline
Fuel Oil Tanks
9
8
Diesel Tanks
Tank 10 Fuel Oil
Tank 4 Gasoline
Tank 3 Gasoline

SOURCE ZONE

ATTENUATION ZONE

TRANSITION ZONE

WESTERN TRANSECT

EASTERN TRANSECT

Location Type

- Monitoring Well
- Seep
- Tax Parcel Boundary
- Former Parcel Line
- Historical Building/Tank/Structure
- Existing Building/Dock
- Former Railroad Spur
- Shoreline/Hylebos Waterway

PROJECT NORTH
TRUE NORTH

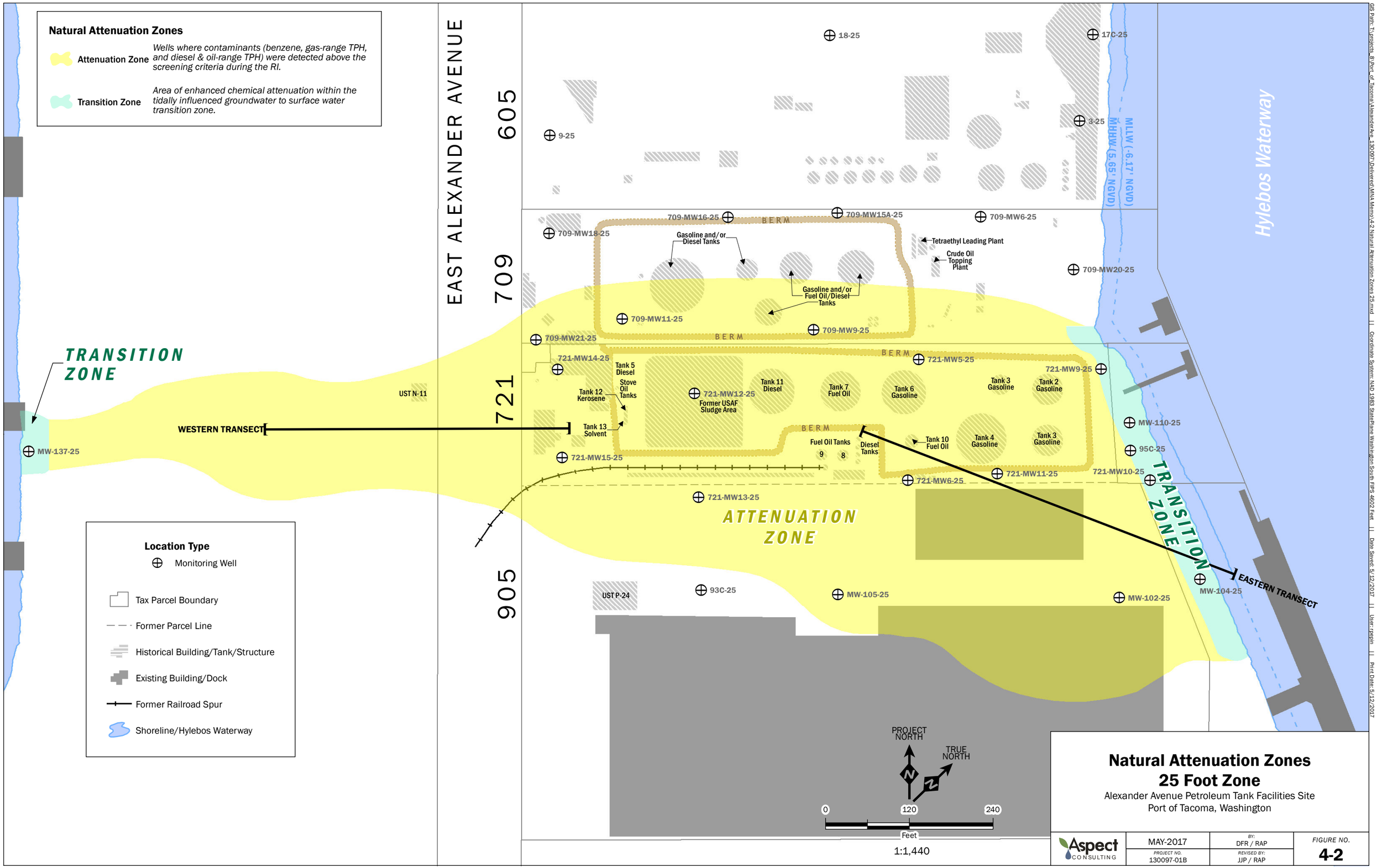
0 120 240
Feet

1:1,440

Natural Attenuation Zones
15 Foot Zone

Alexander Avenue Petroleum Tank Facilities Site
Port of Tacoma, Washington

Aspect CONSULTING	MAY-2017	BY: DFR / RAP	FIGURE NO. 4-1
	PROJECT NO. 130097-01B	REVISED BY: JJP / RAP	



Natural Attenuation Zones
25 Foot Zone

Alexander Avenue Petroleum Tank Facilities Site
Port of Tacoma, Washington

Aspect Consulting	MAY-2017	BY: DFR / RAP	FIGURE NO. 4-2
	PROJECT NO. 130097-01B	REVISED BY: JJP / RAP	

GIS Path: T:\projects_8\Port_of_Tacoma\Alexander Ave_130097\Delivered\MXA Memo\4-2 Natural Attenuation Zones 25.mxd || Coordinate System: NAD 1983 StatePlane Washington South FIPS 4602 Feet || Date Saved: 5/12/2017 || User: rpepin || Print Date: 5/12/2017

Natural Attenuation Zones

Source Zone — *Wells where NAPL, or trace NAPL, was measured in October 2014 (RI Fig. 6.2-2)*

Attenuation Zone — *Wells where contaminants (benzene, gas-range TPH, and diesel & oil-range TPH) were detected above the screening criteria during the RI.*

Transition Zone — *Area of enhanced chemical attenuation within the tidally influenced groundwater to surface water transition zone.*

Restoration Timeframe (years)

- ***BSL*** Below Screening Level, concentration < SL (1.6 µg/L)
- ***36*** Source Zone
- ***17*** Attenuation Zone
- ***5*** Transition Zone

EAST ALEXANDER AVENUE

605

709

721

905

Hylebos Waterway

MLLW (-6.17' NGVD)
MHHW (5.65' NGVD)

28-15
29-14
30-15
51-15
48-15
50-15
52-15
47-15
709-MW17-15
709-MW16-15
709-MW15-15
709-MW3-15
49-15
709-MW6-15
709-MW18-15
B E R M
Gasoline and/or Diesel Tanks
Tetraethyl Leading Plant
Crude Oil Topping Plant
709-MW4-15
709-MW2-15
709-MW20-15
709-MW13-15
709-MW14-15
709-MW19-15
709-MW12-15
Gasoline and/or Fuel Oil/Diesel Tanks
709-MW5-15
709-MW21-15
BSL
709-MW11-15
709-MW9-15
9
709-MW8-15
709-MW1-15
709-MW7-15
B E R M
709-MW-10-15
721-MW5-15
721-MW14-15
13
Tank 5 Diesel
Stove Oil Tanks
721-MW12-15
36
Tank 11 Diesel
Tank 7 Fuel Oil
Tank 6 Gasoline
Tank 3 Gasoline
Tank 2 Gasoline
721-MW9-15
BSL
721-MW7-15
721-MW8-15
15
MW-110-15
SP-101
BSL
Tank 12 Kerosene
Former USAF Sludge Area
MW-130-15
9
UST N-11
HC-N11-6
17
WESTERN TRANSECT
721-MW2
156
Tank 13 Solvent
MW-106-15
19
B E R M
Fuel Oil Tanks
9
8
Diesel Tanks
Tank 10 Fuel Oil
Tank 4 Gasoline
Tank 3 Gasoline
721-MW15-15
44
MW-109-15
42
721-MW11-15
34
95-15
5
721-MW10-15
SP-102
BSL
721-MW3
52
721-MW13-15
721-MW6-15
21
SP-103
26
EASTERN TRANSECT
MW-104-15
67
UST P-24
MW-105-15
MW-102-15

Tax Parcel Boundary
Former Parcel Line
Historical Building/Tank/Structure
Existing Building/Dock
Former Railroad Spur
Shoreline/Hylebos Waterway

Location Type
- Monitoring Well
- Seep

Sampling Schedule
- Biannual Sampling
- Quarterly Sampling
- Existing Sample Location

PROJECT NORTH
TRUE NORTH
N
2
0
120
240
Feet
1:1,440

Benzene Restoration Timeframe
15 Foot Zone

Alexander Avenue Petroleum Tank Facilities Site
Port of Tacoma, Washington

Aspect Consulting	MAY-2017	BY: DFR / RAP	FIGURE NO. 4-3
	PROJECT NO. 130097-01B	REVISED BY: JJP / RAP	

Natural Attenuation Zones

Attenuation Zone — *Wells where contaminants (benzene, gas-range TPH, and diesel & oil-range TPH) were detected above the screening criteria during the RI.*

Transition Zone — *Area of enhanced chemical attenuation within the tidally influenced groundwater to surface water transition zone.*

Restoration Timeframe (years)

BSL	Below Screening Level, concentration < SL (1.6 µg/L)
36	Source Zone
17	Attenuation Zone
5	Transition Zone

EAST ALEXANDER AVENUE

605

709

721

905

Hylebos Waterway

MLLW (-6.17' NGVD)
MHHW (5.65' NGVD)

18-25
17C-25
9-25
3-25
709-MW16-25
709-MW15A-25
709-MW6-25
709-MW18-25
709-MW20-25
709-MW11-25
709-MW9-25
709-MW21-25
721-MW14-25
721-MW5-25
721-MW9-25
721-MW12-25
721-MW15-25
721-MW13-25
721-MW6-25
721-MW11-25
MW-137-25
2
MW-110-25
BSL
95C-25
721-MW10-25
119
MW-104-25
5
MW-105-25
152
MW-102-25
93C-25

BERM

Gasoline and/or Diesel Tanks
Tetraethyl Leading Plant
Crude Oil Topping Plant
Gasoline and/or Fuel Oil/Diesel Tanks
Tank 5 Diesel
Stove Oil Tanks
Tank 12 Kerosene
Former USAF Sludge Area
Tank 13 Solvent
Tank 11 Diesel
Tank 7 Fuel Oil
Tank 6 Gasoline
Tank 3 Gasoline
Tank 2 Gasoline
Fuel Oil Tanks
9
8
Diesel Tanks
Tank 10 Fuel Oil
Tank 4 Gasoline
Tank 3 Gasoline

UST N-11
UST P-24

WESTERN TRANSECT
EASTERN TRANSECT

- Monitoring Well - Quarterly Sampling
- Existing Monitoring Well
- Tax Parcel Boundary
- Former Parcel Line
- Historical Building/Tank/Structure
- Existing Building/Dock
- Former Railroad Spur
- Shoreline/Hylebos Waterway

PROJECT NORTH
TRUE NORTH

0 120 240
Feet
1:1,440

Benzene Restoration Timeframe
25 Foot Zone

Alexander Avenue Petroleum Tank Facilities Site
Port of Tacoma, Washington

Aspect Consulting	MAY-2017	BY: DFR / RAP	FIGURE NO. 4-4
	PROJECT NO. 130097-01B	REVISED BY: JJP / RAP	

Natural Attenuation Zones

Source Zone	*Wells where NAPL, or trace NAPL, was measured in October 2014 (RI Fig. 6.2-2)*
Attenuation Zone	*Wells where contaminants (benzene, gas-range TPH, and diesel & oil-range TPH) were detected above the screening criteria during the RI.*
Transition Zone	*Area of enhanced chemical attenuation within the tidally influenced groundwater to surface water transition zone.*

Restoration Timeframe (years)

BSL	Below Screening Level, concentration < SL (800 µg/L)
36	Source Zone
17	Attenuation Zone
5	Transition Zone

EAST ALEXANDER AVENUE

605

709

721

905

Hylebos Waterway

MLLW (-6.17' NGVD)
MHHW (5.65' NGVD)

28-15
30-15
51-15
29-14
52-15
47-15
709-MW16-15
709-MW15-15
48-15
50-15
49-15
709-MW3-15
709-MW6-15
709-MW17-15 6
709-MW18-15
B E R M
Gasoline and/or Diesel Tanks
Tetraethyl Leading Plant
Crude Oil Topping Plant
709-MW4-15
709-MW2-15
709-MW20-15
709-MW14-15
709-MW13-15
709-MW19-15
709-MW12-15
Gasoline and/or Fuel Oil/Diesel Tanks
709-MW5-15
709-MW11-15 4
709-MW9-15 34
709-MW8-15
709-MW1-15
709-MW7-15
709-MW21-15
B E R M
709-MW-10-15
721-MW5-15
B E R M
721-MW9-15 3
721-MW14-15 16
Tank 5 Diesel
721-MW12-15 15
Tank 11 Diesel
Tank 7 Fuel Oil
Tank 6 Gasoline
Tank 3 Gasoline
Tank 2 Gasoline
721-MW7-15
721-MW8-15 4
MW-130-15 7
UST N-11
HC-N11-6 11
Stove Oil Tanks
Tank 12 Kerosene
Former USAF Sludge Area
721-MW2 124
MW-106-15 17
WESTERN TRANSECT
Tank 13 Solvent
B E R M
Fuel Oil Tanks
9
8
Diesel Tanks
Tank 10 Fuel Oil
Tank 4 Gasoline
Tank 3 Gasoline
MW-110-15
SP-101 BSL
721-MW15-15 15
721-MW11-15 11
95-15 6
SP-102 BSL
721-MW10-15
721-MW3 73
721-MW13-15
MW-109-15 9
721-MW6-15 13
SP-103 BSL
EASTERN TRANSECT
MW-104-15 BSL
USTP-24
MW-105-15
MW-102-15

Tax Parcel Boundary
Former Parcel Line
Historical Building/Tank/Structure
Existing Building/Dock
Former Railroad Spur
Shoreline/Hylebos Waterway

Location Type
- Monitoring Well
- Seep

Sampling Schedule
- Biannual Sampling
- Quarterly Sampling
- Existing Sample Location

PROJECT NORTH
TRUE NORTH

0 120 240
Feet
1:1,440

Gasoline-Range TPH
Restoration Timeframe - 15 Foot Zone

Alexander Avenue Petroleum Tank Facilities Site
Port of Tacoma, Washington

Aspect CONSULTING	MAY-2017	BY: DFR / RAP	FIGURE NO. 4-5
	PROJECT NO. 130097-01B	REVISED BY: JJP / RAP	

Natural Attenuation Zones

Source Zone	*Wells where NAPL, or trace NAPL, was measured in October 2014 (RI Fig. 6.2-2)*
Attenuation Zone	*Wells where contaminants (benzene, gas-range TPH, and diesel & oil-range TPH) were detected above the screening criteria during the RI.*
Transition Zone	*Area of enhanced chemical attenuation within the tidally influenced groundwater to surface water transition zone.*

Restoration Timeframe (years)

BSL	Below Screening Level, concentration < SL (500 µg/L)
36	Source Zone
17	Attenuation Zone
5	Transition Zone

EAST ALEXANDER AVENUE

605

709

721

905

Hylebos Waterway

MLLW (-6.17' NGVD)
MHHW (5.65' NGVD)

28-15
29-14
30-15
51-15
52-15
47-15
48-15
50-15
49-15
709-MW15-15
709-MW3-15
709-MW6-15
709-MW16-15
709-MW17-15
12
709-MW18-15
709-MW4-15
709-MW2-15
709-MW20-15
709-MW19-15
709-MW13-15
709-MW12-15
709-MW5-15
709-MW11-15
10
709-MW9-15
1
709-MW8-15
709-MW1-15
709-MW7-15
709-MW21-15
709-MW-10-15
721-MW5-15
721-MW14-15
22
721-MW14-15
721-MW12-15
20
721-MW9-15
BSL
721-MW7-15
721-MW8-15
BSL
721-MW2
42
MW-106-15
1
721-MW15-15
24
721-MW109-15
BSL
721-MW11-15
1
721-MW10-15
721-MW3
BSL
721-MW13-15
721-MW6-15
BSL
MW-110-15
SP-101
BSL
95-15
BSL
SP-102
BSL
SP-103
BSL
MW-104-15
BSL
EASTERN TRANSECT
MW-130-15
BSL
HC-N11-6
2
WESTERN TRANSECT
UST N-11
UST P-24
MW-105-15
MW-102-15

B E R M

Gasoline and/or Diesel Tanks
Tetraethyl Leading Plant
Crude Oil Topping Plant
Gasoline and/or Fuel Oil/Diesel Tanks
Tank 5 Diesel
Stove Oil Tanks
Tank 12 Kerosene
Tank 13 Solvent
Former USAF Sludge Area
Tank 11 Diesel
Tank 7 Fuel Oil
Tank 6 Gasoline
Tank 3 Gasoline
Tank 2 Gasoline
Fuel Oil Tanks
9
8
Diesel Tanks
Tank 10 Fuel Oil
Tank 4 Gasoline
Tank 3 Gasoline

PROJECT NORTH
TRUE NORTH
0
120
240
Feet
1:1,440

Legend

- Tax Parcel Boundary
- Former Parcel Line
- Historical Building/Tank/Structure
- Existing Building/Dock
- Former Railroad Spur
- Shoreline/Hylebos Waterway

Location Type
- Monitoring Well
- Seep

Sampling Schedule
- Biannual Sampling
- Quarterly Sampling
- Existing Sample Location

Diesel & Oil–Range TPH
Restoration Timeframe - 15 Foot Zone

Alexander Avenue Petroleum Tank Facilities Site
Port of Tacoma, Washington

Aspect CONSULTING	MAY-2017	BY: DFR / RAP	FIGURE NO. 4-6
	PROJECT NO. 130097-01B	REVISED BY: JJP / RAP	

	Manganese	Alkalinity	Methane	Nitrate	Nitrite	Sulfate	DO
709-MW20-15	0.9	175	0.7U	1U	1U	1650	2.76

	Manganese	Alkalinity	Methane	Nitrate	Nitrite	Sulfate	DO
709-MW20-25	184	218	7120	0.5U	0.5U	198	0.65

	Manganese	Alkalinity	Methane	Nitrate	Nitrite	Sulfate	DO
709-MW16-25	12	312	2500	0.5U	0.5U	0.5U	0.08

	Manganese	Alkalinity	Methane	Nitrate	Nitrite	Sulfate	DO
709-MW-09-15	510	374	9670	0.5U	0.5U	0.5U	1.6

	Manganese	Alkalinity	Methane	Nitrate	Nitrite	Sulfate	DO
HC-N11-6	419	326	5850	0.1U	0.1U	0.1U	0.47

	Manganese	Alkalinity	Methane	Nitrate	Nitrite	Sulfate	DO
721-MW12-15	576	379	10400	0.5U	0.5U	0.5U	2.78

	Manganese	Alkalinity	Methane	Nitrate	Nitrite	Sulfate	DO
721-MW12-25	470	502	17100	0.5U	0.5U	0.5U	0.13

	Manganese	Alkalinity	Methane	Nitrate	Nitrite	Sulfate	DO
MW-109-15	625	453	14500	0.5U	0.5U	0.5U	0.69

	Manganese	Alkalinity	Methane	Nitrate	Nitrite	Sulfate	DO
MW-110-25	361	614	9130	0.1U	0.1U	6.5	0.14

	Manganese	Alkalinity	Methane	Nitrate	Nitrite	Sulfate	DO
MW-110-15	34	198	31.4	0.5U	0.5U	670	0.19

605

709

901 (FORMERLY 721 & 905)

EAST ALEXANDER AVENUE

Hylebos Waterway

MLLW (-6.17' NGVD)

MHHW (5.65' NGVD)

BERM

Gasoline and/or Diesel Tanks

Gasoline and/or Fuel Oil/Diesel Tanks

Tetraethyl Leading Plant

Crude Oil Topping Plant

Tank 5 Diesel

Stove Oil Tanks

Former USAF Sludge Area

Tank 11 Diesel

Tank 7 Fuel Oil

Tank 6 Gasoline

Tank 3 Gasoline

Tank 2 Gasoline

Tank 12 Kerosene

Tank 13 Solvent

Fuel Oil Tanks 9 8

Diesel Tanks

Tank 10 Fuel Oil

Tank 4 Gasoline

Tank 3 Gasoline

UST N-11

UST P-24

Natural Attenuation Zones

- Source Zone — *Wells where NAPL, or trace NAPL, was measured in October 2014 (RI Fig. 6.2-2)*
- Attenuation Zone — *Wells where contaminants (benzene, gas-range TPH, and diesel & oil-range TPH) were detected above the screening criteria during the RI.*
- Transition Zone — *Area of enhanced chemical attenuation within the tidally influenced groundwater to surface water transition zone.*

Note: Attenuation zones represent the maximum extent in both the 15 foot and 25 foot zones.

