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Terminal 4 Source Control for Slips 1 and 3 Upland Facilities

Preliminary Engineer's Report Vegetated Infiltration Basin Designs

FINAL

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TABLE OF CONTENTS

APPENDICES

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS

Apex	Apex Companies, LLC (formerly Ash Creek)
Ash Creek	Ash Creek Associates, Inc.
BEBRA	Bank Excavation and Backfill Remedial Action
BEHP	bis(2-ethylhexyl)phthalate
BES	City of Portland Bureau of Environmental Services
BBL	Blasland, Bouck & Lee
BMPs	Best Management Practices
City	City of Portland, Oregon
COI	Constituent of Interest
DDD	dichloro-diphenyl-dichloroethane
DDE	dichloro-diphenyl-dichloroethylene
DDT	dichloro-diphenyl-trichloroethane
DEQ	Oregon Department of Environmental Quality
EPA	U.S. Environmental Protection Agency
ESM	Engineered Soil Media
GAC	Granulated Activated Carbon
GIS	Geographic Information System
H&H	Hydrologic and Hydraulic
JSCS	Joint Source Control Strategy
LNAPL	Light Non-Aqueous Phase Liquid
LWG	Lower Willamette Group
MS4	Municipal Separate Storm Sewer System
O&M	Operation and Maintenance
PAH	Polycyclic Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
PHSS	Portland Harbor Superfund Site
PLC	Programmable Logic Controller
POR	Period of Record
Port	Port of Portland
RI	Remedial Investigation
SLVs	Screening Level Values
SCE	Source Control Evaluation
SCM	Source Control Measure
SDFDM	City of Portland Sewer and Drainage Facilities Design Manual
SVOC	Semivolatile Organic Compound
SWMM	Storm Water Management Model
T4	Port of Portland Terminal 4
TSS	Total Suspended Solids
USGS	United States Geological Survey
VOC	Volatile Organic Compound

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1 INTRODUCTION

This report presents the basis of design for two structural Source Control Measures (SCMs) and associated site work which would be installed at the Port of Portland (Port) Terminal 4 facility located in Portland, Oregon (T4). The SCMs are vegetated infiltration basins (i.e., bioinfiltration basins) that would be constructed to infiltrate stormwater runoff from Basins K1 and M to reduce loading of polycyclic aromatic hydrocarbons (PAHs) and other pollutants to Willamette River sediments required by the Oregon Department of Environmental Quality (DEQ) pursuant to the following:

- Terminal 4 Slip 1 Upland Facility – Voluntary Agreement for Remedial Investigation, Source Control Measures, and Feasibility Study (DEQ No. LQVC-NWR-03-18), December 4, 2003.
- Terminal 4 Slip 3 Upland Facility – Consent Judgement No. 0410-10234, Multnomah Circuit Court, October 7, 2004, Section 3.C.

The Slip 1 and Slip 3 Upland Facilities are collectively referred to in this report as the “Site”. This Engineer’s Report is being submitted with the design drawings as a component of a Source Control Evaluation for the Site. The Agency Plan Set which represents the 30% draft of engineering design drawings is included in Appendix A.

1.1 Document Organization

Following this introductory section, this document is organized into the following sections:

- Section 2 presents an overview of the Site and a background summary of previous stormwater investigations and source control activities
- Section 3 presents an overview of existing Site conditions and constraints
- Section 4 presents a summary of design requirements and applicable standards
- Section 5 presents an alternatives assessment and an overview of the proposed SCMs
- Section 6 presents treatment facility sizing and modeling details
- Section 7 presents an overview proposed operations and maintenance (O&M) activities
- Section 8 describes the performance monitoring approach
- Section 9 presents a preliminary project schedule

Throughout this document and its appendices the terms vegetated infiltration basins and bioinfiltration basins are used interchangeably.

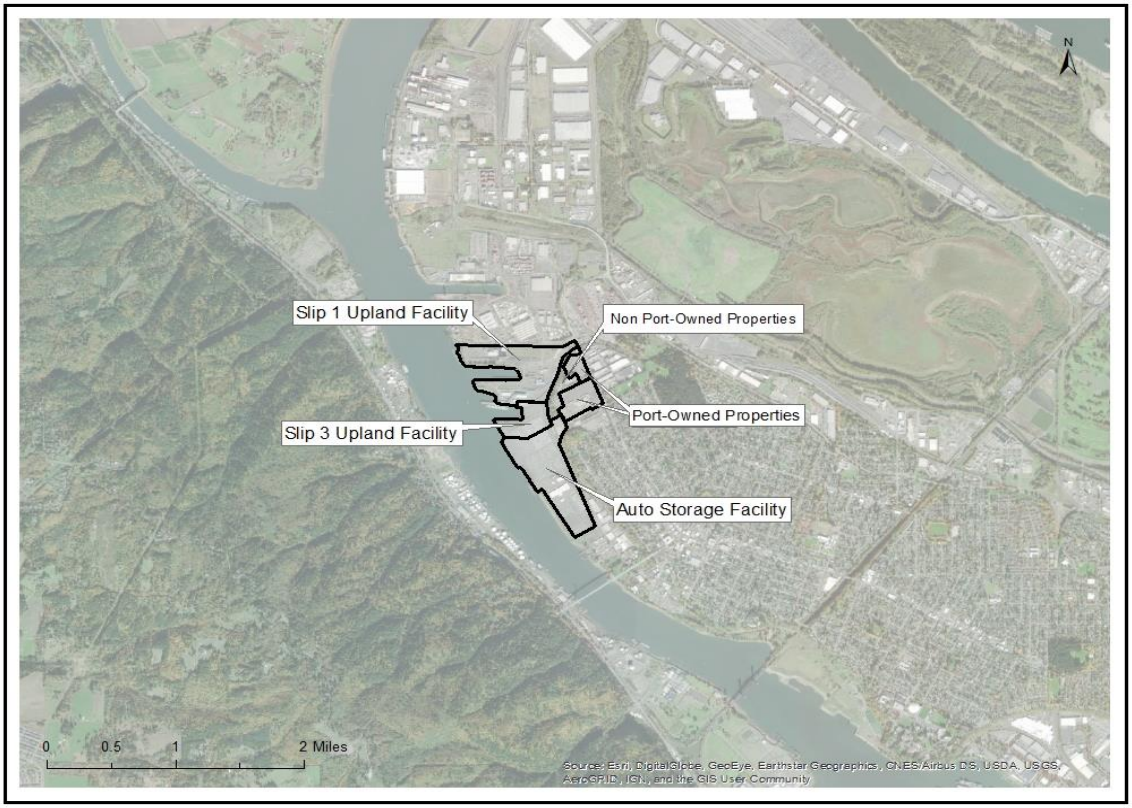
2 SITE OVERVIEW AND BACKGROUND

2.1 Site Overview

T4 occupies approximately 283 acres on the east bank of the lower Willamette River downstream from the St. Johns Bridge in north Portland, Oregon, between River Miles 4.1 and 4.6. The Site is relatively flat on the west side of the Site closer to the Willamette River with a steep hillside and bluff located on the east side of the Site. The lower portions of the Site are located approximately 35 feet above mean sea level. The land cover at T4 is a mixture of pervious open space, rail tracks, industrial buildings, and asphalt and concrete pavement.

For the purposes of DEQ oversight, the T4 upland was divided into four areas: Terminal 4 Slip 1 (ECSI No. 2356), Terminal 4 Slip 3 (ECSI No. 272), Terminal 4 Auto Storage Area (ECSI No. 172) and the other Port-owned properties located to the northeast of the Auto Storage Area. These areas encompass 98 acres, 27 acres, 94 acres and 31 acres, respectively (Figure 1). The non-Port owned properties located between the Site and the Auto Storage Facility include a retirement home, an RV storage facility, residential parcels, and vacant properties owned by Union Pacific Railroad. Runoff from these properties does not enter the Port's stormdrain system. The two vegetated infiltration basin SCMs (a.k.a. bioinfiltration or bioretention basin SCMs) described in this Engineer's Report are for Basin M within the Slip 1 Upland Facility and Basin K1 in the Slip 3 Upland Facility.

Nearly all stormwater at T4 either infiltrates or reaches a conveyance system via overland flow and then discharges to the river through an outfall. The area of Slip 1 and 3 is divided into 12 stormwater subbasins (Figure 2). Basin M is approximately 26.5 acres, relatively flat, and includes a mix of surface conditions. Basin K1 is approximately 1.2 acres, is relatively flat, and consists of paved and gravel areas.



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Figure 1. Upland Facility Areas of Terminal 4.

Figure 2. Stormwater Basins of the Slip 1 and 3 Upland Areas.

2.2 Previous Stormwater Investigations and Source Control Activities

The Port has been working with DEQ for over 20 years on upland investigation and remediation at T4. As presented in Section 2.1, the T4 upland was divided into three areas: Terminal 4 Slip 1, Terminal 4 Slip 3, and the Terminal 4 Auto Storage Area. DEQ has issued a no further action letter with respect to the Auto Storage Area (DEQ, 2004).

Completed milestone documents related to stormwater and stormwater source controls at T4 Slips 1 and 3 upland areas are as follows:

- Remedial Investigation (Slip 1: Ash Creek/Newfields, 2007; Slip 3: Hart Crowser, 2000)
- Stormwater Source Control Evaluation (Ash Creek Associates, 2009a)
- Source Control Completion Report (Ash Creek Associates, 2011)
- Screening-Level Recontamination Analysis (Formation Environmental, 2012)
- Additional Stormwater Sampling Memo (Ash Creek Associates, 2013)
- Additional Source Control Measures Memo (Apex, 2014)

- Source Control Decision Support Data Collection (Geosyntec Consultants, 2016)
- Treatment Effectiveness Pilot Study (Geosyntec Consultants, 2018a)
- Soil Infiltration Testing Report (Geosyntec Consultants, 2018b)

These stormwater-related investigations are briefly summarized below in chronological order. Additional descriptions of the history of source controls activities and studies performed at the site were provided to DEQ in the Terminal 4 Source Control Briefing Paper on August 31, 2018 (Apex, 2018a).

2000-2006: Terminal 4 Removal Action Characterization and Recontamination Analysis

Removal Action Characterization included extensive sediment sampling to define constituents of interest (COIs) in sediments of the river. The COIs for sediments included metals, polycyclic aromatic hydrocarbons (PAHs), bis(2-ethylhexyl)phthalate (BEHP), pesticides (DDT/DDD/DDE), and polychlorinated biphenyls (PCBs; Hart Crowser, 2000; Ash Creek/Newfields, 2007). A Recontamination Analysis, which included stormwater sampling, was deemed necessary to assess ongoing sources that could potentially recontaminate Willamette River sediments following the removal action. The stormwater component of the Recontamination Analysis was intended to better characterize pollutant concentrations in runoff across the site to identify potential pollutant source areas (Blasland, Bouck & Lee, 2006).

2006-2009: Stormwater and Stormwater Solids Sampling and Source Control Evaluation

A stormwater characterization program was initiated in December 2006, concurrent with a program conducted by the Lower Willamette Group (LWG) for the Portland Harbor Superfund Site (PHSS) Study Area under U.S. Environmental Protection Agency (EPA) oversight. The memorandum *Rationale for Basin Selection for Storm Water Sampling and Additional Information* described the rationale for selection of sampling sites (Ash Creek, 2007), with the intent of assessing what, if any, stormwater source control measures (SCMs) were needed at T4. The results were presented in the stormwater source control evaluation (SCE) Report submitted to DEQ on September 9, 2009 (Ash Creek Associates, 2009a).

Results were compared with the LWG dataset of other Portland Harbor sites, and later DEQ compared results to the knee of the curve plots for concentrations at other Portland Harbor heavy industrial sites. The SCE identified elevated concentrations of PAHs and some metals in Basins L and M. In DEQ’s comment letter response to the SCE report, DEQ noted that cadmium (Cd) and BEHP in Basin L stormwater, PCB congeners in both Basins L and M stormwater, and Cd, lead (Pb), zinc (Zn), BEHP, and total PCBs in Basin L stormwater solids were also elevated relative to other Portland Harbor Sites (DEQ, 2009).

The 2009 SCE report recommended cleanout of the stormwater conveyance lines for Basins L and M to remove legacy pollutants from storm drains. DEQ agreed but requested that Basins K and N be cleaned as they were deemed to be similar to Basin L in the Basin Selection memo.

2010: Stormwater Source Control Measures and Performance Monitoring

To remove legacy solids from Site storm drains, cleanouts of the stormwater conveyance systems for Basins L, M, K, and N were conducted in June 2010. Following the cleanouts three rounds of grab samples were collected between October 2010 and May 2011 from Basins L and M to evaluate the effectiveness of the line cleanouts. The results showed that the cleanouts successfully removed legacy solids from the conveyance lines, significantly reducing concentrations of TSS, metals, and PCB congeners (Ash Creek Associates, 2011). However, PAH concentrations were not reduced, and DEQ's response noted concerns about Arsenic and PAHs in Basins L and M (DEQ, 2011).

In parallel with this effort stormwater samples from Basin Q were collected to verify that demolition and removal of grain storage tanks coated in PCB-laden paint did not impact Basin Q runoff. Results confirmed that PCB concentrations in Basin Q were not impacted by the tank removal (Ash Creek Associates, 2011).

2010-2012: Screening Level Recontamination Analysis for Stormwater Basins L and M

The *Screening Level Recontamination Analysis for Storm Water Basins L and M* (Formation Environmental, 2012) was completed following discussion with DEQ and EPA to further assess the potential for contamination of Willamette River sediments due to stormwater runoff from Basins L and M. Results indicated that recontamination with arsenic and PAHs in stormwater was not predicted. However, DEQ and EPA expressed concerns about the assumptions and model parameters.

2012-2013: Additional Stormwater Sampling

The StormFilter® vault in Basin M was altered to route additional flow to the treatment system, and filter media was changed from a leaf-based media to a blend of zeolite, perlite, and granular activated carbon (ZPG). Two rounds of follow up composite samples were collected between October 2012 and February 2013 from Basins M and L (Ash Creek Associates, 2013). DEQ's response to the results noted concerns about PAH and TSS concentrations in Basin M, as well as observed increases in concentrations of various metals as compared to post storm drain clean out samples (although all remained below the knee of the curve; DEQ, 2012).

2013-2014: Additional Stormwater Source Control Measures and Performance Monitoring

Additional stormwater runoff source control measures and performance monitoring were completed, including observation of sediment accumulations in storm drains and comprehensive site sweeping and storm drain cleanouts. An additional round of sampling was then conducted by Apex in 2014 consisting of automated composite sampling, grab sampling, and flow monitoring within Basins L and M. Sampling was conducted for targeted subbasin areas and at the outfalls for the respective basins to further characterize PAHs and arsenic concentrations in stormwater (Apex, 2014).

2015-2016: T4 Source Control Decision Support Data Collection

Stormwater sampling and flow monitoring was conducted in 2015/2016 in Basins L and M to support selection and sizing of potential stormwater SCMs (Geosyntec, 2016). Stormwater quality results indicated that PAHs in stormwater discharges from Basin M were primarily associated with very fine sediment (smaller than 20-micron) while a greater percentage of the PAHs in stormwater discharges from Basin L were associated with larger particle sizes. These data indicate that significant removal of PAHs from stormwater discharges from Basin M would require removal of very fine particulates which is technically challenging using passive filtration-based treatment technologies.

2017-2018: T4 Source Control for Slip 1 Upland Facility Stormwater Treatment Effectiveness Pilot Study

A treatability test was conducted to assess the effectiveness of passive filtration-based treatment alternatives for removing PAHs from stormwater discharge from Basin M (Geosyntec, 2018a). The testing assessed a Contech StormFilter with perlite media as a pretreatment device and five treatment alternatives: a Contech StormFilter with granular activated carbon (GAC) and perlite, a StormwateRx Aquip unit with layered treatment media, and three flow through-columns with different engineered soil media (ESM) blends that could be used in vegetated filtration SCMs. Basin M was selected for this testing because previous testing indicated that PAHs were associated with fine sediment and would be challenging to remove.

Results from this testing indicated limited PAH removal using either of the Contech StormFilters, moderate PAH removal by the StormwateRx Aquip unit, and good removal by the three ESM blends. None of the treatment alternatives reduced PAH concentrations below the applicable Joint Source Control Strategy (JSCS) Screening Level Values (SLVs). Filter clogging was noted to be a problem for the StormwateRx Aquip unit and for the two of the ESM blends. Among all treatment alternatives, the 70% sand / 20% coconut coir pith / 10% GAC ESM blend had the best combination of PAH removal and hydraulic characteristics.

2018 Terminal 4 Source Control for Slips 1 and 3 Upland Facilities Soil Infiltration Testing Report

Infiltration testing was conducted to assess the potential for infiltration-based stormwater SCMs in different locations across T4 (Geosyntec, 2018b). Testing indicated infiltration rates ranging from 2.3 inches per hour to 229 inches per hour, with moderate rates (20-40 inches per hour) in the Basin M infield area and extremely high rates (greater than 100 inches per hour) in the gravel area east of Basin K1. Groundwater was not encountered in any of the test pits, but groundwater levels at three existing monitoring wells were measured at 15 to 19 feet below ground surface (bgs). These measurements were made on May 31, 2018 when the Willamette River was close to its the seasonal maximum.

3 EXISTING SITE CONDITIONS

The following sections document existing site conditions, with a focus on the areas in the vicinity of the proposed bioinfiltration SCMs in Basins K1 and M.

3.1 Storm Sewers

Basins K1 and M each have their own dedicated storm sewer networks, with outfalls discharging directly to the Port of Portland's Slips 3 and 1, respectively. Information regarding the existing pipe networks is primarily based on data in PortGIS, the Port of Portland's GIS-based asset management system. For those pipe networks at T4, PortGIS is known to have data gaps with regard to pipe invert elevations and diameters. Storm sewer features directly related to the design of the proposed bioinfiltration SCMs will be surveyed prior to completion of the 100% design.

3.2 Other Utilities

The locations of other utilities, including sanitary sewer, potable water, electrical, natural gas, and fiber optic are also included in PortGIS. The proposed SCM designs are anticipated to avoid conflicts with other utilities whenever possible, however, some conflicts are unavoidable and will be managed during construction. Potholing will be conducted prior to starting the 100% design. It is not expected that any utility conflicts will result in significant changes to the overall concept of the proposed SCMs.

3.3 Site Survey

Site survey was completed for this project in August 2020, but the Agency Plan Set presented in this report is based on existing survey information from PortGIS and several as-built documents from previous infrastructure improvement projects at T4. The site survey data will be used in the next iteration of the design. This data is not expected to result in any significant changes to the overall concept of the proposed SCMs.

3.4 Infiltration Testing

Infiltration testing at the Site was conducted by Carlson Geotechnical in 2018. Thirteen locations were selected for the infiltration testing using the "Encased Falling Head" test method. Three tests were conducted at each test pit (see Geosyntec Consultants, 2018b for details) and the lowest infiltration rate measured was used for design purposes. Test pit TP-7A is located at the proposed location for the Basin M stormwater SCM and test pit TP-13 is located at the proposed location for the Basin K1 stormwater SCM. The measured infiltration rates were greater than 20 inches/hour at the proposed Basin M stormwater SCM location and greater than 200 inches/hour at the proposed Basin K1 stormwater SCM (Geosyntec Consultants, 2018b).

In February 2020, additional infiltration testing was conducted by GeoDesign (Appendix B) at each of the infiltration SCM locations. Based on the results of the infiltration tests, GeoDesign recommends excavating to at least 7.5 feet below ground surface and using the following unfactored field infiltration rates as part of the design:

- 50 in/hr for the stormwater infiltration Basin M
- 80 in/hr for the stormwater infiltration Basin K1

The more recent infiltration test results align with the previous infiltration test results and verifies the adequacy of Site soils for stormwater infiltration.

3.5 Environmental Investigations and Findings

Relevant stormwater investigations and source controls were summarized in Section 2.2. Other significant environmental investigations related to groundwater and soils at T4 have also occurred in the Slips 1 and 3 upland areas.

3.5.1 Slip 1 Upland Area Soils and Groundwater

A Remedial Investigation (RI) was conducted to assess existing groundwater and soil contamination for the Slip 1 upland area (Ash Creek/Newfields, 2007a). A total of 24 monitoring wells were installed and 95 push-probe soil borings were advanced in the area. The monitoring wells were sampled quarterly for one year and 134 soil samples were collected from surface or near-surface soil. An additional 49 subsurface soil samples were also collected. Groundwater and soil samples were analyzed for petroleum hydrocarbons, PAHs, SVOCs, VOCs, PCBs, pesticides, and metals. The RI did not identify any significant source of groundwater contamination. In a letter dated October 8, 2007, DEQ agreed that groundwater had been adequately assessed and that no further sampling of the T4 Slip 1 monitoring wells was required (DEQ, 2007).

The RI investigation and other investigations summarized in Section 2.2 for the Slip 1 upland area have not indicated the presence of soil or groundwater contamination in the vicinity of the proposed bioinfiltration SCM in Basin M. A discussion of the historical data relative to the proposed bioinfiltration SCMs, as well as the locations of the soil borings and the groundwater monitoring wells are shown in Appendix C. A cross-section drawing of the vicinity of the proposed location for the Basin M SCM with soils and groundwater information from the Slip 1 RI is also attached in Appendix C.

3.5.2 Slip 3 Upland Area Soils and Groundwater

The Remedial Investigation for the Slip 3 upland area included extensive investigation of soil and groundwater (Hart Crowser, 2000). Petroleum hydrocarbons were detected in soil and groundwater, including light non-aqueous phase liquid (LNAPL) hydrocarbons which originated from a release from the former Union Pacific Railroad pipeline at the facility. LNAPL recovery has been on-going since it was identified in 1970 and groundwater monitoring has been conducted since the 1990s (Ash Creek/BBL/Newfields, 2005a; Hart Crowser, 2000). Between 2005 and the present groundwater monitoring and LNAPL recovery have been conducted pursuant to a Consent Judgement (No. 0410-10234) between the DEQ and the Port. Additionally, risk assessment, feasibility studies, design studies (e.g. aquifer testing, product recovery), and LNAPL removal studies were conducted between 2000 and 2004 (Ash Creek/BBL/Newfields, 2005b).

Petroleum seeps, sheen on surface water, and groundwater with petroleum discharging to Slip 3 were addressed in 2004 with the bank excavation and backfill remedial action (BEBRA) activities (Ash Creek/BBL/Newfields, 2005b). Annual sampling and reporting are currently conducted in accordance with the LNAPL Removal, Groundwater Monitoring, and Contingency Plan (Ash Creek/BBL/Newfields, 2005b), and the Site Closure Evaluation and Recommendation – Groundwater (Ash Creek, 2009a). The monitoring activities are required as part of the remedial action for T4 Slip 3 as required in the record of decision (DEQ, 2003).

The proposed bioinfiltration basin in upper Basin L for Basin K1 stormwater is at least 300 feet upgradient from this known groundwater contamination. Appendix D provides an assessment of the potential for infiltration of Basin K1 stormwater in the proposed location to affect the hydraulic gradient and thereby impact the groundwater pathway to Slip 3. This analysis indicates that the infiltration of stormwater at this location would not affect the mobility of the LNAPL plume. In addition, the RI investigation and other investigations summarized in Section 2.2 for the Slip 3 upland area have not indicated the presence of soil or groundwater contamination in the vicinity of the proposed bioinfiltration SCM for Basin K1. A discussion of the historical data relative to the proposed bioinfiltration SCMs, as well as the locations of the soil borings and the groundwater monitoring wells are shown in Appendix C. A cross-section drawing of the vicinity of the proposed location for the Basin K1 SCM with soils and groundwater information from the Slip 3 RI is also attached in Appendix C.

4 APPLICABLE DESIGN AND CONSTRUCTION STANDARDS

The following design and construction standards were considered in the design of the proposed vegetated infiltration basins, or bioinfiltration basins.

4.1 City of Portland Bureau of Environmental Services (BES) Pollution Reduction Standard for Projects with No/Limited New Development/Redevelopment

Based on the BES's pollution reduction standard for owner-initiated stormwater retrofit projects that do not add or replace more than 500 square feet of impervious surface, the stormwater facility is encouraged, but is not required, to be sized to treat 90% of the average annual runoff. Per the City's Rate and Volume Pollution Reduction Standards (pg. 1-40 of the 2016 City of Portland Stormwater Management Manual), a continuous simulation model may be used to demonstrate treatment of 90% of the average annual runoff volume.

4.2 Oregon DEQ 1200-Z Tier II Corrective Action Response Design Storm Criteria

Based on Oregon DEQ 1200-Z Tier II corrective action response design storm criteria, the stormwater facility is required to treat or infiltrate runoff from 50% of the 2-year, 24-hour design storm (per the Tier II checklist), which equates to a total precipitation depth of 1.09 inches for the Site. This design storm is not directly applicable to the stormwater SCM in Basin M but is applicable to the stormwater SCM in Basin K1 because stormwater discharges in this basin are authorized by Kinder Morgan's 1200-Z permit. Because SCMs sized to treat DEQ's design storm will result in greater than 90% capture of the average annual runoff volume, the Port will be using this standard to size the stormwater SCMs in both Basin M and Basin K1. See Section 6 for details on the SCM sizing.

4.3 City of Portland Design Standard for New Development/Redevelopment Projects

Under the Port's Municipal Separate Storm Sewer (MS4) Permit, development or redevelopment projects that add or replace more than 500 square feet of impervious surface must implement post-construction stormwater Best Management Practices (BMPs) according to the City of Portland

Stormwater Management Manual requirements. According to these requirements, sites that meet the impervious surface threshold and have soil infiltration rates greater than 2 inches per hour must implement full onsite infiltration unless site constraints prevent infiltration. The City defines full onsite infiltration as infiltrating the impervious area runoff from the 10-year 24-hour design storm (3.4 inches). .

The proposed bioinfiltration basin designs are intended to treat existing impervious surfaces and do not add or replace more than 500 square feet of impervious surface, so these requirements are not applicable.

For voluntary stormwater retrofit projects that do not add or replace more than 500 square feet of impervious surface, the BES Manual includes requirements for site investigation, design, landscaping, and operations and maintenance (O&M). The applicability of these requirements to Port projects is not clearly presented in the BES Manual or in the Port's MS4 Permit, however, these requirements include best design practices that have been followed in the proposed designs. For the proposed vegetated infiltration basins which are intended to reduce pollutant discharges, the following requirements were followed:

- Facilities must be setback at least 100 feet from slopes greater than 10%.
- Maximum side slope is 3 horizontal to 1 vertical (3:1).
- Maximum ponding depth is 18 inches.
- Treatment systems must be designed to treat at least 90% of average annual runoff.
- Infiltration testing must be completed, and factors of safety must be applied to determine design infiltration rates.
- A landscape plan must be developed for vegetated treatment systems according to requirements in the manual.
- A site-specific O&M Plan must be completed.

4.4 City of Portland Sewer and Drainage Facilities Design Manual

The City of Portland Sewer and Drainage Facilities Design Manual (SDFDM) applies to projects which discharge stormwater runoff to public storm or sanitary sewers. Neither of the proposed bioretention SCMs would discharge stormwater to public storm or sanitary sewers, so the SDFDM is not applicable to this project.

4.5 City of Portland Source Control Manual

Under the City of Portland Source Control Manual, when stormwater infiltration is proposed at sites with known soil or groundwater contamination, project proponents must coordinate with the City of Portland and/or DEQ to assess the potential for infiltration to add to or mobilize existing contamination. As described in Section 3.4, multiple investigations and remedial actions have occurred in Slips 1 and 3 upland areas. Prior investigations in the Slip 1 and Slip 3 upland area have not indicated the presence of soil or groundwater contamination in the vicinity of the proposed bioretention SCMs in Basin M and Basin K1. For the known groundwater contamination in the Slip 3 upland area, the discussion in Section 3.4 and Appendix D confirms that the proposed infiltration of Basin K1 stormwater will not significantly change the hydraulic gradient or the mobility of the existing groundwater contamination.

5 STORMWATER TREATMENT ALTERNATIVES

5.1 Treatment Alternative Selection

Passive filtration-based stormwater treatment alternatives were primarily assessed for their effectiveness at reducing loading of PAHs to the Willamette River during the Treatability Study in 2018. Testing completed during the Treatability Study also considered the susceptibility of treatment alternatives to clogging which could render otherwise effective SCMs unsuitable. The potential for infiltration-based stormwater treatment alternatives was assessed during infiltration testing completed in 2018. Active stormwater treatment alternatives (e.g., chemically enhanced sand filtration) were not assessed because they are maintenance and energy intensive and less sustainable than green stormwater infrastructure. Table 1 presents a summary of treatment alternatives considered and includes a qualitative comparison.

Table 1. Comparison of Stormwater Treatment Alternatives

Alternative	PAH Loading Reduction	Metals Loading Reduction	Stormwater Discharge Reduction	Overall Cost
Contech StormFilters	L	L	L	L
StormwateRx Aquip	M	M	L	H
Biofiltration	M	M	L	M
Bioinfiltration	H	H	H	M

L – Low, M – Medium, H – High

5.2 Proposed Treatment Alternatives

Vegetated infiltration basin SCMs with ESM (i.e., bioinfiltration) is proposed as the best alternative to reduce loadings of COCs and total discharge volume to the Willamette River while also having a moderate cost for construction and O&M. The attached Agency Plan Set (Appendix A) presents 30% designs for conveyance features, pump stations and bioinfiltration SCMs. Certain elements which are not yet included in the Agency Plan Set (e.g., monitoring and control infrastructure) are described in the following subsections and will be included as part of the 100% design plan set.

One bioinfiltration SCM would be located in the Basin M infield and would treat and infiltrate runoff from Basin M (see Appendix A, Sheet C-1). Another bioinfiltration SCM would be located in the gravel area east of Basin L and would treat and infiltrate runoff from Basin K1 (see Appendix A, Sheet C-7). Because stormwater within both basins currently discharges via underground storm drains, one pump station would be installed to convey runoff to each of the proposed bioinfiltration SCMs. Pump stations and bioinfiltration SCMs would be sized to treat and infiltrate at least 90% of average annual runoff and the 1200-Z Tier II design storm (i.e., 50% of the 2-year, 24-hour storm). To remove pollutants prior to infiltration, both bioretention SCMs would include the GAC-based ESM which had the best combination of PAH removal and resistance to clogging during the 2018 Treatability Testing (Geosyntec, 2018a). Both bioretention SCMs would be outfitted with monitoring and control instruments.

The following subsections provide details regarding the design of specific aspects of both proposed bioretention SCMs. Modeling and other details relevant for sizing and design of conveyance features, pump stations, and bioretention basins are presented in Section 6.