- Tax Parcel Boundary
- Former Parcel Line
- Historical Building/Tank/Structure
- Existing Building/Dock
- Former Railroad Spur
- Shoreline/Hylebos Waterway

Location Type

- Well (15 ft)
- Well (25 ft)

	Manganese	Alkalinity	Methane	Nitrate	Nitrite	Sulfate	DO
Units	µg/L	mg/L as CaCO3	µg/L	as Nitrogen in mg-N/L	as Nitrogen in mg-N/L	mg/L	mg/L

PROJECT NORTH

TRUE NORTH

N

0 120 240

Feet

1:1,440

Geochemical Indicators in Groundwater

Alexander Avenue Petroleum Tank Facilities Site
Port of Tacoma, Washington

Aspect CONSULTING

MAY-2017

PROJECT NO. 130097-01D

BY: DFR / PPW

REVISED BY: RAP / RMB

FIGURE NO. 4-7

GIS Path: T:\projects_8\Port of Tacoma\Alexander Ave_130097\Delivered\MNA Memo\4-7 Geochemical Indicators.mxd || Coordinate System: NAD 1983 StatePlane Washington South FIPS 4602 Feet || Date Saved: 5/16/2017 || User: rpepin || Print Date: 5/16/2017

Figure 4-8 - Benzene - Concentration vs Distance

DRAFT

Groundwater Monitoring Data (4Q average)

East Transect

Well ID	Distance	Benzene	ln
MW-106-15	0	323	5.78
MW-109-15	9	1223	7.11
721-MW6-15	76	623	6.43
721-MW11-15	189	570	6.35
MW-104-15	512	368	5.91
SP-103	570	14	2.61

Linear Regression Analysis

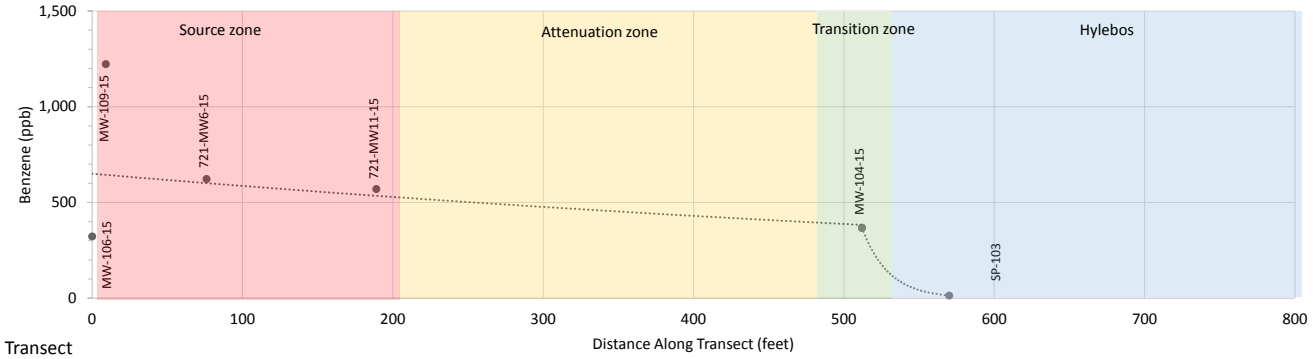
AZ slope	-1.03E-03
AZ R^2	0.18
TZ slope	-5.69E-02
TZ R^2	1.00

West Transect

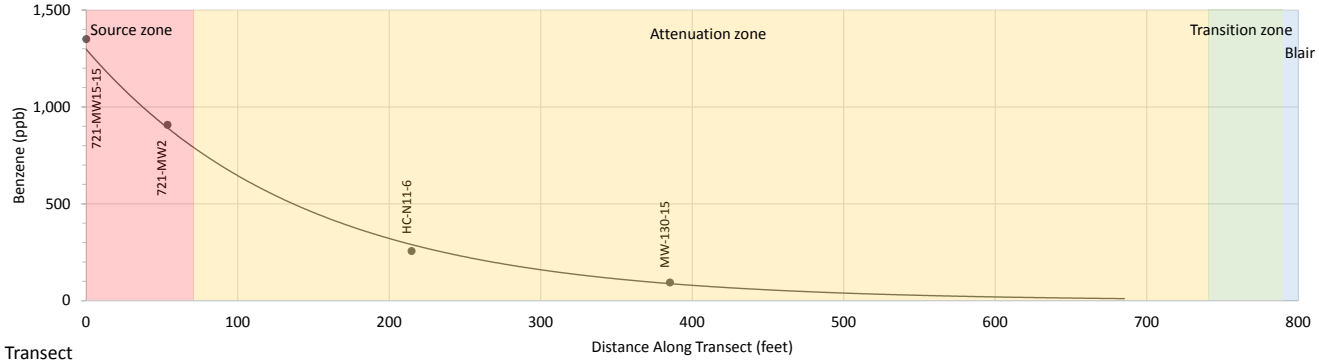
Well ID	Distance	Benzene	ln
721-MW15-15	0	1350	7.21
721-MW2	54	908	6.81
HC-N11-6	215	256	5.55
MW-130-15	385	94	4.55
MHHW	779		

Linear Regression Analysis

AZ slope	-6.98E-03
AZ R^2	1.00



East Transect



West Transect

Note
Concentration data at each location is the average of the last four quarters of monitoring results (sampling events in Q4 2015, Q1 2016, Q2 2016, and Q3 2016).
Solid line indicates the trend is significantly different from zero at a 85% confidence level.

Figure 4-9 - Gasoline-Range TPH - Concentration vs. Distance

DRAFT

Groundwater Monitoring Data (4Q average)

East Transect

Well ID	Distance	Gas	ln
MW-106-15	0	4450	8.40
MW-109-15	9	3750	8.23
721-MW6-15	76	3825	8.25
721-MW11-15	189	2925	7.98
MW-104-15	512	544	6.30
SP-103	570	50	3.22

Linear Regression Analysis

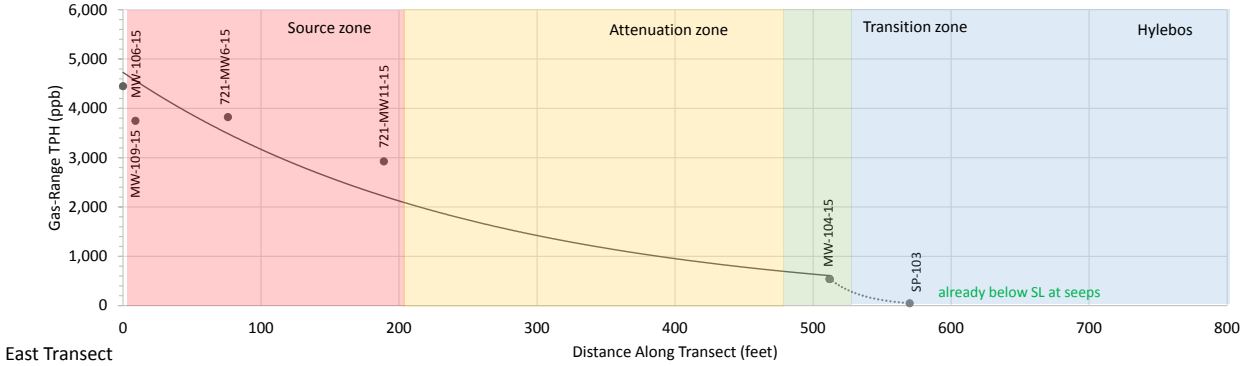
AZ slope	-4.00E-03
AZ R^2	0.95
TZ slope	-5.31E-02
TZ R^2	1.00

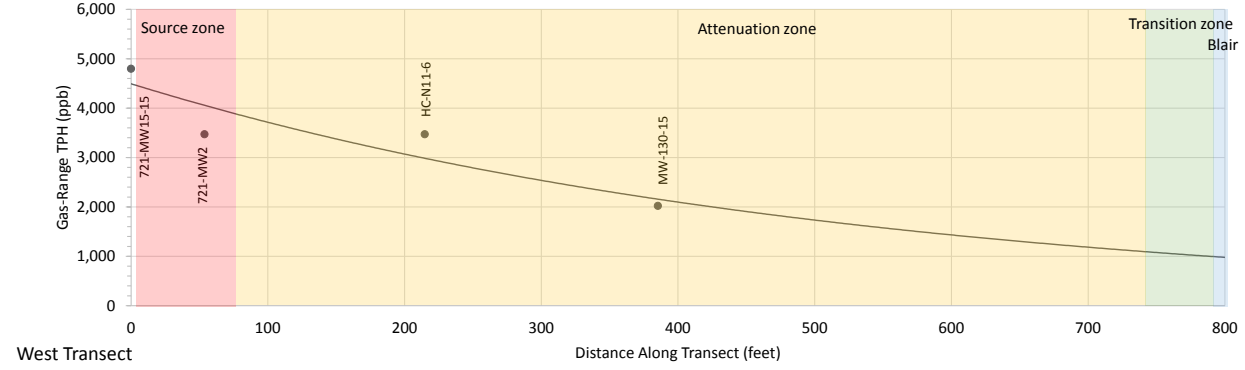
West Transect

Well ID	Distance	Gas	ln
721-MW15-15	0	4800	8.48
721-MW2	54	3475	8.15
HC-N11-6	215	3475	8.15
MW-130-15	385	2025	7.61
MHHW	779		

Linear Regression Analysis

AZ slope	-1.91E-03
AZ R^2	0.86





Note
Concentration data at each location is the average of the last four quarters of monitoring results (sampling events in Q4 2015, Q1 2016, Q2 2016, and Q3 2016).
Solid line indicates the trend is significantly different from zero at a 85% confidence level.

Figure 4-10 - Diesel Oil-Range TPH - Concentration vs. Distance

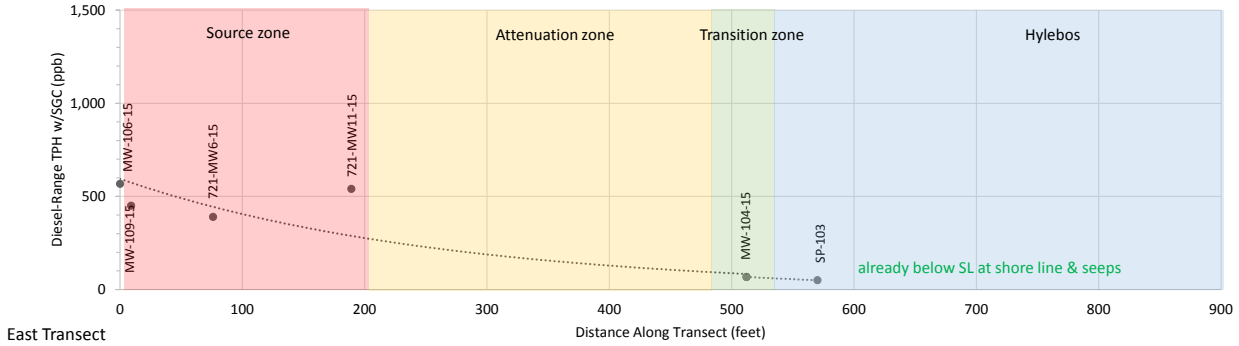
Groundwater Monitoring Data (4Q average)

East Transect			
Well ID	Distance	Diesel	ln
MW-106-15	0	568	6.34
MW-109-15	9	450	6.11
721-MW6-15	76	390	5.97
721-MW11-15	189	540	6.29
MW-104-15	512	68	4.22
SP-103	570	50	3.91

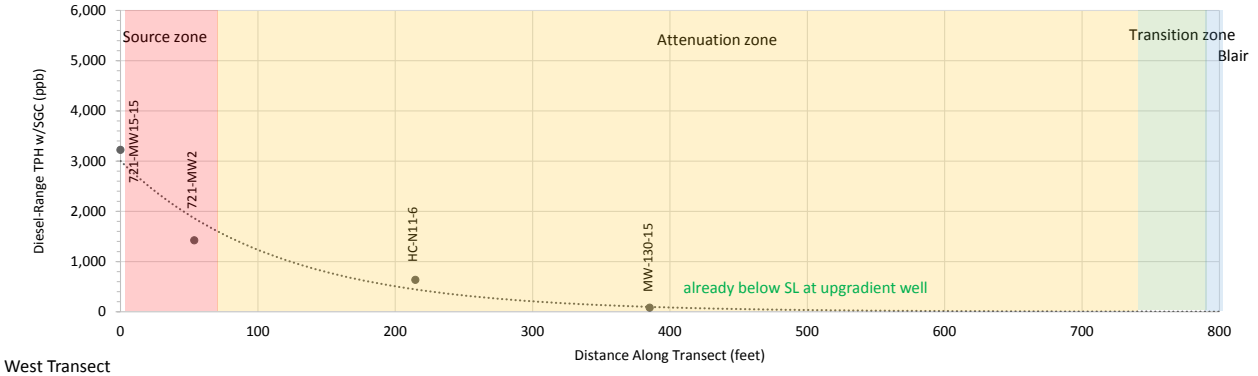
Linear Regression Analysis	
AZ slope	-3.83E-03
AZ R^2	0.84
TZ slope	-5.30E-03
TZ R^2	1.00

West Transect			
Well ID	Distance	Diesel	ln
721-MW15-15	0	3225	8.08
721-MW2	54	1425	7.26
HC-N11-6	215	638	6.46
MW-130-15	385	83	4.42
MHHW	779		

Linear Regression Analysis	
AZ slope	-8.89E-03
AZ R^2	0.92



East Transect



West Transect

Note
Concentration data at each location is the average of the last four quarters of monitoring results (sampling events in Q4 2015, Q1 2016, Q2 2016, and Q3 2016).
Solid line indicates the trend is significantly different from zero at a 85% confidence level.

Table 4-11 - Diesel Oil-Range TPH without Silica Gel Cleanup - Concentration vs. Distance

DRAFT

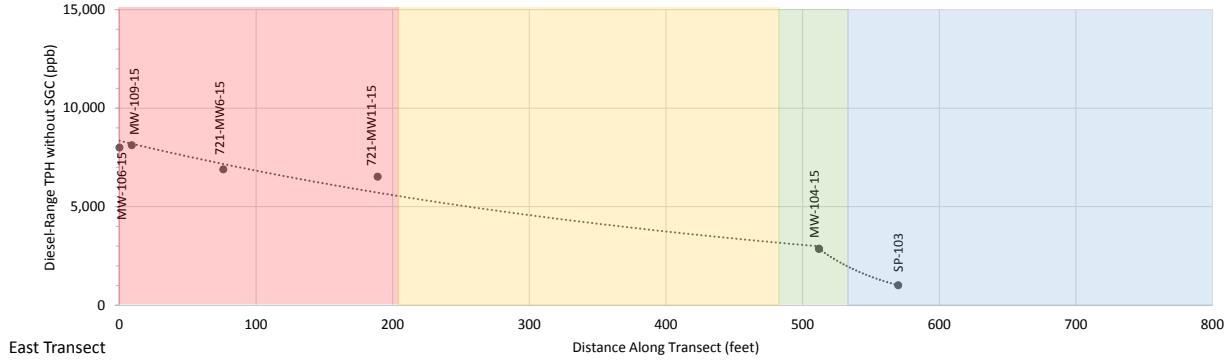
Groundwater Monitoring Data (4Q average)

East Transect			
Well ID	Distance	Diesel	ln
MW-106-15	0	8000	8.99
MW-109-15	9	8125	9.00
721-MW6-15	76	6900	8.84
721-MW11-15	189	6525	8.78
MW-104-15	512	2863	7.96
SP-103	570	1015	6.92

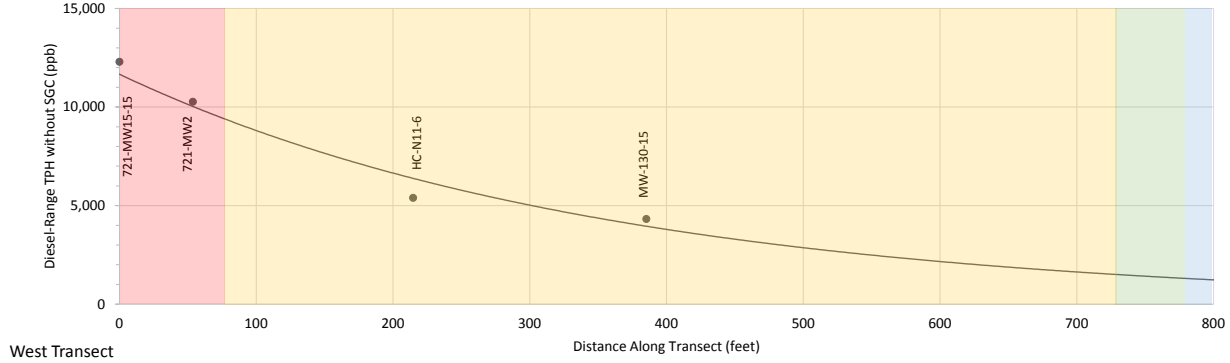
Linear Regression Analysis	
AZ slope	-2.01E-03
AZ R^2	0.97
TZ slope	-1.79E-02
TZ R^2	1.00

East Transect			
Well ID	Distance	Diesel	ln
721-MW15-15	0	12300	9.417354541
721-MW2	53.68421053	10275	9.237469039
HC-N11-6	214.7368421	5400	8.594154233
MW-130-15	385.2631579	4325	8.372167419
MHHW	779		

Linear Regression Analysis	
AZ slope	-2.81E-03
AZ R^2	0.95



East Transect



West Transect

Note
Concentration data at each location is the average of the last four quarters of monitoring results (sampling events in Q4 2015, Q1 2016, Q2 2016, and Q3 2016).
Solid line indicates the trend is significantly different from zero at a 85% confidence level.

TABLES

Table 4-1 - Benzene Time Series Analysis

DRAFT

SL (ppb):	1.6									
Well data					Linear Trend Analysis[1]		Statistical Significance[2]	Restoration Timeframe (years)[3]		Half-Life (years)[4]
Location	Conc. initial sampling event (ppb)	Current conc. (ppb)[5]	Sample size	Record length (years)	Attentuation rate (ln(ppb)/day)[6]	R^2	Decreasing trend	Individual well	Average[7]	Individual well
709-MW-09-15	910	11	10	21	-6.02E-04	0.96	TRUE	9	--	3.2
709-MW-11-15	1700	1.1	8	21	-9.79E-04	0.97	TRUE	0	--	1.9
709-MW-17-15	52	0.37	9	21	-6.78E-04	0.95	TRUE	0	--	2.8
721-MW11-15	1100	570	5	4	-4.74E-04	0.12	--	34	--	4.0
721-MW12-15	450	295	6	4	-3.92E-04	0.12	--	36	--	4.8
721-MW14-15	150	58	5	4	-7.52E-04	0.28	--	13	--	2.5
721-MW15-15	2300	1350	6	4	-4.16E-04	0.81	TRUE	44	--	4.6
721-MW2	1900	908	7	21	-1.11E-04	0.44	TRUE	156	--	17.0
721-MW3	1400	283	8	21	-2.73E-04	0.12	--	52	--	7.0
721-MW6-15	2150	623	6	12	-7.91E-04	0.12	--	21	--	2.4
721-MW8-15	5.4	3.3	7	12	-1.35E-04	0.46	TRUE	15	--	14.0
721-MW9-15	1.25	0.42	10	12	-3.85E-04	0.35	TRUE	0	--	4.9
95-15	26	9.4	9	4	-9.35E-04	0.61	TRUE	5	--	2.0
HC-N11-6	190	256	7	5	1.43E-05	0.00	--	--	15	+slope
MW-104-15	250	368	8	2	-2.22E-04	0.00	--	67	--	8.6
MW-106-15	610	323	6	2	-7.48E-04	0.10	--	19	--	2.5
MW-109-15	1900	1223	6	2	-4.38E-04	0.10	--	42	--	4.3
MW-130-15	110	94	8	2	-1.19E-03	0.48	TRUE	9	--	1.6
SL (ppb):	1.6									
721-MW10-25	125	111	10	12	-9.77E-05	0.06	--	119	--	19
MW-104-25	51	180	8	1	1.99E-04	0.00	--	--	5	+ slope
MW-105-25	140	145	8	2	-8.12E-05	0.00	--	152	--	23
MW-110-25	4.2	2	8	2	-1.08E-03	0.49	TRUE	0	--	2
MW-137-25	48	14	8	2	-3.85E-03	0.49	TRUE	2	--	0

Summary by natural attenuation zone

Average SZ[8]

k_{point}	-3.16E-04
$t_{1/2}$ - attenuation	6.0
$t_{1/2}$ - biodegradation	12.0

Averages AZ[9] - 15-foot zone

k_{point}	-9.50E-04
$t_{1/2}$ - attenuation	2.0
$t_{1/2}$ - biodegradation	4.0

Averages AZ[10] - 25-foot zone

k_{point}	-2.47E-03
$t_{1/2}$ - attenuation	0.8
$t_{1/2}$ - biodegradation	1.5

Averages TZ[11]

k_{point}	-6.60E-04
$t_{1/2}$ - attenuation	2.9
$t_{1/2}$ - biodegradation	5.8

Notes:

1 - Linear trend analysis was applied to calculate the attenduation rate at each well as described in Ecology (2005) Appendix F.2. The concentration data was natural log transformed and plotted versus time, the slope of the trend-line of the regression anaysis is an approximation of the attenuation rate.

2 - The statistical significance of the trend was determined for wells with sample sizes of 8 or greater by linear regression about the mean as described in EPA, 2009. For wells with sample sizes of less than 8 the Mann-Kendall test was applied. Statistical tests applied a confidence level of 85%. Methods described in Section 17.3.1 and 17.3.2 of EPA (2009). No increasing trends were statisticaly significant from zero.

3 - Restoration timeframe equation: See Section 3.1.4 in text.

4 - Half life equation: See section 3.1.3 in text.

5 - Concentration data is an average of the 4Q sampling event results.

6 - Slope of natural log groundwater concentration vs. time plot at a well.

7 - Average attenduation rate was estimated from the statistically significant decreasing trends trends for SZ, AZ and TZ. The average was applied to calculate restoration timeframe.

8 - Calculated from wells with statistically significant attenuation rates in the source zone (709-MW-09-15, 721-MW-15-15, 721-MW2, and 721-MW8-15).

9 - Calculated from well with statistically significant attenuation rates in the 15-foot attenuation zone (709-MW-11-15, 709-MW-17-15, and MW-130-15).

10 - Calculated from wells with statistically significant attenuation rates in the 25-foot attenuation zone (MW-110-15 and MW-137-25).

11 - Calculated from wells with statistically significant attenuation rates in the transition zone (wells 721-MW9-15 and 95-15).

Source zone (SZ) wells

Attenuation zone (AZ) wells

Transition zone (TZ) wells

Table 4-2 - Gasoline-Range TPH Time Series Analysis

DRAFT

SL (ppb):	800										
Well data					Linear Trend Analysis[1]		Statistical Significance[2]		Restoration Timeframe (years)[3]		Half-Life (years)[4]
Location	Conc. initial sampling event (ppb)	Current conc. (ppb)[5]	Sample size	Record length (years)	Attentuation rate (ln(ppb)/day)[6]	R^2	Increasing trend	Decreasing trend	Individual well	Average[7]	Individual well
709-MW-09-15	7100	5725	7	4	-1.56E-04	0.10	--	--	34	--	12
709-MW-11-15	5000	1355	6	12	-3.78E-04	0.29	--	--	4	--	5
709-MW-17-15	1500	1850	7	12	5.53E-05	0.12	--	--	--	6	+ slope
721-MW11-15	2000	2925	5	4	3.03E-04	0.12	--	--	--	11	+ slope
721-MW12-15	3100	5200	6	4	3.83E-04	0.98	TRUE	--	--	16	+ slope
721-MW14-15	3300	5050	5	4	3.31E-04	0.85	TRUE	--	--	16	+ slope
721-MW15-15	2600	4800	6	4	4.29E-04	0.92	TRUE	--	--	15	+ slope
721-MW2	3820	3475	6	8	-3.23E-05	0.05	--	--	124	--	59
721-MW3	2200	1675	8	21	-2.54E-05	0.05	--	--	80	--	75
721-MW6-15	2600	3825	5	4	2.84E-04	0.93	TRUE	--	--	13	+ slope
721-MW8-15	1100	1350	6	2	6.77E-04	0.37	TRUE	--	--	4	+ slope
721-MW9-15	1100	1275	9	4	1.52E-04	0.16	--	--	--	3	+ slope
95-15	140	1906	9	4	1.62E-03	0.34	TRUE	--	--	6	+ slope
HC-N11-6	2200	3475	7	5	4.93E-04	0.64	TRUE	--	--	11	+ slope
MW-104-15	590	544	8	2	5.80E-04	0.02	--	--	0	--	--
MW-106-15	5400	4450	6	2	-2.72E-04	0.03	--	--	17	--	7
MW-109-15	4500	3750	6	2	-4.87E-04	0.11	--	--	9	--	4
MW-130-15	940	2025	8	2	6.60E-04	0.29	--	--	--	7	+ slope
SL (ppb):	800										
721-MW10-25	46	55	9	4	2.81E-05	0.00	--	--	0	--	+ slope
MW-104-25	470	316	8	2	-5.69E-05	0.00	--	--	0	--	33
MW-105-25	125	169	8	2	4.98E-04	0.02	--	--	0	--	+ slope
MW-110-25	125	69	8	2	-1.81E-03	0.25	--	--	0	--	1
MW-137-25	125	69	8	2	-1.68E-03	0.67	--	TRUE	0	--	1

Summary by natural attenuation zone

Average SZ[8]

k_{point}	-3.22E-04
$t_{1/2}$ - attenuation	5.9
$t_{1/2}$ - biodegradation	11.8

AZ[9] - 15-foot zone

k_{point}	-3.78E-04
$t_{1/2}$ - attenuation	5.0
$t_{1/2}$ - biodegradation	10.0

Averages AZ[10] - 25-foot zone

k_{point}	-1.75E-03
$t_{1/2}$ - attenuation	1.1
$t_{1/2}$ - biodegradation	2.2

Notes:

1 - Linear trend analysis was applied to calculate the attenduation rate at each well as described in Ecology (2005) Appendix F.2. The concentration data was natural log transformed and plotted versus time, the slope of the trend-line of the regression anaysis is an approximation of the attenuation rate.