5.2.1 Basin M Bioinfiltration SCM

Design drawings for the proposed Basin M bioinfiltration SCM and associated conveyance are presented in plan set (Appendix A) Sheets C-1 through C-6. This section presents supporting details for the Basin M design drawings.

A proposed flow splitter manhole would be installed to divert stormwater from the existing drainage network to a proposed pump station. As presented in Section 6, a diversion flow rate of 0.81 cfs would treat more than 90% of average annual runoff from Basin M and divert all runoff from the 1200-Z Tier II design storm (i.e., 50% of the 2-year, 24-hour storm). The proposed flow splitter would be located approximately 15 feet north of existing manhole STSMH2589 which is the last manhole upstream of the Basin M outfall. No catch basins or other storm lines enter downstream of STSMH2589, so the proposed flow splitter would receive all runoff from Basin M. The flow splitter would be a precast concrete manhole located in line with existing piping. The vault would contain a baffle wall so that all flows up to approximately 0.81 cfs would be diverted under pressurized conditions (i.e., pipe flow) through a 10” pipe to the proposed pump station. Because this pipe would be capable of conveying significantly more than 0.81 cfs, the actual flow rate through this pipe would be controlled by the rate at which the pump removes water from the pump vault. Flows in excess of 0.81 cfs would overtop the baffle wall and discharge into the existing piping and discharge to the Basin M outfall. Specifications for the baffle wall elevation, and the diameters and elevations of pipes may be refined prior to completion of the 100% design.

The proposed pump station would be located approximately 10 feet southwest of the proposed flow splitter manhole. The pump station would consist of a precast concrete vault, an access hatch, two pumps and associated discharge piping, float switches to trigger the pumps, and other typical pump station infrastructure. Pumps would be selected to convey a flow rate of at least 0.81 cfs at the total system head, so it is likely that the actual system flow rate will be slightly greater than 0.81 cfs. Power would be supplied from an above-ground control panel immediately adjacent to the to the access hatch. The power supply would be connected to a float switch located in the bioinfiltration SCM to shut down the pumps if water levels in the bioinfiltration SCM exceeded the design ponding depth. Additional specifications for the pump station will be determined prior to completion of the 100% design.

Flow from the pump station would be conveyed via parallel 6” force mains to a valve box where the force mains would combine into a single 6” force main. This force main would discharge pumped stormwater into the pretreatment forebay of the bioinfiltration SCM. The force main would run approximately 33 feet laterally from the pump station to the pretreatment forebay. All piping would be installed below the frost line. The valve box would provide easier access to check valves and a shut off valve.

The pretreatment forebay would provide energy dissipation and some amount of settling to remove coarse particulates before entering the bioinfiltration basin. The pretreatment forebay would have an area approximately 15% of the proposed bioinfiltration SCM. Water pumped into the pretreatment forebay would flow into the bioinfiltration SCM either by passing over a weir(s) or through other conveyance. It will be designed to permit easy access for maintenance and sediment removal. Specifications for the pretreatment forebay will be developed prior to completion of the 100% design.

The bioinfiltration SCM would be a large basin consisting of side slopes, riprap near the inlet from the pretreatment forebay, ESM to remove PAHs and other pollutants such as copper and zinc, appropriate vegetation, an overflow structure to convey water deeper than the maximum design ponding depth, and monitoring infrastructure. The side of the basin would be sloped at 3:1 (H:V) and the basin would have a maximum design ponding depth of 18 inches which would be controlled by the elevation of the overflow structure. The top of the side slopes would extend approximately 6" above the invert of the overflow structure to provide freeboard. The basin would contain 20" of ESM placed on native soils, with 3" of mulch above the ESM. The ESM would be a 70% sand / 20% coconut coir pith / 10% GAC, or another similar blend to provide PAH removal similar to the removal documented during the 2017 Treatability Test. Plants would be selected according to guidance contained in the Portland Stormwater Management Manual and irrigation may be added to promote healthy vegetation through summer drought.

The bioinfiltration SCM would be sized to infiltrate 0.9 cfs (10% more than the treatment flow rate of 0.81 cfs) at the design ponding depth of 18 inches. Initial sizing has been conducted based on a raw infiltration rate of 20 inches/hour (Geosyntec, 2018b), a factor of safety of 2 (following the Portland Stormwater Manual), and a design infiltration rate of 10 inches/hour. According to the Portland Stormwater Manual, additional infiltration testing is required within the footprint of the proposed bioinfiltration SCM. Because the basin will be designed to infiltrate 10% more than the treatment flow rate at the maximum ponding depth, the overflow structure is not expected to be engaged unless actual infiltration rates are lower than measured, or if they decline over time due to clogging. To limit the potential for water overtopping and spilling out of the bioinfiltration SCM, the overflow structure and bypass piping would be sized to convey the entire pumped flow rate back to the flow splitter manhole. As an additional safeguard, a float switch would be installed in the bioinfiltration basin to shut down the pumps if the water level in the basin reached the maximum ponding depth.

5.2.2 Basin K1 Bioinfiltration SCM

Design drawings for the proposed Basin K1 bioinfiltration SCM and associated conveyance are presented in plan set (Appendix A) Sheets C-7 through C-12. This section presents supporting details for the Basin K1 design drawings.

A proposed flow splitter manhole would be installed to divert approximately 0.2 cfs from the existing drainage network to a proposed pump station. As presented in Section 6, a diversion flow rate of 0.2 cfs would treat more than 90% of average annual runoff from Basin K1 and divert all runoff from the 1200-Z Tier II design storm (i.e., 50% of the 2-year, 24-hour storm), assuming

100% imperviousness. The proposed flow splitter would be installed to intersect the existing storm pipe STTLN730 where it turns to flow west towards the outfall for Basin K1. No catch basins or other storm lines enter downstream of this location, so the proposed flow splitter would receive all of the runoff from Basin K1. The flow splitter would be a precast concrete vault with a baffle wall so that all flows up to approximately 0.2 cfs would be diverted under pressurized conditions (i.e., pipe flow) through a pipe to the proposed pump station. This pipe will be sized to convey significantly more than 0.2 cfs, so the flow rate through the pipe will be controlled by the rate at which the pumps remove water from the pump vault. Flows in excess of 0.2 cfs would overtop the baffle wall and discharge into the existing piping and discharge to the Basin K1 outfall. Specifications for the baffle wall elevation, and the diameters and elevations of pipes may be refined prior to completion of the 100% design.

The proposed pump station would be located approximately 10 feet northeast of the proposed flow splitter manhole. The pump station would consist of a precast concrete vault, an access hatch, two pumps and associated discharge piping, float switches to trigger the pumps, and other typical pump station infrastructure. Pumps would be selected to convey a flow rate of at least 0.2 cfs at the total system head, so it is likely that the actual system flow rate will be slightly greater than 0.2 cfs. Power would be supplied from an above-ground control panel immediately adjacent to the to the access hatch. The power supply would be connected to a float switch in the bioinfiltration basin to shut down the pumps if water levels in the basin exceeded the design ponding depth. Additional specifications for the pump station will be determined prior to completion of the 100% design.

Flow from the pump station would be conveyed via parallel 4” force mains to a valve box where the force mains would combine into a single 4” force main. This force main would discharge pumped stormwater into the pretreatment forebay of the bioinfiltration SCM. The force main would run approximately 400 feet laterally from the pump station to the pretreatment forebay. All piping would be installed below the frost line by trenching. The valve box would provide easier access to check valves and a shut off valve.

The pretreatment forebay would provide energy dissipation and some amount of settling to remove coarse particulates before entering the bioinfiltration basin. The pretreatment forebay would have an area approximately 50% of the proposed bioinfiltration SCM. Water pumped into the pretreatment forebay would flow into the bioinfiltration SCM either by passing over a weir(s) or through other conveyance. It will be designed to permit easy access for maintenance and sediment removal. Specifications for the pretreatment forebay will be developed prior to completion of the 100% design.

The K1 bioinfiltration SCM would be a small basin consisting of side slopes, riprap near the inlet from the pretreatment forebay, ESM to remove PAHs and other pollutants, appropriate vegetation, and monitoring infrastructure to record system performance and shut down the pumps if the water level were to rise to the maximum ponding depth. The side of the basin would be sloped at 3:1 (H:V) and the basin would have a maximum design ponding depth of 18 inches. The top of the side slopes would extend approximately 6” above the design ponding depth to provide freeboard. The basin would contain 18” of ESM placed on native soils, with 3” of mulch above the ESM. The ESM would be a 70% sand / 20% coconut coir pith / 10 GAC, or another similar blend to provide

PAH removal similar to the removal documented during the 2017 Treatability Test. Plants would be selected according to guidance contained in the Portland Stormwater Manual and irrigation may be added to promote healthy vegetation through summer drought.

The bioinfiltration SCM would be sized to infiltrate the treatment flow rate of 0.2 cfs at the design ponding depth of 18 inches. Initial sizing has been conducted based on a raw infiltration rate of more than 200 inches/hour (from the Infiltration Testing in 2017), and a design infiltration rate of 20 inches/hour which is the maximum rate allowable under the Portland Stormwater Manual. According to the Portland Stormwater Manual, additional infiltration testing is required within the footprint of the proposed bioinfiltration SCM. A programmable logic controller (PLC) will be installed to shut off the pump if maximum ponding depth is exceeded.

6 TREATMENT FACILITY SIZING AND HYDRAULIC ANALYSIS

Both of the proposed bioinfiltration SCMs have been designed to infiltrate at least 90% of average annual runoff from their respective drainage basins based on long-term continuous simulations using hydrologic and hydraulic (H&H) models. Both proposed SCMs are also designed to divert and infiltrate the 1200-Z Tier II design storm based on storm event simulations using the H&H models for each basin. In addition to SCM sizing, the H&H models have also been used to assess potential drainage issues associated with the proposed designs. The following subsections present a summary of the modeling with additional details are contained in Appendix E.

6.1 Baseline Model Development

Baseline H&H models were developed using the Environmental Protection Agency (EPA) Stormwater Management Model (SWMM) version 5.1. Routing and computation parameters were selected based on professional judgement and using available modeling resources. These parameters are presented in Appendix E.

For baseline models, Basin K1 was left as a single basin but Basin M was broken into sub-basins based on land use and whether or not existing surfaces were primarily pervious (e.g., gravel, permeable pavement) or impervious (e.g., standard asphalt pavement). Rail ballast areas in Basin M were modeled as infiltrating storage units based on as-built drawings from the railyard expansion project in 2005.

The baseline model for Basin M was calibrated using flow monitoring data that was collected in 2015-2016 and summarized in the report titled *T4 Source Control Decision Support Data Collection.* Stormwater runoff flow rates were monitored in stormwater manhole STSMH2589 which is the most downstream manhole in Basin M prior to the outfall, so flow monitoring at this location represents the entire discharge from Basin M. Flow monitoring was conducted from March 23, 2015 through June 25th, 2015 and then again from October 10, 2015 through January 25, 2016. This period during which flow was monitored was used as the period of record (POR) for Basin M model calibration. Hourly rainfall data for this calibration POR were downloaded from the United States Geological Survey (USGS) City of Portland Hydra Network Shipyard rain gauge located approximately ½ mile north of T4.

Model calibration was primarily completed by modifying parameters for pervious area infiltration rates and depression (i.e., surface) storage and by modifying the size and infiltration rates of the storage units representing the rail ballasts. Parameter modifications were applied uniformly to all relevant features across Basin M, and not an element-by-element basis (e.g., changes to infiltration rates in gravel areas were applied to all gravel areas across Basin M). The accuracy of subcatchment parametrization for individual sub-basins could be important if multiple distributed stormwater SCMs were considered in the design. However, with a single infiltration basin treating runoff from all of Basin M, the rate and volume of runoff from individual sub-basins is not critical for the design or the performance of the proposed facility. Calibrations were completed for the calibration POR to minimize the root mean squared error between modeled and measured flow rates. Calibration results and final model parameters are presented in the Modeling Appendix (Appendix E).

For Basin K1, no monitoring data were available, so the baseline model was developed using available GIS data, typical parameter values from SWMM references and the SWMM technical manual, certain parameters from the calibrated Basin M model, and professional judgement. GIS analysis was used to estimate the total area of Basin K1, the percent imperviousness, and the slope. It was difficult to accurately estimate percent imperviousness of Basin K1 using available aerial imagery because the open graveled area could not be readily distinguished from paved and graveled access roads. Based on aerial imagery Basin K1 may be as low as 50% imperviousness, but for design conservativeness the area was assumed to be 100% impervious. Pervious area infiltration rates and pervious area depressions storage values were taken from the calibrated Basin M model. See Appendix E for details of the model.

6.2 Design Flow Rates

Long term simulations were completed using the baseline models for Basin M and Basin K1 to estimate the flow rate required to capture and treat at least 90% of average annual runoff volume based on applicable design standards (see Section 4). These simulations were completed in SWMM using twenty years of precipitation data from the USGS Hydra Network WPCL rain gauge, which is located approximately 1.4 miles southeast of T4. The WPCL rain gauge was used instead of the Shipyard gauge because it had a much longer POR, starting on March 23, 1999 and ending on October 11, 2018. Total runoff and peak runoff were assessed for the outfall from each baseline model within each model. This data was then analyzed to determine the diversion flow rate (i.e., cubic feet per second) that would be required to capture at least 90% of the total runoff during the long-term simulation POR. The design of both basins are also intended to meet Tier II corrective action requirements under a 1200-Z benchmark. Therefore, the peak Tier II design storm flow rate for Basin M and Basin K1 were also computed by inputting Type 1A hyetograph for 50% of the 2-year design storm depth. See Appendix E for details. Results from this analysis are presented in Table 2. Based on this table, the design flow rates of 0.2 cfs for Basin K1 and 0.81 cfs for Basin M would conform to both design standards.

Table 2. Stormwater Modeling Areas and Design Flow Rates

Basin / Scenario	Area (acres)	Total POR Runoff (MG)	Average Annual Runoff (in/yr)[1]	Peak Runoff (cfs)	90% Capture Design Flow Rate (cfs)	Tier II Storm Design Flow Rate (cfs)	Proposed Design Flow Rate (cfs) [2]
Basin K / 100% impervious	1.24	23.4	35.5	0.65	0.14	0.20	0.20
Basin M / Calibrated	26.5	150.7	10.7	6.32	0.70	0.81	0.81

[1] Average annual runoff data use a POR length of 19.6 years and basin area values. For reference, average rainfall during the POR was 39.0 inches.

[2] The proposed design flow rate is the greater flow rate required to 1) capture at least 90% of long-term runoff volume, and 2) capture the entirety of runoff from the DEQ Tier II design storm.

6.3 Analysis of Proposed Designs

Long-term simulations of the currently proposed designs have been completed to confirm that the conveyance features, pump stations, and bioinfiltration SCMs capture and infiltrate at least 90% of average annual runoff. Storm event simulations of the currently proposed designs have been completed to confirm that the flow diversion structure diverts the entirety of stormwater runoff from the SCM's respective tributary basin during the DEQ Tier II design storm.

The proposed designs do not increase or modify existing impervious surfaces and both proposed treatment systems remove runoff from existing pipe networks. Therefore, they would not be expected to create adverse drainage conditions, such as storm sewer surcharging or surface flooding. However, this assumption has been confirmed by completing 25-year design storm simulations for the proposed designs. Neither of the proposed 30% designs create any adverse drainage conditions. Modeling details are shown in Appendix E. Additional design storm simulations will be conducted, as needed, before completing the 100% designs.

7 DESIGN SCALABILITY

7. DESIGN SCALABILITY

The design of the stormwater SCMs also incorporates scalability should future new development/redevelopment occur in drainage Basin M and/or Basin K1 or additional stormwater from other areas need to be treated. The designs will accommodate one or more of the following potential future retrofits to the proposed stormwater SCMs if the need arises:

- **Increase the footprint of the proposed infiltration facilities.** Larger footprints would increase the system's treatment capacity. Given the vacant space available adjacent to proposed locations of the two SCMs, expansion of footprint would be feasible to accommodate additional flow to the SCMs in the future.

- **Add in-line storage to the treatment systems.** Adding detention devices, such as a vault or an oversized pipe, before the diversion pump station of the proposed SCMs would shave peak flows and allow the SCMs to capture higher flowrates. There are limited utility conflicts, so the addition of underground, in-line storage prior to the diversion structures would be feasible future retrofits.
- **Increase the depth of the proposed infiltration facilities.** Deepening the SCMs would allow more detention volume and increase the quantity of stormwater that can be infiltrated. Given the low risk of groundwater mounding (Appendix D), it would be feasible to deepen the SCMs in the future.

Each of the potential retrofits identified are feasible to implement based on the current design, specific conditions at T4, and likely regulatory requirements that would govern stormwater controls based on future new development/redevelopment needs. The level of development to require additional stormwater controls and the potential need to implement one of these retrofits would be introduction of more than 500 square feet of impervious surface from redevelopment/new development according to the City of Portland Design Standard for New Development or Redevelopment Projects. Quantitative analysis on the amount of the potential treatment capacity for each retrofit requires additional, specific information of future development. Due to the uncertainty in the extent or specifics of future development including the possible use of localized stormwater infiltration controls such as stormwater planters, green streets, and permeable pavement to meet the new development/redevelopment stormwater management requirements, a hypothetical scenario was evaluated to further demonstrate the feasibility of the three retrofit options. The hypothetical scenario assumes the future water quality design flow rates would be 150% of the current water quality design flow rates (i.e., 50% increase from current design).

Option 1: Increase Infiltration Facility Footprint

The size of the infiltration basin footprint is a function of the design storm hydrograph routed to the basin. For conservatism in the 30% design, the surface storage within the basin was not considered when estimating the footprint. Consequently, the current design footprint is directly proportional to the water quality design flow rate such that a 50% increase in flow rate would result in a 50% expansion of the basin footprint. This assumes the design infiltration rates at the expanded portion of the basins would be identical to the current design infiltration rates for the two stormwater SCMs, which is a reasonable assumption. Figure 3 and Figure 4 show the footprint of the expanded basins. Retrofitting the infiltration facilities with this option would require a larger pump system that delivers flow rates up to the increased water quality design flow rate to the facility.

Option 2: Add Inline Storage

To estimate the inline storage required for a 50% increase in the design flow rate, the design storm inflow hydrographs to the diversion manholes extracted from the SWMM model results were multiplied by 150% to obtain upsized design storm inflow hydrographs. Subsequently, the volume of the upsized inflow hydrograph that is associated with flows greater than the proposed water quality design flow rate equals the excess volume of stormwater runoff that would require detention before entering the treatment system pump stations. Table 3 shows the inline storage volume that would be required for Basin M and Basin K1 treatment systems in a 150% water quality design flowrate scenario. Figure 3 and Figure 4 illustrate the potential locations for the installation of the detention vaults. The precise location, shape, and orientation of the detention vary depending future development needs and associated design efforts.

Table 3. Additional Detention Storage that Would be Required for Basin M and Basin K1 Stormwater SCMs if Design Flow Rates Needed to Increase by 50%.

	Unit	Basin M Stormwater SCM	Basin K1 Stormwater SCM
Total Runoff to the Diversion Manhole during DEQ 1200-Z Storm	Cubic Feet	34,000	4,600
Proposed Water Quality Design Flowrate	Cubic Feet per Second	0.81	0.20
Additional Inline Storage Volume Required to Attenuate a 50% Increase in the Design Storm Flow Rate [1]	Cubic Feet	4,000	300

[1] The additional inline storage volume required is equal to sum of the portion of runoff greater than the proposed water quality design flowrate from the upsized inflow hydrograph.

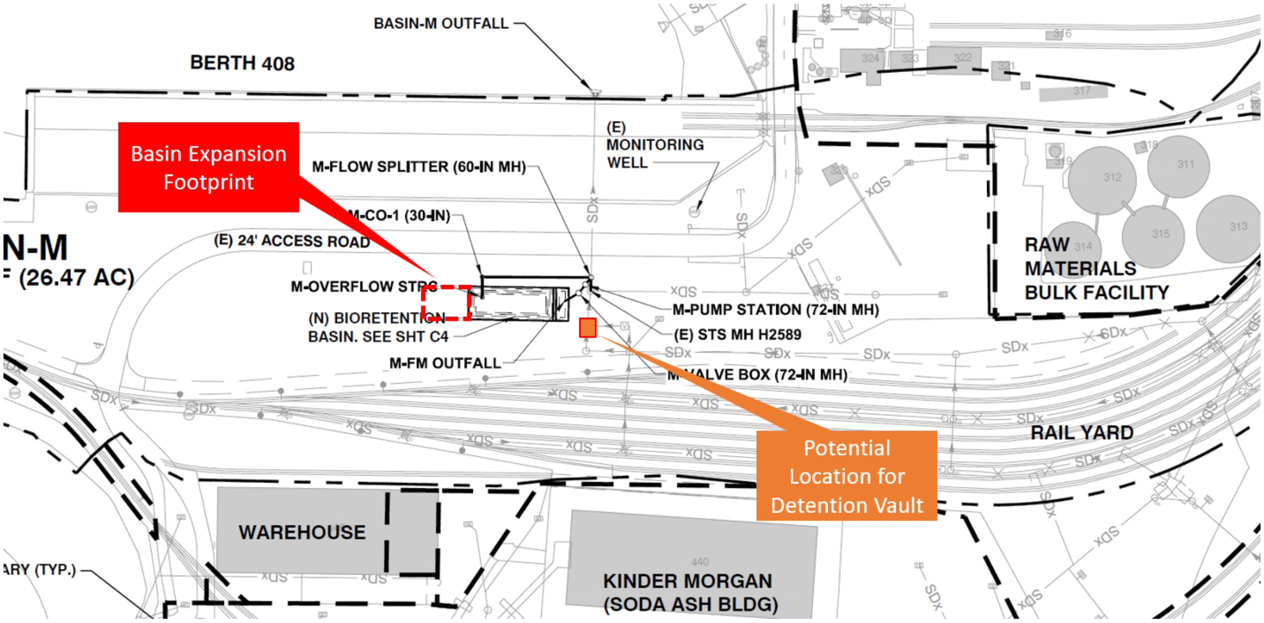


Figure 3. Potential Infiltration Basin Expansion Footprint (Option 1) and Potential Detention Vault Location (Option 2) for the Basin M Stormwater SCM in 150% Water Quality Design Flowrate Scenario.

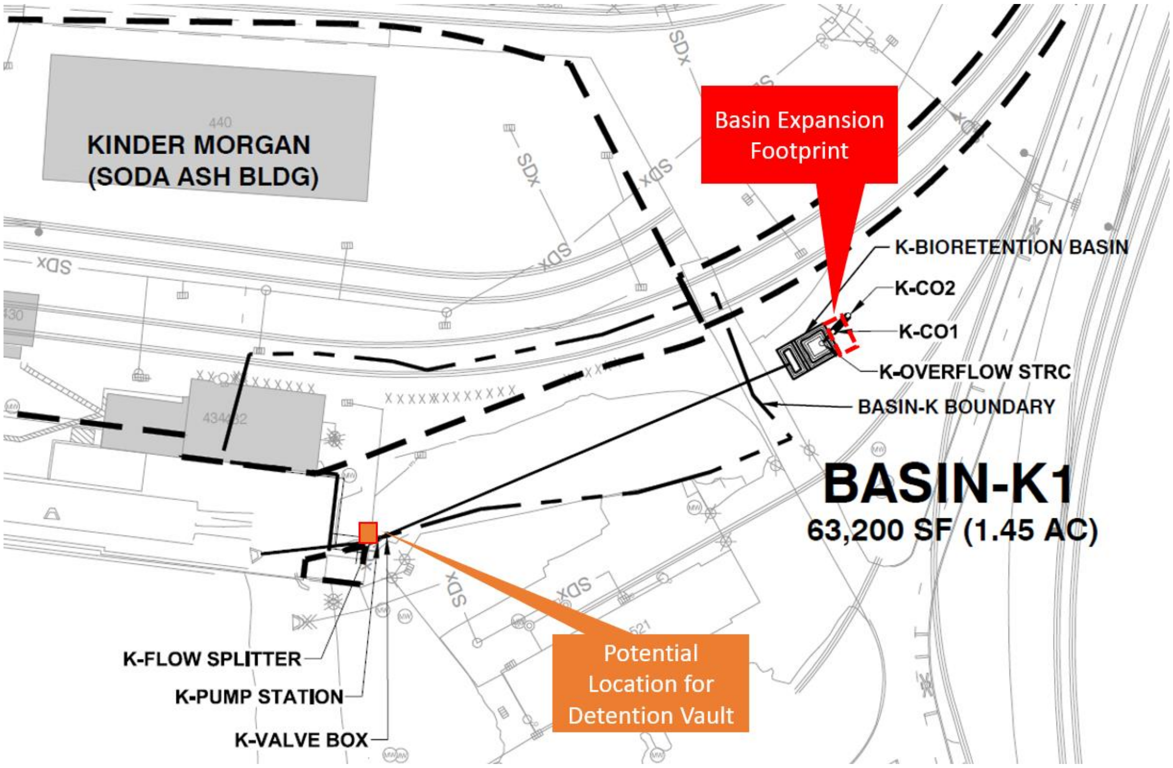


Figure 4. Potential Infiltration Basin Expansion Footprint (Option 1) and Potential Detention Vault Location (Option 2) for the Basin K1 Stormwater SCM in 150% Water Quality Design Flowrate Scenario.

Option 3: Increase Infiltration Facility Depth

Instead of adding inline storage to the systems, the extra detention could also be created by increasing the ponding depths of the infiltration basins. Based on the estimated detention volumes presented in Table 3, 4000 cubic feet of detention would be required for Basin M and 300 cubic feet of detention would be required for Basin K1. These volumes equate to less than one foot of additional ponding depth in the proposed infiltration basins given the currently proposed basin footprint sizes. As a result, the basins could be retrofitted by raising the overflow outlet structures by one foot to accommodate the 50% increase in treatment flowrate. Retrofitting the infiltration facilities with this option would also require a larger pump system that delivers up to the increased water quality design flow rate to the facility (same as Option 1).

In summary, it would be feasible to use one or more of these three options to retrofit the proposed stormwater SCMs without re-designing the entire treatment systems. In addition, the actual infiltration rates at both basins will be monitored upon completion of the construction of the proposed designs. In the case that the actual infiltration rates are higher than the factored and conservative design infiltration rates, the extent of modifications in the potential retrofit could be smaller than described in the analyses above since higher treatment rate would already be achieved by the higher infiltrated volume at the basins. DEQ would be notified if new development requires additional stormwater controls according to the Voluntary Agreement or Consent Judgement presented in Section 1.

8 OPERATION AND MAINTENANCE

The proposed bioinfiltration SCMs will require ongoing operation and maintenance to continue performing. Operation and maintenance would consist primarily of:

- Inspecting each SCM on a regular basis and planning for any corrective action that might be needed.
- Keeping the inlets and outlet structures free of obstructions.
- Raking and scarifying the surface of SCMs as needed to remove trash and debris, and to maintain filter bed permeability.
- Landscape maintenance and care of vegetation, potentially including irrigation during vegetation establishment and during summer months.
- Removal of weeds and annual inspection for evidence of erosion (e.g., scouring or gullies).
- Inspecting, testing, and servicing pumps.
- Inspection and maintenance of flow diversion structures, overflow structures and other flow conveyance structures.
- Structural repairs to the SCMs and associated structures (e.g., cracks) as needed
- Replacement of ESM when other maintenance activities are no longer effective at maintaining filter bed permeability.

Additional details on the operations and maintenance, including a plan, will be prepared with the final 100% design plan set.

9 PERFORMANCE STANDARDS AND MONITORING

The proposed performance standards for the bioinfiltration SCMs is a design standard to remove 100 percent of PAHs from more than 90 percent of average annual runoff from T4 in Basin M and Basin K1. The bioinfiltration SCM performance is based on reducing the loading of pollutants to the Willamette River sediments. Since load reduction will be achieved through infiltration, performance monitoring will include the monitoring of stormwater volumes pumped to and infiltrated in the SCMs. Monitoring infrastructure will be installed to confirm that the pump stations effectively divert the water quality design flow rate and that the bioinfiltration SCM does not overflow. Therefore, performance monitoring will not include stormwater chemistry to evaluate the effectiveness of the bioinfiltration SCMs. Details of the performance monitoring plan including the monitoring equipment that will be installed will be developed prior to completion of the 100% designs.

In addition, the two basins will also be designed to treat and infiltrate 50% of the 2-year storm (1.09/24 hours) based on DEQ guidance for a Tier II corrective action under a 1200-Z permit (2019).

10 PRELIMINARY PROJECT SCHEDULE

The preliminary project schedule for completing the design and construction of the bioinfiltration SCMs is provided in Figure 5. Following construction, the SCMs will be started up and operationally tested (i.e., commissioned) to ensure pump stations and instruments are operating as designed. After hydraulic testing and refinements are complete, performance monitoring will begin. The project schedule will be updated and finalized with the completion of the 100% designs.

Terminal 4: Stormwater Source Control Measures for Basin M and K1	2019				2020				2021				2022			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Preliminary Design		■	■	■	■	■										
Field Verification / Pre-Design Studies					■	■	■									
Final Design and Permitting: Basin M							■	■	■	■	■					
Final Design and Permitting: Basin K1							■	■	■	■	■					
Construction: Basin M											■	■				
Construction: Basin K1											■	■				
Startup / Operational Tests												■	■			
Performance Monitoring													■	■	■	
Source Control Evaluation Report																■

Figure 5. Preliminary Project Schedule.

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Appendix A

Agency Plan Set

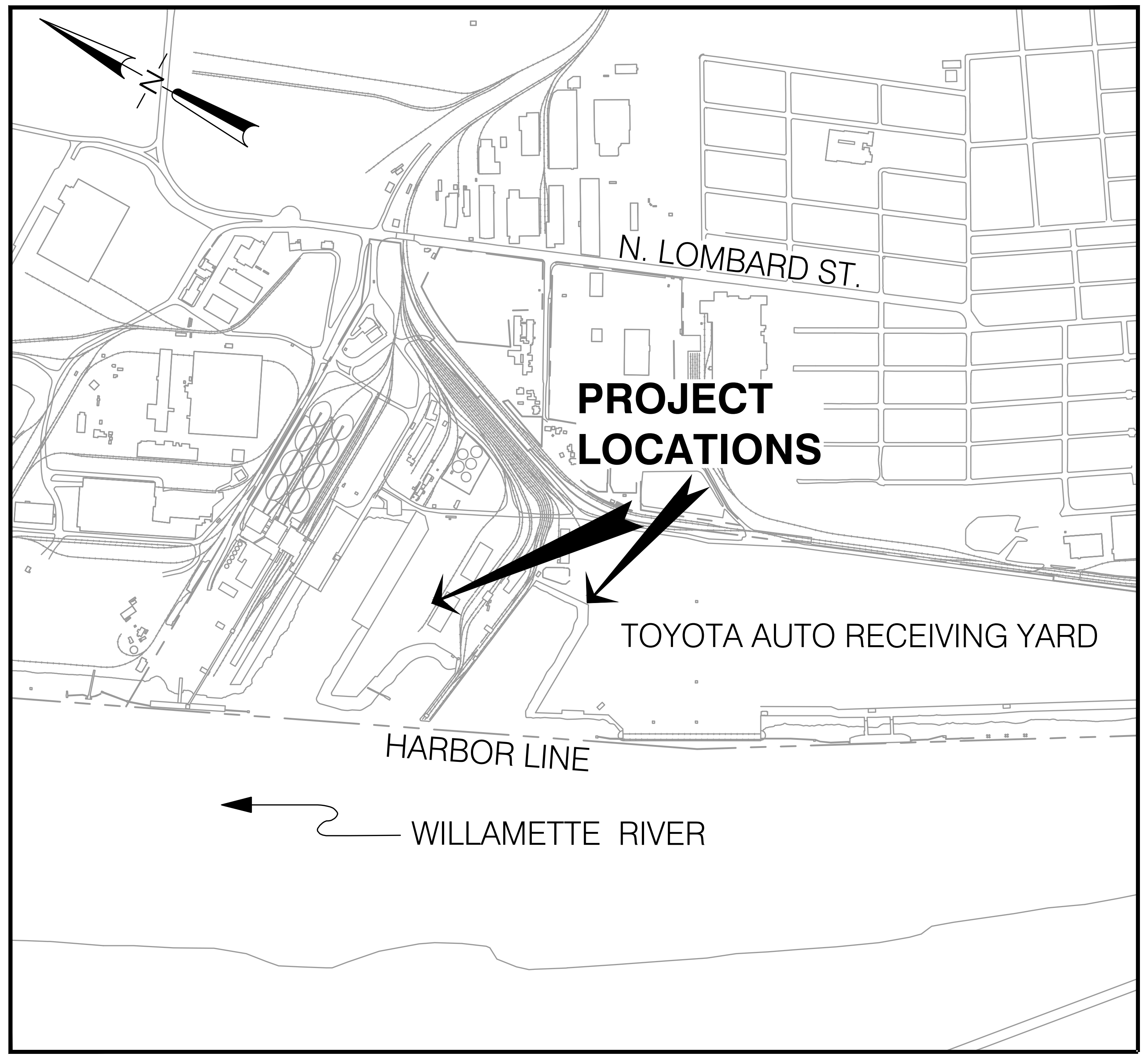
TERMINAL 4 - BASINS K1 & M

Portland, Oregon

AGENCY PLAN SET

November 2019

LOCATION MAP



VICINITY MAP

SHEET INDEX		
SHEET#	DISCIPLINE SHEET	SHEET TITLE
1	GI1	COVER SHEET
2	C1	BASIN-M SITE PLAN (OVERALL)
3	C2	BASIN-M SITE PLAN (ENLARGED)
4	C3	BASIN-M PROFILE
5	C4	BASIN-M INFILTRATION SYSTEM DETAILS
6	C5	BASIN-M PUMP STATION DETAILS
7	C6	BASIN-M FLOW SPLITTER DETAILS
8	C7	BASIN-K1 SITE (OVERALL)
9	C8	BASIN-K1 SITE (ENLARGED)
10	C9	BASIN-K1 PROFILE
11	C10	BASIN-K1 INFILTRATION SYSTEM
12	C11	BASIN-K1 PUMP STATION DETAILS
13	C12	BASIN-K1 FLOW SPLITTER DETAILS

DESIGN NO. ____________ PROJECT MANAGER ____________

PROJECT NO. ____________ DRAWING NO. ____________

NO.	DATE	BY	REVISIONS	APPV'D	CK'D	NO.	DATE	BY	REVISIONS	APPV'D	CK'D

PORT OF PORTLAND
PORTLAND, OREGON

WHPacific
Geosyntec consultants

DESIGN NUMBER ____________
1339
PROJECT NUMBER

DESIGNED BY T. TRAN
DRAWN BY T. TRAN
CHECKED BY M. NELSON
DATE NOVEMBER 2019
SCALE 1" = 500'

TERMINAL 4

COVER SHEET

SUBMITTED BY	TYPE	DRAWING NO.	SHEET NO.	DISC. SHT. NO.
	MD	P0023714W.1 & P0023714W.2	1/13	GI1

DRAWING SCALE IS REDUCED 50% WHEN SHEET SIZE IS 11" x 17".

PRINTED: 11/15/2019 6:51:01 PM TTRAN p:\geosyntec consultants inc\p0023714w.1\400 execution\435 drawings\436 civil\p0023714w-c-cover.dwg

GRAPHIC SCALE: FOR REFERENCE ONLY

— - — BASIN BOUNDARY

— — LEASE BOUNDARY

AGENCY PLAN SET (NOT FOR CONSTRUCTION)

0' 50' 100' 200' 300'

SCALE: IN FEET

NO.	DATE	BY	REVISIONS	APPVD	CKD	NO.	DATE	BY	REVISIONS	APPVD	CKD

PORT OF PORTLAND
PORTLAND, OREGON

WHPacific

Geosyntec consultants

DESIGN NUMBER

PROJECT NUMBER

DESIGNED BY T. TRAN
DRAWN BY T. TRAN
CHECKED BY M. NELSON
DATE NOVEMBER 2019
SCALE 1" = 100'

TERMINAL 4

TERMINAL 4 - BASIN M & K1
BASIN-M SITE PLAN (OVERALL)

SUBMITTED BY ----
TYPE ----
DRAWING NO. ----
2/13 (C1)

**AGENCY PLAN SET
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CAN YOU SEE THE AIRPLANES? THE ADJACENT SAMPLES SHOW THREE DIFFERENT LEVELS OF SHADING. SETTINGS FOR VIEWING AND PRINTING DRAWING CONTENT ARE OPTIMIZED WHEN ALL THREE PLANES ARE VISIBLE. THIS GUIDANCE IS PROVIDED FOR REFERENCE ONLY.

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PORTLAND, OREGON

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Geosyntec consultants

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---- PROJECT NUMBER

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DRAWN BY T. TRAN
CHECKED BY M. NELSON
DATE NOVEMBER 2019
SCALE SCALE

TERMINAL 4

TERMINAL 4 - BASIN M & K1
BASIN-M SITE PLAN (ENLARGED)

SUBMITTED BY ----

TYPE ----
DRAWING NO. ---- 3/13 (C2)

DRAWING SCALE IS REDUCED 50% WHEN SHEET SIZE IS 11" x 17".

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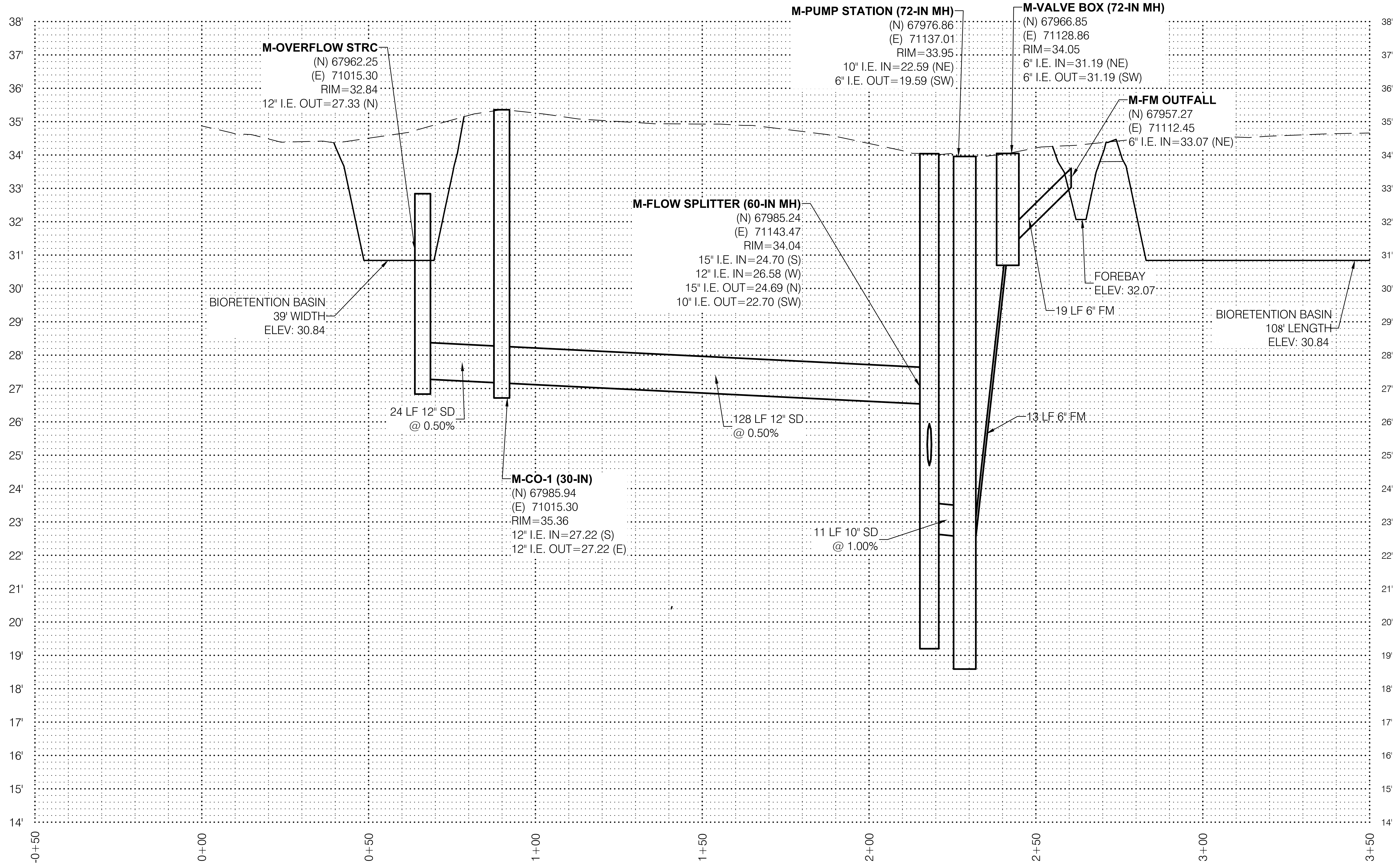

BASIN-M (SECTION A-A')
SCALE: N.T.S.
1
C3

**AGENCY PLAN SET
(NOT FOR
CONSTRUCTION)**

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DATE NOVEMBER 2019
SCALE SCALE

TERMINAL 4

TERMINAL 4 - BASIN M & K1
BASIN-M PROFILE

SUBMITTED BY ----

TYPE	DRAWING NO.
----	---- 4/13 (C3)

BASIN-M INFILTRATION SYSTEM
SCALE: N.T.S.
1
C4

AGENCY PLAN SET (NOT FOR CONSTRUCTION)

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SCALE NTS

TERMINAL 4

TERMINAL 4 - BASIN M & K1
BASIN-M INFILTRATION SYSTEM DETAILS

SUBMITTED BY ----

TYPE ----
DRAWING NO. ----
5/ 13 (C4)

DRAWING SCALE IS REDUCED 50% WHEN SHEET SIZE IS 11" x 17".

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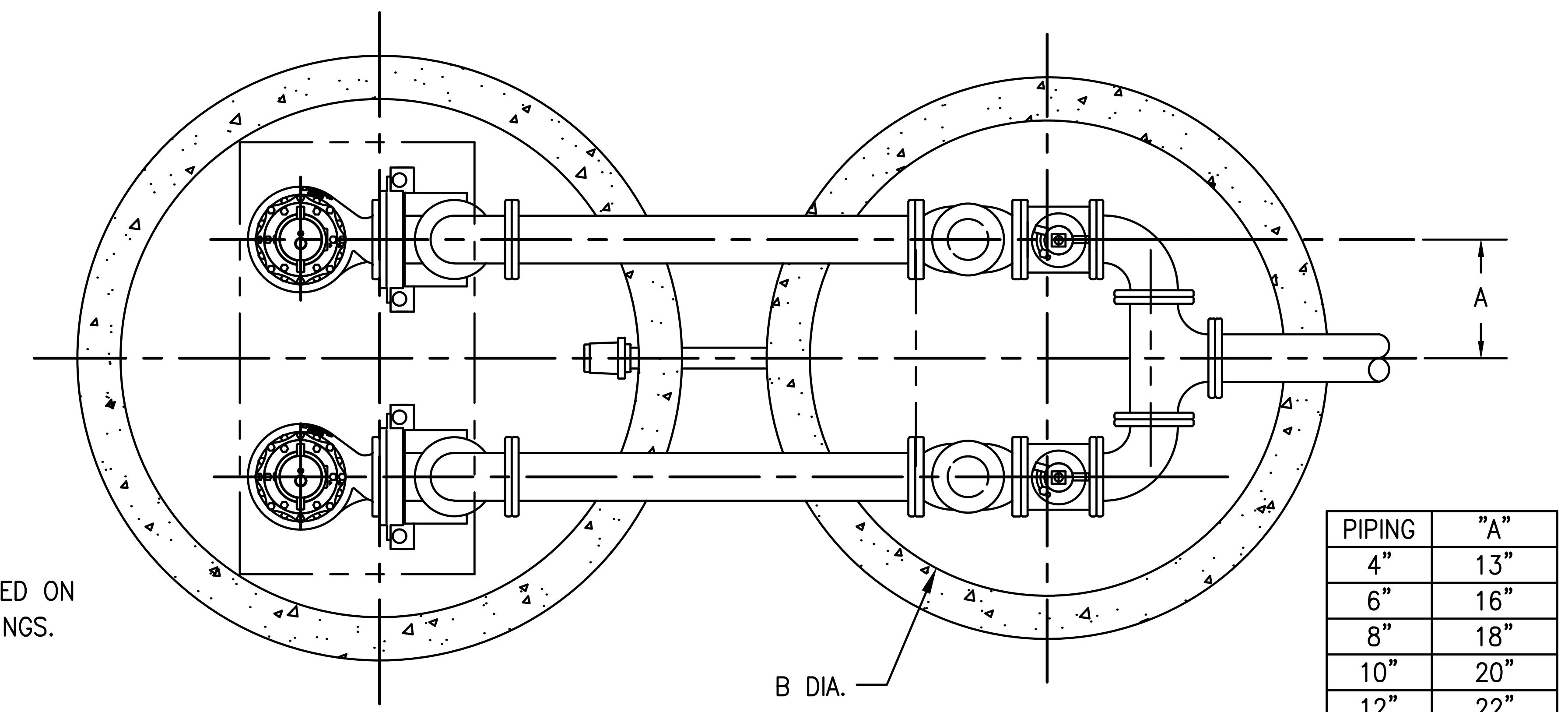
PIPING	"B"
4"	5'-0"
6"	5'-6"
8"	6'-6"
10"	7'-6"
12"	8'-6"
15"	9'-6"

NOTE: DIMENSIONS "A" & "B" ARE BASED ON USING STANDARD ANSI PIPE FITTINGS.



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12"	22"
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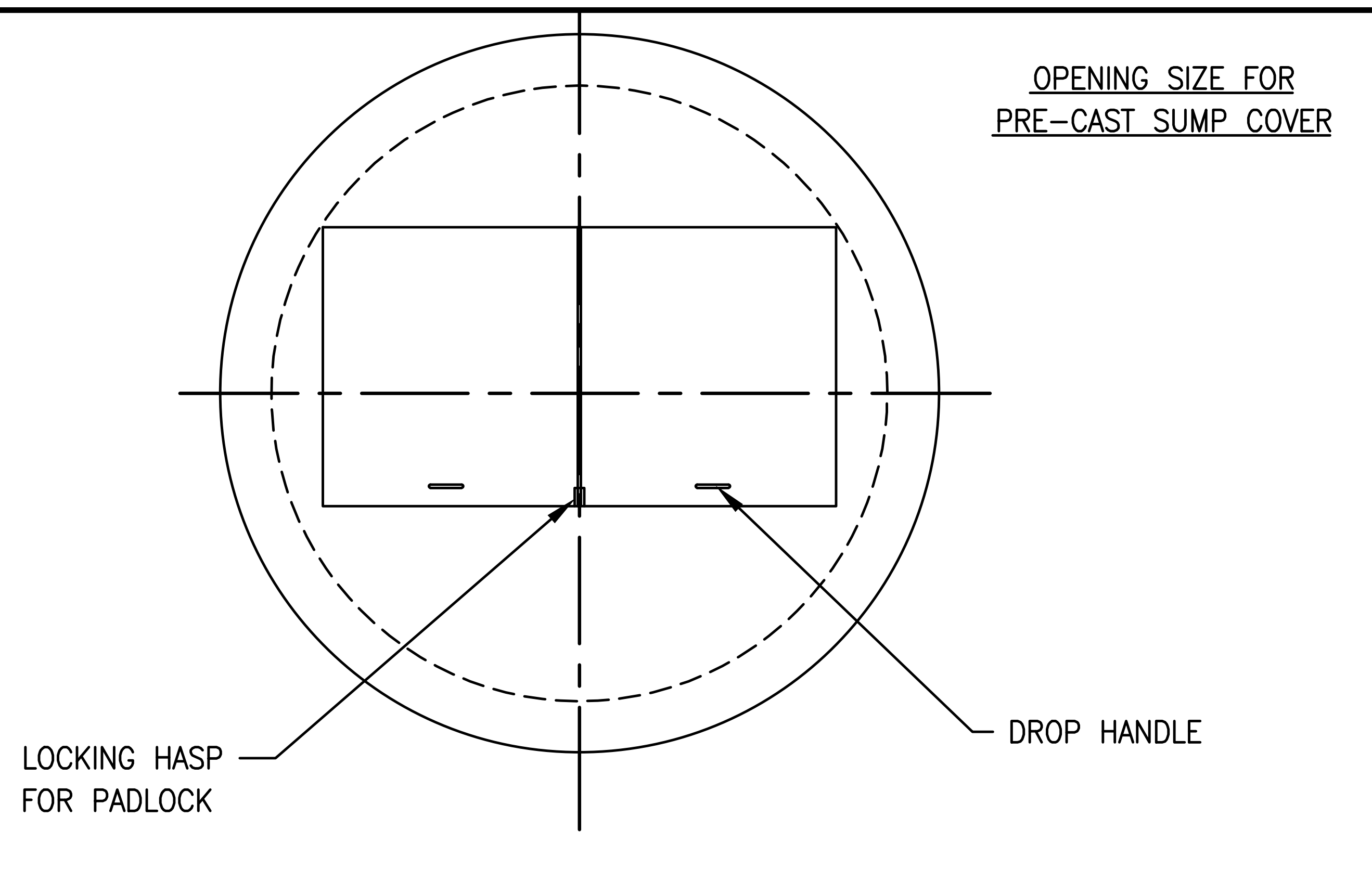
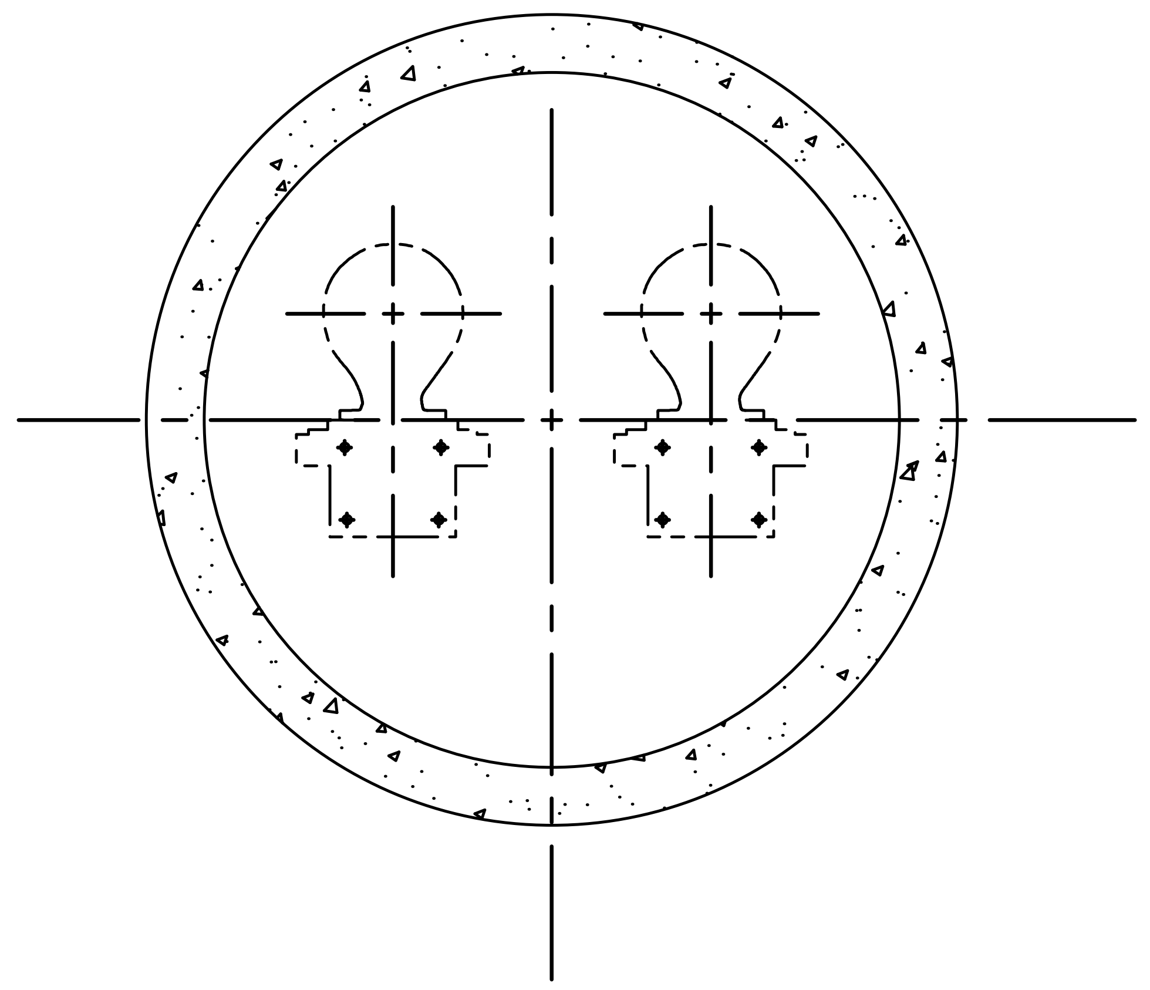
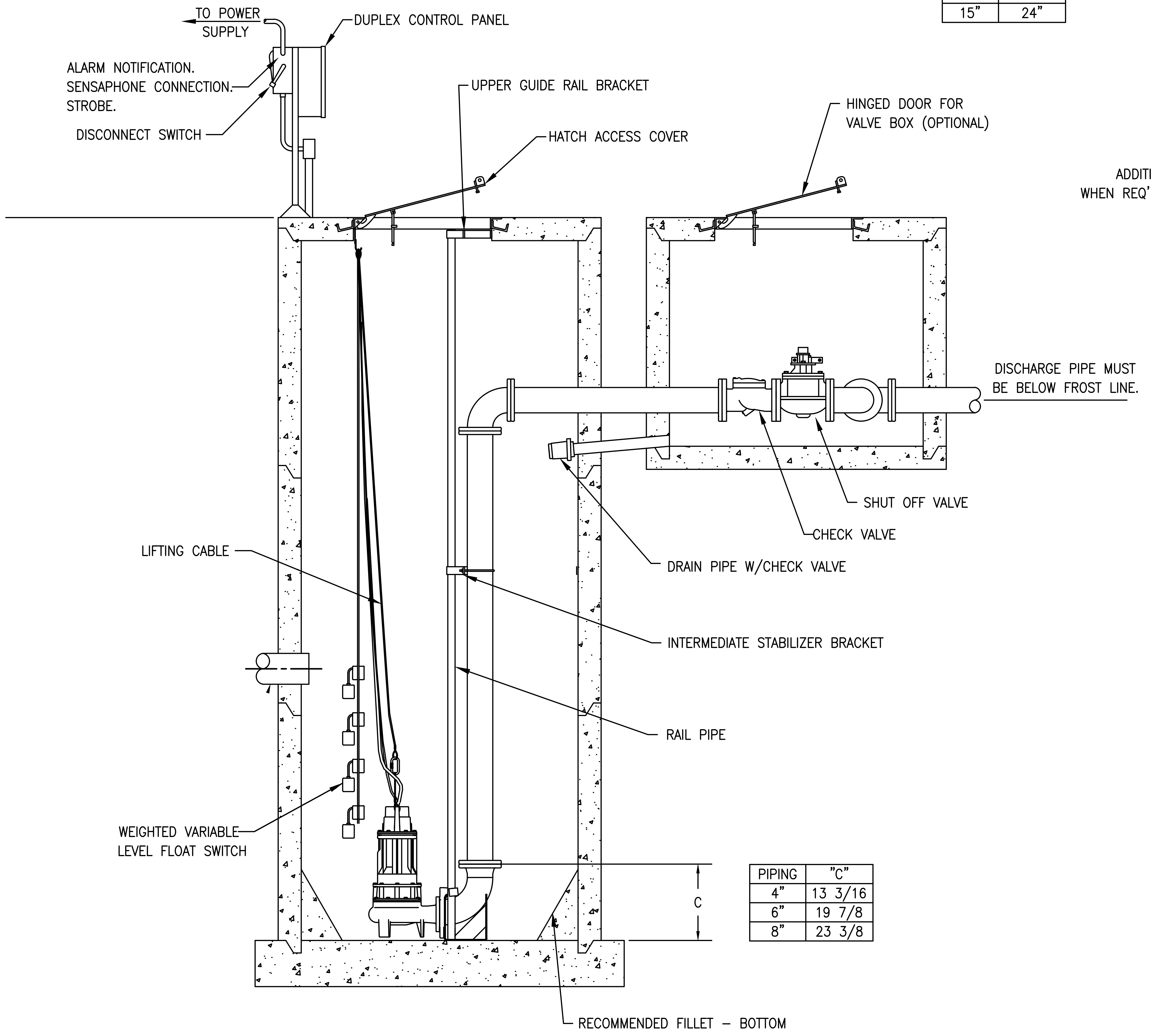




REFERENCE LIFT STATION LAYOUT SHEETS FOR ANCHOR LOCATIONS AND HATCH DIMENSIONS



PIPING	"C"
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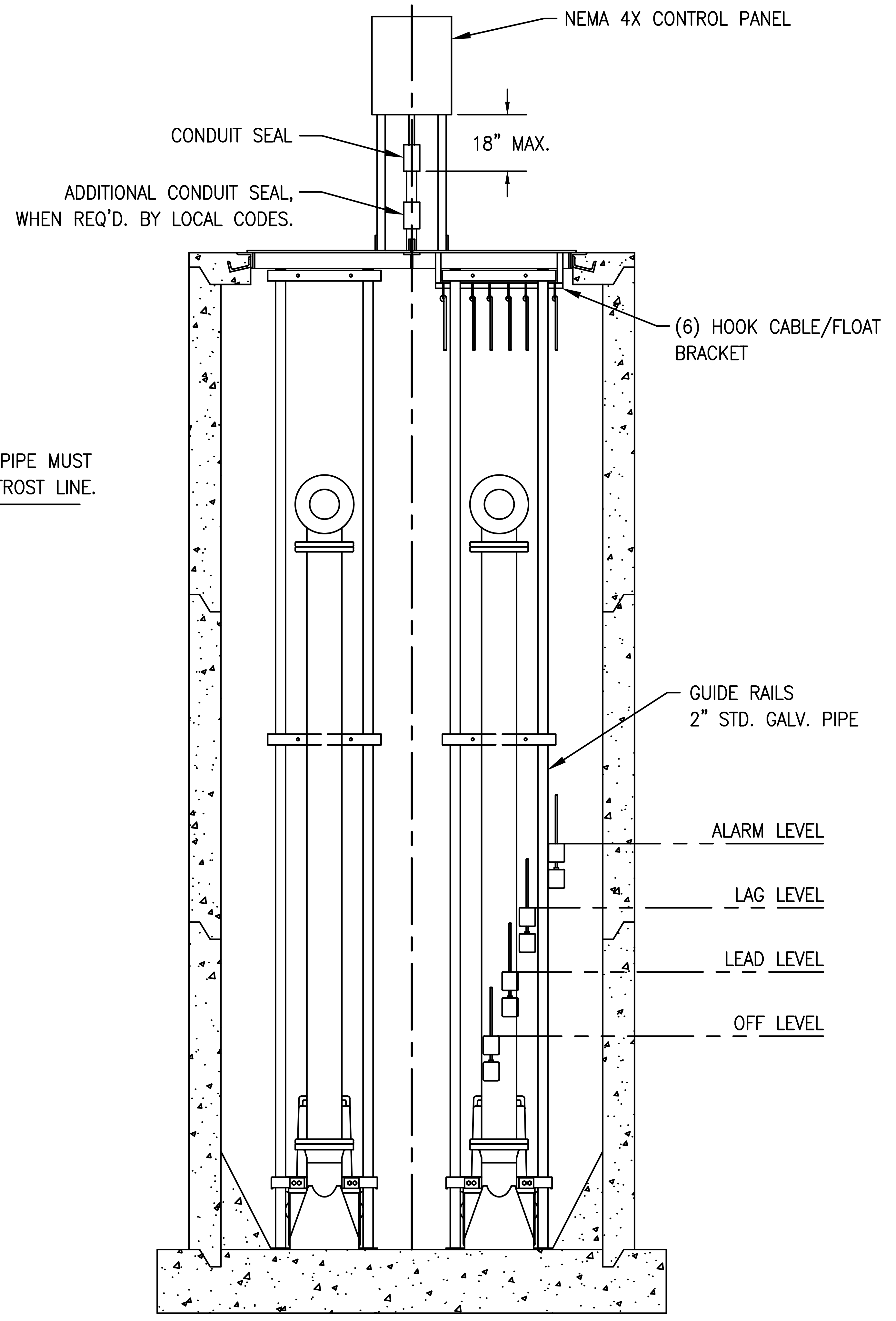
6"	19 7/8
8"	23 3/8



REFERENCE PUMP DIMENSION SHEETS FOR MINIMUM BASIN SIZING.

AGENCY PLAN SET (NOT FOR CONSTRUCTION)

CAN YOU SEE THE AIRPLANES? THE ADJACENT SAMPLES SHOW THREE DIFFERENT LEVELS OF SHADING. SETTINGS FOR VIEWING AND PRINTING DRAWING CONTENT ARE OPTIMIZED WHEN ALL THREE PLANES ARE VISIBLE. THIS GUIDANCE IS PROVIDED FOR REFERENCE ONLY.