2 - The statistical significance of the trend was determined for wells with sample sizes of 8 or greater by linear regression about the mean as described in EPA, 2009. For wells with sample sizes of less than 8 the Mann-Kendall test was applied. Statistical tests applied a confidence level of 85%. Methods described in Section 17.3.1 and 17.3.2 of EPA (2009).

3 - Restoration timeframe equation: See Section 3.1.4 in text.

4 - Half life equation: See section 3.1.3 in text.

5 - Concentration data is an average of the 4Q sampling event results.

6 - Slope of natural log groundwater concentration vs. time plot at a well.

7 - Average attenduation rate was estimated from the decreasing trends with a R^2 value greater than 0.10 for SZ and AZ, emphasized with thick boxed outline . The average was applied to calculate restoration timeframe.

8 - Calculated from wells with a R^2 value greater than 0.10 in the source zone (wells 709-MW-09-15 and MW-109-15).

9 - Calculated from wells with a R^2 value greater than 0.10 in the attenuation zone (well 709-MW-11-15).

10 - Calculated from wells with a R^2 value greater than 0.10 in the attenuation zone (wells MW-110-25 and MW-137-25).

Source zone (SZ) wells

Attenuation zone (AZ) wells

Transition zone (TZ) wells

Table 4-3 - Diesel Oil-Range TPH Time Series Analysis

DRAFT

SL (ppb): 500

Well data[2]					Linear Trend Analysis[1]		Statistical Significance[2]	Restoration Timeframe[3]		Half Life[4]
Location	Conc. initial sampling event (ppb)	Current conc. (ppb)[5]	Sample size	Record length (years)	Attentuation rate (ln(ppb)/day)[6]	R^2	Decreasing trend	Individual well	Average[7]	Individual well
709-MW-09-15	840	523	7	4	-3.65E-04	0.48	--	0.3	--	5
709-MW-11-15	1700	2220	5	4	1.26E-04	0.01	--	--	10	+ slope
709-MW-17-15	870	2850	6	4	5.45E-04	0.16	--	--	12	+ slope
721-MW11-15	360	540	5	4	3.07E-04	0.16	--	--	1	+ slope
721-MW12-15	1600	1300	7	4	-1.33E-04	0.33	--	20	--	14
721-MW14-15	1300	1158	5	4	-1.06E-04	0.16	--	22	--	18
721-MW15-15	590	3225	6	4	8.10E-04	0.27	--	--	24	+ slope
721-MW2	1700	1425	6	8	-6.90E-05	0.06	--	42	--	27
721-MW3	4300	205	9	21	-3.98E-04	0.59	TRUE	0	--	5
721-MW6-15	560	390	5	4	-2.64E-04	0.69	--	0	--	7
721-MW8-15	50	50	6	2			--	0	--	
721-MW9-15	130	63	9	4	-3.18E-04	0.02	--	0	--	6
95-15	130	248	9	4	4.95E-04	0.10	--	0	--	+ slope
HC-N11-6	550	638	8	5	1.23E-04	0.09	--	--	2	+ slope
MW-104-15	50	68	8	2	4.96E-04	0.01	--	0	--	+ slope
MW-106-15	710	568	6	2	-3.07E-04	0.04	--	1	--	6
MW-109-15	570	450	7	2	-1.52E-04	0.08	--	0	--	12
MW-130-15	50	83	8	2	-2.54E-04	0.00	--	0	--	7

Summary by natural attenuation zone

Average SZ[8]

k_{point}	-2.17E-04
$t_{1/2}$ - attenuation	8.7
$t_{1/2}$ - biodegradation	17.5

AZ[9] - 15-foot zone

k_{point}	-3.98E-04
$t_{1/2}$ - attenuation	4.8
$t_{1/2}$ - biodegradation	9.5

Notes:

1 - Linear trend analysis was applied to calculate the attenduation rate at each well as described in Ecology (2005) Appendix F.2. The concentration data was natural log transformed and plotted versus time, the slope of the trend-line of the regression anaysis is an approximation of the attenuation rate.

2 - The statistical significance of the trend was determined for wells with sample sizes of 8 or greater by linear regression about the mean as described in EPA, 2009. For wells with sample sizes of less than 8 the Mann-Kendall test was applied. Statistical tests applied a confidence level of 85%. Methods described in Section 17.3.1 and 17.3.2 of EPA (2009). No increasing trends were statisticaly significant from zero.

3 - Restoration timeframe equation: See Section 4.1.4 in text.

4 - Half life equation: See section 4.1.3 in text.

5 - Concentration data is an average of the 4Q sampling event results.

6 - Slope of natural log groundwater concentration vs. time plot at a well.

7 - Average attenduation rate was estimated from the decreasing trends with a R^2 value greater than 0.10 for SZ and AZ, emphasized with thick boxed outline . The average was applied to calculate restoration timeframe.

8 - Calculated from wells with a R^2 value greater than 0.10 in the source zone (wells 709-MW-09-15, 721-MW12-15, 721-MW14-15, and 721-MW6-15).

9 - Calculated from wells with a R^2 value greater than 0.10 in the attenuation zone (721-MW3).

Diesel-range TPH concentrations were analyzed using silica gel cleanup.

Well 721-MW-8-15 sampling history is all non-detect for diesel-range TPH.

Source zone (SZ) wells

Attenuation zone (AZ) wells

Transition zone (TZ) wells

Table 4-4 - Literature Review - Biodegradation Rates

DRAFT

Aerobic Diesel Biodegradation Rates

Half Life (years)	Degradation Rate (day^{-1})	Data Source	Citation
0.06	-3.29E-02	Lab Measurement of Aerated Samples in soil matrix	Cunningham, 2004
0.50	-3.80E-03	Microcosm study with weathered diesel - nutrient amended at 10^{o} C.	Cross et al., 2011

Anaerobic Diesel Biodegradation Rates

Half Life (years)	Degradation Rate (day^{-1})	Data Source	Citation
1.8	-4.49E-04	Measured from soil columns in the lab under anaerobic conditions and no amendments (13% removal after 310 days).	Boopathy, 2004
2.5	-7.59E-04	Low end member half-life derived from insitu measurements in similar setting.	PGG, 2016
15	-1.27E-04	High endmember half-life derived from insitu measurements in similar setting.	
5.3	-3.58E-04	Geometric mean half-life derived from insitu measurements in similar setting.	
1.9	-9.99E-04	Microcosm study with weathered diesel - nutrient unamended at 20^{o} C.	Cross et al., 2011
1.2	-1.58E-03	Microcosm study with weathered diesel - nutrient amended at 10^{o} C.	

Aerobic Benzene Biodegradation Rates

Half Life (years)	Degradation Rate (day^{-1})	Data Source	Citation
0.16	-0.01	Insitu field measurements	Lawrence, 2006
0.003 to 0.006	-0.31 to -0.69	Labartory column study	Lawrence, 2006

Anaerobic Benzene Biodegradation Rates

Half Life (years)	Degradation Rate (day^{-1})	Data Source	Citation
0.57	-3.30E-03	Insitu field measurements	Lawrence, 2006

Table 4-5 - Benzene - Concentration vs Distance Analysis

DRAFT

Eastern Transect[1]

Linear Regression of Natural Log Transformed Data				Statistical Significance[4]	Calculations for determining concentration at upgradient wells necessary for protectiveness at the seep (SL = 1.6 µg/L)			Restoration Time Frame (years)	
	Sample Size	Slope [3]	R^2	Decreasing trend	$C_{current}$ at upgradient well[5]	Protective concentration at upgradient well[6]	% Reduction	Monitoring Well Time Series Slope[7]	Estimated Restoration Time Frame
Transition Zone	2	-5.69E-02	1.00	--	368	43	0.88	-2.22E-04	26
SZ/AZ	5	-1.03E-03	0.18	--	570	413	0.27	-4.74E-04	2

Western Transect[2]

Linear Regression of Natural Log Transformed Data				Statistical Significance[4]	Calculations for determining concentration at upgradient wells necessary for protectiveness at the seep (SL = 1.6 µg/L)		
	Sample Size	Slope [3]	R^2	Decreasing trend	$C_{current}$ at upgradient well[8]	Protective concentration at upgradient well[6]	% Reduction
Transition Zone	--	--	--	--	--	28	--
SZ/AZ	4	-6.98E-03	0.995	TRUE	94	303	currently protective

Notes:

1 - Eastern Transect includes monitoring wells MW-106-15, MW-109-15, 721-MW6-15, 721-MW11-15, and MW-104-15, and seep SP-103.

2 - Western Transect includes monitoring wells 721-MW15-15, 721-MW2, HC-N11-6, and MW-130-15.

3 - Slope is calculated by a regression around the mean as described in EPA, 2009, and represents the natural log transformed average of 4 quarterly sampling events (Q4 2015, Q1 2016, Q2 2016, and Q3 2016).

4 - Significance is determined by a Mann Kendall trend test appling a confidence level of 85%. Methods described in Section 7.3.2 of EPA (2009).

5 - Upgradient well in the TZ is MW-104-15, upgradient well in the SZ/AZ is 721-MW-11-15.

6 - See Eqn 5 in Sec 3.3 for formula.

7 - See Table 4-1 for individual monitoring well attenuation rate.

8 - There is no upgradient shoreline well in the TZ on the western transect, upgradient well in the SZ/AZ is MW-130-15.

Table 4-6 - Gasoline-Range TPH Concentration vs Distance Analysis

DRAFT

Eastern Transect[1]

Linear Regression of Natural Log Transformed Data				Statistical Significance[4]	Calculations for determining concentration at upgradient wells necessary for protectiveness at the seep (SL = 800 µg/L)		
	Sample Size	Slope[3]	R^2	Decreasing trend	$C_{current}$ at upgradient well[5]	Protective concentration at upgradient well[6]	% Reduction
Transition Zone	2	-5.31E-02	1.00	--	544	already below SL	currently protective
SZ/AZ	5	-4.00E-03	0.95	TRUE	--	--	currently protective

Western Transect[2]

Linear Regression of Natural Log Transformed Data				Statistical Significance[4]	Calculations for determining concentration at upgradient wells necessary for protectiveness at the seep (SL = 800 µg/L)		
	Sample Size	Slope[3]	R^2	Decreasing trend	$C_{current}$ at upgradient well[7]	Protective concentration at upgradient well[6]	% Reduction
Transition Zone	--	--	--	--	--	11,378	--
SZ/AZ	4	-1.91E-03	0.86	TRUE	2,025	21,901	currently protective

Notes:

1 - Eastern Transect includes monitoring wells MW-106-15, MW-109-15, 721-MW6-15, 721-MW11-15, and MW-104-15, and seep SP-103.

2 - Western Transect includes monitoring wells 721-MW15-15, 721-MW2, HC-N11-6, and MW-130-15.

3 - Slope is calculated by a regression around the mean as described in EPA, 2009, and represents the natural log transformed average of 4 quarterly sampling events (Q4 2015, Q1 2016, Q2 2016, and Q3 2016).

4 - Significance is determined by a Mann Kendall trend test appling a confidence level of 85%. Methods described in Section 7.3.2 of EPA (2009).

5 - Upgradient well in the TZ is MW-104-15, upgradinet well in the SZ/AZ is 721-MW-11-15.

6 - See Eqn 5 in Sec 3.3 for formula.

7 - There is no upgradient shoreline well in the TZ on the western transect, upgradient well in the SZ/AZ is MW-130-15.

Table 4-7 - Diesel and Oil-Range TPH - Concentration vs. Distance

DRAFT

Eastern Transect[1]

Linear Regression of Natural Log Transformed Data				Statistical Significance[4]	Calculations for determining concentration at upgradient wells necessary for protectiveness at the seep (SL = 500 µg/L)		
	Sample Size	Slope[3]	R^2	Decreasing trend	$C_{current}$ at upgradient well[5]	Protective concentration at upgradient well[6]	% Reduction
Transition Zone	2	-5.30E-03	1.00	--	68	already below SL	currently protective
SZ/AZ	5	-3.83E-03	0.84	--	540	8,832	currently protective

Western Transect[2]

Linear Regression of Natural Log Transformed Data				Statistical Significance[4]	Calculations for determining concentration at upgradient wells necessary for protectiveness at the seep (SL = 500 µg/L)		
	Sample Size	Slope[3]	R^2	Decreasing trend	$C_{current}$ at upgradient well[7]	Protective concentration at upgradient well[6]	% Reduction
Transition Zone	--	--	--	--	--	--	--
SZ/AZ	4	-8.89E-03	0.92	TRUE	83	already below SL	currently protective

Notes:

1 - Eastern Transect includes monitoring wells MW-106-15, MW-109-15, 721-MW6-15, 721-MW11-15, and MW-104-15, and seep SP-103.

2 - Western Transect includes monitoring wells 721-MW15-15, 721-MW2, HC-N11-6, and MW-130-15.

3 - Slope is calculated by a regression around the mean as described in EPA, 2009, and represents the natural log transformed average of 4 quarterly sampling events (Q4 2015, Q1 2016, Q2 2016, and Q3 2016).

4 - Significance is determined by a Mann Kendall trend test appling a confidence level of 85%. Methods described in Section 7.3.2 of EPA (2009).

5 - Upgradient well in the TZ is MW-104-15, upgradient well in the SZ/AZ is 721-MW-11-15.

6 - See Eqn 5 in Sec 3.3 for formula.

7 - There is no upgradient shoreline well in the TZ on the western transect, upgradient well in the SZ/AZ is MW-130-15.

Table 4-8 - Diesel and Oil-Range TPH without Silica Gel Cleanup - Concentration vs. Distance

DRAFT

Eastern Transect[1]

Linear Regression of Natural Log Transformed Data				Statistical Significance[4]	Calculations for determining concentration at upgradient wells necessary for protectiveness at the seep (SL = 500 µg/L)		
Eastern Transect[2]	Sample Size	Slope[3]	R^2	Decreasing trend	$C_{current}$ at upgradient well[5]	Protective concentration at upgradient well[6]	% Reduction
Transition Zone	2	-1.79E-02	1.00	--	2,863	1,410	0.51
SZ/AZ	5	-2.01E-03	0.97	TRUE	6,525	2,696	0.59

Western Transect[2]

Linear Regression of Natural Log Transformed Data				Statistical Significance[4]	Calculations for determining concentration at upgradient wells necessary for protectiveness at the seep (SL = 500 µg/L)		
Western Transect[1]	Sample Size	Slope[3]	R^2	Decreasing trend	$C_{current}$ at upgradient well[7]	Protective concentration at upgradient well[6]	% Reduction
Transition Zone	--	--	--	--	--	1,222	--
SZ/AZ	4	-2.81E-03	0.95	TRUE	4,325	3,209	0.26

Notes:

1 - Eastern Transect includes monitoring wells MW-106-15, MW-109-15, 721-MW6-15, 721-MW11-15, and MW-104-15, and seep SP-103.

2 - Western Transect includes monitoring wells 721-MW15-15, 721-MW2, HC-N11-6, and MW-130-15.

3 - Slope is calculated by a regression around the mean as described in EPA, 2009, and represents the natural log transformed average of 4 quarterly sampling events (Q4 2015, Q1 2016, Q2 2016, and Q3 2016).

4 - Significance is determined by a Mann Kendall trend test appling a confidence level of 85%. Methods described in Section 7.3.2 of EPA (2009).

5 - Upgradient well in the TZ is MW-104-15, upgradient well in the SZ/AZ is 721-MW-11-15.

6 - See Eqn 5 in Sec 3.3 for formula.

7 - There is no upgradient shoreline well in the TZ on the western transect, upgradient well in the SZ/AZ is MW-130-15.

APPENDIX A

Table A1 - Groundwater Results - 15 Foot Zone

Port of Tacoma - Alexander Avenue Petroleum Tank Facilities

Chemical Name	Groundwater Potential Cleanup Level (15ft zone) (ug/L)	29-14 12/8/15	95-15 12/8/15	95-15 2/22/16	95-15 2/23/16	95-15 5/10/16	95-15 8/2/16	709-MW-09-15 12/8/15	709-MW-09-15 12/9/15	709-MW-09-15 2/23/16	709-MW-09-15 5/10/16	709-MW-09-15 8/1/16
Total Petroleum Hydrocarbons (TPH) - without silica gel cleanup												
Gasoline Range Hydrocarbons in ug/L	800		250 U	2,300		2,700	2,500	4,400		4,300	7,000 J	7,200
Diesel Range Hydrocarbons in ug/L	500	100 U	3,600		2,700 J	2,400	2,800		14,000	11,000 J	9,900	11,000
Oil Range Hydrocarbons in ug/L	500	200 U	870		610	460	520		2,600	1,700	1,300	1,200
Total TPHs D+O (ND=0U) in ug/l	500	ND	4,470		3,310	2,860	3,300		16,600	12,700	11,200	12,200
Total TPHs D+O (ND=1/2U) in ug/l	500	ND	4,470		3,310	2,860	3,300		16,600	12,700	11,200	12,200
Total TPHs G+D+O (ND=0U) in ug/l	720		4,470		5,610	5,560	5,800		21,000	17,000	18,200	19,400
Total TPHs G+D+O (ND=1/2U) in ug/l	720		4,595		5,610	5,560	5,800		21,000	17,000	18,200	19,400
Total Petroleum Hydrocarbons (TPH) - with silica gel cleanup												
Diesel Range Hydrocarbons in ug/L	500	100 U	100 U		320	350	270		470	420	550	650
Oil Range Hydrocarbons in ug/L	500	200 U	200 U		200 U	200 U	200 U		200 U	200 U	200 U	200 U
Total TPHs D+O (ND=0U) in ug/l	500	ND	ND		320	350	270		470	420	550	650
Total TPHs D+O (ND=1/2U) in ug/l	500	ND	ND		420	450	370		570	520	650	750
Total TPHs G+D+O (ND=0U) in ug/l	720		ND		2,620	3,050	2,800		4,870	4,720	7,550	7,900
Total TPHs G+D+O (ND=1/2U) in ug/l	720		ND		2,720	3,150	2,900		4,970	4,820	7,650	8,000
Volatile Organic Compounds (VOC)												
Benzene in ug/l	1.6		17	7.4 J		4.5	8.7 J	5.1 J		14 J	11	12
Field Parameters												
Dissolved Oxygen in mg/L		1.21	0.11	0.19		0.08	0.15	0.57	0.57	0.13	0.92	0.11
ORP in mVolts		-60.5	-162.8	-127.4		-121.3	-94.3	-116.7	-116.7	47.4	-136.4	-89.4
pH in pH Units		7.81	7.79	7.09		7.14	7.09	7.00	7.00	6.40	6.64	6.5
Specific Conductance in us/cm		2,921	11,988	3,295		1,257	957	882	882	514.3	495.7	520.6
Temperature in deg C		15.1	15.3	13.5		16.0	17.6	15.3	15.3	12.3	13.7	17.6
Turbidity in NTU		3.16	5.26	2.27		6.56	2.69	6.50	6.50	6.99	3.54	5.27

Notes

Concentrations in shaded cells indicate value exceeds screening level.

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

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

UJ - Analyte was not detected at or above the reported estimate

Table A1 - Groundwater Results - 15 Foot Zone

Port of Tacoma - Alexander Avenue Petroleum Tank Facilities

Chemical Name	Groundwater Potential Cleanup Level (15ft zone) (ug/L)	709-MW-11-15 12/8/15	709-MW-11-15 12/9/15	709-MW-11-15 2/23/16	709-MW-11-15 5/10/16	709-MW-11-15 8/1/16	709-MW-17-15 12/8/15	709-MW-17-15 12/9/15	709-MW-17-15 2/23/16	709-MW-17-15 5/10/16	709-MW-17-15 8/1/16
Total Petroleum Hydrocarbons (TPH) - without silica gel cleanup											
Gasoline Range Hydrocarbons in ug/L	800	940		190	590	3,700	2,000		1,700	2,000	1,700
Diesel Range Hydrocarbons in ug/L	500		4,900	15,000 J	5,500	12,000		27,000	24,000 J	22,000	20,000
Oil Range Hydrocarbons in ug/L	500		4,200	6,200	7,400	6,500		3,000 J	4,000	4,000	2,700
Total TPHs D+O (ND=0U) in ug/l	500		9,100	21,200	12,900	18,500		30,000	28,000	26,000	22,700
Total TPHs D+O (ND=1/2U) in ug/l	500		9,100	21,200	12,900	18,500		30,000	28,000	26,000	22,700
Total TPHs G+D+O (ND=0U) in ug/l	720		10,040	21,390	13,490	22,200		32,000	29,700	28,000	24,400
Total TPHs G+D+O (ND=1/2U) in ug/l	720		10,040	21,390	13,490	22,200		32,000	29,700	28,000	24,400
Total Petroleum Hydrocarbons (TPH) - with silica gel cleanup											
Diesel Range Hydrocarbons in ug/L	500		890	690	2,000	5,300		1,700	5,800	2,300	1,600
Oil Range Hydrocarbons in ug/L	500		1,200	640	1,400	1,800		200 U	380	200 U	200 U
Total TPHs D+O (ND=0U) in ug/l	500		2,090	1,330	3,400	7,100		1,700	6,180	2,300	1,600
Total TPHs D+O (ND=1/2U) in ug/l	500		2,090	1,330	3,400	7,100		1,800	6,180	2,400	1,700
Total TPHs G+D+O (ND=0U) in ug/l	720		3,030	1,520	3,990	10,800		3,700	7,880	4,300	3,300
Total TPHs G+D+O (ND=1/2U) in ug/l	720		3,030	1,520	3,990	10,800		3,800	7,880	4,400	3,400
Volatile Organic Compounds (VOC)											
Benzene in ug/l	1.6	1.1		0.31 J	1.8	1.1	0.46		0.36 J	0.34	0.31
Field Parameters											
Dissolved Oxygen in mg/L		0.34	0.34	0.21	1.02	0.04	0.28	0.28	0.78	0.92	0.06
ORP in mVolts		10.9	10.9	65.7	-131.1	-80.1	-65.7	-65.7	-69.1	-96.6	-126.1
pH in pH Units		6.24	6.24	6.11	6.37	6.75	6.82	6.82	6.58	6.78	7.06
Specific Conductance in us/cm		391.0	391.0	279.3	289.7	338	927	927	505	604.6	619
Temperature in deg C		14.2	14.2	10.9	13.6	18	15.9	15.9	12.0	13.6	17.6
Turbidity in NTU		20.8	20.8	21.4	12.2	56.1	18.3	18.3	12.0	17.8	16.6

Notes

Concentrations in shaded cells indicate value exceeds screening level.