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DATE NOVEMBER 2019
SCALE NTS

TERMINAL 4

TERMINAL 4 - BASIN M & K1
BASIN-M PUMP STATION DETAILS

SUBMITTED BY ----

TYPE ----
DRAWING NO. ----
6/13 (C5)

DRAWING SCALE IS REDUCED 50% WHEN SHEET SIZE IS 11" x 17".

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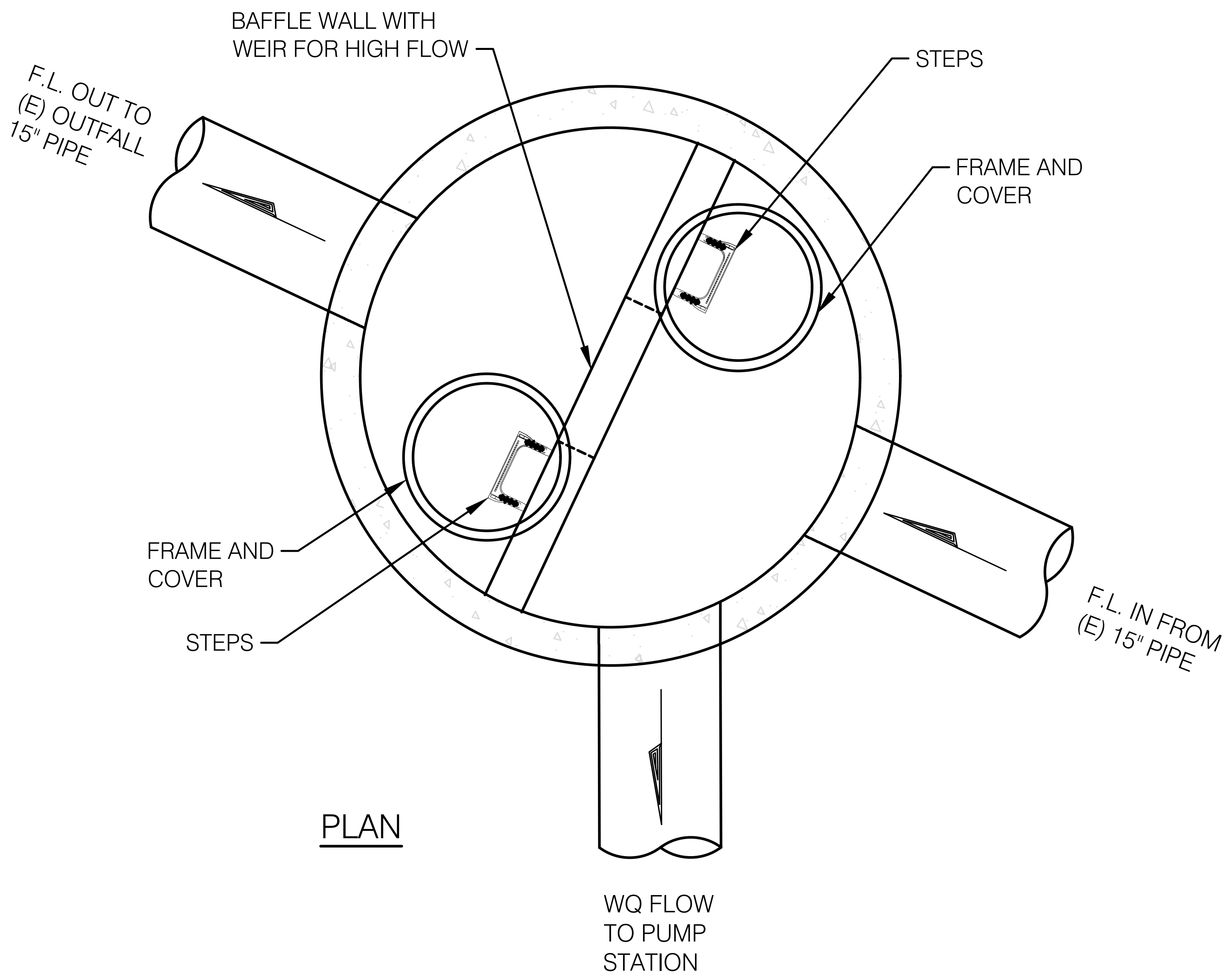
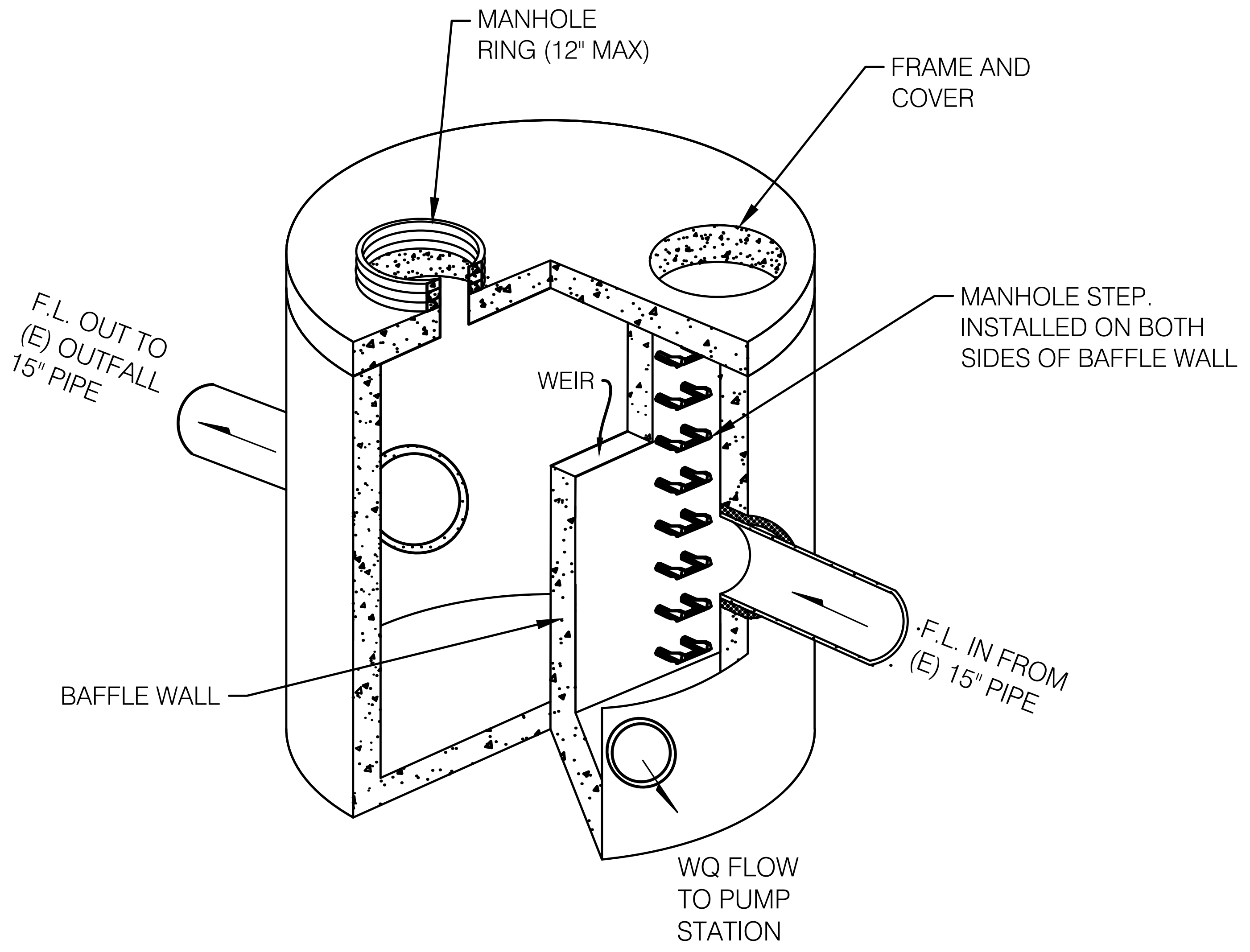


PLAN



ISOMETRIC CUTAWAY

FLOW SPLITTER MANHOLE
SCALE: N.T.S.

1
C6

**AGENCY PLAN SET
(NOT FOR
CONSTRUCTION)**

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SCALE NTS

TERMINAL 4

TERMINAL 4 - BASIN M & K1
BASIN-M FLOW SPLITTER DETAILS

SUBMITTED BY ----

TYPE ----
DRAWING NO. ----
7/13 (C6)

GRAPHIC SCALE: FOR REFERENCE ONLY

BASIN BOUNDARY

LEASE BOUNDARY

AGENCY SET (NOT FOR CONSTRUCTION)

0' 50' 100' 200' 300'

SCALE: IN FEET

CAN YOU SEE THE AIRPLANES? THE ADJACENT SAMPLES SHOW THREE DIFFERENT LEVELS OF SHADING. SETTINGS FOR VIEWING AND PRINTING DRAWING CONTENT ARE OPTIMIZED WHEN ALL THREE PLANES ARE VISIBLE. THIS GUIDANCE IS PROVIDED FOR REFERENCE ONLY.

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PROJECT NUMBER

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DATE NOVEMBER 2019
SCALE SCALE

TERMINAL 4

TERMINAL 4 - BASIN M & K1
BASIN-K1 SITE (OVERALL)

SUBMITTED BY ----

TYPE ----

DRAWING NO. ---- 8/13 (C7)

DRAWING SCALE IS REDUCED 50% WHEN SHEET SIZE IS 11" x 17".

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0 1/4" 1/2" 1" 2"
GRAPHIC SCALE - FOR REFERENCE ONLY

AGENCY PLAN SET
(NOT FOR
CONSTRUCTION)

0' 15' 30' 60' 90'
SCALE: IN FEET

CAN YOU SEE THE AIRPLANES? THE ADJACENT SAMPLES SHOW THREE DIFFERENT LEVELS OF SHADING. SETTINGS FOR VIEWING AND PRINTING DRAWING CONTENT ARE OPTIMIZED WHEN ALL THREE PLANES ARE VISIBLE. THIS GUIDANCE IS PROVIDED FOR REFERENCE ONLY.

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DATE NOVEMBER 2019
SCALE 1" = 30'

TERMINAL 4

TERMINAL 4 - BASIN M & K1
BASIN-K1 SITE (ENLARGED)

SUBMITTED BY ----

TYPE	DRAWING NO.	
----	----	9/13 (C8)

PRINTED: 11/15/2019 5:58:53 PM TTRAN p:\geosyntec consultants inc\p0023714w.1\400 execution\435 drawings\436 civil\p0023714w-c-k1 site (enlarged).dwg

DRAWING SCALE IS REDUCED 50% WHEN SHEET SIZE IS 11" x 17".

BASIN-K1 (SECTION B-B')
SCALE: N.T.S.
1
C9

AGENCY PLAN SET
(NOT FOR
CONSTRUCTION)

CAN YOU SEE THE AIRPLANES? THE ADJACENT SAMPLES SHOW THREE DIFFERENT LEVELS OF SHADING. SETTINGS FOR VIEWING AND PRINTING DRAWING CONTENT ARE OPTIMIZED WHEN ALL THREE PLANES ARE VISIBLE. THIS GUIDANCE IS PROVIDED FOR REFERENCE ONLY.

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Geosyntec
consultants

DESIGN NUMBER

PROJECT NUMBER

DESIGNED BY T. TRAN
DRAWN BY T. TRAN
CHECKED BY M. NELSON
DATE NOVEMBER 2019
SCALE SCALE

TERMINAL 4

TERMINAL 4 - BASIN M & K1
BASIN-K1 PROFILE

SUBMITTED BY

TYPE ----
DRAWING NO. ----
10/13 (C9)

PRINTED: 11/15/2019 5:49:52 PM TTRAN p:\geosyntec consultants inc\p0023714w.1\400 execution\435 drawings\436 civil\p0023714w-c-k1 site (enlarged).dwg

DRAWING SCALE IS REDUCED 50% WHEN SHEET SIZE IS 11" x 17".

BASIN-K1 INFILTRATION SYSTEM
SCALE: N.T.S.
1
C10

AGENCY PLAN SET (NOT FOR CONSTRUCTION)

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PROJECT NUMBER

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DATE NOVEMBER 2019
SCALE NTS

TERMINAL 4

TERMINAL 4 - BASIN M & K1
BASIN-K1 INFILTRATION SYSTEM

SUBMITTED BY ----

TYPE ----
DRAWING NO. ----
11/13 (C10)

DRAWING SCALE IS REDUCED 50% WHEN SHEET SIZE IS 11" x 17".

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PIPING	"B"
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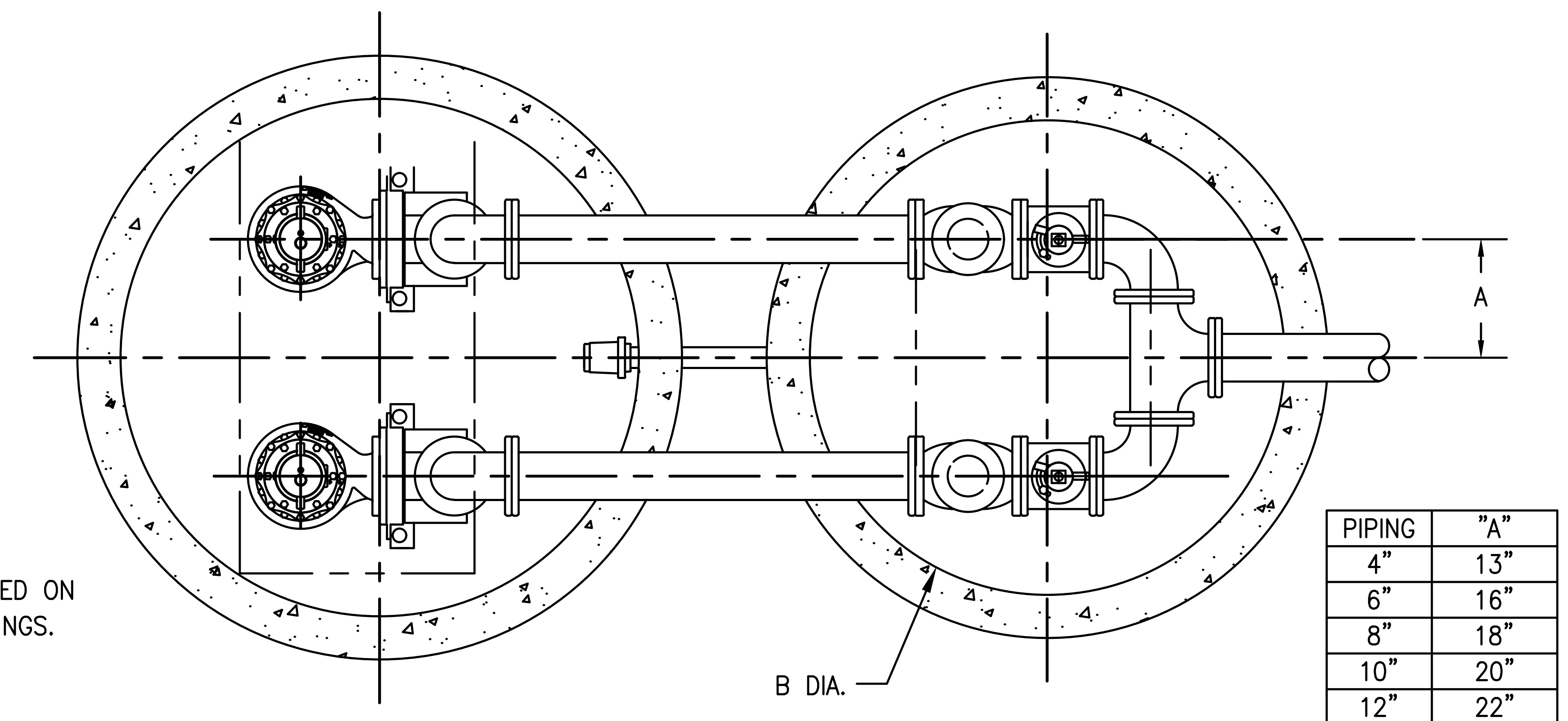
6"	5'-6"
8"	6'-6"
10"	7'-6"
12"	8'-6"
15"	9'-6"

NOTE: DIMENSIONS "A" & "B" ARE BASED ON USING STANDARD ANSI PIPE FITTINGS.



PIPING	"A"
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6"	16"
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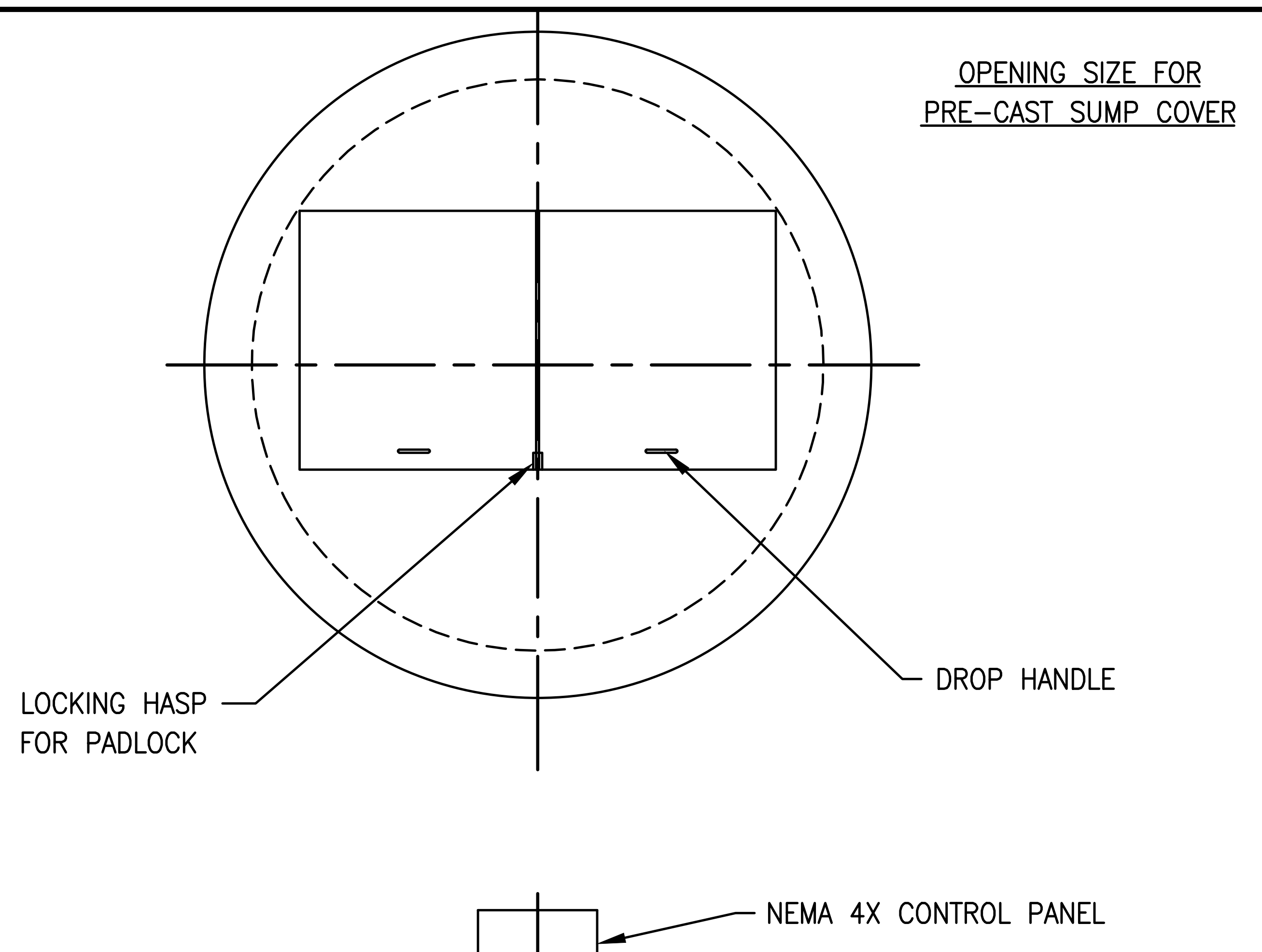
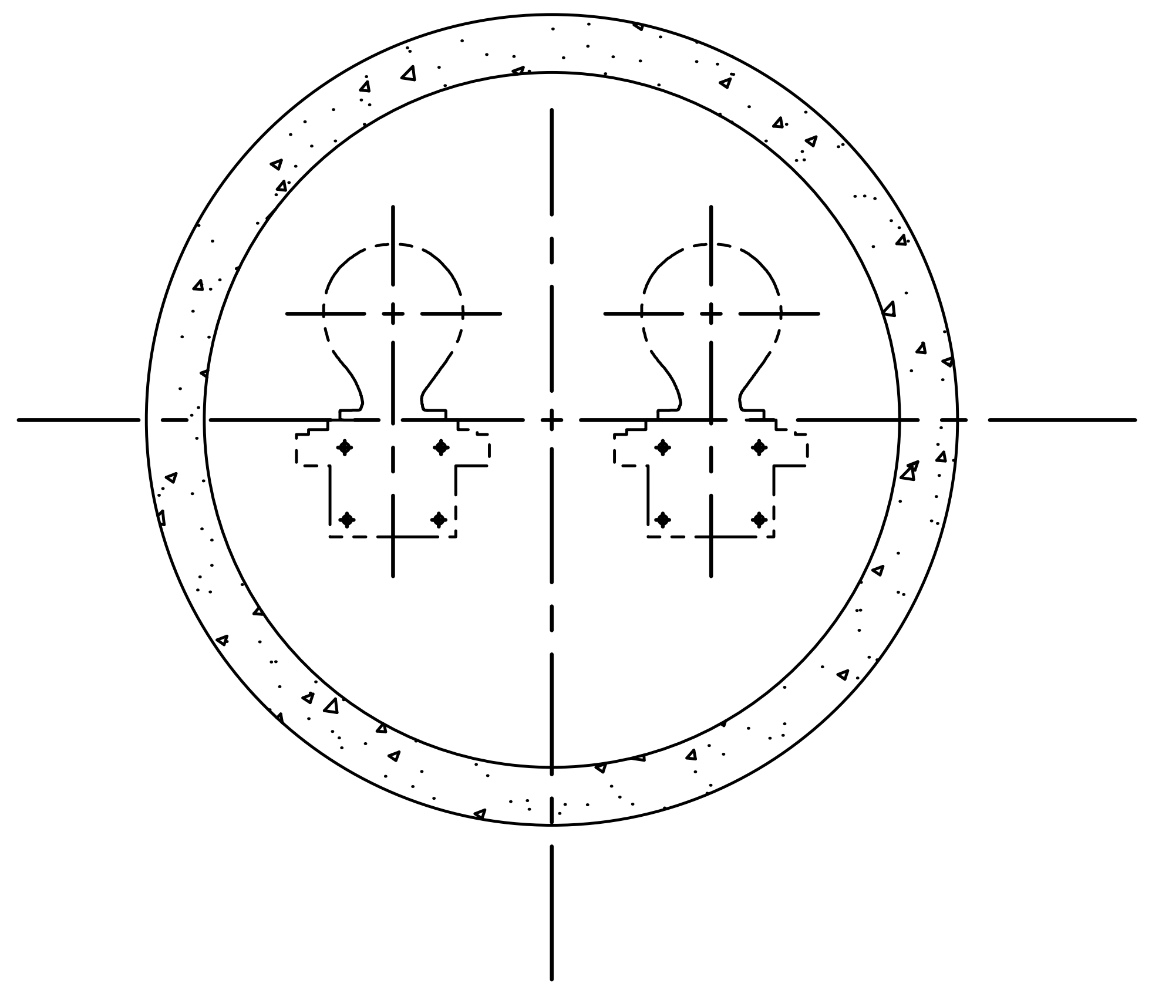
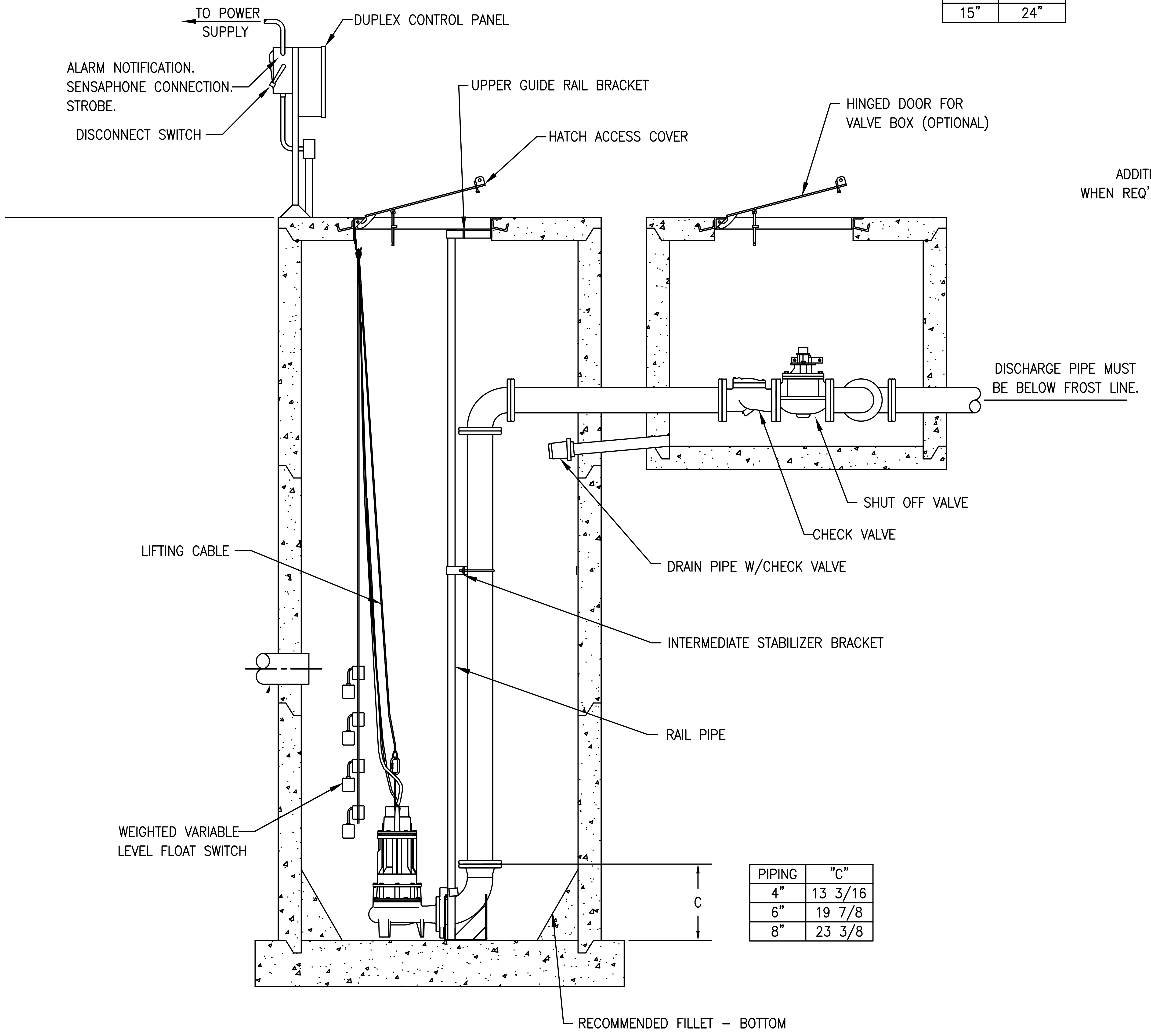
10"	20"
12"	22"
15"	24"





REFERENCE LIFT STATION LAYOUT SHEETS FOR ANCHOR LOCATIONS AND HATCH DIMENSIONS



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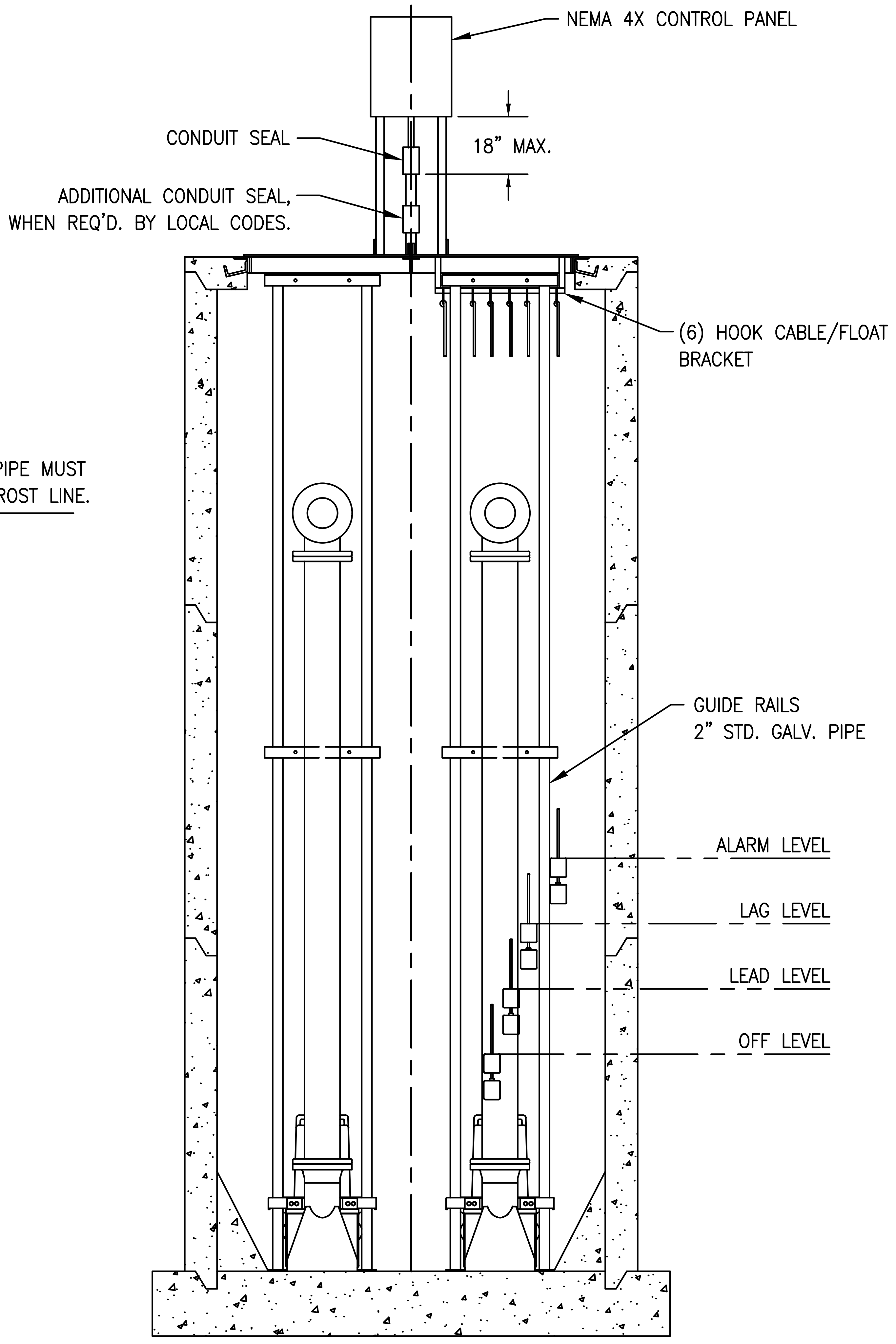
6"	19 7/8
8"	23 3/8



AGENCY PLAN SET (NOT FOR CONSTRUCTION)

REFERENCE PUMP DIMENSION SHEETS FOR MINIMUM BASIN SIZING.

0 1/4" 1/2" 1" 2"
GRAPHIC SCALE - FOR REFERENCE ONLY

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DATE NOVEMBER 2019
SCALE NTS

TERMINAL 4

TERMINAL 4 - BASIN M & K1
BASIN-K1 PUMP STATION DETAILS

SUBMITTED BY ---- ----
TYPE ----
DRAWING NO. ----

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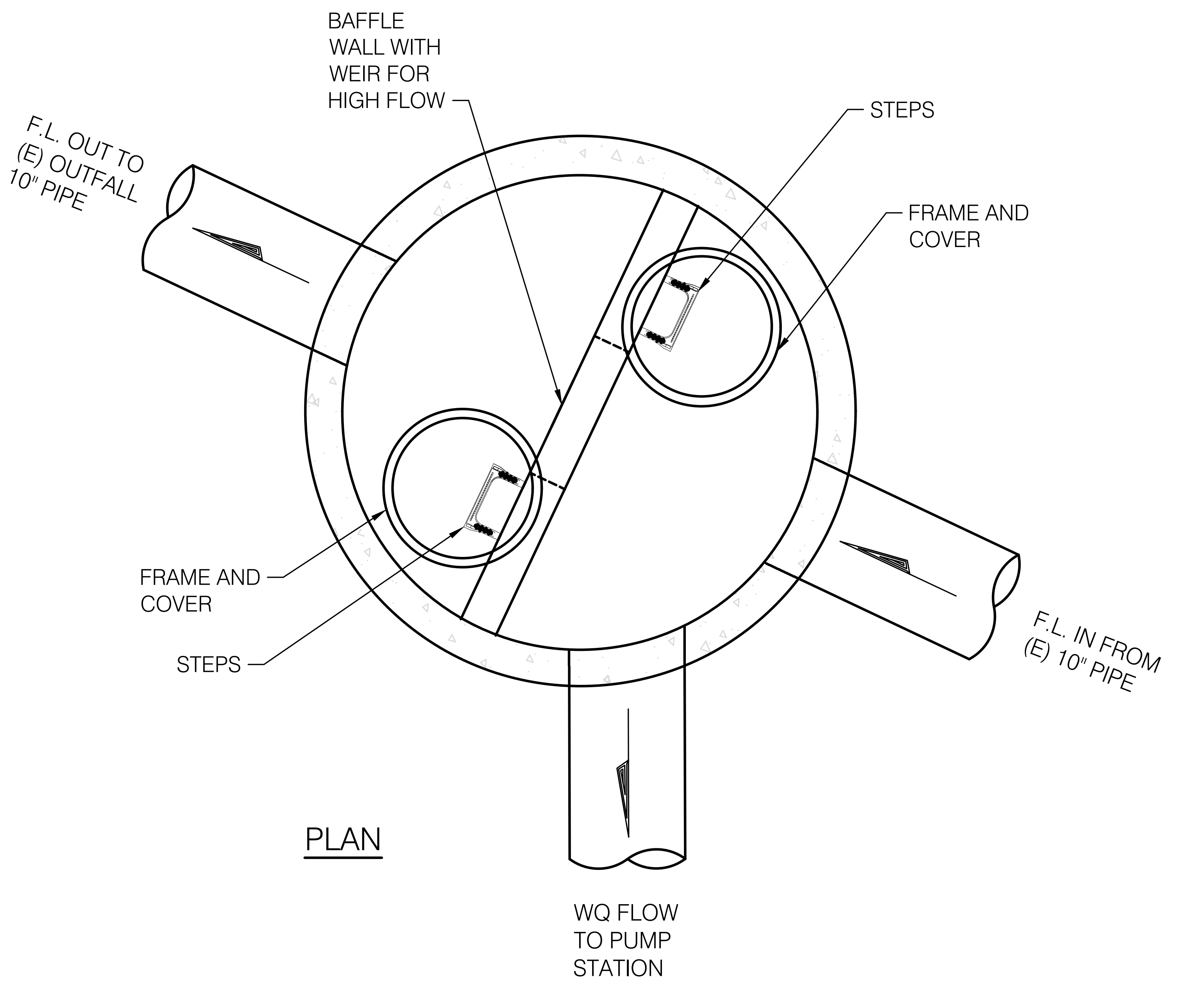
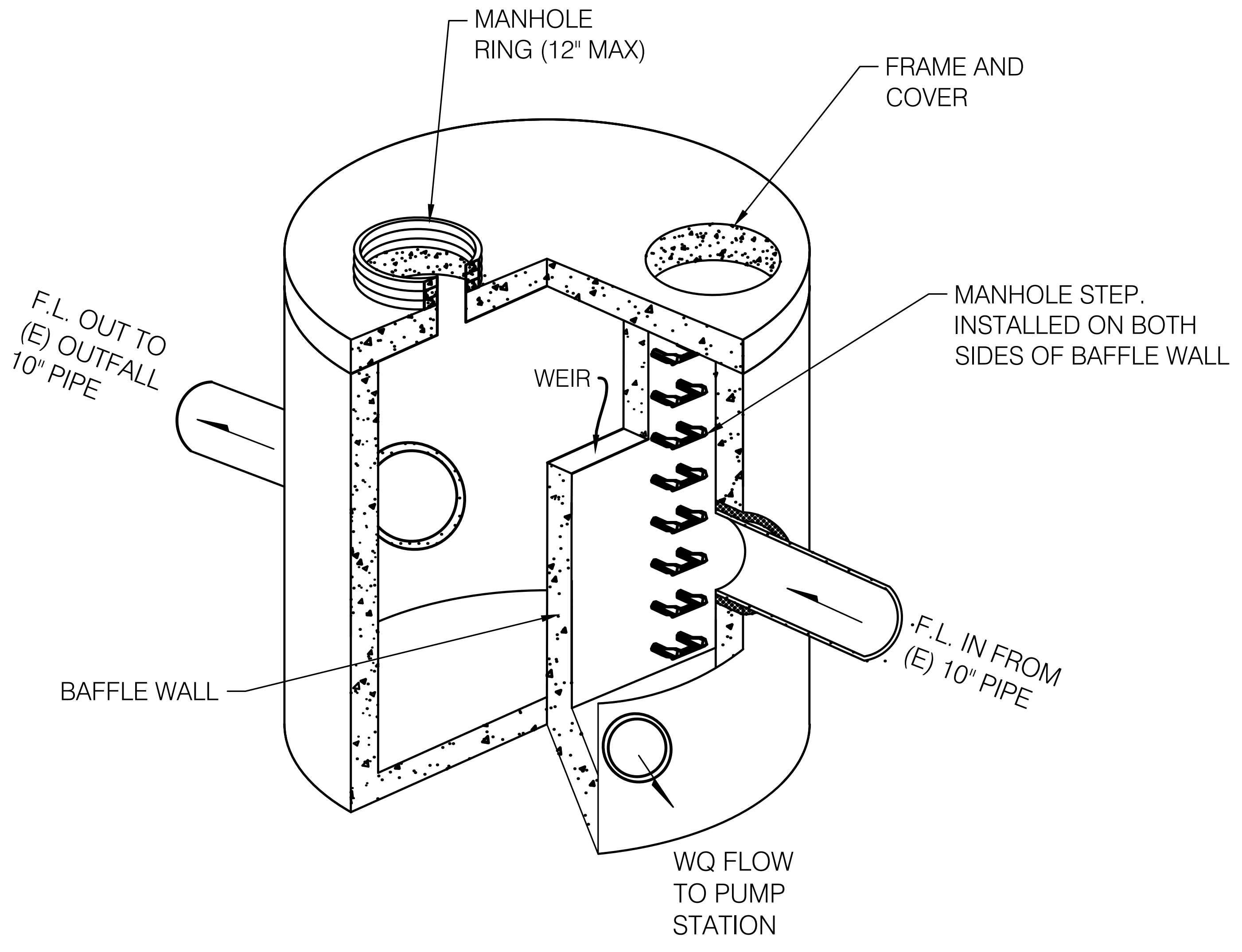
DRAWING SCALE IS REDUCED 50% WHEN SHEET SIZE IS 11" x 17".



PLAN



ISOMETRIC CUTAWAY

FLOW SPLITTER MANHOLE
SCALE: N.T.S.

1
C12

**AGENCY PLAN SET
(NOT FOR
CONSTRUCTION)**

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CHECKED BY M. NELSON
DATE NOVEMBER 2019
SCALE NTS

TERMINAL 4

TERMINAL 4 - BASIN M & K1
BASIN-K1 FLOW SPLITTER DETAILS

SUBMITTED BY ----

TYPE ----
DRAWING NO. ----
13/ 13 (C12)

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DRAWING SCALE IS REDUCED 50% WHEN SHEET SIZE IS 11" x 17".

Appendix B

GeoDesign Infiltration Testing Memorandum

GEODESIGN INC
AN NV5 COMPANY

Memorandum

To:	Benjamin Ahn	From:	Najib A. Kalas, P.E. Brett A. Shipton, P.E., G.E.
Company:	Port of Portland c/o inici Group, Inc.	Date:	February 10, 2020
Address:	4640 SW Macadam Avenue, Suite 100 Portland, OR 97239		

cc:	Roger Anderson, Port of Portland (via email only) Mark Nelson, WHPacific, Inc. an NV5 Company (via email only) Trinh Tran, WHPacific, Inc. an NV5 Company (via email only)

GDI Project:	POP-34-01
RE:	Infiltration Testing Services Terminal 4 – Basins K1 & M 11040 N Lombard Street Portland, Oregon

INTRODUCTION

This memorandum provides results of infiltration testing services for the proposed Terminal 4 – Basins K1 & M site located at 11040 N Lombard Street in Portland, Oregon. The site is shown relative to surrounding physical features on Figure 1. Existing conditions and the proposed site layout (overlay) are shown on Figure 2. Logs of the current explorations are presented in Attachment A.

BACKGROUND

We reviewed the infiltration testing report by Geosyntec Consultants, Inc for the site dated September 21, 2018.[1] Prior explorations at the site included 15 test pits to depths ranging between approximately 2.5 and 6 feet below ground surface (BGS) and 13 infiltration tests. Five test pits (IT-5A, IT-6, IT-6A, IT-7A, and IT-8) were excavated in the vicinity of Basin M and two test pits (IT-12 and IT-13) were excavated in the vicinity of Basin K. Measured unfactored field infiltration rates ranged between 2.3 and 36 inches per hour in the vicinity of Basin M and between 66 and 224 inches per hour in the vicinity of Basin K1. Geosyntec Consultants indicated the following:

Two adjacent test pits (IT-6 and IT-6A) were excavated and tested to conduct infiltration testing both in a shallower fine-textured soil layer and in a deeper coarser-textured soil layer. Test pit IT-7 was not tested because the same impermeable soil layer was encountered, so a separate test pit (IT-7A) was excavated several feet away to test the deeper, more permeable soil layer.

---

[1] Geosyntec Consultants, Inc, 2018. *Terminal 4 Source Control for Slips 1 and 3 Upland Facilities Soil Infiltration Testing Report*, dated September 21, 2018.

Geosyntec Consultants also stated the following:

The approved Workplan specified that test pits would be excavated to depths of 2 to 4 feet deep, however, during excavation several of the test pits were excavated deeper than 4 feet to find and test more permeable soil layers beneath a siltier confining layer.

According to Geosyntec Consultants,

Testing and characterization results for the test pits in the Basin M infield, and the single test pit south of IRM bulk tanks, indicate siltier and less permeable soils. Significant layering was noted in several test pits within the Basin M infield, with a distinctive silt / clay layer between approximately 4 and 5 feet depth [sic] in test pits IT-6 and IT-6A. This layer contained debris including gravel, bark, and wood. Infiltration in IT-6 was conducted directly into this layer while testing in IT-6A was conducted below this layer. Infiltration testing results were dramatically higher in IT-6A compared to IT-6, suggesting that SCMs in Basin M could be designed to infiltrate into deeper sandier soils rather than into any shallower siltier layers.

The prior site plan, infiltration test results, groundwater monitoring data, and relevant exploration logs and laboratory test results provided by Geosyntec Consultants are presented in Attachment B.

PURPOSE AND SCOPE

The purpose of our services was to evaluate the infiltration rates of on-site soil for use in design of proposed stormwater management systems. Specifically, we have performed the following scope of services:

- Coordinated and managed the field explorations, including public utility locates and scheduling the drilling contractor and GeoDesign, Inc. field staff.
- Drilled three borings to a depth of 16.5 feet BGS.
- Performed five infiltration tests in general accordance with City of Portland requirements. The infiltration testing was conducted at depths between 5 and 7.5 feet BGS.
- Maintained continuous logs of the explorations and collected samples at representative intervals.
- Conducted a laboratory testing program consisting of the following:
    - Four moisture content determinations in general accordance with ASTM D2216
    - Four particle-size analyses in general accordance with ASTM D1140
- Provided this technical memorandum that presents the results of our findings and recommendations.

SURFACE CONDITIONS

The site is located within the Port of Portland's Terminal 4 facility on the east bank of the Willamette River. The project area is surrounded by Port of Portland facilities, including warehouses and other buildings, railroad tracks, access roads and yard areas, and aboveground storage tanks. The site is generally level.

SUBSURFACE CONDITIONS

Subsurface explorations consisted of three borings (B-1 through B-3) to a depth of 16.5 feet BGS. The borings were drilled to facilitate infiltration testing. The approximate locations of our explorations are shown on Figure 2. A description of our explorations, logs of the borings, and laboratory test results are presented in Attachment A. Subsurface conditions encountered in our explorations are generally consistent with prior explorations by Geosyntec Consultants at the site. In general, the subsurface conditions consist of loose to medium dense sand fill with varying amounts of silt and trace gravel, cobbles, and concrete fragments as well as interbedded layers of silt to the depth explored. In boring B-3, refusal (likely on cobbles) was encountered at a depth of approximately 6 feet BGS during the first and second drilling attempts.

The moisture content of sand samples measured between 9 and 13 percent at the time of our explorations and fines content analyses indicate fines contents between 8 and 11 percent.

Groundwater was not observed in our explorations. Wet soil conditions were observed in boring B-2 at a depth of 16.5 feet BGS. The Geosyntec Consultants report indicates that the depth to groundwater was measured in three existing monitoring wells at Terminal 4 on May 31, 2018. The water levels ranged from 15.62 to 18.47 feet below the top of the casing in each well (Attachment B).

Based on our review of local groundwater conditions and our experience in the area, we estimate static groundwater at depths between approximately 15 and 20 feet BGS. The static groundwater levels at the site are closely tied to the water level in the adjacent Willamette River, and static water levels at the site will fluctuate in response to rising and falling river levels. Perched water might be present at shallow depths during the wet season or after prolonged periods of heavy rainfall.

INFILTRATION TESTING AND RECOMMENDATIONS

The proposed development includes stormwater infiltration systems Basins K1 and M. Infiltration tests were performed in general accordance with the recommendations presented in the *City of Portland Stormwater Management Manual*. Five infiltration tests were performed in borings B-1 through B-3 (Attachment A) at depths ranging between 5 and 7.5 feet BGS. In general, negligible to low infiltration rates were measured at a depth of 5 feet BGS in borings B-1 and B-3. We performed additional infiltration tests at a depth of 7.5 feet BGS, where higher infiltration rates were measured. The underlying soil was saturated by allowing the water to infiltrate into the subsurface. The infiltration rate was measured under low hydrostatic head conditions after saturated conditions had been achieved. The infiltration testing procedures are described in Attachment A. The infiltration testing locations and depths were based on correspondence with the project team. The results of our field infiltration testing are presented in Table 1.

Table 1. Infiltration Testing Summary

Location	Depth (feet BGS)	Observed Infiltration Rate[1] (inches per hour)	Fines Content[2] (percent)
B-1	5	3	9
B-1	7.5	100	10
B-2	5	48	11
B-3	5	~0	Not tested
B-3	7.5	100	8

1. In situ infiltration rate observed in the field.
2. Fines content is the percent material passing the U.S. Standard No. 200 sieve.

The infiltration rates shown in Table 1 are short-term field rates, and factors of safety have not been applied.

Based on our review of plans for the proposed basins, we understand the bottoms of the basins will be at a depth of approximately 5 feet BGS. We recommend all infiltration systems be at least 7.5 feet deep and installed in clean sand soil. Based on the results of our current infiltration tests and prior infiltration tests by Geosyntec Consultants at the site, we recommend the following unfactored field infiltration rates:

- For the stormwater infiltration Basin M (see Figure 2), we recommend an unfactored field infiltration rate of 50 inches per hour.
- For the stormwater infiltration Basin K1 (see Figure 2), we recommend an unfactored field infiltration rate of 80 inches per hour.

The recommended infiltration rates are measured rates and are unfactored. Correction factors should be applied to the recommended infiltration rates by the civil engineer during design to account for the degree of long-term maintenance and influent/pre-treatment control, as well as the potential for long-term clogging due to siltation and buildup of organic material, depending on the proposed length, location, and type of infiltration facility. We recommend a minimum factor of safety of at least 2 be applied to the recommended unfactored rates.

The actual depths and estimated infiltration rates can vary significantly from the values presented above. We recommend that the design infiltration values for the stormwater systems be confirmed by field testing performed during installation of the systems. The results of this field testing might necessitate that the stormwater system be enlarged to achieve the design infiltration rate.

We recommend a minimum vertical separation of 5 feet between the bottom of the stormwater infiltration systems and the seasonal high groundwater levels at the site in accordance with City of Portland requirements. Based on the information available, we estimate the seasonal high groundwater level to be approximately 15 feet BGS.

LIMITATIONS

We have prepared this memorandum for use by the Port of Portland and the design and construction team for the proposed project. The data and memorandum can be used for bidding or estimating purposes, but our memorandum, conclusions, and interpretations should not be construed as warranty of the subsurface conditions and are not applicable to other sites.

Exploration observations indicate soil conditions only at specific locations and only to the depths penetrated. They do not necessarily reflect soil strata or water level variations that may exist between exploration locations. If subsurface conditions differing from those described are noted during the course of excavation and construction, re-evaluation will be necessary.

The site development plans and design details were preliminary at the time this memorandum was prepared. When the design has been finalized and if there are changes in stormwater disposal plans, the conclusions and recommendations presented may not be applicable. If design changes are made, we request that we be retained to review our conclusions and recommendations and to provide a written modification or verification.

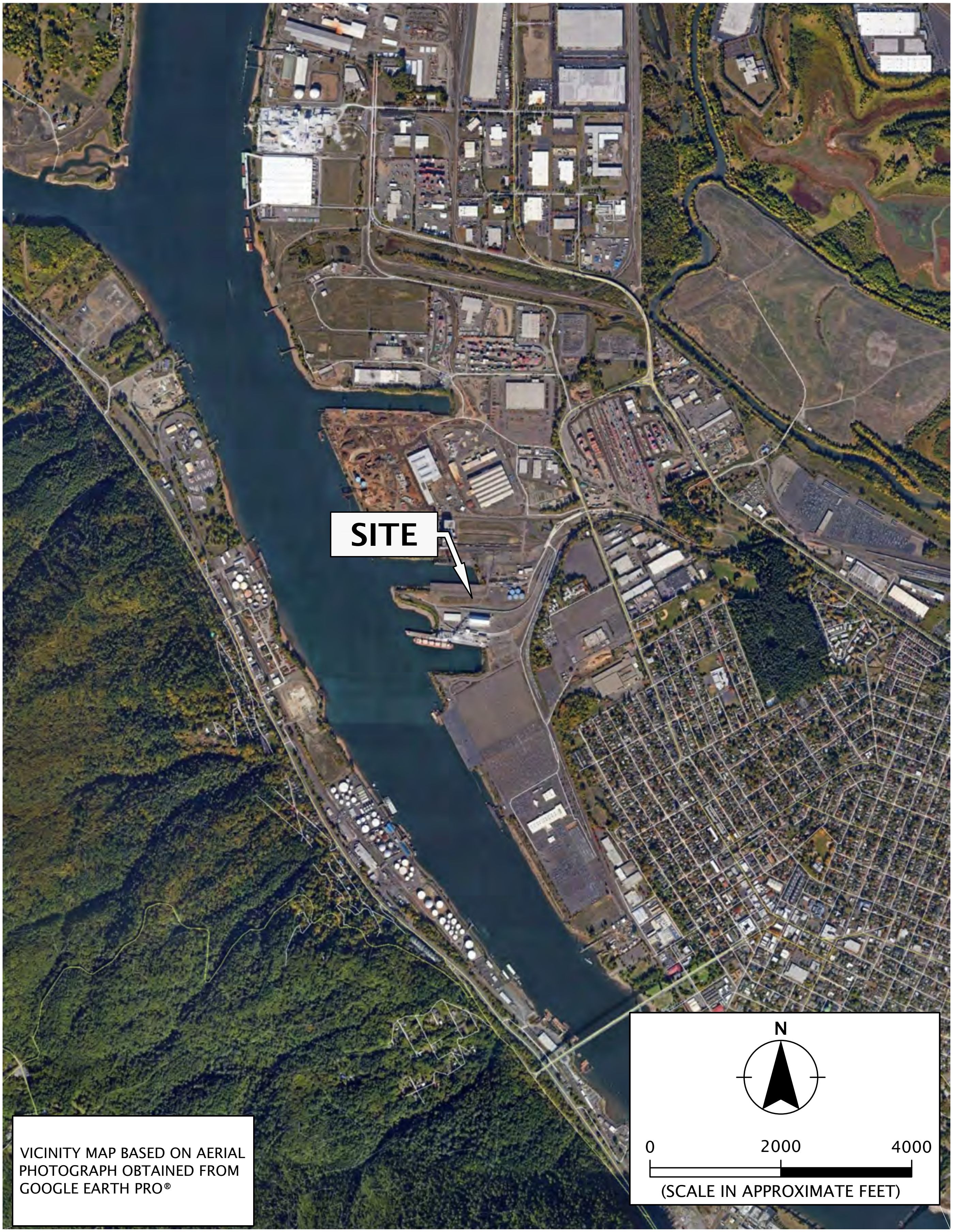
The scope of our services does not include services related to construction safety precautions, and our recommendations are not intended to direct the contractor's methods, techniques, sequences, or procedures, except as specifically described in our memorandum for consideration in design.

Within the limitations of scope, schedule, and budget, our services have been executed in accordance with generally accepted practices in this area at the time the memorandum was prepared. No warranty, express or implied, should be understood.

NAK:BAS:sn
Attachments
One copy submitted (via email only)
Document ID: POP-34-01-021020-geom.docx

84829PE
November 10, 2015
NAJIB A. KALAS
EXPIRES: 06/30/21

FIGURES



VICINITY MAP BASED ON AERIAL PHOTOGRAPH OBTAINED FROM GOOGLE EARTH PRO®

GEODESIGN INC AN NV5 COMPANY	POP-34-01	**VICINITY MAP**
	FEBRUARY 2020	TERMINAL 4 - BASINS K1 & M PORTLAND, OR
		FIGURE 1

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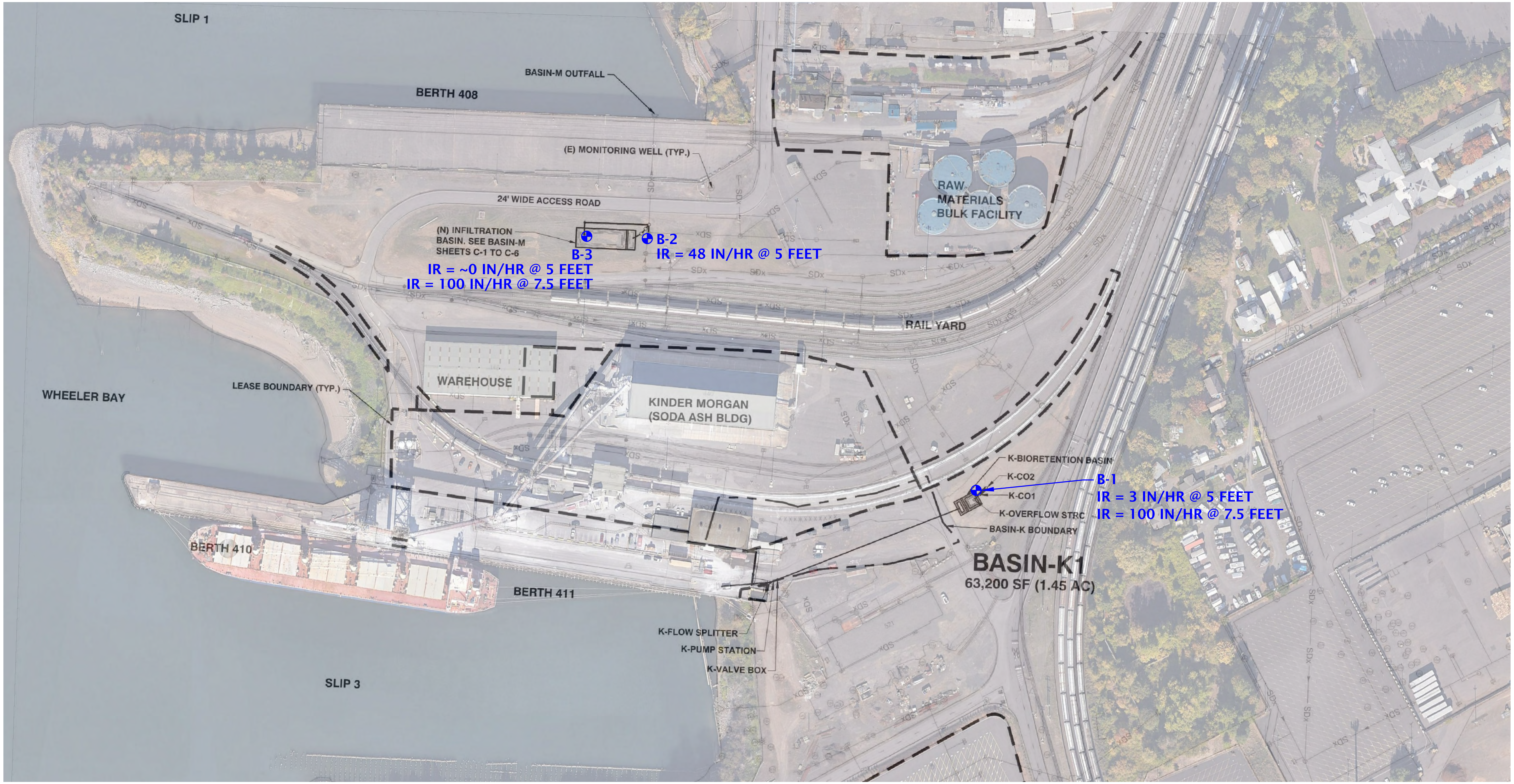
File Name: J:\M-R\POP\POP-34\POP-34-01\Figures\CAD\POP-34-01-VM01.dwg | Layout: FIGURE 1



LEGEND:

B-1●	BORING
IR = 3 IN/HR @ 5 FEET	UNFACTORED INFILTRATION RATE

N

0 200 400

(SCALE IN FEET)

NOTES:

1. SITE PLAN BASED ON IMAGE OF SHEET C7 TERMINAL 4 - BASIN-K1 SITE (OVERALL).
2. AERIAL PHOTOGRAPH OBTAINED FROM GOOGLE EARTH PRO JANUARY 24, 2020.

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FIGURE 2

SITE PLAN

TERMINAL 4 - BASINS K1 & M
PORTLAND, OR

POP-34-01

FEBRUARY 2020

GEODESIGN INC
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ATTACHMENT A

ATTACHMENT A

FIELD EXPLORATIONS

GENERAL

We explored subsurface conditions at the site by drilling three borings (B-1 through B-3) to a depth of 16.5 feet BGS. The explorations were completed on January 21, 2020 by Dan J. Fischer Excavating, Inc. The borings were drilled using a trailer-mounted drill rig with solid-stem auger drilling methods. A member of our geology staff observed the explorations. The exploration logs are presented in this attachment.

Approximate locations of our explorations are shown on Figure 2. The locations of the explorations were surveyed in the field by Port of Portland staff. This information should be considered accurate only to the degree implied by the methods used.

SOIL SAMPLING

Samples were collected from the borings using 1½-inch-inner-diameter SPT split-barrel sampler in general accordance with ASTM D1586. The sampler was driven into the soil with a 140-pound hammer free-falling 30 inches. The sampler was driven a total distance of 18 inches. The number of blows required to drive the sampler the final 12 inches is recorded on the exploration logs, unless otherwise noted. Samples were generally taken at approximately 2.5-foot intervals throughout the depth of the borings. Sampling methods and intervals are shown on the exploration logs. The SPTs completed by Dan J. Fischer Excavating were conducted using two wraps around the cathead.

SOIL CLASSIFICATION

The soil samples were classified in accordance with the “Exploration Key” (Table A-1) and “Soil Classification System” (Table A-2), which are presented in this attachment. The exploration logs indicate the depths at which the soils or their characteristics change, although the change could be gradual. Classifications are shown on the exploration logs.

INFILTRATION TESTING

Infiltration testing was conducted in borings B-1 through B-3 at depths ranging between 5 and 7.5 feet BGS. The infiltration rates were estimated by filling a 6-inch-inside-diameter pipe with water, allowing the area to saturate, and then measuring the drop in water with time. The tests were conducted under a hydrostatic head of generally less than approximately 12 to 18 inches. Representative soil samples were collected from at or below the infiltration test locations.

LABORATORY TESTING

We visually examined soil samples collected from the explorations to confirm field classifications. We also performed the following laboratory testing.

MOISTURE CONTENT

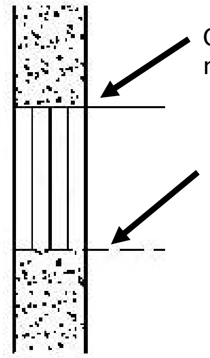
The natural moisture content of select soil samples was determined in general accordance with ASTM D2216. The natural moisture content is a ratio of the weight of the water to dry soil in a test sample and is expressed as a percentage. The test results are presented in this attachment.