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

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

UJ - Analyte was not detected at or above the reported estimate

Table A1 - Groundwater Results - 15 Foot Zone

Port of Tacoma - Alexander Avenue Petroleum Tank Facilities

Chemical Name	Groundwater Potential Cleanup Level (15ft zone) (ug/L)	709-MW-18-15 12/9/15	709-MW20-15 12/8/15	721-MW2 12/9/15	721-MW2 2/22/16	721-MW2 2/24/16	721-MW2 5/10/16	721-MW2 8/1/16	721-MW3 12/9/15	721-MW3 12/9/15 FD	721-MW3 2/22/16	721-MW3 2/24/16
Total Petroleum Hydrocarbons (TPH) - without silica gel cleanup												
Gasoline Range Hydrocarbons in ug/L	800			3,200	3,500		3,400	3,800	1,200	1,200	1,200 J	
Diesel Range Hydrocarbons in ug/L	500	140	110	9,400		6,800 J	5,900	19,000	5,200	5,100		3,700 J
Oil Range Hydrocarbons in ug/L	500	200 U	200 U	1,400		790 J	930	1,600	420	420		340
Total TPHs D+O (ND=0U) in ug/l	500	140	110	10,800		7,590	6,830	20,600	5,620	5,520		4,040
Total TPHs D+O (ND=1/2U) in ug/l	500	240	210	10,800		7,590	6,830	20,600	5,620	5,520		4,040
Total TPHs G+D+O (ND=0U) in ug/l	720			14,000		11,090	10,230	24,400	6,820	6,720		5,240
Total TPHs G+D+O (ND=1/2U) in ug/l	720			14,000		11,090	10,230	24,400	6,820	6,720		5,240
Total Petroleum Hydrocarbons (TPH) - with silica gel cleanup												
Diesel Range Hydrocarbons in ug/L	500	100 U	100 U	1,400 J		800	1,300	2,200	100 U	100 U		100 U
Oil Range Hydrocarbons in ug/L	500	200 U	200 U	200 U		200 U	200 U	200 U	200 U	200 U		200 U
Total TPHs D+O (ND=0U) in ug/l	500	ND	ND	1,400		800	1,300	2,200	ND	ND		ND U
Total TPHs D+O (ND=1/2U) in ug/l	500	ND	ND	1,500		900	1,400	2,300	ND	ND		ND U
Total TPHs G+D+O (ND=0U) in ug/l	720			4,600		4,300	4,700	6,000	1,200	1,200		1,200
Total TPHs G+D+O (ND=1/2U) in ug/l	720			4,700		4,400	4,800	6,100	1,350	1,350		1,350
Volatile Organic Compounds (VOC)												
Benzene in ug/l	1.6			530 J	1,200 J		800	1,100	3.3	3.2	220 J	
Field Parameters												
Dissolved Oxygen in mg/L		4.9	2.53	0.46	0.72		1.15	0.1	0.59		0.44	
ORP in mVolts		23.6	-3.7	-133.3	-142.6		-133.3	-148	-104.7		-20.5	
pH in pH Units		7.34	7.46	8.86	6.75		6.87	7.04	8.80		6.69	
Specific Conductance in us/cm		629	19,636	787	957		1,053	944	758		1,079	
Temperature in deg C		14.5	13.7	16.4	13.5		15	18.5	16.7		13.1	
Turbidity in NTU		4.33	0.38	1.83	108		4.06	14.8	5.34		38.3	
				1400		800	1300	2200				

Notes

Concentrations in shaded cells indicate value exceeds screening level.

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

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

UJ - Analyte was not detected at or above the reported estimate

Table A1 - Groundwater Results - 15 Foot Zone

Port of Tacoma - Alexander Avenue Petroleum Tank Facilities

Chemical Name	Groundwater Potential Cleanup Level (15ft zone) (ug/L)	721-MW3 2/22/16 FD	721-MW3 5/10/16	721-MW3 5/10/16 FD	721-MW3 8/1/16	721-MW3 8/1/16 FD	721-MW6-15 12/9/15	721-MW6-15 2/23/16	721-MW6-15 2/23/16 FD	721-MW6-15 5/10/16	721-MW6-15 8/2/16	721-MW8-15 12/9/15
Total Petroleum Hydrocarbons (TPH) - without silica gel cleanup												
Gasoline Range Hydrocarbons in ug/L	800	1,100	1,600 J	2,100 J	2,200	1,900	3,900	3,500		3,900	4,000	1,000
Diesel Range Hydrocarbons in ug/L	500		10,000	9,300	13,000	15,000	8,000	6,800 J	7,200 J	6,300	6,100	330
Oil Range Hydrocarbons in ug/L	500		1,300	1,100	1,800	1,600	1,400	1,300	1,200	1,100	1,200	200 U
Total TPHs D+O (ND=0U) in ug/l	500		11,300	10,400	14,800	16,600	9,400	8,100	8,400	7,400	7,300	330
Total TPHs D+O (ND=1/2U) in ug/l	500		11,300	10,400	14,800	16,600	9,400	8,100	8,400	7,400	7,300	430
Total TPHs G+D+O (ND=0U) in ug/l	720		12,900	12,400	17,000	18,500	13,300	11,600		11,300	11,300	1,330
Total TPHs G+D+O (ND=1/2U) in ug/l	720		12,900	12,400	17,000	18,500	13,300	11,600		11,300	11,300	1,430
Total Petroleum Hydrocarbons (TPH) - with silica gel cleanup												
Diesel Range Hydrocarbons in ug/L	500		320 J	140 J	400	300	430 J	330 J	440 J	380	420	100 UJ
Oil Range Hydrocarbons in ug/L	500		200 U	200 U	200 U	200 U	200 U	200 U	200 U	200 U	200 U	200 U
Total TPHs D+O (ND=0U) in ug/l	500		320	140	400	300	430	330	440	380	420	ND
Total TPHs D+O (ND=1/2U) in ug/l	500		420	240	500	400	530	430	540	480	520	ND
Total TPHs G+D+O (ND=0U) in ug/l	720		1,920	2,240	2,600	2,200	4,330	3,830		4,280	4,400	1,000
Total TPHs G+D+O (ND=1/2U) in ug/l	720		2,020	2,340	2,700	2,300	4,430	3,930		4,380	4,500	1,150
Volatile Organic Compounds (VOC)												
Benzene in ug/l	1.6	200 J	380	420	420	490	880 J	0.2 U		610	1,000	4.8 J
Field Parameters												
Dissolved Oxygen in mg/L			0.31		0.12		0.50	0.52		0.09	0.21	0.18
ORP in mVolts			34.9		-138.4		-127.1	28.2		-118.2	-107.2	-242.5
pH in pH Units			6.64		6.67		8.76	6.73		6.72	6.62	11.19
Specific Conductance in us/cm			1,472		1,146		846	659		835	868	1,309
Temperature in deg C			15.3		18.6		17.0	14.7		16	18	16.8
Turbidity in NTU			18.1		11.7		1.76	2.74		2.27	3.05	7.55

Notes

Concentrations in shaded cells indicate value exceeds screening level.

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

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

UJ - Analyte was not detected at or above the reported estimate

Table A1 - Groundwater Results - 15 Foot Zone

Port of Tacoma - Alexander Avenue Petroleum Tank Facilities

Chemical Name	Groundwater Potential Cleanup Level (15ft zone) (ug/L)	721-MW8-15 2/23/16	721-MW8-15 5/10/16	721-MW8-15 8/1/16	721-MW9-15 12/9/15	721-MW9-15 2/23/16	721-MW9-15 5/10/16	721-MW9-15 8/1/16	721-MW11-15 12/9/15	721-MW11-15 2/24/16	721-MW11-15 5/11/16	721-MW11-15 8/1/16
Total Petroleum Hydrocarbons (TPH) - without silica gel cleanup												
Gasoline Range Hydrocarbons in ug/L	800	1,500	1,100	1,800	1,100	1,500	1,200	1,300	1,100	3,200	3,000	4,400
Diesel Range Hydrocarbons in ug/L	500	620 J	1,000	1,300	880	1,700 J	2,000	1,600	4,400	7,900 J	5,500	8,300
Oil Range Hydrocarbons in ug/L	500	200 U	310	200 U	200 U	340	330	200 U	850	1,400	780	2,000
Total TPHs D+O (ND=0U) in ug/l	500	620	1,310	1,300	880	2,040	2,330	1,600	5,250	9,300	6,280	10,300
Total TPHs D+O (ND=1/2U) in ug/l	500	720	1,310	1,400	980	2,040	2,330	1,700	5,250	9,300	6,280	10,300
Total TPHs G+D+O (ND=0U) in ug/l	720	2,120	2,410	3,100	1,980	3,540	3,530	2,900	6,350	12,500	9,280	14,700
Total TPHs G+D+O (ND=1/2U) in ug/l	720	2,220	2,410	3,200	2,080	3,540	3,530	3,000	6,350	12,500	9,280	14,700
Total Petroleum Hydrocarbons (TPH) - with silica gel cleanup												
Diesel Range Hydrocarbons in ug/L	500	100 U	100 U	100 U	100 UJ	100	100 U	100 U	270 J	650	400 J	840
Oil Range Hydrocarbons in ug/L	500	200 U	200 U	200 U	200 U	200 U	200 U	200 U	200 U	200 U	200 U	200 U
Total TPHs D+O (ND=0U) in ug/l	500	ND U	ND	ND U	ND	100	ND	ND U	270	650	400	840
Total TPHs D+O (ND=1/2U) in ug/l	500	ND U	ND	ND U	ND	200	ND	ND U	370	750	500	940
Total TPHs G+D+O (ND=0U) in ug/l	720	1,500	1,100	1,800	1,100	1,600	1,200	1,300	1,370	3,850	3,400	5,200
Total TPHs G+D+O (ND=1/2U) in ug/l	720	1,650	1,250	2,000	1,250	1,700	1,350	1,500	1,470	3,950	3,500	5,300
Volatile Organic Compounds (VOC)												
Benzene in ug/l	1.6	3.4	2.8	2.2	0.66 J	0.31 J	0.41 J	0.31 J	140 J	540	600	1,000
Field Parameters												
Dissolved Oxygen in mg/L		0.07	0.09	0.15	0.41	0.69	1.42	0.06	0.46	0.72	0.15	0.17
ORP in mVolts		-241.3	-154.9	-143.6	-100.2	-62.9	-146.4	-80.9	-138.9	-0131.0	44.3	-97.3
pH in pH Units		8.67	7.69	7.61	8.84	7.16	7.32	7.36	9.36	6.76	6.94	6.97
Specific Conductance in us/cm		457.8	472.0	478.3	6,222	296.1	565.2	565	1,227	1,038	1,153	1,073
Temperature in deg C		14.1	15.5	18.4	16.1	12.7	19.6	16.2	15.9	13.1	15.1	17.8
Turbidity in NTU		2.55	1.23	1.81	1.37	1.28	7.45	2.33	57.2	20.1	10.6	15.3

Notes

Concentrations in shaded cells indicate value exceeds screening level.

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

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

UJ - Analyte was not detected at or above the reported estimate

Table A1 - Groundwater Results - 15 Foot Zone

Port of Tacoma - Alexander Avenue Petroleum Tank Facilities

Chemical Name	Groundwater Potential Cleanup Level (15ft zone) (ug/L)	721-MW12-15 12/9/15	721-MW12-15 2/24/16	721-MW12-15 5/11/16	721-MW12-15 8/1/16	721-MW14-15 12/9/15	721-MW14-15 2/22/16	721-MW14-15 2/24/16	721-MW14-15 5/11/16	721-MW14-15 8/1/16	721-MW15-15 12/9/15	721-MW15-15 12/9/15 FD
Total Petroleum Hydrocarbons (TPH) - without silica gel cleanup												
Gasoline Range Hydrocarbons in ug/L	800	4,700	5,200	5,400	5,500	4,200	5,200		5,200	5,600	4,800	4,900
Diesel Range Hydrocarbons in ug/L	500	8,400	6,900 J	7,100	8,700	6,900		22,000 J	13,000	7,000	18,000	15,000
Oil Range Hydrocarbons in ug/L	500	840	740	740	1,500	970		970	680	380	2,500	2,400
Total TPHs D+O (ND=0U) in ug/l	500	9,240	7,640	7,840	10,200	7,870		22,970	13,680	7,400	20,500	17,400
Total TPHs D+O (ND=1/2U) in ug/l	500	9,240	7,640	7,840	10,200	7,870		22,970	13,680	7,400	20,500	17,400
Total TPHs G+D+O (ND=0U) in ug/l	720	13,940	12,840	13,240	15,700	12,070		28,170	18,880	13,000	25,300	22,300
Total TPHs G+D+O (ND=1/2U) in ug/l	720	13,940	12,840	13,240	15,700	12,070		28,170	18,880	13,000	25,300	22,300
Total Petroleum Hydrocarbons (TPH) - with silica gel cleanup												
Diesel Range Hydrocarbons in ug/L	500	1,300 J	1,200	1,200 J	1,500	1,400 J		930	1,200 J	1,100	7,000 J	8,300 J
Oil Range Hydrocarbons in ug/L	500	200 U	200 U	200 U	200 U	200 U		200 U	200 U	200 U	250	270
Total TPHs D+O (ND=0U) in ug/l	500	1,300	1,200	1,200	1,500	1,400		930	1,200	1,100	7,250	8,570
Total TPHs D+O (ND=1/2U) in ug/l	500	1,400	1,300	1,300	1,600	1,500		1,030	1,300	1,200	7,250	8,570
Total TPHs G+D+O (ND=0U) in ug/l	720	6,000	6,400	6,600	7,000	5,600		6,130	6,400	6,700	12,050	13,470
Total TPHs G+D+O (ND=1/2U) in ug/l	720	6,100	6,500	6,700	7,100	5,700		6,230	6,500	6,800	12,050	13,470
Volatile Organic Compounds (VOC)												
Benzene in ug/l	1.6	150 J	150	290	590	16 J	100 J		46	68	1,400 J	1,400 J
Field Parameters												
Dissolved Oxygen in mg/L		0.24	0.50	0.12	0.09	0.34	0.64		0.16	0.13	0.59	
ORP in mVolts		-124.2	-124.4	44.8	-119.1	-0112.0	-0127.0		43.7	-116.1	-106.6	
pH in pH Units		7.10	6.71	6.79	6.68	7.04	6.72		6.84	6.83	6.55	
Specific Conductance in us/cm		735	427.5	599.4	767	824	587		773	646	1,134	
Temperature in deg C		16.1	13.3	14.8	18	15.5	12.8		14.4	16.8	16.1	
Turbidity in NTU		6.66	10.2	6.22	5.89	7.40	48.1		3.96	2.28	4.52	

Notes

Concentrations in shaded cells indicate value exceeds screening level.

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

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

UJ - Analyte was not detected at or above the reported estimate

Table A1 - Groundwater Results - 15 Foot Zone

Port of Tacoma - Alexander Avenue Petroleum Tank Facilities

Chemical Name	Groundwater Potential Cleanup Level (15ft zone) (ug/L)	721-MW15-15 2/22/16	721-MW15-15 2/24/16	721-MW15-15 2/22/16 FD	721-MW15-15 5/11/16	721-MW15-15 5/11/16 FD	721-MW15-15 8/1/16	721-MW15-15 8/1/16 FD	HC-N11-6 12/8/15	HC-N11-6 2/22/16	HC-N11-6 5/10/16	HC-N11-6 8/1/16
Total Petroleum Hydrocarbons (TPH) - without silica gel cleanup												
Gasoline Range Hydrocarbons in ug/L	800	4,400 J		4,200	4,700	3,800	5,000	5,200	3,900	3,400	3,200	3,400
Diesel Range Hydrocarbons in ug/L	500		11,000 J		9,200	7,700	11,000	10,000	4,900	3,200 J	4,000	9,500
Oil Range Hydrocarbons in ug/L	500		2,400		1,500	1,300	2,000	1,700	780	260	320	1,200
Total TPHs D+O (ND=0U) in ug/l	500		13,400		10,700	9,000	13,000	11,700	5,680	3,460	4,320	10,700
Total TPHs D+O (ND=1/2U) in ug/l	500		13,400		10,700	9,000	13,000	11,700	5,680	3,460	4,320	10,700
Total TPHs G+D+O (ND=0U) in ug/l	720		17,800		15,400	12,800	18,000	16,900	9,580	6,860	7,520	14,100
Total TPHs G+D+O (ND=1/2U) in ug/l	720		17,800		15,400	12,800	18,000	16,900	9,580	6,860	7,520	14,100
Total Petroleum Hydrocarbons (TPH) - with silica gel cleanup												
Diesel Range Hydrocarbons in ug/L	500		1,000		1,400 J	1,400 J	1,800	2,200	550	430	600	970
Oil Range Hydrocarbons in ug/L	500		200 U		200 U	200 U	200 U	200 U	200 U	200 U	200 U	200 U
Total TPHs D+O (ND=0U) in ug/l	500		1,000		1,400	1,400	1,800	2,200	550	430	600	970
Total TPHs D+O (ND=1/2U) in ug/l	500		1,100		1,500	1,500	1,900	2,300	650	530	700	1,070
Total TPHs G+D+O (ND=0U) in ug/l	720		5,400		6,100	5,200	6,800	7,400	4,450	3,830	3,800	4,400
Total TPHs G+D+O (ND=1/2U) in ug/l	720		5,500		6,200	5,300	6,900	7,500	4,550	3,930	3,900	4,500
Volatile Organic Compounds (VOC)												
Benzene in ug/l	1.6	1,300 J		1,300 J	1,100	1,200	1,500	1,500	360	360 J	210	95
Field Parameters												
Dissolved Oxygen in mg/L		0.67			0.23		0.08		0.19	0.17	0.17	0.07
ORP in mVolts		-124.1			46.7		-128.4		-93.6	-104.1	37.4	-89.7
pH in pH Units		6.67			6.73		6.9		7.14	7.04	6.94	7.08
Specific Conductance in us/cm		876			963		961		664	714	759	542.6
Temperature in deg C		13.8			15.2		17.9		16.6	13.0	14.8	18.1
Turbidity in NTU		10.8			4.52		5.25		3.17	4.04	8.86	8.17

Notes

Concentrations in shaded cells indicate value exceeds screening level.

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

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

UJ - Analyte was not detected at or above the reported estimate

Table A1 - Groundwater Results - 15 Foot Zone

Port of Tacoma - Alexander Avenue Petroleum Tank Facilities

Chemical Name	Groundwater Potential Cleanup Level (15ft zone) (ug/L)	MW-104-15 12/8/15	MW-104-15 2/22/16	MW-104-15 2/24/16	MW-104-15 5/10/16	MW-104-15 8/2/16	MW-106-15 12/9/15	MW-106-15 2/23/16	MW-106-15 2/23/16 FD	MW-106-15 5/10/16	MW-106-15 8/2/16	MW-109-15 12/9/15
Total Petroleum Hydrocarbons (TPH) - without silica gel cleanup												
Gasoline Range Hydrocarbons in ug/L	800	250 U	250		1,000 U	1,300	2,500	3,800		4,900	6,600	4,500
Diesel Range Hydrocarbons in ug/L	500	100 U		1,900 J	4,600	4,900	7,200	8,000 J	8,400 J	7,400	9,000	6,300
Oil Range Hydrocarbons in ug/L	500	200 U		430	880	870	1,100	1,200	1,100	1,400	1,400	1,100
Total TPHs D+O (ND=0U) in ug/l	500	ND		2,330	5,480	5,800	8,300	9,200	9,500	8,800	10,400	7,400
Total TPHs D+O (ND=1/2U) in ug/l	500	ND		2,330	5,480	5,800	8,300	9,200	9,500	8,800	10,400	7,400
Total TPHs G+D+O (ND=0U) in ug/l	720	ND		2,580	5,480	7,100	10,800	13,000		13,700	17,000	11,900
Total TPHs G+D+O (ND=1/2U) in ug/l	720	ND		2,580	5,980	7,100	10,800	13,000		13,700	17,000	11,900
Total Petroleum Hydrocarbons (TPH) - with silica gel cleanup												
Diesel Range Hydrocarbons in ug/L	500	100 U		100 U	100 U	120	340 J	380 J	520 J	710	700	460 J
Oil Range Hydrocarbons in ug/L	500	200 U		200 U	200 U	200 U	200 U	200 U	200 U	200 U	200 U	200 U
Total TPHs D+O (ND=0U) in ug/l	500	ND		ND U	ND	120	340	380	520	710	700	460
Total TPHs D+O (ND=1/2U) in ug/l	500	ND		ND U	ND	220	440	480	620	810	800	560
Total TPHs G+D+O (ND=0U) in ug/l	720	ND		250	ND	1,400	2,840	4,180		5,610	7,300	4,960
Total TPHs G+D+O (ND=1/2U) in ug/l	720	ND		400	ND	1,500	2,940	4,280		5,710	7,400	5,060
Volatile Organic Compounds (VOC)												
Benzene in ug/l	1.6	0.2 U	290 J		530	650	150 J	190 J		430	520	790 J
Field Parameters												
Dissolved Oxygen in mg/L		3.94	0.82		0.21	0.13	0.20	0.12		0.09	0.09	0.47
ORP in mVolts		25.1	-10.5		74.0	-92.5	-131.3	-95.3		-108.2	-126.4	-121.7
pH in pH Units		6.91	7.17		6.80	6.83	7.33	6.81		6.66	6.81	8.82
Specific Conductance in us/cm		7,571	1,806		1,145	1,020	1,031	788		719	754	887
Temperature in deg C		13.8	11.8		16.1	19.1	16.0	13.2		14.9	17.9	16.1
Turbidity in NTU		17.5	25.5		20.2	3.02	7.26	5.68		2.00	10.4	2.69

Notes

Concentrations in shaded cells indicate value exceeds screening level.