PARTICLE-SIZE ANALYSIS

Particle-size analysis was performed on select soil samples in general accordance with ASTM D1140. This test is a quantitative determination of the amount of material finer than the U.S. Standard No. 200 sieve expressed as a percentage of dry soil weight. The test results are presented in this attachment.

SYMBOL	SAMPLING DESCRIPTION
▯	Location of sample collected in general accordance with ASTM D1586 using Standard Penetration Test with recovery
▮	Location of sample collected using thin-wall Shelby tube or Geoprobe® sampler in general accordance with ASTM D1587 with recovery
▤	Location of sample collected using Dames & Moore sampler and 300-pound hammer or pushed with recovery
▦	Location of sample collected using Dames & Moore sampler and 140-pound hammer or pushed with recovery
◩	Location of sample collected using 3-inch-O.D. California split-spoon sampler and 140-pound hammer with recovery
☒	Location of grab sample
▒	Rock coring interval
▽	Water level during drilling
▼	Water level taken on date shown

Graphic Log of Soil and Rock Types



Observed contact between soil or rock units (at depth indicated)

Inferred contact between soil or rock units (at approximate depths indicated)

GEOTECHNICAL TESTING EXPLANATIONS

ATT	Atterberg Limits	P	Pushed Sample
CBR	California Bearing Ratio	PP	Pocket Penetrometer
CON	Consolidation	P200	Percent Passing U.S. Standard No. 200 Sieve
DD	Dry Density		
DS	Direct Shear	RES	Resilient Modulus
HYD	Hydrometer Gradation	SIEV	Sieve Gradation
MC	Moisture Content	TOR	Torvane
MD	Moisture-Density Relationship	UC	Unconfined Compressive Strength
NP	Non-Plastic	VS	Vane Shear
OC	Organic Content	kPa	Kilopascal

ENVIRONMENTAL TESTING EXPLANATIONS

CA	Sample Submitted for Chemical Analysis	ND	Not Detected
P	Pushed Sample	NS	No Visible Sheen
PID	Photoionization Detector Headspace Analysis	SS	Slight Sheen
		MS	Moderate Sheen
ppm	Parts per Million	HS	Heavy Sheen

GEODESIGN INC AN NV5 COMPANY	EXPLORATION KEY	TABLE A-1

RELATIVE DENSITY - COARSE-GRAINED SOIL

Relative Density	Standard Penetration Resistance	Dames & Moore Sampler (140-pound hammer)	Dames & Moore Sampler (300-pound hammer)
Very Loose	0 – 4	0 – 11	0 – 4
Loose	4 – 10	11 – 26	4 – 10
Medium Dense	10 – 30	26 – 74	10 – 30
Dense	30 – 50	74 – 120	30 – 47
Very Dense	More than 50	More than 120	More than 47

CONSISTENCY - FINE-GRAINED SOIL

Consistency	Standard Penetration Resistance	Dames & Moore Sampler (140-pound hammer)	Dames & Moore Sampler (300-pound hammer)	Unconfined Compressive Strength (tsf)
Very Soft	Less than 2	Less than 3	Less than 2	Less than 0.25
Soft	2 – 4	3 – 6	2 – 5	0.25 – 0.50
Medium Stiff	4 – 8	6 – 12	5 – 9	0.50 – 1.0
Stiff	8 – 15	12 – 25	9 – 19	1.0 – 2.0
Very Stiff	15 – 30	25 – 65	19 – 31	2.0 – 4.0
Hard	More than 30	More than 65	More than 31	More than 4.0

PRIMARY SOIL DIVISIONS			GROUP SYMBOL	GROUP NAME
COARSE-GRAINED SOIL (more than 50% retained on No. 200 sieve)	GRAVEL (more than 50% of coarse fraction retained on No. 4 sieve)	CLEAN GRAVEL (< 5% fines)	GW or GP	GRAVEL
		GRAVEL WITH FINES (≥ 5% and ≤ 12% fines)	GW-GM or GP-GM	GRAVEL with silt
			GW-GC or GP-GC	GRAVEL with clay
		GRAVEL WITH FINES (> 12% fines)	GM	silty GRAVEL
			GC	clayey GRAVEL
			GC-GM	silty, clayey GRAVEL
	SAND (50% or more of coarse fraction passing No. 4 sieve)	CLEAN SAND (<5% fines)	SW or SP	SAND
		SAND WITH FINES (≥ 5% and ≤ 12% fines)	SW-SM or SP-SM	SAND with silt
			SW-SC or SP-SC	SAND with clay
		SAND WITH FINES (> 12% fines)	SM	silty SAND
			SC	clayey SAND
			SC-SM	silty, clayey SAND
FINE-GRAINED SOIL (50% or more passing No. 200 sieve)	SILT AND CLAY	Liquid limit less than 50	ML	SILT
			CL	CLAY
			CL-ML	silty CLAY
			OL	ORGANIC SILT or ORGANIC CLAY
		Liquid limit 50 or greater	MH	SILT
			CH	CLAY
			OH	ORGANIC SILT or ORGANIC CLAY
HIGHLY ORGANIC SOIL			PT	PEAT

MOISTURE CLASSIFICATION

Term	Field Test
dry	very low moisture, dry to touch
moist	damp, without visible moisture
wet	visible free water, usually saturated

ADDITIONAL CONSTITUENTS

Secondary granular components or other materials such as organics, man-made debris, etc.					
Percent	Silt and Clay In:		Percent	Sand and Gravel In:	
	Fine-Grained Soil	Coarse-Grained Soil		Fine-Grained Soil	Coarse-Grained Soil
< 5	trace	trace	< 5	trace	trace
5 – 12	minor	with	5 – 15	minor	minor
> 12	some	silty/clayey	15 – 30	with	with
			> 30	sandy/gravelly	Indicate %

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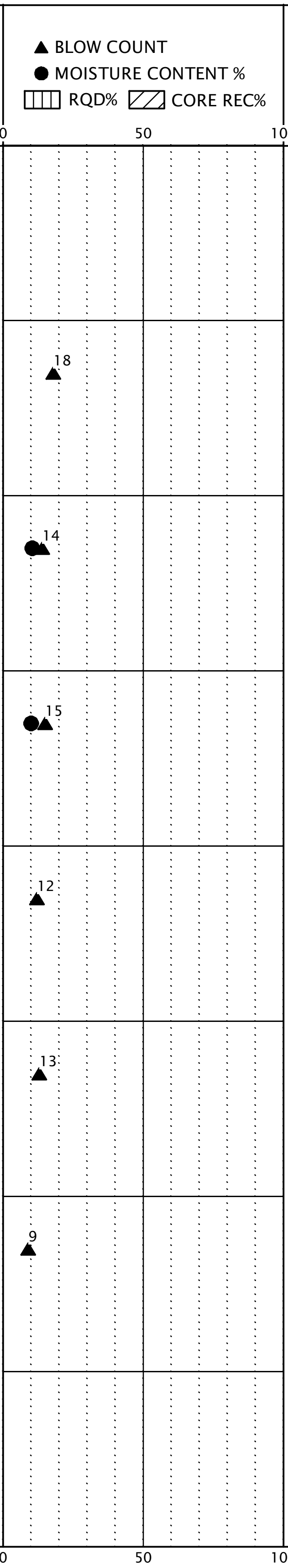
SOIL CLASSIFICATION SYSTEM

TABLE A-2

DEPTH FEET	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	BLOW COUNT	INSTALLATION AND COMMENTS
0.0	Medium dense, brown SAND with silt (SP-SM), trace shells; moist, sand is fine to medium - **FILL**.				
2.5				18	
5.0			P200	14	Infiltration test: 3 inches per hour at 5.0 feet. P200 = 9%
7.5	trace gravel at 7.5 feet		P200	15	Infiltration test: 100 inches per hour at 7.5 feet. P200 = 10%
10.0	without shells at 10.0 feet			12	
12.5	without gravel at 12.5 feet			13	
15.0	loose at 15.0 feet			9	
16.5	Exploration completed at a depth of 16.5 feet. SPT completed using two wraps with a cathead.	16.5			Surface elevation was not measured at the time of exploration.
17.5					
20.0					



DRILLED BY: Dan J. Fischer Excavating, Inc.

LOGGED BY: L. Gose

COMPLETED: 01/21/20

BORING METHOD: solid-stem auger (see document text)

BORING BIT DIAMETER: 6 inches

GEODESIGN INC
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POP-34-01

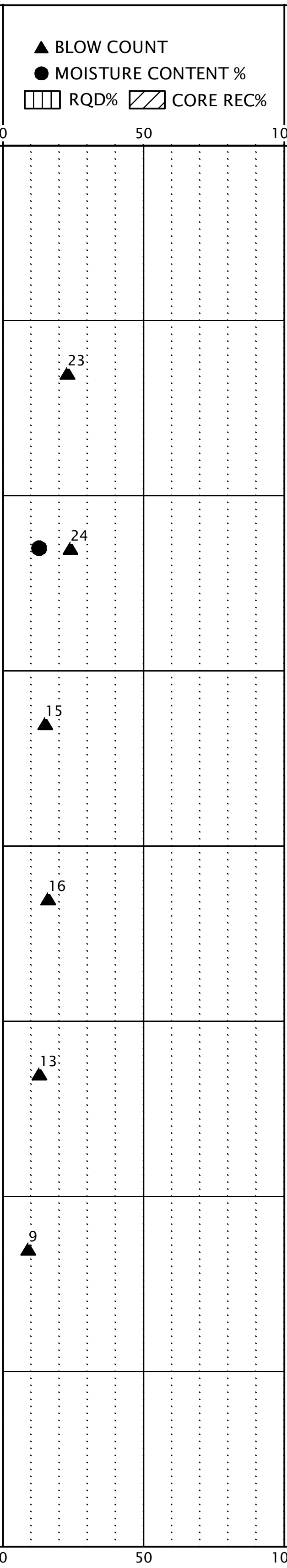
FEBRUARY 2020

BORING B-1

TERMINAL 4 – BASINS K1 & M
PORTLAND, OR

FIGURE A-1

DEPTH FEET	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	BLOW COUNT	INSTALLATION AND COMMENTS
0.0	Medium dense, dark brown SAND with silt (SP-SM); moist, sand is fine to coarse - **FILL**.				
2.5				23	Driller Comment: drill rig chatter at 2.0 feet. Concrete in cuttings at 3.5 feet. Driller Comment: smooth drilling at 4.0 feet.
5.0			P200	24	Infiltration test: 48 inches per hour at 5.0 feet. P200 = 11%
7.5	interbeds of SILT (0.5-inch thick) at 8.5 feet			15	
10.0				16	
12.5	trace gravel at 12.5 feet			13	
15.0				9	
16.5	loose, gray-brown; wet at 16.5 feet Exploration completed at a depth of 16.5 feet. SPT completed using two wraps with a cathead.	16.5			Surface elevation was not measured at the time of exploration.
17.5					
20.0					



DRILLED BY: Dan J. Fischer Excavating, Inc.
LOGGED BY: L. Gose
COMPLETED: 01/21/20

BORING METHOD: solid-stem auger (see document text)
BORING BIT DIAMETER: 6 inches

GEODESIGN INC
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POP-34-01

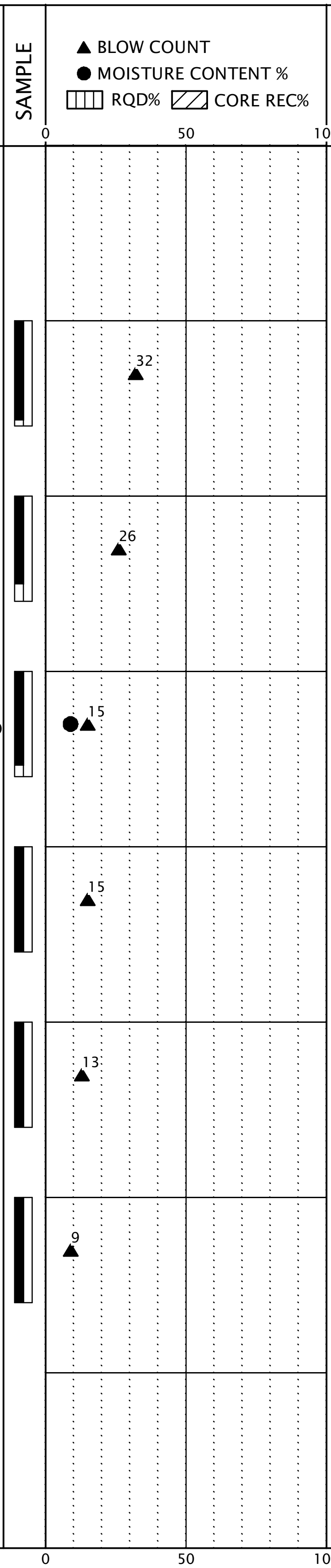
FEBRUARY 2020

BORING B-2

TERMINAL 4 – BASINS K1 & M
PORTLAND, OR

FIGURE A-2

DEPTH FEET	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	INSTALLATION AND COMMENTS
0.0	Dense, black-brown, silty SAND (SM); moist, sand is fine to coarse - **FILL**.			
4.5	Medium dense, brown SAND with silt and cobbles (SP-SM), trace gravel; moist, sand is fine to coarse, gravel is angular to subangular - **FILL**.	4.5		
5.0				Infiltration test: ~0 inches per hour at 5.0 feet. Refusal to drilling at 6.0 feet. Moved 7 feet north and re-drilled but encountered refusal again. Moved 5 feet west and re-drilled.
7.5			P200	Infiltration test: 100 inches per hour at 7.5 feet. P200 = 8%
10.0	without gravel at 10.0 feet			
16.5	Exploration completed at a depth of 16.5 feet. SPT completed using two wraps with a cathead.	16.5		Surface elevation was not measured at the time of exploration.



DRILLED BY: Dan J. Fischer Excavating, Inc.
LOGGED BY: L. Gose
COMPLETED: 01/21/20

BORING METHOD: solid-stem auger (see document text)
BORING BIT DIAMETER: 6 inches

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FEBRUARY 2020

BORING B-3

TERMINAL 4 – BASINS K1 & M
PORTLAND, OR

FIGURE A-3

SAMPLE INFORMATION			MOISTURE CONTENT (PERCENT)	DRY DENSITY (PCF)	SIEVE			ATTERBERG LIMITS		
EXPLORATION NUMBER	SAMPLE DEPTH (FEET)	ELEVATION (FEET)			GRAVEL (PERCENT)	SAND (PERCENT)	P200 (PERCENT)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
B-1	5.0		10				9			
B-1	7.5		10				10			
B-2	5.0		13				11			
B-3	7.5		9				8			

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POP-34-01

FEBRUARY 2020

SUMMARY OF LABORATORY DATA

TERMINAL 4 – BASINS K1 & M
PORTLAND, OR

FIGURE A-4

ATTACHMENT B

ATTACHMENT B

The prior site plan, infiltration test results, groundwater monitoring data, and relevant exploration logs and laboratory test results provided by Geosyntec Consultants, Inc in its September 21, 2018 report are presented in this attachment.

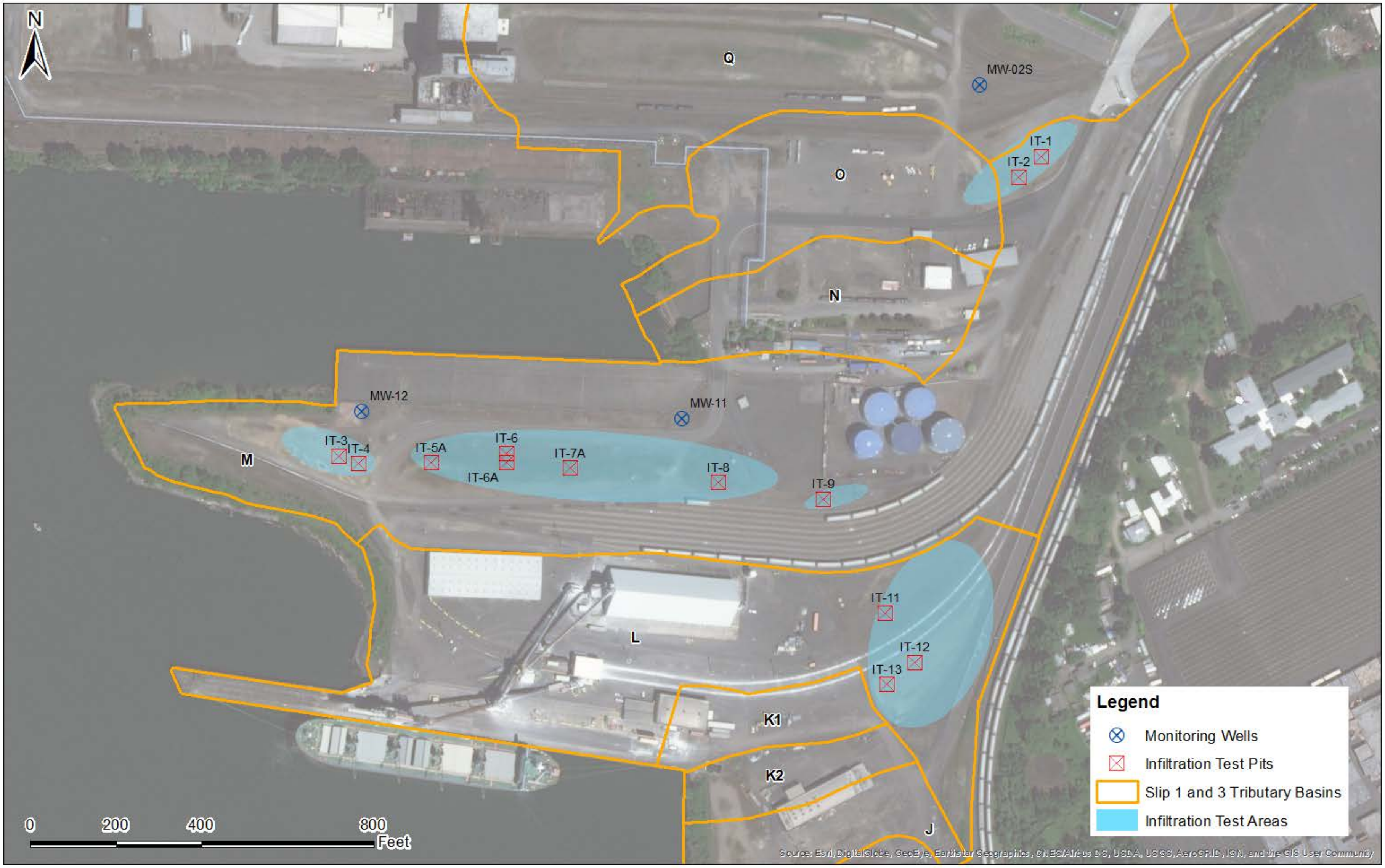

Figure 2: Infiltration Testing Areas, Test Pit Locations, and Monitoring Wells

IT-3 and IT-4, however, because of the sandy soils at the site, the side walls of the open pit excavations repeatedly collapsed into the pit during the presoaking period. Due to these issues, the Encased Falling Head Procedure was used instead and for subsequent testing at other locations. Briefly, infiltration testing was completed as follows:

1. A 6-inch diameter, 4-foot long hollow metal pipe, was pounded approximately 6 inches into the bottom surface of the excavation to create a tight seal between the tube and the surrounding soil.
2. The pipe was filled with 12 inches of water and maintained at this depth for 4 hours to presoak the soil. In excavations with very permeable soil, if the water in the pipe drained in less than 10 minutes, no additional presoaking was completed in accordance with the Portland Stormwater Manual (City of Portland, 2016).
3. After presoaking was completed, the water level in the pipe was filled to 12 inches.
4. Manual depth measurements were made using a tape measure every 10 minutes for a total period of 1 hour. For faster draining soils, manual measurements were made more frequently, and the test was completed only for the time required to drain the entire 12 inches of water.
5. Three drawdown tests were completed (according to Steps 3 and 4) for each test pit.
6. The final raw infiltration rate was calculated as the average rate during the final drawdown test. Factored infiltration rates were calculated according to the Portland Stormwater Manual as the smaller of 20 inches per hour or the raw infiltration rate divided by a factor of safety of 2 (for the Encased Falling Head Procedure).

After infiltration testing was completed, excavations were backfilled using the excavator.

3.0 INFILTRATION TESTING RESULTS

Infiltration testing and physical soil characteristics data are summarized in Table 1. More detailed information is provided in the testing and boring logs in the Carlson Infiltration Testing report in Appendix A.

Table 1. Summary of infiltration test pits.

Test Pit #	General Location	Test Pit Depth (ft)	Soil Type	Fines Content (%)	Raw Infiltration rate (in/hr)	Factored infiltration rate (in/hr)[1]
1	Near entrance road	4.5	Poorly graded sand fill	1	229	20
2	Near entrance road	5	Poorly graded sand fill	1	220	20
3	Peninsula between Slip 1 and Wheeler Bay	3	Poorly graded sand with silt fill	8	4.5	2.3

Test Pit #	General Location	Test Pit Depth (ft)	Soil Type	Fines Content (%)	Raw Infiltration rate (in/hr)	Factored infiltration rate (in/hr)[1]
4	Peninsula between Slip 1 and Wheeler Bay	4	Poorly graded sand with silt and gravel fill	7	12	6
5A	Basin M infield	5.5	Poorly graded sand with silt and gravel fill	6	15	7.5
6	Basin M infield	4.5	Clayey sand fill	26	2.3	1.1
6A	Basin M infield	6	Poorly graded sand with silt fill	10	36	18
7A	Basin M infield	6	Poorly graded sand with silt and gravel fill	9	29	14
8	Basin M infield	4.5	Poorly graded sand with silt and gravel fill	12	24	12
9	Gravel south of IRM tanks	2.5	Poorly graded sand with silt and gravel fill	10	35	18
11	Area east of Kinder Morgan	4	Poorly graded sand fill	4	167	20
12	Area east of Kinder Morgan	5	Poorly graded sand with gravel fill	4	66	20
13	Area east of Kinder Morgan	5	Poorly graded sand with gravel fill	4	224	20

[1] Raw infiltration rate divided by a factor of safety of 2 or 20 inches per hour, whichever is less.

Soil characterization and infiltration testing results generally indicated that soils were sandy and highly permeable in the area near the entrance road and in the areas between railroad tracks east of Kinder Morgan. Raw infiltration rates in these areas were greater than 40 inches per hour, such that factored infiltration rates in these areas, for the purposes of design, would be capped at 20 inches per hour per the Portland Stormwater Manual (City of Portland, 2016).

Testing and characterization results for the test pits in the Basin M infield, and the single test pit south of IRM bulk tanks, indicate siltier and less permeable soils. Significant layering was noted in several test pits within the Basin M infield, with a distinctive silt / clay layer between approximately 4 and 5 feet depth in test pits IT-6 and IT-6A. This layer contained debris including gravel, bark, and wood. Infiltration in IT-6 was conducted directly into this layer while testing in IT-6A was conducted below this layer. Infiltration testing results were dramatically higher in IT-6A compared to IT-6, suggesting that SCMs in Basin M could be designed to infiltrate into deeper sandier soils rather than into any shallower siltier layers. Excluding infiltration testing results from IT-6, the average factored infiltration rate in the Basin M infield and the area south of IRM tanks was approximately 14 inches per hour.

Infiltration rates and soil characterization data for the two test pits on the Peninsula between Wheeler Bay and Slip1 indicate that this area is underlain by slower infiltrating soils. These soils contain some fines, but they may also be compacted from vehicle traffic or other activities.

Soils in all excavations were noted to be derived from fill materials, including soils with different textures. This corresponds with regional geologic maps (Oregon DOGAMI, 2012) and soil series mapping resources (NRCS), both of which indicate that T4 is underlain by artificial fill. Beneath surface soils, deeper soils are likely alluvial sand deposits, most likely derived from Willamette River sediments. Similar geomorphically located areas (i.e. flood plain areas adjacent to the Willamette River) north of T4 are mapped as Pilchuck series soils, which are highly permeable, alluvially-deposited gravelly sands. This description matches soil characterization data in the deeper portions of many of the infiltration test pits.

Groundwater was not encountered in any of the test pits. To identify depth to groundwater at the site, depth to groundwater was measured in three existing monitoring wells at T4 on May 31, 2018. These three monitoring wells are identified in Site Maps in Appendix A. Water levels ranged from 15.62 to 18.47 feet below the top of casing in each well (Table 2). Compared to historic water levels measured during the 2007 Remedial Investigation (Ash Creek/Newfields 2007), water depths measured on May 31, 2018 were similar to historic seasonal values in MW-02S and MW-11 but were less than (i.e., higher groundwater) historic seasonal values in MW-12. Infiltration testing activities corresponded with extremely high-water levels in the Willamette River due to high-water levels in the Columbia River caused by prolonged snow melt. Gauging data from the Morrison Bridge USGS Gauge (Site Number 14211720) indicates that water levels in the Willamette River ranged from approximately 13 to 15 feet above mean sea level (MSL) during infiltration testing activities (May 30 through June 1, 2018). These data, in combination with other historic groundwater monitoring data, suggest that some of the monitoring wells at the site, especially those located near the peninsulas between Slips (e.g. MW-12) are likely in hydraulic equilibrium with the Willamette River. Additionally, given extremely high-water levels in the Willamette River and the fact that testing was completed during May when groundwater levels are typically close to seasonal maximums, measured groundwater elevations in gauged monitoring wells likely represent seasonal high groundwater levels.

Table 2. Site monitoring well groundwater elevations (May 31, 2018).

Monitoring Well	Top of Casing Elevation (ft above MSL)	Measured Depth to Groundwater (ft)	Approximate GW Elevation (ft above MSL)
MW-02S	35.18	16.94	18.24
MW-11	32.09	15.62	16.47
MW-12	33.36	18.47	14.89

4.0 IMPLICATIONS AND NEXT STEPS

Infiltration rates and depth to groundwater measurements appear to support infiltration-based SCMs as viable options. Infiltration testing and characterization results will be used in combination with results from the concurrent Stormwater Treatment Effectiveness Pilot Study (Geosyntec, 2018b) to support selection and design of SCMs to reduce PAH loading to Willamette River sediments. Additional infiltration testing and depth to groundwater may be conducted to support full-scale design of any infiltration-based SCMs.

Carlson Geotechnical
7185 SW Sandburg Street, Suite 200
Tigard, Oregon 97281
(503) 601-8250
www.carlsontesting.com

FIGURE 10

Test Pit IT-5A

PAGE 1 OF 1

CLIENT Myles Gray with Geosyntec Consultants, Inc.
PROJECT NAME Port of Portland - Terminal 4
PROJECT NUMBER G1804850
PROJECT LOCATION 11040 North Lombard Street, Portland, Oregon
DATE STARTED 5/31/18
GROUND ELEVATION 34 ft
ELEVATION DATUM NAVD88 - See Figure 2
WEATHER Cloudy 57~°F
SURFACE Soil and grass
LOGGED BY CRH
REVIEWED BY JAJ
DRILLING CONTRACTOR Port of Portland
SEEPAGE ---
EQUIPMENT Takeuchi TB240 w/ 18-inch toothed bucket
GROUNDWATER AT END ---
DRILLING METHOD 18-inch wide toothed bucket
GROUNDWATER AFTER DRILLING ---

ELEVATION (ft)	GRAPHIC LOG	GROUP SYMBOL	MATERIAL DESCRIPTION	GROUNDWATER	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	WDCP N_{60} VALUE	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ WDCP N_{60} VALUE ▲ PL MC LL ☐ FINES CONTENT (%) ☐ 0 20 40 60 80 100
		SP	**POORLY GRADED SAND FILL:** Loose, light brown, dry, rootlets in upper 6 inches.		0						
33			**POORLY GRADED SAND WITH SILT AND GRAVEL FILL:** Loose, brown, moist, fine to medium grained, trace subrounded to rounded gravel from ¼ to 2 inches in diameter.		1						
			Asphaltic debris at 1.5 feet bgs								
32			Concrete encountered at 2 feet bgs. Subrounded gravel ¼ to 1 inch in diameter below 2 feet bgs.		2						
31		SP			3						
30					4						
29					5						
						✋ GRAB 1	100				6 ☐ ● 12
28											
27											

- Test pit terminated at 5½ feet bgs.
- No groundwater encountered.
- No caving observed.
- Test pit loosely backfilled with excavated materials.

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7185 SW Sandburg Street, Suite 200
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(503) 601-8250
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FIGURE 11

Test Pit IT-6

PAGE 1 OF 1

CLIENT Myles Gray with Geosyntec Consultants, Inc.
PROJECT NAME Port of Portland - Terminal 4
PROJECT NUMBER G1804850
PROJECT LOCATION 11040 North Lombard Street, Portland, Oregon
DATE STARTED 5/31/18
GROUND ELEVATION 34 ft
ELEVATION DATUM NAVD88 - See Figure 2
WEATHER Cloudy 50~°F
SURFACE Soil and grass
LOGGED BY CRH
REVIEWED BY JAJ
DRILLING CONTRACTOR Port of Portland
SEEPAGE ---
EQUIPMENT Takeuchi TB240 w/ 18-inch toothed bucket
GROUNDWATER AT END ---
DRILLING METHOD 18-inch wide toothed bucket
GROUNDWATER AFTER DRILLING ---

ELEVATION (ft)	GRAPHIC LOG	GROUP SYMBOL	MATERIAL DESCRIPTION	GROUNDWATER	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	WDCP N_{60} VALUE	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ WDCP N_{60} VALUE ▲ PL MC LL ☐ FINES CONTENT (%) ☐ 0 20 40 60 80 100
		SP	**POORLY GRADED SAND FILL:** Loose, light brown, dry, rootlets in upper 6 inches.		0						
33		SP	**POORLY GRADED SAND WITH GRAVEL FILL:** Loose, dark brown to brown, moist, medium grained, trace subrounded to rounded gravel up to ¼ inch in diameter.		1						
32					2						
31					3						
30		SC	**CLAYEY SAND FILL:** Loose, dark brown to dark gray, moist, low plasticity, medium grained, with some subangular gravel ¼ to 2 inches in diameter.		4	GRAB 1	100				● 17 ☐ 26

- Test pit terminated at 4½ feet bgs.
- No groundwater encountered.
- No caving observed.
- Test pit loosely backfilled with excavated materials.

29
28
27

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FIGURE 12

Test Pit IT-6A

PAGE 1 OF 1

CLIENT Myles Gray with Geosyntec Consultants, Inc.
PROJECT NAME Port of Portland - Terminal 4
PROJECT NUMBER G1804850
PROJECT LOCATION 11040 North Lombard Street, Portland, Oregon
DATE STARTED 5/31/18
GROUND ELEVATION 34 ft
ELEVATION DATUM NAVD88 - See Figure 2
WEATHER Cloudy 57~°F
SURFACE Soil and grass
LOGGED BY CRH
REVIEWED BY JAJ
DRILLING CONTRACTOR Port of Portland
SEEPAGE ---
EQUIPMENT Takeuchi TB240 w/ 18-inch toothed bucket
GROUNDWATER AT END ---
DRILLING METHOD 18-inch wide toothed bucket
GROUNDWATER AFTER DRILLING ---

ELEVATION (ft)	GRAPHIC LOG	GROUP SYMBOL	MATERIAL DESCRIPTION	GROUNDWATER	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	WDCP N_{60} VALUE	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ WDCP N_{60} VALUE ▲ PL MC LL ☐ FINES CONTENT (%) ☐ 0 20 40 60 80 100
		SP	**POORLY GRADED SAND FILL:** Loose, light brown, dry, with rootlets.		0						
33		SP	**POORLY GRADED SAND WITH GRAVEL FILL:** Loose, dark brown to brown, moist, medium grained, trace subrounded to rounded gravel up to ¼ inch in diameter.		1						
32					2						
31					3						
		SC	**CLAYEY SAND FILL:** Loose, dark brown to dark gray, moist, low plasticity, medium grained, with some subangular gravel from ¼ to 2 inches in diameter, with some wood debris.								
30					4						
		SP-SM	**POORLY GRADED SAND WITH SILT FILL:** Loose, brown, moist, no plasticity, medium grained.								
29					5						
28					6	GRAB 1	100				10 ☐ ● 12
27			• Test pit terminated at 6 feet bgs. • No groundwater encountered. • No caving observed. • Test pit loosely backfilled with excavated materials.								

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FIGURE 13

Test Pit IT-7A

PAGE 1 OF 1

CLIENT Myles Gray with Geosyntec Consultants, Inc.
PROJECT NAME Port of Portland - Terminal 4
PROJECT NUMBER G1804850
PROJECT LOCATION 11040 North Lombard Street, Portland, Oregon
DATE STARTED 5/31/18
GROUND ELEVATION 33 ft
ELEVATION DATUM NAVD88 - See Figure 2
WEATHER Mostly Cloudy 62~°F
SURFACE Soil and grass
LOGGED BY CRH
REVIEWED BY JAJ
DRILLING CONTRACTOR Port of Portland
SEEPAGE ---
EQUIPMENT Takeuchi TB240 w/ 18-inch toothed bucket
GROUNDWATER AT END ---
DRILLING METHOD 18-inch wide toothed bucket
GROUNDWATER AFTER DRILLING ---

ELEVATION (ft)	GRAPHIC LOG	GROUP SYMBOL	MATERIAL DESCRIPTION	GROUNDWATER	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	WDCP N_{60} VALUE	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ WDCP N_{60} VALUE ▲ PL ●MC LL ☐ FINES CONTENT (%) ☐ 0 20 40 60 80 100
		SP	**POORLY GRADED SAND FILL:** Loose, light brown, dry, no plasticity, dry rootlets upper 6 inches.		0						
32		SP-SM	**POORLY GRADED SAND WITH SILT AND GRAVEL FILL:** Loose, light brown, dry, no plasticity, subrounded to rounded gravel from ¼ to 2 inches in diameter.		1						
31					2						
30		GP-GM	**POORLY GRADED GRAVEL WITH SAND AND SILT FILL:** Dense, gray, moist, no plasticity, subrounded to rounded gravel up to 2 inches in diameter.		3						
29		SP-SM	**POORLY GRADED SAND WITH SILT AND GRAVEL FILL:** Loose, brown, moist, no plasticity, medium to coarse grained. Angular to subrounded gravel from ¼ to 1 inches diameter.		4						
28					5						
27			Decreased gravel content below 5½ feet bgs.		6	GRAB 1	100				9 ☐● 11

- Test pit terminated at 6 feet bgs.
- No groundwater encountered.
- No caving observed.
- Test pit loosely backfilled with excavated materials.

26

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FIGURE 14

Test Pit IT-8

PAGE 1 OF 1

CLIENT Myles Gray with Geosyntec Consultants, Inc.
PROJECT NAME Port of Portland - Terminal 4
PROJECT NUMBER G1804850
PROJECT LOCATION 11040 North Lombard Street, Portland, Oregon
DATE STARTED 5/31/18
GROUND ELEVATION 33 ft
ELEVATION DATUM NAVD88 - See Figure 2
WEATHER Cloudy 60~°F
SURFACE Soil and grass
LOGGED BY CRH
REVIEWED BY JAJ
DRILLING CONTRACTOR Port of Portland
SEEPAGE ---
EQUIPMENT Takeuchi TB240 w/ 18-inch toothed bucket
GROUNDWATER AT END ---
DRILLING METHOD 18-inch wide toothed bucket
GROUNDWATER AFTER DRILLING ---

ELEVATION (ft)	GRAPHIC LOG	GROUP SYMBOL	MATERIAL DESCRIPTION	GROUNDWATER	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	WDCP N_{60} VALUE	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ WDCP N_{60} VALUE ▲ PL MC LL ☐ FINES CONTENT (%) ☐ 0 20 40 60 80 100
	▨		**POORLY GRADED SAND FILL:** Loose, light brown, dry, no plasticity, fine grained, with dry rootlets upper 1 inch.		0						
32	▨	SP	Increased subrounded gravel up to 2 inches diameter between 1 and 2 feet bgs.		1						
31	▨		**POORLY GRADED SAND WITH SILT AND GRAVEL FILL:** Loose, brown, moist, no plasticity, medium grained. Subrounded gravel from ¼ to 2 inches diameter, and trace subrounded cobble up to 4 inches in diameter.		2						
30	▨	SP-SM			3						
29	▨				4	GRAB 1	100				12 ●☐ 9
28											
27											
26											

- Test pit terminated at 4½ feet bgs.
- No groundwater encountered.
- No caving observed.
- Test pit loosely backfilled with excavated materials.

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FIGURE 17

Test Pit IT-12

PAGE 1 OF 1

CLIENT Myles Gray with Geosyntec Consultants, Inc.
PROJECT NAME Port of Portland - Terminal 4
PROJECT NUMBER G1804850
PROJECT LOCATION 11040 North Lombard Street, Portland, Oregon
DATE STARTED 6/1/18
GROUND ELEVATION 37 ft
ELEVATION DATUM NAVD88 - See Figure 2
WEATHER Cloudy 58~°F
SURFACE Gravel and grass
LOGGED BY CRH
REVIEWED BY JAJ
DRILLING CONTRACTOR Port of Portland
SEEPAGE ---
EQUIPMENT Takeuchi TB240 w/ 18-inch toothed bucket
GROUNDWATER AT END ---
DRILLING METHOD 18-inch wide toothed bucket
GROUNDWATER AFTER DRILLING ---

ELEVATION (ft)	GRAPHIC LOG	GROUP SYMBOL	MATERIAL DESCRIPTION	GROUNDWATER	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	WDCP N_{60} VALUE	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ WDCP N_{60} VALUE ▲ PL MC LL ☐ FINES CONTENT (%) ☐ 0 20 40 60 80 100
		SP	**POORLY GRADED SAND FILL:** Loose, light brown, dry, fine grained, with rootlets in upper 8 inches.		0						
			POORLY GRADED GRAVEL WITH SAND FILL: Dense, gray, moist, angular, from ½ to 1 inch in diameter. Medium grained sand.								
36		GP			1						
35			**POORLY GRADED SAND WITH GRAVEL FILL:** Loose, brown to gray, moist, fine to medium grained, with some subrounded gravel from ¼ to 1 inch in diameter.		2						
34					3						
		SP									
33			Decreased gravel below 4 feet bgs.		4						
						GRAB 1	100				4 ☐ ● 10
32					5						

- Test pit terminated at 5 feet bgs.
- No groundwater encountered.
- No caving observed.
- Test pit loosely backfilled with excavated materials.

31

30

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FIGURE 18

Test Pit IT-13

CLIENT Myles Gray with Geosyntec Consultants, Inc.
PROJECT NAME Port of Portland - Terminal 4
PROJECT NUMBER G1804850
PROJECT LOCATION 11040 North Lombard Street, Portland, Oregon
DATE STARTED 6/1/18
GROUND ELEVATION 37 ft
ELEVATION DATUM NAVD88 - See Figure 2
WEATHER Cloudy 58~°F
SURFACE Gravel and grass
LOGGED BY CRH
REVIEWED BY JAJ
DRILLING CONTRACTOR Port of Portland
SEEPAGE ---
EQUIPMENT Takeuchi TB240 w/ 18-inch toothed bucket
GROUNDWATER AT END ---
DRILLING METHOD 18-inch wide toothed bucket
GROUNDWATER AFTER DRILLING ---

ELEVATION (ft)	GRAPHIC LOG	GROUP SYMBOL	MATERIAL DESCRIPTION	GROUNDWATER	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	WDCP N_{60} VALUE	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	▲ WDCP N_{60} VALUE ▲ PL ● MC LL ☐ FINES CONTENT (%) ☐ 0 20 40 60 80 100
		SP	**POORLY GRADED SAND FILL:** Loose, light brown, dry, fine grained, with rootlets in upper 8 inches.		0						
36		GP	**POORLY GRADED GRAVEL WITH SAND FILL:** Dense, gray, moist, angular, from ½ to 1 inch in diameter. Medium grained sand.		1						
35 34 33 32		SP	**POORLY GRADED SAND WITH GRAVEL FILL:** Loose, dark brown, moist, medium grained, with some subrounded gravel up to 1½ inches in diameter.		2 3 4 5	GRAB 1	100				☐ 4 ● 11
31 30											

- Test pit terminated at 5 feet bgs.
- No groundwater encountered.
- No caving observed.
- Test pit loosely backfilled with excavated materials.

CGT EXPLORATION WITH WDCP G1804850 - PORT OF PORTLAND IT.GPJ 6/15/18 DRAFTED BY: CRH

Appendix C

Discussion of Historical T4 Data Relative to Proposed Bioinfiltration SCMs

Discussion of Historical T4 Data Relative to Proposed Bioinfiltration SCMs

The Port has conducted extensive source investigations and analyses of historical industrial activities at T4. The data and findings from the Remedial Investigations (RIs) are still considered representative of site conditions due to very limited change in activities or land uses at the site since the RIs were completed. These data and findings were used to help identify the proposed locations for the bioinfiltration SCMs. This appendix discusses the RI data and presents the sampling locations relative to the proposed bioinfiltration SCM locations (Attachment C1), the RI data tables for the sampling locations (Attachment C2), and geological cross-sections beneath the SCM locations (Attachment C3).

BASIN M

Land Uses

The current land use for Basin M is largely open space and is partially occupied by the International Raw Materials (IRM) leasehold and a small portion of the Kinder Morgan (KM) leasehold. Activities conducted by IRM include storing, handling, and distributing bulk liquid and granular products. Activities conducted by KM in this area are limited to rail operations. Land uses have not changed since the Remedial Investigation (RI) in 2007 (Ash Creek Associates, Inc./Newfields, 2007), and data from the RI study remains representative of the area today.

Soil Data

Soil data near the future Basin M bioinfiltration SCM was collected as part of the Terminal 4 Slip 1 RI (Ash Creek Associates, Inc./Newfields, 2007). Representative sample locations include SB-55, SB-56, SB-57, SB-58, SB-07, and MW-11, each of which were analyzed for a subset of total petroleum hydrocarbons (TPH), polycyclic aromatic hydrocarbons (PAHs), volatile organic carbons (VOCs), and metals. The proximity of these locations to the future bioinfiltration SCM can be seen on Attachment B1, and results are provided in the RI tables reproduced at the end of this document (Attachment B2). A summary of findings is as follows:

- **TPH**: SB-55, SB-56, SB-57, SB-58 were analyzed for TPH, and all results were non-detect.
- **PAHs**: SB-55 and SB-58 were analyzed for PAHs, and all results were below associated screening level values (SLVs) and Portland Harbor clean-up levels (CULs).
- **VOCs**: SB-55 and SB-58 were analyzed for VOCs, and all results were non-detect.
- **Metals**: SB-55, SB-58, SB-07, and MW-11 were analyzed for metals; all results for SB-58, SB-07, and MW-11 were below associated SLVs, and only zinc was above the SLV for SB-55, but was below the CULs.

Groundwater Data

Groundwater data near the future Basin M infiltration basin was also collected as part of the RI (Ash Creek Associates, Inc./Newfields, 2007). The representative sample location for this infiltration basin is MW-11, which was analyzed for TPH, PAHs, VOCs, pesticides, and metals. Four samples were obtained for this location. The proximity of this location to the future infiltration basin can be seen on Attachment B1, and results are provided in the RI tables reproduced at the end of this document (Attachment B2). A summary of findings is as follows:

- **TPH**: all results were below associated SLVs; the CUL is based on the TPH-diesel (C10-C12 aliphatic) fraction which was not analyzed in this data set.
- **PAHs**: all results were below associated SLVs; several analytes had concentrations above detection, but below laboratory reporting limits (i.e., “J” values). These J values were no greater than about an order of magnitude higher than the associated CULs.
- **VOCs**: all results were below associated SLVs; one sample was slightly above the CUL for tetrachloroethylene.
- **Pesticides**: one sample was above the fish consumption SLV, but not the aquatic SLV, for Aldrin, which does not have an associated CUL for groundwater; one sample each were above both aquatic and fish consumption SLVs, as well as CULs for 4,4’-DDD and 4,4’-DDT.
- **Metals**: all metals were below associated SLVs and CULs except for arsenic, which was above the associated CUL.

Conclusion

Historical data indicates that the area planned for the Basin M bioinfiltration SCM is not an area where contaminants are present in elevated concentrations. Slightly elevated levels of cPAHs may be present in groundwater; however, the magnitude of the cPAHs exceedances were generally low, and were not present at elevated concentrations in soil borings. Slightly elevated concentrations of three pesticides were each found in one of three groundwater samples; however, these pesticides have not been found at elevated concentrations in Slip sediments. As such, the location selected for the Basin M bioinfiltration SCM is deemed acceptable based on this representative, historical data.

BASIN K1

Basin K1 has historically been used for warehousing and rail and ship import and export of materials, including soda ash and pencil pitch. The current land use for Basin K1 is soda ash loading operations under KM’s leasehold. As such, this land use has not changed since the 2007 RI, and data from this study remains representative of the area today.

Soil Data

Soil data near the future Basin K1 bioinfiltration SCM was collected as part of the RI (Ash Creek Associates, Inc./Newfields, 2007). The primary representative sample location is SB-76, however results from SB-75 were also considered. These samples were each analyzed for TPH, PAHs, other semi-volatile organic carbons (SVOCs), VOCs, and metals. The proximity of these locations to the future infiltration basin can be seen on Attachment B1, and results are provided in the RI tables reproduced at the end of this document (Attachment B2). A summary of findings is as follows:

- **TPH**: all results were non-detect for both SB-76 and SB-75
- **PAHs**: all results were below associated SLVs for both SB-76 and SB-75; cPAH equivalents, but not total PAHs, were elevated as compared to CULs for SB-75 only.
- **Other SVOCs**: all results were non-detect for both SB-76 and SB-75.
- **VOCs**: all results were below associated SLVs and CULs for both SB-76 and SB-75.

- **Metals**: only zinc was above the SLV for SB-76 but was not above the associated CUL; zinc was above the SLV but not the CUL, cadmium was above the CUL but not the SLV, and lead and arsenic were above both the CUL and SLV for SB-75.

Groundwater Data

Groundwater data near the future Basin K1 bioinfiltration SCM was also collected as part of the RI (Ash Creek Associates, Inc. and Newfields, 2007). The nearest sample location for this infiltration basin is MW-21, which was analyzed for TPH, PAHs, VOCs, and metals. Three samples were obtained from this location. The proximity of these locations to the future bioinfiltration SCM can be seen on Attachment B1, and results are provided in the RI tables reproduced at the end of this document (Attachment B2). A summary of findings is as follows:

- **TPH**: all results were below associated SLVs; the CUL is based on the TPH-diesel (C10-C12 aliphatic) fraction which was not analysed in this data set.
- **PAHs**: all results were below associated SLVs; one sample have detected concentrations below reporting limits ("J" values) that were slightly above the CULs for three cPAHs.
- **VOCs**: all results were below associated SLVs; the concentration of vinyl chloride in one sample was detected at the detection limit (flagged as a "UJ" value). The detection limit was an order of magnitude above the CUL.
- **Metals**: cadmium was above the aquatic SLV in one sample and the CUL in two samples; arsenic was above the CUL but not the SLV in two samples; lead was above the CUL but not the SLV in one sample.

Conclusion

Historical data indicates that the area planned for the Basin K1 bioinfiltration SCM is not an area where contaminants are present in elevated concentrations. Detected levels of some cPAHs may be present in soil and groundwater, however, cPAHs were below the CUL in soil at SB-76, which is the most representative location for the future bioinfiltration basin. In addition, elevated levels of some metals may be present in soil and groundwater, however, again, all exceedances of soil metal CULs occurred at SB-75, which is further away from the future bioinfiltration basin location than SB-76, which did not see elevated metal concentrations. In addition, metals are not a focused contaminant of concern for the Portland Harbor. As such, the location selected for the Basin K1 infiltration basin is considered acceptable based on representative, historical data.

REFERENCES

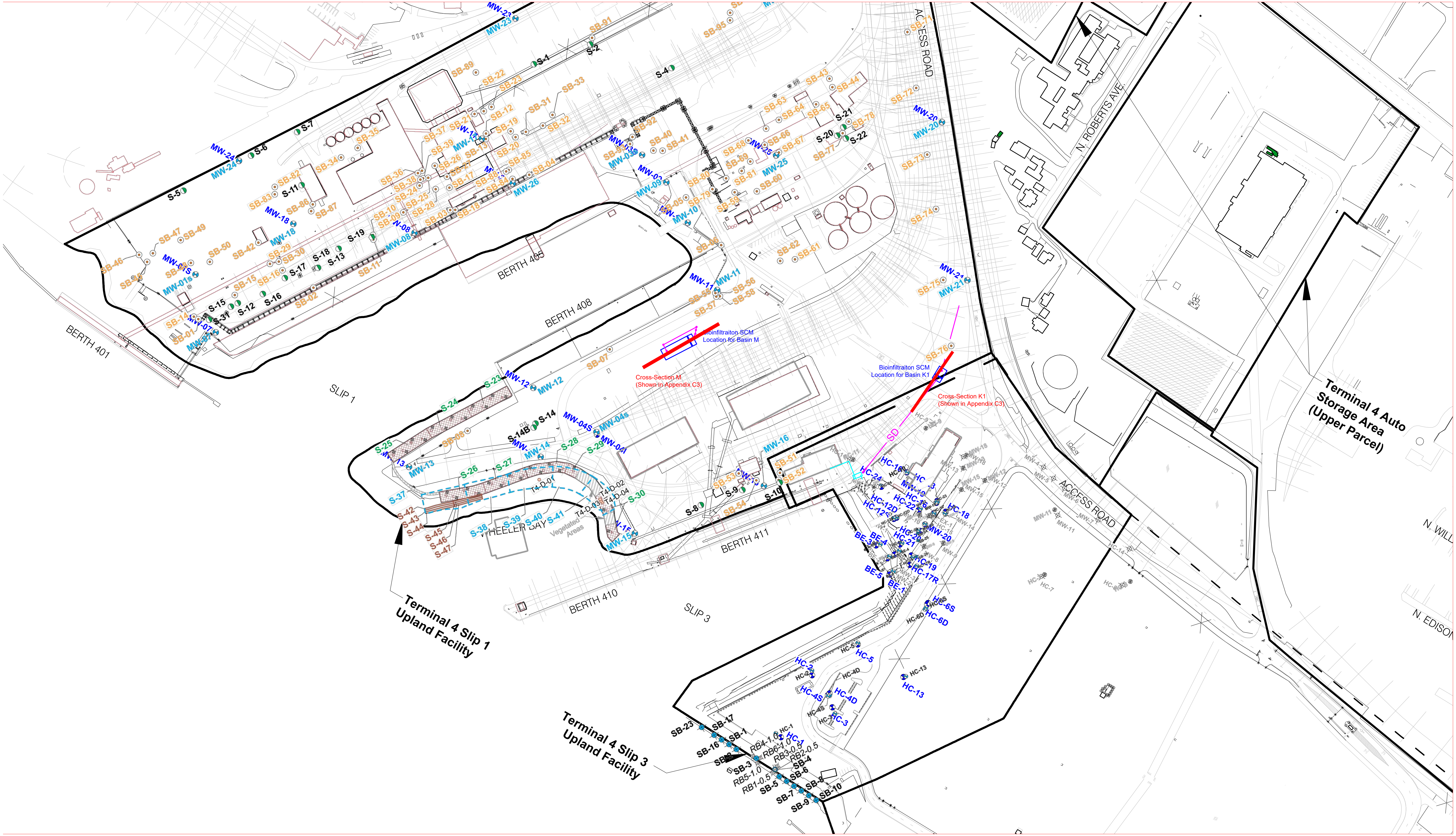
Ash Creek Associates, Inc./Newfields (2007). Remedial Investigation Report, Terminal 4 Slip 1 Upland Facility. August.

Blasland, Bouck, and Lee (2006). Appendix N – Terminal 4 Recontamination Analysis. November.

U.S. Environmental Protection Agency (2017). Record of Decision: Portland Harbor Superfund Site. January.

Attachment C1

Map of T4 Historical Sampling Locations Relative to Proposed Bioinfiltration SCMs



Attachment C1: Map of T4 Historical Sampling Locations Relative to Proposed Bioinfiltration SCMs

Attachment C2

Data Tables from the

Remedial Investigation Report, Terminal 4 Slip 1 Upland Facility

TABLE 6B
SOIL CHEMISTRY RESULTS: PETROLEUM HYDROCARBONS - OU2

REMEDIAL INVESTIGATION
PORT OF PORTLAND - TERMINAL 4 SLIP 1

Sample Location:	**T4S1SB-51**	**T4S1SB-51**	**T4S1SB-52**	**T4S1SB-53**	**T4S1SB-55**	**T4S1SB-55**	**T4S1SB-56**	**T4S1SB-57**	**T4S1SB-58**	**T4S1SB-58**
Sample ID:	**T4S1SB-51-2.5-1**	**T4S1SB-51-12-1**	**T4S1SB-52-13-1**	**T4S1SB-53-1-1**	**T4S1SB-55-1-1**	**T4S1SB-55-8-1**	**T4S1SB-56-8-1**	**T4S1SB-57-8-1**	**T4S1SB-58-1-1**	**T4S1SB-58-9-1**
Sample Interval:	**2 - 2.5**	**11 - 12**	**12 - 13**	**0.5 - 1**	**1 - 2**	**7.5 - 8.5**	**7.5 - 8.5**	**7 - 8**	**1 - 2**	**8.5 - 9.5**
Date Sampled:	**8/27/2004**	**8/27/2004**	**8/27/2004**	**8/27/2004**	**8/27/2004**	**8/31/2004**	**8/31/2004**	**8/31/2004**	**8/31/2004**	**8/31/2004**
HCID (mg/kg)										
Gasoline Range	20 U	20 U	20 U	--	11 U	11 U	11 U	11 U	11 U	11 U
Diesel Range	Det	50 U	50 U	--	26 U	26 U	27 U	27 U	26 U	26 U
Residual Range	Det	100 U	100 U	--	52 U	52 U	54 U	53 U	51 U	52 U
TPH (mg/kg)										
Gasoline Range		--	--	4.3 U	--	--	--	--	--	--
Diesel Range	88 Z	--	--	43 U	--	--	--	--	--	--
Residual Range	190 Z	--	--	170 U	--	--	--	--	--	--

Sample Location:	**T4S1SB-67**	**T4S1SB-70**	**T4S1SB-71**	**T4S1SB-72**	**T4S1SB-73**	**T4S1SB-74**	**T4S1SB-75**	**T4S1SB-76**	**T4S1SB-77**	**T4S1SB-78**
Sample ID:	**T4S1SB-67-18-1**	**T4S1SB-70-1-1**	**T4S1SB-71-1-1**	**T4S1SB-72-1-1**	**T4S1SB-73-1-1**	**T4S1SB-74-1-1**	**T4S1SB-75-1-1**	**T4S1SB-76-1-1**	**T4S1SB-77-1-1**	**T4S1SB-78-1-1**
Sample Interval:	**18 - 19**	**1 - 2**	**1 - 2**	**1 - 2**	**0.5 - 1.5**	**1 - 2**	**1 - 2**	**1 - 2**	**0.5 - 1**	**0.5 - 1.5**
Date Sampled:	**9/8/2004**	**8/26/2004**	**8/26/2004**	**8/26/2004**	**8/26/2004**	**8/26/2004**	**8/26/2004**	**38225**	**8/30/2004**	**8/30/2004**
HCID (mg/kg)										
Gasoline Range	Det	20 U	20 U	20 U	20 U	20 U	20 U	20 U	--	--
Diesel Range	Det	50 U	50 U	50 U	50 U	50 U	50 U	50 U	--	--
Residual Range	Det	100 U	100 U	100 U	100 U	100 U	100 U	100 U	--	--
TPH (mg/kg)										
Gasoline Range	1,400 Z	--	--	--	--	--	--	--	3.6 U	1.3 J
Diesel Range	21,000 DY	--	--	--	--	--	--	--	46 U	42 U
Residual Range	14,000 DO	--	--	--	--	--	--	--	190 U	26 J

Sample Location:	**T4S1SB-79**	**T4S1SB-80**	**T4S1SB-81**	**AOC72-S1**	**AOC72-S1**	**AOC72-S2**	**AOC72-S2**	**AOC72-S3**	**AOC72-S3**	**T4S1S-14**
Sample ID:	**T4S1SB-79-3-1**	**T4S1SB-80-3-1**	**T4S1SB-81-3-1**	**AOC72-S1-0.5**	**AOC72-S1-1.5**	**AOC72-S2-0.5**	**AOC72-S2-1.5**	**AOC72-S3-0.5**	**AOC72-S3-1.5**	**T4S1S-14**
Sample Interval:	**2.5 - 3.5**	**2.5 - 3.5**	**2.5 - 3.5**	**0.5 - 1.5**	**1.5 - 2.5**	**0.5 - 1.5**	**1.5 - 2.5**	**0.5 - 1.5**	**1.5 - 2.5**	**0 - 0.5**
Date Sampled:	**8/30/2004**	**8/30/2004**	**8/30/2004**	**3/8/2004**	**3/8/2004**	**3/8/2004**	**3/8/2004**	**3/8/2004**	**3/8/2004**	**3/22/2005**
HCID (mg/kg)										
Gasoline Range	--	--	--	--	--	--	--	--	--	--
Diesel Range	--	--	--	--	--	--	--	--	--	--
Residual Range	--	--	--	--	--	--	--	--	--	--
TPH (mg/kg)										
Gasoline Range	1.1 J	3.4 U	4.1 U	2.9 U	2.8 U	2.7 U	2.8 U	2.7 U	2.7 U	--
Diesel Range	42 U	39 U	41 U	14 U	14 U	14 U	14 U	14 U	14 U	120 Z
Residual Range	170 U	160 U	170 U	56 U	55 U	54 U	53 U	52 U	53 U	600 Z

Sample Location:	**T4S1MW-25**	**T4S1MW-25**	**T4S1MW-25**	**T4S1S-23**	**T4S1S-24**	**T4S1S-25**	**T4S1S-26**	**T4S1S-27**	**T4S1S-28**	**T4S1S-29**	**T4S1S-30**
Sample ID:	**T4S1MW-25-7.5-1**	**T4S1MW-25-17.5-1**	**T4S1MW-25-18.5-1**	**T4S1S-23**	**T4S1S-24**	**T4S1S-25**	**T4S1S-26**	**T4S1S-27**	**T4S1S-28**	**T4S1S-29**	**T4S1S-30**
Sample Interval:	**7.5 - 10**	**17.5 - 18.5**	**18.5 - 20**	**0 - 1**	**0 - 1**	**0 - 1**	**0 - 1**	**0 - 1**	**0 - 1**	**0 - 1**	**0 - 1**
Date Sampled:	**9/8/2005**	**9/8/2005**	**9/8/2005**	**9/12/2005**	**9/12/2005**	**9/12/2005**	**9/13/2005**	**9/13/2005**	**9/13/2005**	**9/13/2005**	**9/13/2005**
HCID (mg/kg)											
Gasoline Range	--	--	--	--	--	--	--	--	--	--	--
Diesel Range	--	--	--	--	--	--	--	--	--	--	--
Residual Range	--	--	--	--	--	--	--	--	--	--	--
TPH (mg/kg)											
Gasoline Range	--	--	--	--	--	--	--	--	--	--	--
Diesel Range	27.5 U	30 U	29.8 U	26.6 U	27.1 U	29.5 U	26.4 U	18.7 J, D	25.4 U	36.2 D	14.9 J, D
Residual Range	55 U	60 U	59.6 U	53.1 U, D	54.2 U	59.0 U	42.2 J, D	68.2 D	34.0 J, D	138 D	57.3 D

Notes:

1. Only detected compounds are reported in the table.
2. TPH =Total petroleum hydrocarbons (TPH) by Northwest Total Petroleum Hydrocarbons (NWTPH). Diesel and residual range performed with silica gel cleanup.
3. mg/kg = Milligrams per kilogram.
4. -- = No screening level available or not analyzed.
5. J = The result is an estimated concentration that is less than the method reporting limit (MRL) but greater than or equal to the method detection limit (MDL).
6. U = The compound was analyzed for but was not detected at or above the MRL/MDL.
7. D = The reported result is from a dilution.
8. Y = The chromatographic fingerprint of the sample resembles a petroleum product eluting in approximately the correct carbon range, but the elution pattern does not.
9. O = The chromatographic fingerprint of the sample resembles an oil, but does not match the calibration standard.
10. Z = The chromatographic fingerprint does not resemble a petroleum product.
11. Det = Detected at or above the MRL. Follow-up analyses were performed in order to obtain quantitative results.
12. Sample ID nomenclature is per the following: type of sample-sample number-depth in feet-designation. For example T4S1SB-46-1-1 = soil boring (SB) number 46, collected 1 foot below the ground surface, primary sample (1). T4S1S-6 = surface soil sample number 6.