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

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

UJ - Analyte was not detected at or above the reported estimate

Table A1 - Groundwater Results - 15 Foot Zone

Port of Tacoma - Alexander Avenue Petroleum Tank Facilities

Chemical Name	Groundwater Potential Cleanup Level (15ft zone) (ug/L)	MW-109-15 2/24/16	MW-109-15 5/10/16	MW-109-15 8/2/16	MW-130-15 12/8/15	MW-130-15 2/22/16	MW-130-15 5/10/16	MW-130-15 8/1/16
Total Petroleum Hydrocarbons (TPH) - without silica gel cleanup								
Gasoline Range Hydrocarbons in ug/L	800	5,000 U	5,000 U	5,500	2,500	2,000	1,700	1,900
Diesel Range Hydrocarbons in ug/L	500	7,200 J	8,000	11,000	4,800	3,800 J	4,800	3,900
Oil Range Hydrocarbons in ug/L	500	1,800	1,800	3,600	720	280	500	310
Total TPHs D+O (ND=0U) in ug/l	500	9,000	9,800	14,600	5,520	4,080	5,300	4,200
Total TPHs D+O (ND=1/2U) in ug/l	500	9,000	9,800	14,600	5,520	4,080	5,300	4,200
Total TPHs G+D+O (ND=0U) in ug/l	720	9,000	9,800	20,100	8,020	6,080	7,000	6,100
Total TPHs G+D+O (ND=1/2U) in ug/l	720	11,500	12,300	20,100	8,020	6,080	7,000	6,100
Total Petroleum Hydrocarbons (TPH) - with silica gel cleanup								
Diesel Range Hydrocarbons in ug/L	500	440	460	440	100 U	110	120	100 U
Oil Range Hydrocarbons in ug/L	500	200 U	200 U	200 U	200 U	200 U	200 U	200 U
Total TPHs D+O (ND=0U) in ug/l	500	440	460	440	ND	110	120	ND U
Total TPHs D+O (ND=1/2U) in ug/l	500	540	560	540	ND	210	220	ND U
Total TPHs G+D+O (ND=0U) in ug/l	720	440	460	5,900	2,500	2,110	1,820	1,900
Total TPHs G+D+O (ND=1/2U) in ug/l	720	3,040	3,060	6,000	2,650	2,210	1,920	2,100
Volatile Organic Compounds (VOC)								
Benzene in ug/l	1.6	1,000	1,400	1,700	150	100 J	76	51
Field Parameters								
Dissolved Oxygen in mg/L		0.10	0.11	0.08	0.17	0.19	0.13	0.07
ORP in mVolts		-131.1	-110.6	-127	76.0	-84.6	38.5	-93.9
pH in pH Units		6.89	6.63	6.75	7.11	7.02	6.93	6.98
Specific Conductance in us/cm		930	903	975	834	800	717	742
Temperature in deg C		13.4	14.9	17.6	17.0	13.6	16.1	18.5
Turbidity in NTU		3.31	1.92	13	10.5	13.3	8.99	2.94

Notes

Concentrations in shaded cells indicate value exceeds screening level.

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

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

UJ - Analyte was not detected at or above the reported estimate

Table A2 - Groundwater Results - 25 Foot Zone

Port of Tacoma - Alexander Avenue Petroleum Tank Facilities

Chemical Name	Groundwater Potential Cleanup Level (25ft zone) (ug/L)	721-MW10-25 12/9/15	721-MW10-25 2/22/16	721-MW10-25 2/24/16	721-MW10-25 5/10/16	721-MW10-25 8/2/16	MW-104-25 12/8/15	MW-104-25 2/22/16	MW-104-25 2/24/16	MW-104-25 5/10/16	MW-104-25 8/2/16	MW-105-25 12/8/15
Total Petroleum Hydrocarbons (TPH) - without silica gel cleanup												
Gasoline Range Hydrocarbons in ug/L	800	250 U	100 U		100 U	100 U	250 U	100 U		440	650	250 U
Diesel Range Hydrocarbons in ug/L	500	3,400		3,800 J	4,900	4,100	1,300		2,500 J	6,100	5,500	1,800
Oil Range Hydrocarbons in ug/L	500	600		470	640	460	400		650	1,700	1,500	490
Total TPHs D+O (ND=0U) in ug/l	500	4,000		4,270	5,540	4,600	1,700		3,150	7,800	7,000	2,290
Total TPHs D+O (ND=1/2U) in ug/l	500	4,000		4,270	5,540	4,600	1,700		3,150	7,800	7,000	2,290
Total TPHs G+D+O (ND=0U) in ug/l	720	4,000		4,270	5,540	4,600	1,700		3,150	8,240	7,700	2,290
Total TPHs G+D+O (ND=1/2U) in ug/l	720	4,125		4,320	5,590	4,600	1,825		3,200	8,240	7,700	2,415
Total Petroleum Hydrocarbons (TPH) - with silica gel cleanup												
Diesel Range Hydrocarbons in ug/L	500	100 UJ		100 U	100 U	100 U	100 U		100 U	100 U	100 U	100 U
Oil Range Hydrocarbons in ug/L	500	200 U		200 U	200 U	200 U	200 U		200 U	200 U	200 U	200 U
Total TPHs D+O (ND=0U) in ug/l	500	ND		ND U	ND	ND U	ND		ND U	ND	ND U	ND
Total TPHs D+O (ND=1/2U) in ug/l	500	ND		ND U	ND	ND U	ND		ND U	ND	ND U	ND
Total TPHs G+D+O (ND=0U) in ug/l	720	ND		ND U	ND	ND U	ND		ND U	440	650	ND
Total TPHs G+D+O (ND=1/2U) in ug/l	720	ND		ND U	ND	ND U	ND		ND U	590	800	ND
Volatile Organic Compounds (VOC)												
Benzene in ug/l	1.6	150 J	130 J		42	120	25	3.9 J		330	360	210
Field Parameters												
Dissolved Oxygen in mg/L		0.18	0.63		0.14	0.17	0.12	0.59		0.15	0.19	0.49
ORP in mVolts		-66.4	3.9		72.3	-46.2	-148.8	-103.8		74.0	-167.7	753.4
pH in pH Units		8.56	8.25		8.18	8.04	7.54	6.86		7.02	7.22	8.71
Specific Conductance in us/cm		2,315	1,802		2,848	2,409	21,485	13,677		4,433	2,446	867
Temperature in deg C		14.8	13.6		16.2	16.3	16.2	13.6		16.1	16.6	15.6
Turbidity in NTU		3.02	7.88		6.88	15.2	5.11	7.50		3.34	3.45	

Notes

Concentrations in shaded cells indicate value exceeds screening level.

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

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

UJ - Analyte was not detected at or above the reported estimate

Table A2 - Groundwater Results - 25 Foot Zone

Port of Tacoma - Alexander Avenue Petroleum Tank Facilities

Chemical Name	Groundwater Potential Cleanup Level (25ft zone) (ug/L)	MW-105-25 2/23/16	MW-105-25 5/10/16	MW-105-25 8/2/16	MW-110-25 12/8/15	MW-110-25 2/23/16	MW-110-25 5/10/16	MW-110-25 8/2/16	MW-137-25 12/8/15	MW-137-25 2/22/16	MW-137-25 5/10/16	MW-137-25 8/1/16
Total Petroleum Hydrocarbons (TPH) - without silica gel cleanup												
Gasoline Range Hydrocarbons in ug/L	800	100 U	500 U	500 U	250 U	100 U	100 U	100 U	250 U	100 U	100 U	100 U
Diesel Range Hydrocarbons in ug/L	500	1,300 J	1,300	1,300	4,800	6,200 J	4,800	5,400	950	290 J	340	240
Oil Range Hydrocarbons in ug/L	500	290	290	200 U	1,100	1,200	800	770	230	200 U	200 U	200 U
Total TPHs D+O (ND=0U) in ug/l	500	1,590	1,590	1,300	5,900	7,400	5,600	6,200	1,180	290	340	240
Total TPHs D+O (ND=1/2U) in ug/l	500	1,590	1,590	1,400	5,900	7,400	5,600	6,200	1,180	390	440	340
Total TPHs G+D+O (ND=0U) in ug/l	720	1,590	1,590	1,300	5,900	7,400	5,600	6,200	1,180	290	340	240
Total TPHs G+D+O (ND=1/2U) in ug/l	720	1,640	1,840	1,700	6,025	7,450	5,650	6,200	1,305	440	490	390
Total Petroleum Hydrocarbons (TPH) - with silica gel cleanup												
Diesel Range Hydrocarbons in ug/L	500	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U
Oil Range Hydrocarbons in ug/L	500	200 U	200 U	200 U	200 U	200 U	200 U	200 U	200 U	200 U	200 U	200 U
Total TPHs D+O (ND=0U) in ug/l	500	ND U	ND	ND U	ND	ND U	ND	ND U	ND	ND U	ND	ND U
Total TPHs D+O (ND=1/2U) in ug/l	500	ND U	ND	ND U	ND	ND U	ND	ND U	ND	ND U	ND	ND U
Total TPHs G+D+O (ND=0U) in ug/l	720	ND U	ND	ND U	ND	ND U	ND	ND U	ND	ND U	ND	ND U
Total TPHs G+D+O (ND=1/2U) in ug/l	720	ND U	ND	ND U	ND	ND U	ND	ND U	ND	ND U	ND	ND U
Volatile Organic Compounds (VOC)												
Benzene in ug/l	1.6	150 J	120	100	1.9	1.6	1.2	2.1	34	14 J	2.4	3.8
Field Parameters												
Dissolved Oxygen in mg/L		0.54	0.08	0.23	0.43	0.12	1.50	0.23	0.14	0.19	0.16	0.06
ORP in mVolts		-147.8	122.4	-43.3	-92.2	-160.3	-190.01	-120.9	-183.3	-101.7	56.0	-154.1
pH in pH Units		8.21	8.21	8.23	8.00	7.71	7.79	7.8	8.14	7.81	7.89	7.74
Specific Conductance in us/cm		689	833	807	546.8	4,319	3,817	4,046	23,401	30,921	26,155	30,223
Temperature in deg C		14.4	15.6	16.9	15.5	14.5	15.5	15.9	14.6	11.1	15.0	15.8
Turbidity in NTU		1.21	0.83	2.11	3.33	1.81		5.9	1.71	1.75	3.19	0.45

Notes

Concentrations in shaded cells indicate value exceeds screening level.

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

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

UJ - Analyte was not detected at or above the reported estimate

Table A3 - Seep Results

Port of Tacoma - Alexander Avenue Petroleum Tank Facilities

Chemical Name	Porewater Potential Cleanup Level (ug/L)	SP-101 5/10/16	SP-101 8/1/16	SP-102 5/10/16	SP-102 8/1/16	SP-103 5/10/16	SP-103 8/1/16
Total Petroleum Hydrocarbons (TPH) - without silica gel cleanup							
Gasoline Range Hydrocarbons in ug/L	800	290	360	370	100 U	100 U	100 U
Diesel Range Hydrocarbons in ug/L	500	1,100	1,400	1,200	440	130	1,900
Oil Range Hydrocarbons in ug/L	500	330	300	260	200 U	200 U	280
Total TPHs D+O (ND=0U) in ug/l	500	1,430	1,700	1,460	440	130	2,200
Total TPHs D+O (ND=1/2U) in ug/l	500	1,430	1,700	1,460	540	230	2,200
Total TPHs G+D+O (ND=0U) in ug/l	720	1,720	2,100	1,830	440	130	2,200
Total TPHs G+D+O (ND=1/2U) in ug/l	720	1,720	2,100	1,830	590	280	2,200
Total Petroleum Hydrocarbons (TPH) - with silica gel cleanup							
Diesel Range Hydrocarbons in ug/L	500	100 U	100 U	100	100 U	100 U	100 U
Oil Range Hydrocarbons in ug/L	500	200 U	200 U	200 U	200 U	200 U	200 U
Total TPHs D+O (ND=0U) in ug/L	500	ND	ND U	100	ND U	ND	ND U
Total TPHs D+O (ND=1/2U) in ug/l	500	ND	ND U	200	ND U	ND	ND U
Total TPHs G+D+O (ND=0U) in ug/L	720	290	360	470	ND U	ND	ND U
Total TPHs G+D+O (ND=1/2U) in ug/l	720	440	510	570	ND U	ND	ND U
Volatile Organic Compounds (VOC)							
Benzene in ug/l	1.6	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	27
Field Parameters							
Dissolved Oxygen in mg/L		5.55		0.06		3.41	
ORP in mVolts		-231.4	-147.2	-90.4	-173.3	-221.5	-248.1
pH in pH Units		7.55	7.08	6.98	7.04	7.68	8.39
Specific Conductance in us/cm		10,650	16,653	26,103	27,903	25,170	8,326
Temperature in deg C		13.8	16.3	13.5	14.6	13.4	14.6
Turbidity in NTU							

Notes

Concentrations in shaded cells indicate value exceeds screening level.

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

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

UJ - Analyte was not detected at or above the reported estimate

Table A4 - Groundwater Elevations

Port of Tacoma - Alexander Avenue Petroleum Tank Facilities

Well Number/ TOC Elevation (feet)	Date of Measurement	Depth to Water (feet BTOC)	Groundwater Elevation
29-14 15.64	12/8/2015	5.48	10.16
709-MW-11-15 17.96	12/8/2015	8.61	9.35
	2/23/2016	7.64	10.32
	5/10/2016	9.13	8.83
	8/1/2016	10.78	7.18
709-MW-17-15 17.48	12/8/2015	7.86	9.62
	2/23/2016	6.84	10.64
	5/10/2016	8.60	8.88
	8/1/2016	10.15	7.33
709-MW-18-15 17.31	12/9/2015	8.24	9.07
709-MW20-15 16.05	12/8/2015	6.80	9.25
709-MW-09-15 16.70	12/8/2015	7.30	9.40
	2/23/2016	6.39	10.31
	5/10/2016	7.87	8.83
	8/1/2016	9.05	7.65
721-MW10-25 13.97	12/9/2015	12.75	1.22
	2/22/2016	14.33	-0.36
	5/10/2016	16.07	-2.10
	8/2/2016	14.59	-0.62
721-MW11-15 14.39	12/9/2015	4.18	10.21
	2/24/2016	5.86	8.53
	5/11/2016	6.40	7.99
	8/1/2016	7.15	7.24
721-MW12-15 14.27	12/9/2015	5.20	9.07
	2/24/2016	4.21	10.06
	5/11/2016	5.38	8.89
	8/1/2016	6.54	7.73
721-MW14-15 14.33	12/9/2015	5.34	8.99
	2/22/2016	4.43	9.90
	5/11/2016	5.66	8.67
	8/1/2016	6.79	7.54
721-MW15-15 14.28	12/9/2015	5.96	8.32
	2/22/2016	5.52	8.76
	5/11/2016	6.77	7.51
	8/1/2016	7.73	6.55
721-MW2 14.20	12/9/2015	5.90	8.30
	2/22/2016	4.88	9.32
	5/10/2016	6.23	7.97
	8/1/2016	7.45	6.75
721-MW3 14.70	12/9/2015	6.10	8.60
	2/22/2016	5.03	9.67
	5/10/2016	5.95	8.75
	8/1/2016	6.98	7.72
721-MW6-15 14.37	12/9/2015	5.90	8.47
	2/23/2016	5.05	9.32
	5/10/2016	5.95	8.42
	8/2/2016	6.83	7.54

Table A4 - Groundwater Elevations

Port of Tacoma - Alexander Avenue Petroleum Tank Facilities

Well Number/ TOC Elevation (feet)	Date of Measurement	Depth to Water (feet BTOC)	Groundwater Elevation
721-MW8-15 14.00	5/19/2015	6.57	7.43
	12/9/2015	6.51	7.49
	2/23/2016	2.55	11.45
	5/10/2016	6.24	7.76
	8/1/2016	6.97	7.03
721-MW9-15 14.27	12/9/2015	6.42	7.85
	2/23/2016	6.69	7.58
	5/10/2016	7.25	7.02
	8/1/2016	8.03	6.24
95-15 14.07	2/22/2016	6.32	7.75
	5/10/2016	6.74	7.33
	8/2/2016	7.03	7.04
HC-N11-6 14.33	12/8/2015	6.49	7.84
	2/22/2016	5.22	9.11
	5/10/2016	6.13	8.20
	8/1/2016	7.07	7.26
MW-104-15 14.43	12/8/2015	6.17	8.26
	2/22/2016	6.51	7.92
	5/10/2016	6.88	7.55
	8/2/2016	7.18	7.25
MW-104-25 14.43	12/8/2015	13.23	1.20
	2/22/2016	11.40	3.03
	5/10/2016	14.51	-0.08
	8/2/2016	14.14	0.29
MW-105-25 14.54	12/8/2015	6.00	8.54
	2/23/2016	7.25	7.29
	5/10/2016	8.01	6.53
	8/2/2016	9.06	5.48
MW-106-15 14.59	12/9/2015	5.50	9.09
	2/23/2016	4.57	10.02
	5/10/2016	5.64	8.95
	8/2/2016	6.65	7.94
MW-109-15 14.89	12/9/2015	6.09	8.80
	2/24/2016	4.99	9.90
	5/10/2016	5.91	8.98
	8/2/2016	6.89	8.00
MW-110-25 14.28	12/8/2015	12.22	2.06
	2/23/2016	13.12	1.16
	5/10/2016	15.51	-1.23
	8/2/2016	12.40	1.88
MW-130-15 14.60	12/8/2015	6.89	7.71
	2/22/2016	5.78	8.82
	5/10/2016	6.53	8.07
	8/1/2016	7.29	7.31
MW-137-25 15.28	12/8/2015	11.56	3.72
	2/22/2016	13.97	1.31
	5/10/2016	12.81	2.47
	8/1/2016	16.42	-1.14

Table A5 - LNAPL Measurements

DRAFT

Port of Tacoma - Alexander Avenue Petroleum Tank Facilities

Exploration Name	Date	Depth to LNAPL	Depth to Water	LNAPL Thickness
29-14	12/8/2015	ND	5.48	ND
709-MW9-15	10/9/2014	TR	9.42	TR
	5/10/2016	ND	7.87	ND
	8/1/2016	TR	9.05	TR
709-MW9-25	10/16/2014	ND	9.13	ND
709-MW11-15	10/1/2014	ND	7.98	ND
	10/9/2014	ND	10.83	ND
	10/17/2014	TR	10.84	TR
	5/19/2015	9.88	10.01	0.13
	8/28/2015	TR	8.84	TR
	12/8/2015	8.59	8.61	0.02
	5/10/2016	TR	9.13	TR
	8/1/2016	ND	10.78	ND
709-MW11-25	10/9/2014	ND	7.98	ND
709-MW14-15	10/1/2014	ND	7.31	ND
	10/16/2014	ND	7.32	ND
	5/19/2015	ND	6.4	ND
	8/28/2015	TR	7.45	TR
709-MW17-15	12/8/2015	7.84	7.86	0.02
	5/10/2016	TR	8.6	TR
	8/1/2016	ND	10.15	ND
709-MW18-15	12/8/2015	ND	8.24	ND
709-MW21-15	10/1/2014	7.54	7.6	0.06
	10/17/2014	7.62	7.66	0.04
	5/19/2015	6.75	6.76	0.01
	8/28/2015	7.67	7.66	0.01
709-MW21-25	10/17/2014	TR	9.04	TR
721-MW1	10/1/2014	7.13	7.14	0.01
	5/20/2015	TR	6.34	TR
	8/28/2015	7.24	7.25	0.01
721-MW2	10/10/2014	7.25	8.01	0.76
	10/16/2014	7.27	8.08	0.81
	5/20/2015	6.54	6.8	0.26
	8/28/2015	7.27	8.2	0.93
	12/9/2015	ND	5.9	ND
	5/10/2016	5.85	6.23	0.38
721-MW3	10/1/2014	ND	7.3	ND
	10/16/2014	TR	7.37	TR
	1/26/2015	ND	6.1	ND
	5/20/2015	TR	6.1	TR
	8/28/2015	TR	7.39	TR
	12/9/2015	ND	6.1	ND
	5/10/2016	ND	5.95	ND
	8/1/2016	ND	6.98	ND

Table A5 - LNAPL Measurements

Port of Tacoma - Alexander Avenue Petroleum Tank Facilities

Exploration Name	Date	Depth to LNAPL	Depth to Water	LNAPL Thickness
721-MW4	10/2/2014	6.89	7.72	0.83
	5/19/2015	6.23	6.31	0.08
	8/28/2015	6.89	8.08	1.19
721-MW5-15	10/9/2014	ND	7.1	ND
721-MW6-15	10/1/2014	TR	7.14	TR
	10/17/2014	7.09	7.1	0.01
	5/19/2015	TR	6.53	TR
	8/28/2016	TR	7.18	TR
	12/9/2015	ND	5.9	ND
	5/10/2016	TR	5.95	TR
721-MW7-15	10/9/2014	ND	6.94	ND
721-MW8-15	10/9/2014	TR	6.85	TR
721-MW9-15	10/9/2014	ND	7.43	ND
	12/9/2015	TR	6.42	TR
721-MW9-25	10/16/2014	TR	11.92	TR
721-MW10-15	10/9/2014	ND	6.58	ND
721-MW10-25	10/15/2014	TR	13.11	TR
721-MW11-15	10/9/2014	TR	7.14	TR
	10/14/2014	ND	7.08	ND
	5/19/2015	ND	6.72	ND
	8/28/2015	ND	7.29	ND
	12/9/2015	TR	4.18	TR
	5/11/2016	6.23	6.4	0.17
	8/1/2016	6.95	7.15	0.2
721-MW11-25	10/14/2014	ND	7.55	ND
721-MW12-15	10/1/2014	TR	6.93	TR
	10/16/2014	TR	6.99	TR
	1/27/2015	ND	5.35	ND
	5/19/2015	ND	6.07	ND
	8/28/2015	TR	6.79	TR
	12/9/2015	ND	5.2	ND
	5/11/2016	TR	5.38	TR
	8/1/2016	TR	6.54	TR
721-MW13-25	10/17/2014	ND	8.19	ND
721-MW14-15	10/1/2014	7.11	7.14	0.03
	10/17/2014	5.54	7.27	1.73
	8/28/2015	7.18	7.45	0.27
	12/9/2015	TR	5.34	TR
	8/1/2016	TR	6.79	TR
721-MW14-25	5/20/2015	TR	6.33	TR
721-MW15-15	10/1/2014	7.97	8.14	0.17
	5/19/2015	6.27	7.3	1.03
	12/9/2015	5.84	5.96	0.12
721-MW15-25	10/17/2015	TR	8.42	TR
HC-N11-5	10/8/2014	ND	8.07	ND

Table A5 - LNAPL Measurements

Port of Tacoma - Alexander Avenue Petroleum Tank Facilities

Exploration Name	Date	Depth to LNAPL	Depth to Water	LNAPL Thickness
HC-N11-6	10/8/2014	ND	7.37	ND
	12/8/2015	6.4	6.49	0.09
	5/10/2016	*	6.49	*
	8/1/2016	*	7.07	*
MW-102-25	10/16/2014	TR	11.65	TR
MW-104-25	10/15/2014	TR	12.22	TR
MW-106-15	10/1/2014	ND	6.96	ND
	10/16/2014	ND	6.93	ND
	5/19/2015	ND	6.24	ND
	8/28/2015	TR	6.99	TR
	12/9/2015	ND	5.5	ND
	5/10/2016	5.63	5.64	0.01
MW-109-15	10/1/2014	ND	7.23	ND
	10/16/2014	ND	7.23	ND
	1/27/2015	ND	5.91	ND
	5/19/2015	ND	6.52	ND
	8/28/2015	TR	7.26	TR
	12/9/2015	ND	16.1	ND
	5/10/2016	TR	5.91	TR
	8/2/2016	ND	6.89	ND
MW-110-15	10/9/2014	ND	6.78	ND
MW-112-25	10/16/2014	TR	8.96	TR
MW-137-25	10/15/2014	ND	13.02	ND

Notes:
TR - Trace thickness less than 0.01 ft.
ND- Product not detected
* - Product was observed but thickness was not measured

Table A7 - Historical Groundwater Data - 15 Foot Zone

Port of Tacoma - Alexander Avenue Petroleum Tank Facilities

Chemical Name	Groundwater Potential Cleanup Level (15ft zone) (ug/L)	29-14 12/5/95	29-14 3/23/04	29-14 10/17/14	29-14 12/8/15	95-15 8/25/12	95-15 10/15/14	95-15 1/27/15	95-15 5/18/15	95-15 8/28/15	95-15 8/28/15 FD	95-15 12/8/15
Total Petroleum Hydrocarbons (TPH) - without silica gel cleanup												
Gasoline Range Hydrocarbons in ug/L	800			250 U		140 J	1,500	1,800	1,500	1,900	2,000	250 U
Diesel Range Hydrocarbons in ug/L	500				100 U			3,300	2,900	2,600	2,600	3,600
Oil Range Hydrocarbons in ug/L	500				200 U			820	750	670	640	870
Total TPHs D+O (ND=0U) in ug/L	500				ND			4,100	3,600	3,300	3,200	4,470
Total TPHs D+O (ND=1/2U) in ug/L	500				ND			4,100	3,700	3,300	3,200	4,470
Total TPHs G+D+O (ND=0U) in ug/L	720							5,900	5,200	5,200	5,200	4,470
Total TPHs G+D+O (ND=1/2U) in ug/L	720							5,900	5,200	5,200	5,200	4,595
Total Petroleum Hydrocarbons (TPH) - with silica gel cleanup												
Diesel Range Hydrocarbons in ug/L	500			100 U	100 U	260 U	140	270	200	510	490	100 U
Oil Range Hydrocarbons in ug/L	500			200 U	200 U	520 U	200 U	200 U	200 U	200 U	200 U	200 U
Total TPHs D+O (ND=0U) in ug/L	500			ND	ND	ND	140	270	200	510	490	ND
Total TPHs D+O (ND=1/2U) in ug/L	500			ND	ND	ND	140	370	300	610	590	ND
Total TPHs G+D+O (ND=0U) in ug/L	720			ND		140 J	1,600	2,100	1,700	2,400	2,500	ND
Total TPHs G+D+O (ND=1/2U) in ug/L	720			ND		530 J	1,700	2,200	1,800	2,500	2,600	ND
Volatile Organic Compounds (VOC)												
Benzene in ug/L	1.6	5 U	5 U	0.20 U		26	16	15	13	13	13	17
Field Parameters												
Conductivity in umhos/cm												
Dissolved Oxygen in mg/L				0.1	1.21		0.63	0.16	0.09	0.05		0.11
ORP in mVolts				-32.9	-60.5		-124.4	-12.1	-118.6	-135.4		-162.8
pH in pH Units			8.62	7.71	7.81	7.55	7.39	7.17	7.37	7.23		7.79
Salinity in %												
Specific Conductance in us/cm				337.4	2,921		898	1,264	1,342	1,404		11,988
Temperature in Deg C				16.5	15.1		18.3	14.9	15.4	18.8		15.3
Turbidity in NTU				6.93	3.16		2.28	7.53	31.7	2.71		5.26

Notes

Concentrations in shaded cells indicate value exceeds screening level.

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

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

UJ - Analyte was not detected at or above the reported estimate

Table A7 - Historical Groundwater Data - 15 Foot Zone

Port of Tacoma - Alexander Avenue Petroleum Tank Facilities

Chemical Name	Groundwater Potential Cleanup Level (15ft zone) (ug/L)	95-15 2/22/16	95-15 2/23/16	95-15 5/10/16	95-15 8/2/16	709-MW-09-15 8/1/95	709-MW-09-15 3/10/04	709-MW-09-15 8/14/12	709-MW-09-15 10/16/14	709-MW-09-15 5/20/15	709-MW-09-15 12/8/15	709-MW-09-15 12/9/15
Total Petroleum Hydrocarbons (TPH) - without silica gel cleanup												
Gasoline Range Hydrocarbons in ug/L	800	2,300		2,700	2,500			7,100	7,300	7,400	4,400	
Diesel Range Hydrocarbons in ug/L	500		2,700 J	2,400	2,800					10,000		14,000
Oil Range Hydrocarbons in ug/L	500		610	460	520					1,400		2,600
Total TPHs D+O (ND=0U) in ug/L	500		3,310	2,860	3,300					11,000		16,600
Total TPHs D+O (ND=1/2U) in ug/L	500		3,310	2,860	3,300					11,400		16,600
Total TPHs G+D+O (ND=0U) in ug/L	720		5,610	5,560	5,800					19,000		21,000
Total TPHs G+D+O (ND=1/2U) in ug/L	720		5,610	5,560	5,800					19,000		21,000
Total Petroleum Hydrocarbons (TPH) - with silica gel cleanup												
Diesel Range Hydrocarbons in ug/L	500		320	350	270			840	810	540		470
Oil Range Hydrocarbons in ug/L	500		200 U	200 U	200 U			110 J	200 U	200 U		200 U
Total TPHs D+O (ND=0U) in ug/L	500		320	350	270			950	810	540		470
Total TPHs D+O (ND=1/2U) in ug/L	500		420	450	370			950	810	640		570
Total TPHs G+D+O (ND=0U) in ug/L	720		2,620	3,050	2,800			8,000	8,100	7,900		4,870
Total TPHs G+D+O (ND=1/2U) in ug/L	720		2,720	3,150	2,900			8,000	8,200	8,000		4,970
Volatile Organic Compounds (VOC)												
Benzene in ug/L	1.6	7.4 J		4.5	8.7 J	910	280	42	14	17	5.1 J	
Field Parameters												
Conductivity in umhos/cm								0.643				
Dissolved Oxygen in mg/L		0.19		0.08	0.15			1.38	1.6	0.14	0.57	0.57
ORP in mVolts		-127.4		-121.3	-94.3			-186	-49.5	29.9	-116.7	-116.7
pH in pH Units		7.09		7.14	7.09		6.36	5.9	6.48	6.44	7.00	7.00
Salinity in %								0				
Specific Conductance in us/cm		3,295		1,257	957				697	645	882	882
Temperature in Deg C		13.5		16.0	17.6			17	17.2	14.1	15.3	15.3
Turbidity in NTU		2.27		6.56	2.69			122	8.22	2.47	6.50	6.50

Notes

Concentrations in shaded cells indicate value exceeds screening level.

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

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

UJ - Analyte was not detected at or above the reported estimate

Table A7 - Historical Groundwater Data - 15 Foot Zone

Port of Tacoma - Alexander Avenue Petroleum Tank Facilities

Chemical Name	Groundwater Potential Cleanup Level (15ft zone) (ug/L)	709-MW-09-15 2/23/16	709-MW-09-15 5/10/16	709-MW-09-15 8/1/16	709-MW-11-15 8/1/95	709-MW-11-15 3/10/04	709-MW-11-15 7/29/12	709-MW-11-15 12/8/15	709-MW-11-15 12/9/15	709-MW-11-15 2/23/16	709-MW-11-15 5/10/16	709-MW-11-15 8/1/16
Total Petroleum Hydrocarbons (TPH) - without silica gel cleanup												
Gasoline Range Hydrocarbons in ug/L	800	4,300	7,000 J	7,200		5,000	480	940		190	590	3,700
Diesel Range Hydrocarbons in ug/L	500	11,000 J	9,900	11,000					4,900	15,000 J	5,500	12,000
Oil Range Hydrocarbons in ug/L	500	1,700	1,300	1,200					4,200	6,200	7,400	6,500
Total TPHs D+O (ND=0U) in ug/L	500	12,700	11,200	12,200					9,100	21,200	12,900	18,500
Total TPHs D+O (ND=1/2U) in ug/L	500	12,700	11,200	12,200					9,100	21,200	12,900	18,500
Total TPHs G+D+O (ND=0U) in ug/L	720	17,000	18,200	19,400					10,040	21,390	13,490	22,200
Total TPHs G+D+O (ND=1/2U) in ug/L	720	17,000	18,200	19,400					10,040	21,390	13,490	22,200
Total Petroleum Hydrocarbons (TPH) - with silica gel cleanup												
Diesel Range Hydrocarbons in ug/L	500	420	550	650			1,700		890	690	2,000	5,300
Oil Range Hydrocarbons in ug/L	500	200 U	200 U	200 U			520 U		1,200	640	1,400	1,800
Total TPHs D+O (ND=0U) in ug/L	500	420	550	650			1,700		2,090	1,330	3,400	7,100
Total TPHs D+O (ND=1/2U) in ug/L	500	520	650	750			1,960		2,090	1,330	3,400	7,100
Total TPHs G+D+O (ND=0U) in ug/L	720	4,720	7,550	7,900			2,200		3,030	1,520	3,990	10,800
Total TPHs G+D+O (ND=1/2U) in ug/L	720	4,820	7,650	8,000			2,400		3,030	1,520	3,990	10,800
Volatile Organic Compounds (VOC)												
Benzene in ug/L	1.6	14 J	11	12	1,700	55	7.1	1.1		0.31 J	1.8	1.1
Field Parameters												
Conductivity in umhos/cm							0.314					
Dissolved Oxygen in mg/L		0.13	0.92	0.11			0	0.34	0.34	0.21	1.02	0.04
ORP in mVolts		47.4	-136.4	-89.4			-0260	10.9	10.9	65.7	-131.1	-80.1
pH in pH Units		6.40	6.64	6.5		6.08	6.17	6.24	6.24	6.11	6.37	6.75
Salinity in %							0					
Specific Conductance in us/cm		514.3	495.7	520.6				391.0	391.0	279.3	289.7	338
Temperature in Deg C		12.3	13.7	17.6			14.87	14.2	14.2	10.9	13.6	18
Turbidity in NTU		6.99	3.54	5.27			34.8	20.8	20.8	21.4	12.2	56.1

Notes

Concentrations in shaded cells indicate value exceeds screening level.

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

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

UJ - Analyte was not detected at or above the reported estimate

Table A7 - Historical Groundwater Data - 15 Foot Zone

Port of Tacoma - Alexander Avenue Petroleum Tank Facilities

Chemical Name	Groundwater Potential Cleanup Level (15ft zone) (ug/L)	709-MW-17-15 8/1/95	709-MW-17-15 3/11/04	709-MW-17-15 7/21/12	709-MW-17-15 10/17/14	709-MW-17-15 12/8/15	709-MW-17-15 12/9/15	709-MW-17-15 2/23/16	709-MW-17-15 5/10/16	709-MW-17-15 8/1/16	709-MW-18-15 8/1/95	709-MW-18-15 3/11/04
Total Petroleum Hydrocarbons (TPH) - without silica gel cleanup												
Gasoline Range Hydrocarbons in ug/L	800		1,500	960	1,300	2,000		1,700	2,000	1,700		
Diesel Range Hydrocarbons in ug/L	500						27,000	24,000 J	22,000	20,000		
Oil Range Hydrocarbons in ug/L	500						3,000 J	4,000	4,000	2,700		
Total TPHs D+O (ND=0U) in ug/L	500						30,000	28,000	26,000	22,700		
Total TPHs D+O (ND=1/2U) in ug/L	500						30,000	28,000	26,000	22,700		
Total TPHs G+D+O (ND=0U) in ug/L	720						32,000	29,700	28,000	24,400		
Total TPHs G+D+O (ND=1/2U) in ug/L	720						32,000	29,700	28,000	24,400		
Total Petroleum Hydrocarbons (TPH) - with silica gel cleanup												
Diesel Range Hydrocarbons in ug/L	500			870	5,700		1,700	5,800	2,300	1,600		
Oil Range Hydrocarbons in ug/L	500			150 J	270		200 U	380	200 U	200 U		
Total TPHs D+O (ND=0U) in ug/L	500			1,000	6,000		1,700	6,180	2,300	1,600		
Total TPHs D+O (ND=1/2U) in ug/L	500			1,020 J	5,700		1,800	6,180	2,400	1,700		
Total TPHs G+D+O (ND=0U) in ug/L	720			2,000	7,300		3,700	7,880	4,300	3,300		
Total TPHs G+D+O (ND=1/2U) in ug/L	720			2,000	7,300		3,800	7,880	4,400	3,400		
Volatile Organic Compounds (VOC)												
Benzene in ug/L	1.6	52	25	2.4	1.0 U	0.46		0.36 J	0.34	0.31	1 U	5 U
Field Parameters												
Conductivity in umhos/cm				0.796								
Dissolved Oxygen in mg/L				0	0.07	0.28	0.28	0.78	0.92	0.06		
ORP in mVolts				-85	-133.4	-65.7	-65.7	-69.1	-96.6	-126.1		
pH in pH Units			6.4	6.07	6.87	6.82	6.82	6.58	6.78	7.06		7.12
Salinity in %				0								
Specific Conductance in us/cm					763	927	927	505	604.6	619		
Temperature in Deg C				17.3	17.2	15.9	15.9	12.0	13.6	17.6		
Turbidity in NTU				0	12.8	18.3	18.3	12.0	17.8	16.6		

Notes

Concentrations in shaded cells indicate value exceeds screening level.

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

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

UJ - Analyte was not detected at or above the reported estimate

Table A7 - Historical Groundwater Data - 15 Foot Zone

Port of Tacoma - Alexander Avenue Petroleum Tank Facilities

Chemical Name	Groundwater Potential Cleanup Level (15ft zone) (ug/L)	709-MW-18-15 7/26/12	709-MW-18-15 12/9/15	709-MW20-15 7/21/04	709-MW20-15 8/21/12	709-MW20-15 10/17/14	709-MW20-15 12/8/15	721-MW2 7/14/95	721-MW2 2/16/08	721-MW2 10/16/14	721-MW2 12/9/15	721-MW2 2/22/16
Total Petroleum Hydrocarbons (TPH) - without silica gel cleanup												
Gasoline Range Hydrocarbons in ug/L	800	250 U			250 U	250 U				2,400	3,200	3,500
Diesel Range Hydrocarbons in ug/L	500		140				110				9,400	
Oil Range Hydrocarbons in ug/L	500		200 U				200 U				1,400	
Total TPHs D+O (ND=0U) in ug/L	500		140				110				10,800	
Total TPHs D+O (ND=1/2U) in ug/L	500		240				210				10,800	
Total TPHs G+D+O (ND=0U) in ug/L	720										14,000	
Total TPHs G+D+O (ND=1/2U) in ug/L	720										14,000	
Total Petroleum Hydrocarbons (TPH) - with silica gel cleanup												
Diesel Range Hydrocarbons in ug/L	500	12 J	100 U		260 U	100 U	100 U		1,700	1,600	1,400 J	
Oil Range Hydrocarbons in ug/L	500	31 J	200 U		520 U	200 U	200 U		500 U	200 U	200 U	
Total TPHs D+O (ND=0U) in ug/L	500	43 J	ND		ND	ND	ND		1,700	1,600	1,400	
Total TPHs D+O (ND=1/2U) in ug/L	500	43 J	ND		ND	ND	ND		1,950	1,600	1,500	
Total TPHs G+D+O (ND=0U) in ug/L	720	43 J			ND	ND			5,500	4,000	4,600	
Total TPHs G+D+O (ND=1/2U) in ug/L	720	170 J			ND	ND			5,800	4,100	4,700	
Volatile Organic Compounds (VOC)												
Benzene in ug/L	1.6	0.5 U		0.8 U	2.5 U	1.0 U		1,900	2,100	1,300	530 J	1,200 J
Field Parameters												
Conductivity in umhos/cm		0.475			7.77							
Dissolved Oxygen in mg/L		0.24	4.9		1.3	2.76	2.53			0.75	0.46	0.72
ORP in mVolts		98	23.6		87	203.7	-3.7			-97.8	-133.3	-142.6
pH in pH Units		7.36	7.34	7.54	7.52	7.29	7.46			6.65	8.86	6.75
Salinity in %		0			0.4							
Specific Conductance in us/cm			629			34,701	19,636			645	787	957
Temperature in Deg C		13.8	14.5		18.3	16.4	13.7			16.9	16.4	13.5
Turbidity in NTU		0.2	4.33		-010	0.44	0.38			55.3	1.83	108

Notes

Concentrations in shaded cells indicate value exceeds screening level.

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

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

UJ - Analyte was not detected at or above the reported estimate

Table A7 - Historical Groundwater Data - 15 Foot Zone

Port of Tacoma - Alexander Avenue Petroleum Tank Facilities

Chemical Name	Groundwater Potential Cleanup Level (15ft zone) (ug/L)	721-MW2 2/24/16	721-MW2 5/10/16	721-MW2 8/1/16	721-MW3 7/14/95	721-MW3 2/17/08	721-MW3 10/16/14	721-MW3 1/26/15	721-MW3 5/19/15	721-MW3 12/9/15	721-MW3 12/9/15 FD	721-MW3 2/22/16
Total Petroleum Hydrocarbons (TPH) - without silica gel cleanup												
Gasoline Range Hydrocarbons in ug/L	800		3,400	3,800			1,300		1,900	1,200	1,200	1,200 J
Diesel Range Hydrocarbons in ug/L	500	6,800 J	5,900	19,000				8,800	14,000	5,200	5,100	
Oil Range Hydrocarbons in ug/L	500	790 J	930	1,600				390	1,200	420	420	
Total TPHs D+O (ND=0U) in ug/L	500	7,590	6,830	20,600				9,200	15,000	5,620	5,520	
Total TPHs D+O (ND=1/2U) in ug/L	500	7,590	6,830	20,600				9,200	15,200	5,620	5,520	
Total TPHs G+D+O (ND=0U) in ug/L	720	11,090	10,230	24,400					17,000	6,820	6,720	
Total TPHs G+D+O (ND=1/2U) in ug/L	720	11,090	10,230	24,400					17,000	6,820	6,720	
Total Petroleum Hydrocarbons (TPH) - with silica gel cleanup												
Diesel Range Hydrocarbons in ug/L	500	800	1,300	2,200	4,300	250 U	260	210	250	100 U	100 U	
Oil Range Hydrocarbons in ug/L	500	200 U	200 U	200 U	750 U	500 U	200 U	200 U	200 U	200 U	200 U	
Total TPHs D+O (ND=0U) in ug/L	500	800	1,300	2,200	4,300	ND	260	210	250	ND	ND	
Total TPHs D+O (ND=1/2U) in ug/L	500	900	1,400	2,300	4,675	ND	260	310	350	ND	ND	
Total TPHs G+D+O (ND=0U) in ug/L	720	4,300	4,700	6,000	6,500	920	1,600		2,200	1,200	1,200	
Total TPHs G+D+O (ND=1/2U) in ug/L	720	4,400	4,800	6,100	6,900	1,300	1,700		2,200	1,350	1,350	
Volatile Organic Compounds (VOC)												
Benzene in ug/L	1.6		800	1,100	1,400	16	11		180	3.3	3.2	220 J
Field Parameters												
Conductivity in umhos/cm												
Dissolved Oxygen in mg/L			1.15	0.1			0.6	0.35	0.11	0.59		0.44
ORP in mVolts			-133.3	-148			-104.1	-026.0	-74.2	-104.7		-20.5
pH in pH Units			6.87	7.04			6.71	6.67	6.80	8.80		6.69
Salinity in %												
Specific Conductance in us/cm			1,053	944			603	953	1,113	758		1,079
Temperature in Deg C			15	18.5			18.2	15.0	14.5	16.7		13.1
Turbidity in NTU			4.06	14.8			53.3	23.6	9.64	5.34		38.3

Notes

Concentrations in shaded cells indicate value exceeds screening level.

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

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

UJ - Analyte was not detected at or above the reported estimate

Table A7 - Historical Groundwater Data - 15 Foot Zone

Port of Tacoma - Alexander Avenue Petroleum Tank Facilities

Chemical Name	Groundwater Potential Cleanup Level (15ft zone) (ug/L)	721-MW3 2/24/16	721-MW3 2/22/16 FD	721-MW3 5/10/16	721-MW3 5/10/16 FD	721-MW3 8/1/16	721-MW3 8/1/16 FD	721-MW6-15 7/19/04	721-MW6-15 7/25/12	721-MW6-15 12/9/15	721-MW6-15 2/23/16	721-MW6-15 2/23/16 FD
Total Petroleum Hydrocarbons (TPH) - without silica gel cleanup												
Gasoline Range Hydrocarbons in ug/L	800		1,100	1,600 J	2,100 J	2,200	1,900		2,600	3,900	3,500	
Diesel Range Hydrocarbons in ug/L	500	3,700 J		10,000	9,300	13,000	15,000			8,000	6,800 J	7,200 J
Oil Range Hydrocarbons in ug/L	500	340		1,300	1,100	1,800	1,600			1,400	1,300	1,200
Total TPHs D+O (ND=0U) in ug/L	500	4,040		11,300	10,400	14,800	16,600			9,400	8,100	8,400
Total TPHs D+O (ND=1/2U) in ug/L	500	4,040		11,300	10,400	14,800	16,600			9,400	8,100	8,400
Total TPHs G+D+O (ND=0U) in ug/L	720	5,240		12,900	12,400	17,000	18,500			13,300	11,600	
Total TPHs G+D+O (ND=1/2U) in ug/L	720	5,240		12,900	12,400	17,000	18,500			13,300	11,600	
Total Petroleum Hydrocarbons (TPH) - with silica gel cleanup												
Diesel Range Hydrocarbons in ug/L	500	100 U		320 J	140 J	400	300		560	430 J	330 J	440 J
Oil Range Hydrocarbons in ug/L	500	200 U		200 U	200 U	200 U	200 U		510 U	200 U	200 U	200 U
Total TPHs D+O (ND=0U) in ug/L	500	ND U		320	140	400	300		560	430	330	440
Total TPHs D+O (ND=1/2U) in ug/L	500	ND U		420	240	500	400		815	530	430	540
Total TPHs G+D+O (ND=0U) in ug/L	720	1,200		1,920	2,240	2,600	2,200		3,200	4,330	3,830	
Total TPHs G+D+O (ND=1/2U) in ug/L	720	1,350		2,020	2,340	2,700	2,300		3,400	4,430	3,930	
Volatile Organic Compounds (VOC)												
Benzene in ug/L	1.6		200 J	380	420	420	490	2,300	2,400	880 J	0.2 U	
Field Parameters												
Conductivity in umhos/cm									0.98			
Dissolved Oxygen in mg/L				0.31		0.12			0.69	0.50	0.52	
ORP in mVolts				34.9		-138.4			-156	-127.1	28.2	
pH in pH Units				6.64		6.67		6.39	6.74	8.76	6.73	
Salinity in %									0			
Specific Conductance in us/cm				1,472		1,146				846	659	
Temperature in Deg C				15.3		18.6			19.4	17.0	14.7	
Turbidity in NTU				18.1		11.7			0	1.76	2.74	

Notes

Concentrations in shaded cells indicate value exceeds screening level.

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

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

UJ - Analyte was not detected at or above the reported estimate

Table A7 - Historical Groundwater Data - 15 Foot Zone

Port of Tacoma - Alexander Avenue Petroleum Tank Facilities

Chemical Name	Groundwater Potential Cleanup Level (15ft zone) (ug/L)	721-MW6-15 5/10/16	721-MW6-15 8/2/16	721-MW8-15 7/20/04	721-MW8-15 10/15/14	721-MW8-15 5/19/15	721-MW8-15 12/9/15	721-MW8-15 2/23/16	721-MW8-15 5/10/16	721-MW8-15 8/1/16	721-MW9-15 7/20/04	721-MW9-15 7/22/12
Total Petroleum Hydrocarbons (TPH) - without silica gel cleanup												
Gasoline Range Hydrocarbons in ug/L	800	3,900	4,000		1,100	860	1,000	1,500	1,100	1,800		1,100
Diesel Range Hydrocarbons in ug/L	500	6,300	6,100			870	330	620 J	1,000	1,300		
Oil Range Hydrocarbons in ug/L	500	1,100	1,200			290	200 U	200 U	310	200 U		
Total TPHs D+O (ND=0U) in ug/L	500	7,400	7,300			1,200	330	620	1,310	1,300		
Total TPHs D+O (ND=1/2U) in ug/L	500	7,400	7,300			1,200	430	720	1,310	1,400		
Total TPHs G+D+O (ND=0U) in ug/L	720	11,300	11,300			2,000	1,330	2,120	2,410	3,100		
Total TPHs G+D+O (ND=1/2U) in ug/L	720	11,300	11,300			2,000	1,430	2,220	2,410	3,200		
Total Petroleum Hydrocarbons (TPH) - with silica gel cleanup												
Diesel Range Hydrocarbons in ug/L	500	380	420		100 U	100 U	100 UJ	100 U	100 U	100 U		260 U
Oil Range Hydrocarbons in ug/L	500	200 U	200 U		200 U	200 U	200 U	200 U	200 U	200 U		520 U
Total TPHs D+O (ND=0U) in ug/L	500	380	420		ND	ND	ND	ND U	ND	ND U		ND
Total TPHs D+O (ND=1/2U) in ug/L	500	480	520		ND	ND	ND	ND U	ND	ND U		ND
Total TPHs G+D+O (ND=0U) in ug/L	720	4,280	4,400		1,100	860	1,000	1,500	1,100	1,800		1,100
Total TPHs G+D+O (ND=1/2U) in ug/L	720	4,380	4,500		1,200	1,000	1,150	1,650	1,250	2,000		1,500
Volatile Organic Compounds (VOC)												
Benzene in ug/L	1.6	610	1,000	5.3 J	3	3.0	4.8 J	3.4	2.8	2.2	1.6 U	2.3
Field Parameters												
Conductivity in umhos/cm												0.514
Dissolved Oxygen in mg/L		0.09	0.21		0.54	0.12	0.18	0.07	0.09	0.15		0.15
ORP in mVolts		-118.2	-107.2		-137.7	-0104.0	-242.5	-241.3	-154.9	-143.6		-96
pH in pH Units		6.72	6.62	7.47	7.51	7.46	11.19	8.67	7.69	7.61	7.61	7.21
Salinity in %												0
Specific Conductance in us/cm		835	868		470	450.6	1,309	457.8	472.0	478.3		
Temperature in Deg C		16	18		17.6	15.4	16.8	14.1	15.5	18.4		16.3
Turbidity in NTU		2.27	3.05		0.67	1.05	7.55	2.55	1.23	1.81		0

Notes

Concentrations in shaded cells indicate value exceeds screening level.

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

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

UJ - Analyte was not detected at or above the reported estimate

Table A7 - Historical Groundwater Data - 15 Foot Zone

Port of Tacoma - Alexander Avenue Petroleum Tank Facilities

Chemical Name	Groundwater Potential Cleanup Level (15ft zone) (ug/L)	721-MW9-15 10/16/14	721-MW9-15 1/27/15	721-MW9-15 5/19/15	721-MW9-15 8/28/15	721-MW9-15 12/9/15	721-MW9-15 2/23/16	721-MW9-15 5/10/16	721-MW9-15 8/1/16	721-MW11-15 7/31/12	721-MW11-15 12/9/15	721-MW11-15 2/24/16
Total Petroleum Hydrocarbons (TPH) - without silica gel cleanup												
Gasoline Range Hydrocarbons in ug/L	800	840	1,100	1,000	1,000	1,100	1,500	1,200	1,300	2,000	1,100	3,200
Diesel Range Hydrocarbons in ug/L	500			1,900	2,000	880	1,700 J	2,000	1,600		4,400	7,900 J
Oil Range Hydrocarbons in ug/L	500			400	490	200 U	340	330	200 U		850	1,400
Total TPHs D+O (ND=0U) in ug/L	500			2,300	2,500	880	2,040	2,330	1,600		5,250	9,300
Total TPHs D+O (ND=1/2U) in ug/L	500			2,300	2,500	980	2,040	2,330	1,700		5,250	9,300
Total TPHs G+D+O (ND=0U) in ug/L	720			3,300	3,500	1,980	3,540	3,530	2,900		6,350	12,500
Total TPHs G+D+O (ND=1/2U) in ug/L	720			3,300	3,500	2,080	3,540	3,530	3,000		6,350	12,500
Total Petroleum Hydrocarbons (TPH) - with silica gel cleanup												
Diesel Range Hydrocarbons in ug/L	500	100 U	100 U	100 U	1,000	100 UJ	100	100 U	100 U	360	270 J	650
Oil Range Hydrocarbons in ug/L	500	200 U	200 U	200 U	200 U	200 U	200 U	200 U	200 U	580 U	200 U	200 U
Total TPHs D+O (ND=0U) in ug/L	500	ND	ND	ND	1,000	ND	100	ND	ND U	360	270	650
Total TPHs D+O (ND=1/2U) in ug/L	500	ND	ND	ND	1,100	ND	200	ND	ND U	650	370	750
Total TPHs G+D+O (ND=0U) in ug/L	720	840	1,100	1,000	2,000	1,100	1,600	1,200	1,300	2,400	1,370	3,850
Total TPHs G+D+O (ND=1/2U) in ug/L	720	990	1,200	1,200	2,100	1,250	1,700	1,350	1,500	2,600	1,470	3,950
Volatile Organic Compounds (VOC)												
Benzene in ug/L	1.6	0.43 J	0.48	0.26	0.2 U	0.66 J	0.31 J	0.41 J	0.31 J	1,100	140 J	540
Field Parameters												
Conductivity in umhos/cm										1.83		
Dissolved Oxygen in mg/L		0.84	0.2	0.09	0.41	0.41	0.69	1.42	0.06	0.46	0.46	0.72
ORP in mVolts		-106.6	-2.5	34.5	31.3	-100.2	-62.9	-146.4	-80.9	-164	-138.9	-0131.0
pH in pH Units		7.07	7.15	7.21	6.92	8.84	7.16	7.32	7.36	6.65	9.36	6.76
Salinity in %										0.1		
Specific Conductance in us/cm		334.9	389.5	437.2	533.0	6,222	296.1	565.2	565		1,227	1,038
Temperature in Deg C		15.8	14.1	13.9	11.2	16.1	12.7	19.6	16.2	19.53	15.9	13.1
Turbidity in NTU		0.85	7.53	2.39	2.26	1.37	1.28	7.45	2.33	252	57.2	20.1

Notes

Concentrations in shaded cells indicate value exceeds screening level.

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

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

UJ - Analyte was not detected at or above the reported estimate

Table A7 - Historical Groundwater Data - 15 Foot Zone

Port of Tacoma - Alexander Avenue Petroleum Tank Facilities

Chemical Name	Groundwater Potential Cleanup Level (15ft zone) (ug/L)	721-MW11-15 5/11/16	721-MW11-15 8/1/16	721-MW12-15 7/30/12	721-MW12-15 10/16/14	721-MW12-15 1/27/15	721-MW12-15 12/9/15	721-MW12-15 2/24/16	721-MW12-15 5/11/16	721-MW12-15 8/1/16	721-MW14-15 8/8/12	721-MW14-15 12/9/15
Total Petroleum Hydrocarbons (TPH) - without silica gel cleanup												
Gasoline Range Hydrocarbons in ug/L	800	3,000	4,400	3,100	4,400		4,700	5,200	5,400	5,500	3,300	4,200
Diesel Range Hydrocarbons in ug/L	500	5,500	8,300			12,000	8,400	6,900 J	7,100	8,700		6,900
Oil Range Hydrocarbons in ug/L	500	780	2,000			1,200	840	740	740	1,500		970
Total TPHs D+O (ND=0U) in ug/L	500	6,280	10,300			13,000	9,240	7,640	7,840	10,200		7,870
Total TPHs D+O (ND=1/2U) in ug/L	500	6,280	10,300			13,000	9,240	7,640	7,840	10,200		7,870
Total TPHs G+D+O (ND=0U) in ug/L	720	9,280	14,700				13,940	12,840	13,240	15,700		12,070
Total TPHs G+D+O (ND=1/2U) in ug/L	720	9,280	14,700				13,940	12,840	13,240	15,700		12,070
Total Petroleum Hydrocarbons (TPH) - with silica gel cleanup												
Diesel Range Hydrocarbons in ug/L	500	400 J	840	1,600	1,400	1,200	1,300 J	1,200	1,200 J	1,500	1,300	1,400 J
Oil Range Hydrocarbons in ug/L	500	200 U	200 U	530 U	200 U	200 U	200 U	200 U	200 U	200 U	550 U	200 U
Total TPHs D+O (ND=0U) in ug/L	500	400	840	1,600	1,400	1,200	1,300	1,200	1,200	1,500	1,300	1,400
Total TPHs D+O (ND=1/2U) in ug/L	500	500	940	1,865	1,400	1,300	1,400	1,300	1,300	1,600	1,575	1,500
Total TPHs G+D+O (ND=0U) in ug/L	720	3,400	5,200	4,700	5,800		6,000	6,400	6,600	7,000	4,600	5,600
Total TPHs G+D+O (ND=1/2U) in ug/L	720	3,500	5,300	5,000	5,900		6,100	6,500	6,700	7,100	4,900	5,700
Volatile Organic Compounds (VOC)												
Benzene in ug/L	1.6	600	1,000	450	560		150 J	150	290	590	150	16 J
Field Parameters												
Conductivity in umhos/cm				0.539							0.7	
Dissolved Oxygen in mg/L		0.15	0.17	0	2.78	0.21	0.24	0.50	0.12	0.09	0	0.34
ORP in mVolts		44.3	-97.3	-123	-97.6	-9.9	-124.2	-124.4	44.8	-119.1	-118	-0112.0
pH in pH Units		6.94	6.97	6.76	6.53	6.67	7.10	6.71	6.79	6.68	6.65	7.04
Salinity in %				0							0.03	
Specific Conductance in us/cm		1,153	1,073		810	728	735	427.5	599.4	767		824
Temperature in Deg C		15.1	17.8	17.7	17.1	13.7	16.1	13.3	14.8	18	18.63	15.5
Turbidity in NTU		10.6	15.3	17.1	4.01	12.1	6.66	10.2	6.22	5.89	0	7.40

Notes

Concentrations in shaded cells indicate value exceeds screening level.

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

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

UJ - Analyte was not detected at or above the reported estimate

Table A7 - Historical Groundwater Data - 15 Foot Zone

Port of Tacoma - Alexander Avenue Petroleum Tank Facilities

Chemical Name	Groundwater Potential Cleanup Level (15ft zone) (ug/L)	721-MW14-15 2/22/16	721-MW14-15 2/24/16	721-MW14-15 5/11/16	721-MW14-15 8/1/16	721-MW15-15 7/30/12	721-MW15-15 10/17/14	721-MW15-15 12/9/15	721-MW15-15 12/9/15 FD	721-MW15-15 2/22/16	721-MW15-15 2/24/16	721-MW15-15 2/22/16 FD
Total Petroleum Hydrocarbons (TPH) - without silica gel cleanup												
Gasoline Range Hydrocarbons in ug/L	800	5,200		5,200	5,600	2,600 J	3,600	4,800	4,900	4,400 J		4,200
Diesel Range Hydrocarbons in ug/L	500		22,000 J	13,000	7,000			18,000	15,000		11,000 J	
Oil Range Hydrocarbons in ug/L	500		970	680	380			2,500	2,400		2,400	
Total TPHs D+O (ND=0U) in ug/L	500		22,970	13,680	7,400			20,500	17,400		13,400	
Total TPHs D+O (ND=1/2U) in ug/L	500		22,970	13,680	7,400			20,500	17,400		13,400	
Total TPHs G+D+O (ND=0U) in ug/L	720		28,170	18,880	13,000			25,300	22,300		17,800	
Total TPHs G+D+O (ND=1/2U) in ug/L	720		28,170	18,880	13,000			25,300	22,300		17,800	
Total Petroleum Hydrocarbons (TPH) - with silica gel cleanup												
Diesel Range Hydrocarbons in ug/L	500		930	1,200 J	1,100	590	1,700	7,000 J	8,300 J		1,000	
Oil Range Hydrocarbons in ug/L	500		200 U	200 U	200 U	520 U	200 U	250	270		200 U	
Total TPHs D+O (ND=0U) in ug/L	500		930	1,200	1,100	590	1,700	7,250	8,570		1,000	
Total TPHs D+O (ND=1/2U) in ug/L	500		1,030	1,300	1,200	850	1,700	7,250	8,570		1,100	
Total TPHs G+D+O (ND=0U) in ug/L	720		6,130	6,400	6,700	3,200	5,300	12,050	13,470		5,400	
Total TPHs G+D+O (ND=1/2U) in ug/L	720		6,230	6,500	6,800	3,400	5,400	12,050	13,470		5,500	
Volatile Organic Compounds (VOC)												
Benzene in ug/L	1.6	100 J		46	68	2,300	1,900	1,400 J	1,400 J	1,300 J		1,300 J
Field Parameters												
Conductivity in umhos/cm						1.09						
Dissolved Oxygen in mg/L		0.64		0.16	0.13	3.82	0.45	0.59		0.67		
ORP in mVolts		-0127.0		43.7	-116.1	-113	67.4	-106.6		-124.1		
pH in pH Units		6.72		6.84	6.83	5.97	6.82	6.55		6.67		
Salinity in %						0						
Specific Conductance in us/cm		587		773	646		708	1,134		876		
Temperature in Deg C		12.8		14.4	16.8	18.91	17	16.1		13.8		
Turbidity in NTU		48.1		3.96	2.28	0	11.2	4.52		10.8		

Notes

Concentrations in shaded cells indicate value exceeds screening level.

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

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

UJ - Analyte was not detected at or above the reported estimate

Table A7 - Historical Groundwater Data - 15 Foot Zone

Port of Tacoma - Alexander Avenue Petroleum Tank Facilities

Chemical Name	Groundwater Potential Cleanup Level (15ft zone) (ug/L)	721-MW15-15 5/11/16	721-MW15-15 5/11/16 FD	721-MW15-15 8/1/16	721-MW15-15 8/1/16 FD	HC-N11-6 11/9/11	HC-N11-6 8/16/12	HC-N11-6 10/15/14	HC-N11-6 1/27/15	HC-N11-6 12/8/15	HC-N11-6 2/22/16	HC-N11-6 5/10/16
Total Petroleum Hydrocarbons (TPH) - without silica gel cleanup												
Gasoline Range Hydrocarbons in ug/L	800	4,700	3,800	5,000	5,200	2,200	1,100	2,800		3,900	3,400	3,200
Diesel Range Hydrocarbons in ug/L	500	9,200	7,700	11,000	10,000				4,900	4,900	3,200 J	4,000
Oil Range Hydrocarbons in ug/L	500	1,500	1,300	2,000	1,700				740	780	260	320
Total TPHs D+O (ND=0U) in ug/L	500	10,700	9,000	13,000	11,700				5,600	5,680	3,460	4,320
Total TPHs D+O (ND=1/2U) in ug/L	500	10,700	9,000	13,000	11,700				5,600	5,680	3,460	4,320
Total TPHs G+D+O (ND=0U) in ug/L	720	15,400	12,800	18,000	16,900					9,580	6,860	7,520
Total TPHs G+D+O (ND=1/2U) in ug/L	720	15,400	12,800	18,000	16,900					9,580	6,860	7,520
Total Petroleum Hydrocarbons (TPH) - with silica gel cleanup												
Diesel Range Hydrocarbons in ug/L	500	1,400 J	1,400 J	1,800	2,200	1,100 U	500	440	460	550	430	600
Oil Range Hydrocarbons in ug/L	500	200 U	200 U	200 U	200 U	410 U	530 U	200 U	200 U	200 U	200 U	200 U
Total TPHs D+O (ND=0U) in ug/L	500	1,400	1,400	1,800	2,200	ND	500	440	460	550	430	600
Total TPHs D+O (ND=1/2U) in ug/L	500	1,500	1,500	1,900	2,300	ND	765	440	560	650	530	700
Total TPHs G+D+O (ND=0U) in ug/L	720	6,100	5,200	6,800	7,400	2,200	1,600	3,200		4,450	3,830	3,800
Total TPHs G+D+O (ND=1/2U) in ug/L	720	6,200	5,300	6,900	7,500	3,000	1,900	3,300		4,550	3,930	3,900
Volatile Organic Compounds (VOC)												
Benzene in ug/L	1.6	1,100	1,200	1,500	1,500	190	220	170		360	360 J	210
Field Parameters												
Conductivity in umhos/cm							0.673					
Dissolved Oxygen in mg/L		0.23		0.08			0	0.47	0.18	0.19	0.17	0.17
ORP in mVolts		46.7		-128.4			-156	-88.4	-104.3	-93.6	-104.1	37.4
pH in pH Units		6.73		6.9			7.06	6.89	6.87	7.14	7.04	6.94
Salinity in %							0					
Specific Conductance in us/cm		963		961				620	644	664	714	759
Temperature in Deg C		15.2		17.9			18.27	18	14.4	16.6	13.0	14.8
Turbidity in NTU		4.52		5.25			0	1.47	4.58	3.17	4.04	8.86

Notes

Concentrations in shaded cells indicate value exceeds screening level.

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

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

UJ - Analyte was not detected at or above the reported estimate

Table A7 - Historical Groundwater Data - 15 Foot Zone

Port of Tacoma - Alexander Avenue Petroleum Tank Facilities

Chemical Name	Groundwater Potential Cleanup Level (15ft zone) (ug/L)	HC-N11-6 8/1/16	MW-104-15 10/15/14	MW-104-15 1/26/15	MW-104-15 5/18/15	MW-104-15 8/28/15	MW-104-15 12/8/15	MW-104-15 2/22/16	MW-104-15 2/24/16	MW-104-15 5/10/16	MW-104-15 8/2/16	MW-106-15 10/16/14
Total Petroleum Hydrocarbons (TPH) - without silica gel cleanup												
Gasoline Range Hydrocarbons in ug/L	800	3,400	590	250 U	1,600	1,200 U	250 U	250		1,000 U	1,300	5,400
Diesel Range Hydrocarbons in ug/L	500	9,500		2,900	5,700	4,800	100 U		1,900 J	4,600	4,900	
Oil Range Hydrocarbons in ug/L	500	1,200		780	1,600	1,400	200 U		430	880	870	
Total TPHs D+O (ND=0U) in ug/L	500	10,700		3,700	7,300	6,200	ND		2,330	5,480	5,800	
Total TPHs D+O (ND=1/2U) in ug/L	500	10,700		3,700	7,300	6,200	ND		2,330	5,480	5,800	
Total TPHs G+D+O (ND=0U) in ug/L	720	14,100		3,700	8,900	6,200	ND		2,580	5,480	7,100	
Total TPHs G+D+O (ND=1/2U) in ug/L	720	14,100		3,800	8,900	6,800	ND		2,580	5,980	7,100	
Total Petroleum Hydrocarbons (TPH) - with silica gel cleanup												
Diesel Range Hydrocarbons in ug/L	500	970	100 U	100 U	100 U	820	100 U		100 U	100 U	120	710
Oil Range Hydrocarbons in ug/L	500	200 U	200 U	200 U	200 U	200 U	200 U		200 U	200 U	200 U	200 U
Total TPHs D+O (ND=0U) in ug/L	500	970	ND	ND	ND	820	ND		ND U	ND	120	710
Total TPHs D+O (ND=1/2U) in ug/L	500	1,070	ND	ND	ND	920	ND		ND U	ND	220	710
Total TPHs G+D+O (ND=0U) in ug/L	720	4,400	590	ND	1,600	820	ND		250	ND	1,400	6,100
Total TPHs G+D+O (ND=1/2U) in ug/L	720	4,500	740	ND	1,800	1,500	ND		400	ND	1,500	6,200
Volatile Organic Compounds (VOC)												
Benzene in ug/L	1.6	95	250	170	510	340	0.2 U	290 J		530	650	610
Field Parameters												
Conductivity in umhos/cm												
Dissolved Oxygen in mg/L		0.07	0.18	1.15	0.15	0.57	3.94	0.82		0.21	0.13	0.66
ORP in mVolts		-89.7	-123.7	17.6	-58.2	-43.7	25.1	-10.5		74.0	-92.5	-83.3
pH in pH Units		7.08	6.9	6.83	6.85	6.61	6.91	7.17		6.80	6.83	6.62
Salinity in %												
Specific Conductance in us/cm		542.6	6,051	8,182	1,108	4,289	7,571	1,806		1,145	1,020	480.1
Temperature in Deg C		18.1	18.4	12.9	16.0	21.1	13.8	11.8		16.1	19.1	18.5
Turbidity in NTU		8.17	12	3.04	4.94	2.42	17.5	25.5		20.2	3.02	2.98

Notes

Concentrations in shaded cells indicate value exceeds screening level.

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

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

UJ - Analyte was not detected at or above the reported estimate

Table A7 - Historical Groundwater Data - 15 Foot Zone

Port of Tacoma - Alexander Avenue Petroleum Tank Facilities

Chemical Name	Groundwater Potential Cleanup Level (15ft zone) (ug/L)	MW-106-15 5/20/15	MW-106-15 5/20/15 FD	MW-106-15 12/9/15	MW-106-15 2/23/16	MW-106-15 2/23/16 FD	MW-106-15 5/10/16	MW-106-15 8/2/16	MW-109-15 10/16/14	MW-109-15 1/27/15	MW-109-15 5/19/15	MW-109-15 12/9/15
Total Petroleum Hydrocarbons (TPH) - without silica gel cleanup												
Gasoline Range Hydrocarbons in ug/L	800	7,600	7,600	2,500	3,800		4,900	6,600	4,500		5,400	4,500
Diesel Range Hydrocarbons in ug/L	500	9,500	9,100	7,200	8,000 J	8,400 J	7,400	9,000		7,900	8,800	6,300
Oil Range Hydrocarbons in ug/L	500	1,400	1,400	1,100	1,200	1,100	1,400	1,400		2,000	3,000	1,100
Total TPHs D+O (ND=0U) in ug/L	500	11,000	10,000	8,300	9,200	9,500	8,800	10,400		9,900	12,000	7,400
Total TPHs D+O (ND=1/2U) in ug/L	500	10,900	10,500	8,300	9,200	9,500	8,800	10,400		9,900	11,800	7,400
Total TPHs G+D+O (ND=0U) in ug/L	720	18,000	18,000	10,800	13,000		13,700	17,000			17,000	11,900
Total TPHs G+D+O (ND=1/2U) in ug/L	720	18,000	18,000	10,800	13,000		13,700	17,000			17,000	11,900
Total Petroleum Hydrocarbons (TPH) - with silica gel cleanup												
Diesel Range Hydrocarbons in ug/L	500	730	730	340 J	380 J	520 J	710	700	570	450	360	460 J
Oil Range Hydrocarbons in ug/L	500	200 U	200 U	200 U	200 U	200 U	200 U	200 U	200 U	200 U	200 U	200 U
Total TPHs D+O (ND=0U) in ug/L	500	730	730	340	380	520	710	700	570	450	360	460
Total TPHs D+O (ND=1/2U) in ug/L	500	830	830	440	480	620	810	800	570	550	460	560
Total TPHs G+D+O (ND=0U) in ug/L	720	8,300	8,300	2,840	4,180		5,610	7,300	5,100		5,800	4,960
Total TPHs G+D+O (ND=1/2U) in ug/L	720	8,400	8,400	2,940	4,280		5,710	7,400	5,200		5,900	5,060
Volatile Organic Compounds (VOC)												
Benzene in ug/L	1.6	510	480	150 J	190 J		430	520	1,900 J		1,500	790 J
Field Parameters												
Conductivity in umhos/cm												
Dissolved Oxygen in mg/L		0.04		0.20	0.12		0.09	0.09	0.69	0.35	0.05	0.47
ORP in mVolts		-7.9		-131.3	-95.3		-108.2	-126.4	-110.9	-21.2	61.5	-121.7
pH in pH Units		6.67		7.33	6.81		6.66	6.81	6.61	6.68	6.90	8.82
Salinity in %												
Specific Conductance in us/cm		828		1,031	788		719	754	952	860	929	887
Temperature in Deg C		15.2		16.0	13.2		14.9	17.9	17.1	14.3	15.0	16.1
Turbidity in NTU		3.14		7.26	5.68		2.00	10.4	10.4	6.18	3.71	2.69

Notes

Concentrations in shaded cells indicate value exceeds screening level.

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

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

UJ - Analyte was not detected at or above the reported estimate

Table A7 - Historical Groundwater Data - 15 Foot Zone

Port of Tacoma - Alexander Avenue Petroleum Tank Facilities

Chemical Name	Groundwater Potential Cleanup Level (15ft zone) (ug/L)	MW-109-15 2/24/16	MW-109-15 5/10/16	MW-109-15 8/2/16	MW-130-15 10/15/14	MW-130-15 1/27/15	MW-130-15 5/19/15	MW-130-15 8/27/15	MW-130-15 12/8/15	MW-130-15 2/22/16	MW-130-15 5/10/16	MW-130-15 8/1/16
Total Petroleum Hydrocarbons (TPH) - without silica gel cleanup												
Gasoline Range Hydrocarbons in ug/L	800	5,000 U	5,000 U	5,500	940	1,900	1,900	2,000	2,500	2,000	1,700	1,900
Diesel Range Hydrocarbons in ug/L	500	7,200 J	8,000	11,000			5,900	5,000	4,800	3,800 J	4,800	3,900
Oil Range Hydrocarbons in ug/L	500	1,800	1,800	3,600			630	530	720	280	500	310
Total TPHs D+O (ND=0U) in ug/L	500	9,000	9,800	14,600			6,500	5,500	5,520	4,080	5,300	4,200
Total TPHs D+O (ND=1/2U) in ug/L	500	9,000	9,800	14,600			6,500	5,500	5,520	4,080	5,300	4,200
Total TPHs G+D+O (ND=0U) in ug/L	720	9,000	9,800	20,100			8,400	7,500	8,020	6,080	7,000	6,100
Total TPHs G+D+O (ND=1/2U) in ug/L	720	11,500	12,300	20,100			8,400	7,500	8,020	6,080	7,000	6,100
Total Petroleum Hydrocarbons (TPH) - with silica gel cleanup												
Diesel Range Hydrocarbons in ug/L	500	440	460	440	100 U	130	100	740	100 U	110	120	100 U
Oil Range Hydrocarbons in ug/L	500	200 U	200 U	200 U	200 U	200 U	200 U	200 U	200 U	200 U	200 U	200 U
Total TPHs D+O (ND=0U) in ug/L	500	440	460	440	ND	130	100	740	ND	110	120	ND U
Total TPHs D+O (ND=1/2U) in ug/L	500	540	560	540	ND	230	200	840	ND	210	220	ND U
Total TPHs G+D+O (ND=0U) in ug/L	720	440	460	5,900	940	2,000	2,000	2,700	2,500	2,110	1,820	1,900
Total TPHs G+D+O (ND=1/2U) in ug/L	720	3,040	3,060	6,000	1,100	2,100	2,100	2,800	2,650	2,210	1,920	2,100
Volatile Organic Compounds (VOC)												
Benzene in ug/L	1.6	1,000	1,400	1,700	110	170	140	87	150	100 J	76	51
Field Parameters												
Conductivity in umhos/cm												
Dissolved Oxygen in mg/L		0.10	0.11	0.08	0.71	0.08	0.37	0.14	0.17	0.19	0.13	0.07
ORP in mVolts		-131.1	-110.6	-127	-34.9	-80.5	-41.3	-84.2	76.0	-84.6	38.5	-93.9
pH in pH Units		6.89	6.63	6.75	7.03	6.97	6.76	6.95	7.11	7.02	6.93	6.98
Salinity in %												
Specific Conductance in us/cm		930	903	975	802	755	765	781	834	800	717	742
Temperature in Deg C		13.4	14.9	17.6	18.8	15.1	16.1	20.0	17.0	13.6	16.1	18.5
Turbidity in NTU		3.31	1.92	13	0.84	7.11	8.25	13.4	10.5	13.3	8.99	2.94

Notes

Concentrations in shaded cells indicate value exceeds screening level.

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

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

UJ - Analyte was not detected at or above the reported estimate

Table A8 - Historical Groundwater Data - 25 Foot Zone

Port of Tacoma - Alexander Avenue Petroleum Tank Facilities

Chemical Name	Groundwater Potential Cleanup Level (25ft zone) (ug/L)	721-MW10-25 7/21/04	721-MW10-25 4/19/06	721-MW10-25 7/25/06	721-MW10-25 8/7/12	721-MW10-25 10/15/14	721-MW10-25 1/26/15	721-MW10-25 5/18/15	721-MW10-25 8/28/15	721-MW10-25 12/9/15	721-MW10-25 2/22/16	721-MW10-25 2/24/16
Total Petroleum Hydrocarbons (TPH) - without silica gel cleanup												
Gasoline Range Hydrocarbons in ug/L	800				46 J	250 U	250 U	250 U	250 U	250 U	100 U	
Diesel Range Hydrocarbons in ug/L	500							6,100	3,600	3,400		3,800 J
Oil Range Hydrocarbons in ug/L	500							1,100	510	600		470
Total TPHs D+O (ND=0U) in ug/L	500							7,200	4,100	4,000		4,270
Total TPHs D+O (ND=1/2U) in ug/L	500							7,200	4,100	4,000		4,270
Total TPHs G+D+O (ND=0U) in ug/L	720							7,200	4,100	4,000		4,270
Total TPHs G+D+O (ND=1/2U) in ug/L	720							7,300	4,200	4,125		4,320
Total Petroleum Hydrocarbons (TPH) - with silica gel cleanup												
Diesel Range Hydrocarbons in ug/L	500				25 J	100 U	100 U	100 U	350	100 UJ		100 U
Oil Range Hydrocarbons in ug/L	500				530 U	200 U	200 U	200 U	200 U	200 U		200 U
Total TPHs D+O (ND=0U) in ug/L	500				25 J	ND	ND	ND	350	ND		ND U
Total TPHs D+O (ND=1/2U) in ug/L	500				290 J	ND	ND	ND	450	ND		ND U
Total TPHs G+D+O (ND=0U) in ug/L	720				71 J	ND	ND	ND	350	ND		ND U
Total TPHs G+D+O (ND=1/2U) in ug/L	720				340 J	ND	ND	ND	580	ND		ND U
Volatile Organic Compounds (VOC)												
Benzene in ug/L	1.6	130			170	140	160	43	69	150 J	130 J	
Field Parameters												
Conductivity in umhos/cm			2.48	5.37	1.68							
Dissolved Oxygen in mg/L			0	3.33	1.18	0.53	0.05	0.1	0.58	0.18	0.63	
ORP in mVolts			-148	-231	-159	126.9	22.1	-179.4	45.4	-66.4	3.9	
pH in pH Units		8.4	7.98	8.12	8.38	8.31	8.63	8.26	8.17	8.56	8.25	
Salinity in %					0.08							
Specific Conductance in us/cm						1,339	1,901	2,987	2,227	2,315	1,802	
Temperature in Deg C			12.8	17.31	16.62	15.2	14.6	15.1	16.2	14.8	13.6	
Turbidity in NTU			217	12.4	173	6.97	7.86	1.01	2.65	3.02	7.88	

Notes

Concentrations in shaded cells indicate value exceeds screening level.

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

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

UJ - Analyte was not detected at or above the reported estimate

Table A8 - Historical Groundwater Data - 25 Foot Zone

Port of Tacoma - Alexander Avenue Petroleum Tank Facilities

Chemical Name	Groundwater Potential Cleanup Level (25ft zone) (ug/L)	721-MW10-25 5/10/16	721-MW10-25 8/2/16	MW-104-25 10/15/14	MW-104-25 1/26/15	MW-104-25 5/18/15	MW-104-25 8/28/15	MW-104-25 12/8/15	MW-104-25 2/22/16	MW-104-25 2/24/16	MW-104-25 5/10/16	MW-104-25 8/2/16
Total Petroleum Hydrocarbons (TPH) - without silica gel cleanup												
Gasoline Range Hydrocarbons in ug/L	800	100 U	100 U	470	250 U	660	250 U	250 U	100 U		440	650
Diesel Range Hydrocarbons in ug/L	500	4,900	4,100			7,400	2,400	1,300		2,500 J	6,100	5,500
Oil Range Hydrocarbons in ug/L	500	640	460			2,100	580	400		650	1,700	1,500
Total TPHs D+O (ND=0U) in ug/L	500	5,540	4,600			9,500	3,000	1,700		3,150	7,800	7,000
Total TPHs D+O (ND=1/2U) in ug/L	500	5,540	4,600			9,500	3,000	1,700		3,150	7,800	7,000
Total TPHs G+D+O (ND=0U) in ug/L	720	5,540	4,600			10,000	3,000	1,700		3,150	8,240	7,700
Total TPHs G+D+O (ND=1/2U) in ug/L	720	5,590	4,600			10,000	3,100	1,825		3,200	8,240	7,700
Total Petroleum Hydrocarbons (TPH) - with silica gel cleanup												
Diesel Range Hydrocarbons in ug/L	500	100 U	100 U	100 U	100 U	100 U	260	100 U		100 U	100 U	100 U
Oil Range Hydrocarbons in ug/L	500	200 U	200 U	200 U	200 U	200 U	200 U	200 U		200 U	200 U	200 U
Total TPHs D+O (ND=0U) in ug/L	500	ND	ND U	ND	ND	ND	260	ND		ND U	ND	ND U
Total TPHs D+O (ND=1/2U) in ug/L	500	ND	ND U	ND	ND	ND	360	ND		ND U	ND	ND U
Total TPHs G+D+O (ND=0U) in ug/L	720	ND	ND U	470	ND	660	260	ND		ND U	440	650
Total TPHs G+D+O (ND=1/2U) in ug/L	720	ND	ND U	620	ND	810	480	ND		ND U	590	800
Volatile Organic Compounds (VOC)												
Benzene in ug/L	1.6	42	120	51	8.2	390	73	25	3.9 J		330	360
Field Parameters												
Conductivity in umhos/cm												
Dissolved Oxygen in mg/L		0.14	0.17	0.1	0.24	0.06	0.10	0.12	0.59		0.15	0.19
ORP in mVolts		72.3	-46.2	-119.8	-6.1	-122.4	-90.3	-148.8	-103.8		74.0	-167.7
pH in pH Units		8.18	8.04	6.88	6.95	7.08	6.84	7.54	6.86		7.02	7.22
Salinity in %												
Specific Conductance in us/cm		2,848	2,409	9,697	18,663	3,025	11,869	21,485	13,677		4,433	2,446
Temperature in Deg C		16.2	16.3	15.8	14.6	15.7	17.9	16.2	13.6		16.1	16.6
Turbidity in NTU		6.88	15.2	8.72	16.3	2.58	9.97	5.11	7.50		3.34	3.45

Notes

Concentrations in shaded cells indicate value exceeds screening level.

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

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

UJ - Analyte was not detected at or above the reported estimate

Table A8 - Historical Groundwater Data - 25 Foot Zone

Port of Tacoma - Alexander Avenue Petroleum Tank Facilities

Chemical Name	Groundwater Potential Cleanup Level (25ft zone) (ug/L)	MW-105-25 10/17/14	MW-105-25 1/26/15	MW-105-25 1/26/15 FD	MW-105-25 5/18/15	MW-105-25 8/27/15	MW-105-25 12/8/15	MW-105-25 2/23/16	MW-105-25 5/10/16	MW-105-25 8/2/16	MW-110-25 10/15/14	MW-110-25 1/26/15
Total Petroleum Hydrocarbons (TPH) - without silica gel cleanup												
Gasoline Range Hydrocarbons in ug/L	800	250 U	250 U	250 U	250 U	1,200 U	250 U	100 U	500 U	500 U	250 U	250 U
Diesel Range Hydrocarbons in ug/L	500				2,600	1,800	1,800	1,300 J	1,300	1,300		
Oil Range Hydrocarbons in ug/L	500				550	360	490	290	290	200 U		
Total TPHs D+O (ND=0U) in ug/L	500				3,200	2,200	2,290	1,590	1,590	1,300		
Total TPHs D+O (ND=1/2U) in ug/L	500				3,200	2,200	2,290	1,590	1,590	1,400		
Total TPHs G+D+O (ND=0U) in ug/L	720				3,200	2,200	2,290	1,590	1,590	1,300		
Total TPHs G+D+O (ND=1/2U) in ug/L	720				3,300	2,800	2,415	1,640	1,840	1,700		
Total Petroleum Hydrocarbons (TPH) - with silica gel cleanup												
Diesel Range Hydrocarbons in ug/L	500	100 U	100 U	100 U	100 U	210	100 U	100 U	100 U	100 U	100 U	100 U
Oil Range Hydrocarbons in ug/L	500	200 U	200 U	200 U	200 U	200 U	200 U	200 U	200 U	200 U	200 U	200 U
Total TPHs D+O (ND=0U) in ug/L	500	ND	ND	ND	ND	210	ND	ND U	ND	ND U	ND	ND
Total TPHs D+O (ND=1/2U) in ug/L	500	ND	ND	ND	ND	310	ND	ND U	ND	ND U	ND	ND
Total TPHs G+D+O (ND=0U) in ug/L	720	ND	ND	ND	ND	210	ND	ND U	ND	ND U	ND	ND
Total TPHs G+D+O (ND=1/2U) in ug/L	720	ND	ND	ND	ND	910	ND	ND U	ND	ND U	ND	ND
Volatile Organic Compounds (VOC)												
Benzene in ug/L	1.6	140	170	160	67	96	210	150 J	120	100	4.2	2.2
Field Parameters												
Conductivity in umhos/cm												
Dissolved Oxygen in mg/L		0.52	0.21		0.09	0.10	0.49	0.54	0.08	0.23	0.14	0.18
ORP in mVolts		-86.1	87.0		-186.9	29.3	753.4	-147.8	122.4	-43.3	-211.5	-08.0
pH in pH Units		7.49	8.41		8.30	7.97	8.71	8.21	8.21	8.23	7.8	7.34
Salinity in %												
Specific Conductance in us/cm		522.3	953		972	932	867	689	833	807	5,192	5,326
Temperature in Deg C		18	15.4		16.1	17.2	15.6	14.4	15.6	16.9	15.5	14.0
Turbidity in NTU		7.68	13.7		3.03	5.16		1.21	0.83	2.11	12.2	1.81

Notes

Concentrations in shaded cells indicate value exceeds screening level.

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

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

UJ - Analyte was not detected at or above the reported estimate

Table A8 - Historical Groundwater Data - 25 Foot Zone

Port of Tacoma - Alexander Avenue Petroleum Tank Facilities

Chemical Name	Groundwater Potential Cleanup Level (25ft zone) (ug/L)	MW-110-25 5/18/15	MW-110-25 8/27/15	MW-110-25 12/8/15	MW-110-25 2/23/16	MW-110-25 5/10/16	MW-110-25 8/2/16	MW-137-25 10/15/14	MW-137-25 1/27/15	MW-137-25 5/19/15	MW-137-25 8/27/15	MW-137-25 12/8/15
Total Petroleum Hydrocarbons (TPH) - without silica gel cleanup												
Gasoline Range Hydrocarbons in ug/L	800	250 U	1,200 U	250 U	100 U	100 U	100 U	250 U	250 U	250 U	250 U	250 U
Diesel Range Hydrocarbons in ug/L	500	6,800	4,200	4,800	6,200 J	4,800	5,400			660	410	950
Oil Range Hydrocarbons in ug/L	500	1,400	880	1,100	1,200	800	770			200 U	200 U	230
Total TPHs D+O (ND=0U) in ug/L	500	8,200	5,100	5,900	7,400	5,600	6,200			660	410	1,180
Total TPHs D+O (ND=1/2U) in ug/L	500	8,200	5,100	5,900	7,400	5,600	6,200			760	510	1,180
Total TPHs G+D+O (ND=0U) in ug/L	720	8,200	5,100	5,900	7,400	5,600	6,200			660	410	1,180
Total TPHs G+D+O (ND=1/2U) in ug/L	720	8,300	5,700	6,025	7,450	5,650	6,200			880	640	1,305
Total Petroleum Hydrocarbons (TPH) - with silica gel cleanup												
Diesel Range Hydrocarbons in ug/L	500	100 U	420	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U
Oil Range Hydrocarbons in ug/L	500	200 U	200 U	200 U	200 U	200 U	200 U	200 U	200 U	200 U	200 U	200 U
Total TPHs D+O (ND=0U) in ug/L	500	ND	420	ND	ND U	ND	ND U	ND	ND	ND	ND	ND
Total TPHs D+O (ND=1/2U) in ug/L	500	ND	520	ND	ND U	ND	ND U	ND	ND	ND	ND	ND
Total TPHs G+D+O (ND=0U) in ug/L	720	ND	420	ND	ND U	ND	ND U	ND	ND	ND	ND	ND
Total TPHs G+D+O (ND=1/2U) in ug/L	720	ND	1,100	ND	ND U	ND	ND U	ND	ND	ND	ND	ND
Volatile Organic Compounds (VOC)												
Benzene in ug/L	1.6	1.8	2	1.9	1.6	1.2	2.1	48	61	9.5	3.5	34
Field Parameters												
Conductivity in umhos/cm												
Dissolved Oxygen in mg/L		0.03	0.08	0.43	0.12	1.50	0.23	1.8	0.05	0.33	0.13	0.14
ORP in mVolts		-0249.0	185.3	-92.2	-160.3	-190.01	-120.9	-0110	-172.6	-49.7	-99.7	-183.3
pH in pH Units		7.70	7.84	8.00	7.71	7.79	7.8	7.81	8.01	7.79	7.94	8.14
Salinity in %												
Specific Conductance in us/cm		4,877	47,724	546.8	4,319	3,817	4,046	26,604	17,832	24,501	27,182	23,401
Temperature in Deg C		16.2	17.5	15.5	14.5	15.5	15.9	15.7	13.9	14.0	17.3	14.6
Turbidity in NTU		4.46		3.33	1.81		5.9	3.24	3.96	0.79	0.59	1.71

Notes

Concentrations in shaded cells indicate value exceeds screening level.

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

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

UJ - Analyte was not detected at or above the reported estimate

Table A8 - Historical Groundwater Data - 25 Foot Zone

Port of Tacoma - Alexander Avenue Petroleum Tank Facilities

Chemical Name	Groundwater Potential Cleanup Level (25ft zone) (ug/L)	MW-137-25 2/22/16	MW-137-25 5/10/16	MW-137-25 8/1/16
Total Petroleum Hydrocarbons (TPH) - without silica gel cleanup				
Gasoline Range Hydrocarbons in ug/L	800	100 U	100 U	100 U
Diesel Range Hydrocarbons in ug/L	500	290 J	340	240
Oil Range Hydrocarbons in ug/L	500	200 U	200 U	200 U
Total TPHs D+O (ND=0U) in ug/L	500	290	340	240
Total TPHs D+O (ND=1/2U) in ug/L	500	390	440	340
Total TPHs G+D+O (ND=0U) in ug/L	720	290	340	240
Total TPHs G+D+O (ND=1/2U) in ug/L	720	440	490	390
Total Petroleum Hydrocarbons (TPH) - with silica gel cleanup				
Diesel Range Hydrocarbons in ug/L	500	100 U	100 U	100 U
Oil Range Hydrocarbons in ug/L	500	200 U	200 U	200 U
Total TPHs D+O (ND=0U) in ug/L	500	ND U	ND	ND U
Total TPHs D+O (ND=1/2U) in ug/L	500	ND U	ND	ND U
Total TPHs G+D+O (ND=0U) in ug/L	720	ND U	ND	ND U
Total TPHs G+D+O (ND=1/2U) in ug/L	720	ND U	ND	ND U
Volatile Organic Compounds (VOC)				
Benzene in ug/L	1.6	14 J	2.4	3.8
Field Parameters				
Conductivity in umhos/cm				
Dissolved Oxygen in mg/L		0.19	0.16	0.06
ORP in mVolts		-101.7	56.0	-154.1
pH in pH Units		7.81	7.89	7.74
Salinity in %				
Specific Conductance in us/cm		30,921	26,155	30,223
Temperature in Deg C		11.1	15.0	15.8
Turbidity in NTU		1.75	3.19	0.45

Notes

Concentrations in shaded cells indicate value exceeds screening level.

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

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

UJ - Analyte was not detected at or above the reported estimate