TABLE 7B
SOIL CHEMISTRY RESULTS: POLYNUCLEAR AROMATIC HYDROCARBONS - OU2

REMEDIAL INVESTIGATION
PORT OF PORTLAND - TERMINAL 4 SLIP 1

Sample Location:	Preliminary Screening Levels		T4S1SB-53	T4S1SB-55	T4S1SB-58	T4S1SB-67	T4S1SB-70	T4S1SB-71	T4S1SB-72	T4S1SB-73	T4S1SB-74	T4S1SB-75	T4S1SB-76
Sample ID:			T4S1SB-53-1-1	T4S1SB-55-1-1	T4S1SB-58-1-1	T4S1SB-67-18-1	T4S1SB-70-1-1	T4S1SB-71-1-1	T4S1SB-72-1-1	T4S1SB-73-1-1	T4S1SB-74-1-1	T4S1SB-75-1-1	T4S1SB-76-1-1
Sample Interval:	PRG	SLV	0.5 - 1	1 - 2	1 - 2	18 - 19	1 - 2	1 - 2	1 - 2	0.5 - 1.5	1 - 2	1 - 2	1 - 2
Date Sampled:			8/27/2004	8/31/2004	8/31/2004	9/8/2004	8/26/2004	8/26/2004	8/26/2004	8/26/2004	8/26/2004	8/26/2004	8/26/2004
PAHs (µg/kg)													
Naphthalene	190,000	10,000	3.2 J	1.9 J	0.98 J	2,600 D	330 U	330 U	330 U	330 U	340 U	120 J	330 U
2-Methylnaphthalene	--	--	1.5 J	1 J	0.5 J	140,000 D	330 U	330 U	330 U	330 U	340 U	93 J	330 U
Acenaphthylene	--	--	1.5 J	0.47 J	4.3 U	500 U	330 U	330 U	330 U	330 U	340 U	22 J	330 U
Acenaphthene	29,000,000	20,000	0.28 J	4.4 U	4.3 U	5,500 D	330 U	330 U	330 U	330 U	340 U	330 U	330 U
Fluorene	26,000,000	30,000	0.8 J	0.3 J	0.21 J	10,000 D	330 U	330 U	330 U	330 U	340 U	330 U	330 U
Dibenzofuran	3,100,000	2	0.54 J	0.38 J	0.25 J	2,000 D	330 U	330 U	330 U	330 U	340 U	43 J	330 U
Phenanthrene	--	--	5.2	3.9 J	0.74 J	36,000 D	330 U	330 U	330 U	330 U	340 U	150 J	16 J
Anthracene	100,000,000	--	2.4 J	0.59 J	4.3 U	6,800 D	330 U	330 U	330 U	330 U	340 U	46 J	330 U
Fluoranthene	22,000,000	--	11	4.6	0.81 J	2,000 D	39 J	330 U	330 U	22 J	340 U	250 J	36 J
Pyrene	29,000,000	--	15	4.7	0.93 J	16,000 D	34 J	330 U	330 U	19 J	340 U	200 J	31 J
Benzo(b)fluoranthene	2,100	--	5.7	3.1 J	1.2 J	620 D	30 J	330 U	330 U	330 U	340 U	190 J	22 J
Benzo(k)fluoranthene	21,000	--	8.8	2.2 J	0.81 J	340 J, D	330 U	330 U	330 U	330 U	340 U	150 J	330 U
Benzo(a)anthracene	2,100	--	4.5 J	2.6 J	0.41 J	5,500 D	22 J	330 U	330 U	330 U	340 U	120 J	19 J
Chrysene	210,000	--	9.3	4.2 J	1.3 J	12,000 D	30 J	330 U	330 U	14 J	340 U	240 J	25 J
Benzo(a)pyrene	210	125,000	8	2.1 J	0.7 J	1,700 D	26 J	330 U	330 U	330 U	340 U	150 J	330 U
Indeno(1,2,3-cd)pyrene	2,100	--	9.2	2.3 J	1.1 J	230 J, D	330 U	330 U	330 U	330 U	340 U	170 J	330 U
Dibenz(a,h)anthracene	210	--	1.5 J	0.47 J	0.35 J	240 J, D	330 U	330 U	330 U	330 U	340 U	38 J	330 U
Benzo(g,h,i)perylene	--	--	11	2.6 J	1.4 J	870 D	34 J	330 U	330 U	330 U	340 U	190 J	33 J

Sample Location:	Preliminary Screening Levels		T4S1SB-77	T4S1SB-78	T4S1SB-79	T4S1SB-80	T4S1SB-81	T4S1MW-25	T4S1MW-25	T4S1MW-25
Sample ID:			T4S1SB-77-1-1	T4S1SB-78-1-1	T4S1SB-79-3-1	T4S1SB-80-3-1	T4S1SB-81-3-1	T4S1MW-25-7.5-1	T4S1MW-25-17.5-1	T4S1MW-25-18.5-1
Sample Interval:	PRG	SLV	0.5 - 1	0.5 - 1.5	2.5 - 3.5	2.5 - 3.5	2.5 - 3.5	7.5 - 10	17.5 - 18.5	18.5 - 20
Date Sampled:			8/30/2005	8/30/2005	8/30/2005	8/30/2005	8/30/2005	9/8/2005	9/8/2005	9/8/2005
PAHs (µg/kg)										
Naphthalene	190,000	10,000	330 U	330 U	5	1.3 J	0.84 J	14.6 U	16.0 U	15.9 U
2-Methylnaphthalene	--	--	330 U	330 U	6.6	0.58 J	5 U	--	--	--
Acenaphthylene	--	--	330 U	330 U	0.78 J	5 U	5 U	14.6 U	16.0 U	15.9 U
Acenaphthene	29,000,000	20,000	330 U	330 U	0.46 J	5 U	5 U	14.6 U	16.0 U	15.9 U
Fluorene	26,000,000	30,000	330 U	330 U	0.57 J	5 U	5 U	14.6 U	16.0 U	15.9 U
Dibenzofuran	3,100,000	2	330 U	330 U	2.3 J	0.22 J	5 U	--	--	--
Phenanthrene	--	--	14 J	330 U	11	5 U	5 U	21.9 D	16.0 U	4.93 J, D
Anthracene	100,000,000	--	330 U	330 U	0.92 J	5 U	5 U	6.86 J, D	16.0 U	15.9 U
Fluoranthene	22,000,000	--	19 J	18 J	9.1	0.44 J	0.39 J	32.8 D	16.0 U	8.72 J, D
Pyrene	29,000,000	--	330 U	17 J	11	0.4 J	5 U	37.5 D	16.0 U	12.8 J, D
Benzo(b)fluoranthene	2,100	--	330 U	330 U	5.8	0.54 J	5 U	10.8 J, D	16.0 U	15.9 U
Benzo(k)fluoranthene	21,000	--	330 U	330 U	5.3	5 U	5 U	13.1 J, D	16.0 U	5.02 J, D
Benzo(a)anthracene	2,100	--	330 U	330 U	5.5	0.27 J	5 U	17.9 D	16.0 U	5.86 J, D
Chrysene	210,000	--	330 U	330 U	8.3	5 U	5 U	19.1 D	16.0 U	6.74 J, D
Benzo(a)pyrene	210	125,000	330 U	330 U	6.6	0.26 J	5 U	14.3 J, D	16.0 U	5.75 J, D
Indeno(1,2,3-cd)pyrene	2,100	--	330 U	330 U	6.2	0.28 J	5 U	5.45 J, D	16.0 U	15.9 U
Dibenz(a,h)anthracene	210	--	330 U	330 U	1.1 J	5 U	5 U	14.6 U	16.0 U	15.9 U
Benzo(g,h,i)perylene	--	--	330 U	330 U	7.4	0.31 J	5 U	5.56 J, D	16.0 U	15.9 U

Please refer to notes at end of table.

TABLE 7B
SOIL CHEMISTRY RESULTS: POLYNUCLEAR AROMATIC HYDROCARBONS - OU2

REMEDIAL INVESTIGATION
PORT OF PORTLAND - TERMINAL 4 SLIP 1

Sample Location:	**Preliminary Screening Levels**		**AOC72-S1**	**AOC72-S1**	**AOC72-S2**	**AOC72-S2**	**AOC72-S3**	**AOC72-S3**	**T4S1S-8**	**T4S1S-9**	**T4S1S-10**	**T4S1S-14**	**T4S1S-14B**	**T4S1MW16**
Sample ID:			**AOC72-S1-0.5**	**AOC72-S1-1.5**	**AOC72-S2-0.5**	**AOC72-S2-1.5**	**AOC72-S3-0.5**	**AOC72-S3-1.5**	**T4S1S-8-1**	**T4S1S-9-1**	**T4S1S-10-1**	**T4S1S-14**	**T4S1S-14B**	**MW16-0.5-1**
Sample Interval:	**PRG**	**SLV**	**0.5 - 1.5**	**1.5 - 2.5**	**0.5 - 1.5**	**1.5 - 2.5**	**0.5 - 1.5**	**1.5 - 2.5**	**0 - 0.5**	**0 - 0.5**	**0 - 0.5**	**0 - 0.5**	**0.5 - 1**	**0.5 - 1**
Date Sampled:			**3/8/2004**	**3/8/2004**	**3/8/2004**	**3/8/2004**	**3/8/2004**	**3/8/2004**	**8/27/2004**	**8/27/2004**	**8/27/2004**	**3/22/2005**	**9/8/2005**	**3/29/2004**
PAHs (µg/kg)														
Naphthalene	190,000	10,000	1.3 J	4.8 U	0.24 J	4.8 U	4.7 U	0.34 J	1.9 J	6.5	19	140 D	14.1 U	3.6 J
2-Methylnaphthalene	--	--	1.1 J	4.8 U	4.7 U	4.8 U	4.7 U	4.8 U	0.7 J	2.1 J	5.9	69 D	--	--
Acenaphthylene	--	--	2.0 J	4.8 U	0.36 J	4.8 U	4.7 U	0.25 J	1.3 J	6	10	26 D	14.1 U	3.3 J
Acenaphthene	29,000,000	20,000	0.66 J	4.8 U	4.7 U	4.8 U	4.7 U	4.8 U	0.21 J	0.7 J	2.1 J	1,000 D	27.4 D	0.60 J
Fluorene	26,000,000	30,000	1.7 J	4.8 U	0.20 J	4.8 U	4.7 U	4.8 U	0.31 J	1.1 J	1.9 J	380 D	12.5 J, D	0.56 J
Dibenzofuran	3,100,000	2	0.79 J	4.8 U	4.7 U	4.8 U	4.7 U	4.8 U	0.35 J	0.88 J	1.5 J	200 D	347 U	--
Phenanthrene	--	--	6.6	1.3 J	1.5 J	1.1 J	1.2 J	0.25 J	1.9 J	14	52	6,400 D	183 D	9.5
Anthracene	100,000,000	--	2.9 J	0.63 J	1.4 J	0.75 J	0.62 J	0.33 J	1 J	5.6	13	1100 D	30.9 D	3.2 J
Fluoranthene	22,000,000	--	7.9	1.2 J	2.7 J	0.98 J	1.1 J	0.44 J	7.3	38	270	18,000 D	483 D	30
Pyrene	29,000,000	--	11	1.2 J	2.9 J	0.91 J	1.1 J	0.55 J	10	54	380	16,000 D	437 D	41
Benzo(b)fluoranthene	2,100	--	3.7 J	0.16 J	2.3 J	4.8 U	4.7 U	0.42 J	7.7	40	200	17,000 D	476 D	26
Benzo(k)fluoranthene	21,000	--	5.3	0.19 J	1.5 J	0.18 J	0.22 J	0.40 J	6.4	37	170	12,000 D	438 D	25
Benzo(a)anthracene	2,100	--	4.2 J	0.45 J	1.3 J	4.8 U	0.22 J	0.21 J	5.8	26	180	10,000 D	315 D	17
Chrysene	210,000	--	6.3	0.38 J	1.9 J	0.21 J	0.31 J	0.41 J	7	36	250	13,000 D	388 D	25
Benzo(a)pyrene	210	125,000	4.5 J	0.26 J	0.8 J	0.23 J	0.23 J	0.19 J	10	55	270	16,000 D	455 D	37
Indeno(1,2,3-cd)pyrene	2,100	--	3.7 J	4.8 U	0.90 J	4.8 U	4.7 U	0.28 J	10	63	240	15,000 D	209 D	51
Dibenz(a,h)anthracene	210	--	0.44 J	4.8 U	4.7 U	4.8 U	4.7 U	4.8 U	1.5 J	7.9	35	2,900 D	76.9 D	7.4
Benzo(g,h,i)perylene	--	--	4.9 J	0.15 J	1.1 J	0.21 J	4.7 U	0.49 J	13	79	270	13,000 D	210 D	64

Sample Location:	**Preliminary Screening Levels**		**T4S1S-23**	**T4S1S-24**	**T4S1S-25**	**T4S1S-26**	**T4S1S-26A**	**T4S1S-26B**	**T4S1S-26C**	**T4S1S-26D**	**T4S1S-27**	**T4S1S-27A**	**T4S1S-27B**
Sample ID:			**T4S1S-23**	**T4S1S-24**	**T4S1S-25**	**T4S1S-26**	**T4S1S-26A**	**T4S1S-26B**	**T4S1S-26C**	**T4S1S-26D**	**T4S1S-27**	**T4S1S-27A**	**T4S1S-27B**
Sample Interval:	**PRG**	**SLV**	**0 - 1**	**0 - 1**	**0 - 1**	**0 - 1**	**0 - 1**	**0 - 1**	**0 - 1**	**0 - 1**	**0 - 1**	**0 - 1**	**0 - 1**
Date Sampled:			**9/12/2005**	**9/12/2005**	**9/12/2005**	**9/13/2005**	**9/13/2005**	**9/13/2005**	**9/13/2005**	**9/13/2005**	**9/13/2005**	**9/13/2005**	**9/13/2005**
PAHs (µg/kg)													
Naphthalene	190,000	10,000	14.2 U	14.3 U	15.8 U	30.3 J, D	13.6 U	5.55 J, D	13.9 U	83.2 D	69.2 D	269 D	13.6 U
2-Methylnaphthalene	--	--	--	--	--	--	--	--	--	--	--	--	--
Acenaphthylene	--	--	4.74 J, D	14.3 U	15.8 U	35.7 J, D	13.6 U	48.8 D	13.9 U	108 D	18.7 J, D	114 D	13.6 U
Acenaphthene	29,000,000	20,000	14.2 U	14.3 U	15.8 U	70.1 U	13.6 U	27.1 D	13.9 U	77.3 U	97.4 D	375 D	9.59 J, D
Fluorene	26,000,000	30,000	14.2 U	14.3 U	15.8 U	70.1 U	13.6 U	28.7 D	13.9 U	77.3 U	48.0 J, D	207 D	7.51 J, D
Dibenzofuran	3,100,000	2	--	--	--	--	--	--	--	--	--	--	--
Phenanthrene	--	--	10.9 J, D	9.65 J, D	37.7 D	234 D	23.2 D	361 D	25.4 D	443 D	376 D	1,680 D	141 D
Anthracene	100,000,000	--	17.6 D	14.3 U	6.51 J, D	57.0 J, D	3.40 J, D	206 D	3.63 J, D	99.6 D	93.5 D	471 D	19.7 D
Fluoranthene	22,000,000	--	28.9 D	26.5 D	104 D	962 D	87.5 D	7,990 D	95.4 D	1,640 D	986 D	4,650 D	511 D
Pyrene	29,000,000	--	22.3 D	19.5 D	75.1 D	883 D	83.6 D	7,220 D	86.7 D	1,750 D	722 D	3,440 D	402 D
Benzo(b)fluoranthene	2,100	--	59.6 D	21.3 D	102 D	874 D	89.4 D	2,270 D	94.0 D	1,500 D	916 D	3,690 D	485 D
Benzo(k)fluoranthene	21,000	--	37.9 D	17.2 D	58.8 D	597 D	84.8 D	2,070 D	90.2 D	1,300 D	583 D	3,240 D	409 D
Benzo(a)anthracene	2,100	--	30.8 D	15.1 D	62.3 D	581 D	62.5 D	2,380 D	68.0 D	1,110 D	597 D	2,700 D	320 D
Chrysene	210,000	--	77.4 D	17.9 D	70.7 D	898 D	79.2 D	4,170 D	87.3 D	1,590 D	705 D	3,590 D	393 D
Benzo(a)pyrene	210	125,000	48.1 D	20.9 D	89.1 D	776 D	92.4 D	1,460 D	97.4 D	1,830 D	786 D	3,560 D	445 D
Indeno(1,2,3-cd)pyrene	2,100	--	46.4 D	15.4 D	62.8 D	514 D	55.4 D	433 D	54.8 D	790 D	581 D	2,280 D	181 D
Dibenz(a,h)anthracene	210	--	14.9 D	4.79 J, D	20.5 D	151 D	17.9 D	160 D	17.7 D	183 D	194 D	795 D	64.2 D
Benzo(g,h,i)perylene	--	--	50.9 D	17.5 D	70.2 D	611 D	61.4 D	358 D	60.1 D	926 D	655 D	2,560 D	181 D

Please refer to notes at end of table.

TABLE 7B
SOIL CHEMISTRY RESULTS: POLYNUCLEAR AROMATIC HYDROCARBONS - OU2

REMEDIAL INVESTIGATION
PORT OF PORTLAND - TERMINAL 4 SLIP 1

Sample Location:	**Preliminary Screening Levels**		**T4S1S-27C**	**T4S1S-27D**	**T4S1S-28**	**T4S1S-28A**	**T4S1S-28B**	**T4S1S-28C**	**T4S1S-28D**	**T4S1S-29**	**T4S1S-30**	**T4S1S-30A**	**T4S1S-30C**	**T4S1S-30D**
Sample ID:	**PRG**	**SLV**	**T4S1S-27C**	**T4S1S-27D**	**T4S1S-28**	**T4S1S-28A**	**T4S1S-28B**	**T4S1S-28C**	**T4S1S-28D**	**T4S1S-29**	**T4S1S-30**	**T4S1S-30A**	**T4S1S-30C**	**T4S1S-30D**
Sample Interval:			**0 - 1**	**0 - 1**	**0 - 1**	**0 - 1**	**0 - 1**	**0 - 1**	**0 - 1**	**0 - 1**	**0 - 1**	**0 - 1**	**0 - 1**	**0 - 1**
Date Sampled:			**9/13/2005**	**9/13/2005**	**9/13/2005**	**9/13/2005**	**9/13/2005**	**9/13/2005**	**9/13/2005**	**9/13/2005**	**9/13/2005**	**9/13/2005**	**9/13/2005**	**9/13/2005**
PAHs (µg/kg)														
Naphthalene	190,000	10,000	54.7 U	54.5 U	28.3 J, D	107 D	55.2 U	13.8 U	68.4 U	388 D	39.5 J, D	344 U	33.2 J, D	6,480 D
2-Methylnaphthalene	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Acenaphthylene	--	--	54.7 U	54.5 U	67.6 U	18.2 J, D	55.2 U	13.8 U	68.4 U	176 D	69.2 U	344 U	55.2 U	347 U
Acenaphthene	29,000,000	20,000	54.7 U	54.5 U	151 D	843 D	55.2 U	13.8 U	68.4 U	164 J, D	183 D	295 J, D	171 D	1,180 D
Fluorene	26,000,000	30,000	54.7 U	54.5 U	114 D	825 D	55.2 U	13.8 U	68.4 U	116 J, D	72.5 D	105 J, D	70.3 D	1,240 D
Dibenzofuran	3,100,000	2	--	--	--	--	--	--	--	--	--	--	--	--
Phenanthrene	--	--	28.5 J, D	35.0 J, D	1,040 D	6,300 D	29.8 J, D	22.4 D	137 D	1,710 D	972 D	1,630 D	873 D	1,830 D
Anthracene	100,000,000	--	54.7 U	54.5 U	166 D	717 D	55.2 U	13.8 U	24.8 J, D	314 D	173 D	251 J, D	162 D	520 U
Fluoranthene	22,000,000	--	88.1 D	113 D	2,390 D	11,300 D	93.5 D	80.1 D	400 D	5,780 D	2,650 D	4,340 D	2,110 D	139 J, D
Pyrene	29,000,000	--	94.2 D	105 D	1,640 D	8,280 D	85.7 D	63.1 D	379 D	5,490 D	1,870 D	3,610 D	1,770 D	147 D
Benzo(b)fluoranthene	2,100	--	91.0 D	107 D	2,020 D	8,010 D	87.7 D	85.4 D	378 D	4,440 D	2,300 D	3,560 D	1,690 D	7.49 J, D
Benzo(k)fluoranthene	21,000	--	88.6 D	101 D	1,230 D	7,260 D	80.7 D	64.0 D	331 D	3,660 D	1,270 D	3,240 D	1,620 D	5.34 J, D
Benzo(a)anthracene	2,100	--	62.9 D	74.4 D	1,390 D	6,580 D	61.6 D	48.4 D	263 D	3,610 D	1,590 D	2,810 D	1,500 D	16.4 D
Chrysene	210,000	--	83.2 D	98.7 D	1,650 D	8,190 D	83.4 D	64.0 D	357 D	4,510 D	1,850 D	3,600 D	1,720 D	24.3 D
Benzo(a)pyrene	210	125,000	104 D	110 D	1,660 D	7,790 D	85.1 D	74.5 D	376 D	4,920 D	1,880 D	3,610 D	1,840 D	8.08 J, D
Indeno(1,2,3-cd)pyrene	2,100	--	60.6 D	61.4 D	1,130 D	4,460 D	49.1 J, D	30.5 D	247 D	3,500 D	1,220 D	1,950 D	950 D	13.9 U
Dibenz(a,h)anthracene	210	--	18.2 J, D	20.4 J, D	394 D	1,530 D	16.7 J, D	10.9 J, D	73.3 D	1,060 D	427 D	662 D	322 D	13.9 U
Benzo(g,h,i)perylene	--	--	74.4 D	68.3 D	1,240 D	4,770 D	56.3 D	30.5 D	290 D	4,160 D	1,280 D	2,160 D	997 D	13.9 U

Notes:

1. Only detected compounds are reported in the table. The complete analyte list is presented in the Sampling and Analysis Plan (Appendix A) of the RI Work Plan (Hart Crowser, 2004a).
2. PAHs = Polynuclear Aromatic Hydrocarbons by EPA Method 8270C (SIM).
3. µg/kg = Micrograms per kilogram.
4. PRG = EPA Region 9 Preliminary Remediation Goal (PRG) for Industrial Soil (October 2004).
5. -- = No screening level available or not analyzed.
6. J = The result is an estimated concentration that is less than the method reporting limit (MRL) but greater than or equal to the method detection limit (MDL).
7. U = The compound was analyzed for but was not detected at or above the MRL/MDL.
8. D = Dilution.
9. Shaded values indicate that the detected concentration exceeds the PRG.
10. Sample ID nomenclature is per the following: type of sample-sample number-depth in feet-designation.
    For example T4S1SB-46-1-1 = soil boring (SB) number 46, collected 1 foot below the ground surface, primary sample (1). T4S1S-6 = surface soil sample number 6.
11. SLV = Oregon Department of Environmental Quality Level II Screening Level Values (SLVs) for Terrestrial Receptors (lowest available value).
12. Boxed values indicate that the detected concentration exceeds the SLV (only samples from 0 to 3 feet were screened against the SLV).

TABLE 8B
SOIL CHEMISTRY RESULTS: SEMI-VOLATILE ORGANIC COMPOUNDS (EXCEPT PAHs) - OU2

REMEDIAL INVESTIGATION
PORT OF PORTLAND - TERMINAL 4 SLIP 1

Sample Location:	**Preliminary Screening Levels**		**T4S1SB-70**	**T4S1SB-71**	**T4S1SB-72**	**T4S1SB-73**	**T4S1SB-74**	**T4S1SB-75**	**T4S1SB-76**	**T4S1SB-77**	**T4S1SB-78**
Sample ID:			**T4S1SB-70-1-1**	**T4S1SB-71-1-1**	**T4S1SB-72-1-1**	**T4S1SB-73-1-1**	**T4S1SB-74-1-1**	**T4S1SB-75-1-1**	**T4S1SB-76-1-1**	**T4S1SB-77-1-1**	**T4S1SB-78-1-1**
Sample Interval:	**PRG**	**SLV**	**1 - 2**	**1 - 2**	**1 - 2**	**0.5 - 1.5**	**1 - 2**	**1 - 2**	**1 - 2**	**0.5 - 1**	**0.5 - 1.5**
Date Sampled:			**8/26/2004**	**8/26/2004**	**8/26/2004**	**8/26/2004**	**8/26/2004**	**8/26/2004**	**8/26/2004**	**8/30/2005**	**8/30/2005**
SVOCs (µg/kg)											
Phenol	100,000,000	30,000	330 U	330 U	330 U	330 U	340 U	330 U	330 U	330 U	330 U
Di-n-butyl Phthalate	62,000,000	450	330 U	330 U	330 U	330 U	340 U	330 U	330 U	330 U	330 U
Bis(2-ethylhexyl) Phthalate	120,000	4,500	330 U	47 J	330 U	330 U	340 U	330 U	330 U	330 U	330 U

Sample Location:	**Preliminary Screening Levels**		**T4S1S-23**	**T4S1S-24**	**T4S1S-25**	**T4S1S-26**	**T4S1S-27**	**T4S1S-28**	**T4S1S-29**	**T4S1S-30**
Sample ID:			**T4S1S-23**	**T4S1S-24**	**T4S1S-25**	**T4S1S-26**	**T4S1S-27**	**T4S1S-28**	**T4S1S-29**	**T4S1S-30**
Sample Interval:	**PRG**	**SLV**	**0 - 1**	**0 - 1**	**0 - 1**	**0 - 1**	**0 - 1**	**0 - 1**	**0 - 1**	**0 - 1**
Date Sampled:			**9/12/2005**	**9/12/2005**	**9/12/2005**	**9/13/2005**	**9/13/2005**	**9/13/2005**	**9/13/2005**	**9/13/2005**
SVOCs (µg/kg)										
Phenol	100,000,000	30,000	--	--	--	--	--	--	--	--
Di-n-butyl Phthalate	62,000,000	450	14.2 U	14.4 U	15.9 U	27.9 U	27.0 U	27.2 U	54.8 U	27.7 U
Bis(2-ethylhexyl) Phthalate	120,000	4,500	14.2 U	14.4 U	17.6 D	27.9 U	27.0 U	27.2 U	54.8 U	27.7 U

Notes:

1. Only detected compounds are reported in the table. The complete analyte list is presented in the Sampling and Analysis Plan (Appendix A) of the RI Work Plan (Hart Crowser, 2004a).
2. SVOCs = Semi-Volatile Organic Compounds by EPA Method 8270C.
3. µg/kg = Micrograms per kilogram.
4. PRG = EPA Region 9 Preliminary Remediation Goal (PRG) for Industrial Soil (October 2004).
5. -- = No screening level available or not analyzed.
6. J = The result is an estimated concentration that is less than the method reporting limit (MRL) but greater than or equal to the method detection limit (MDL).
7. U = The compound was analyzed for but was not detected at or above the MRL/MDL.
8. Sample ID nomenclature is per the following: type of sample-sample number-depth in feet-designation.
   For example T4S1SB-46-1-1 = soil boring (SB) number 46, collected 1 foot below the ground surface, primary sample (1). T4S1S-6 = surface soil sample number 6.
9. SLV = Oregon Department of Environmental Quality Level II Screening Level Values (SLVs) for Terrestrial Receptors (lowest available value).

TABLE 9B
SOIL CHEMISTRY RESULTS: VOLATILE ORGANIC COMPOUNDS - OU2

REMEDIAL INVESTIGATION
PORT OF PORTLAND - TERMINAL 4 SLIP 1

Sample Location:	Preliminary Screening Levels		T4S1SB-51	T4S1SB-53	T4S1SB-55	T4S1SB-58	T4S1SB-67	T4S1SB-70	T4S1SB-71	T4S1SB-72	T4S1SB-73	T4S1SB-74
Sample ID:			T4S1SB-51-2.5-1	T4S1SB-53-1-1	T4S1SB-55-1-1	T4S1SB-58-1-1	T4S1SB-67-18-1	T4S1SB-70-1-1	T4S1SB-71-1-1	T4S1SB-72-1-1	T4S1SB-73-1-1	T4S1SB-74-1-1
Sample Interval:	PRG	SLV	2 - 2.5	0.5 - 1	1 - 2	1 - 2	18 - 19	1 - 2	1 - 2	1 - 2	0.5 - 1.5	1 - 2
Date Sampled:			8/27/2004	8/27/2004	8/31/2004	8/31/2004	9/8/2004	8/26/2004	8/26/2004	8/26/2004	8/26/2004	8/26/2004
VOCs (µg/kg)												
Acetone	54,000,000	1,250,000	96	12 J	21 U	21 U	250	24 U	20 J	26 U	23 U	22 U
Carbon Disulfide	720,000	--	5.6 U	5.5 U	5.2 U	5.2 U	27 U	6 U	5.7 U	6.5 U	5.6 U	5.4 U
Dichloromethane (Methylene Chloride)	21,000	730,000	8.8 J	8.3 J	11 U	11 U	87	26	14	3.6 J	3.2 J	5.9 J
2-Butanone (MEK)	110,000,000	200,000,000	12 J	22 U	21 U	21 U	110 U	24 U	23 U	26 U	23 U	22 U
Chloroform	470	1,875,000	5.6 U	5.5 U	5.2 U	5.2 U	27 U	6 U	5.7 U	6.5 U	5.6 U	5.4 U
Carbon Tetrachloride	550	1,000,000	5.6 U	5.5 U	5.2 U	5.2 U	27 U	6 U	5.7 U	6.5 U	5.6 U	5.4 U
Benzene	1,400	3,300,000	5.6 U	5.5 U	5.2 U	5.2 U	130	6 U	5.7 U	6.5 U	5.6 U	5.4 U
Trichloroethene (TCE)	110	40,000	5.6 U	5.5 U	5.2 U	5.2 U	27 U	6 U	5.7 U	6.5 U	5.6 U	5.4 U
Toluene	520,000	200,000	5.6 U	5.5 U	5.2 U	5.2 U	58	6 U	5.7 U	6.5 U	5.6 U	5.4 U
Tetrachloroethene (PCE)	1,300	10,000	5.6 U	5.5 U	5.2 U	5.2 U	4.8 J	6 U	5.7 U	6.5 U	5.6 U	5.4 U
Chlorobenzene	530,000	40,000	5.6 U	5.5 U	5.2 U	5.2 U	27 U	6 U	5.7 U	6.5 U	5.6 U	5.4 U
Ethylbenzene	400,000	--	5.6 U	5.5 U	5.2 U	5.2 U	790	6 U	5.7 U	6.5 U	5.6 U	5.4 U
m,p-Xylenes	420,000	--	5.6 U	5.5 U	5.2 U	5.2 U	560	6 U	5.7 U	6.5 U	5.6 U	5.4 U
o-Xylene	420,000	1,000	5.6 U	5.5 U	5.2 U	5.2 U	2.6	6 U	5.7 U	6.5 U	5.6 U	5.4 U
Isopropylbenzene	2,000,000	--	23 U	22 U	21 U	21 U	290	24 U	23 U	26 U	23 U	22 U
n-Propylbenzene	240,000	--	23 U	22 U	21 U	21 U	1.8	24 U	23 U	26 U	23 U	22 U
1,2,3-Trichlorobenzene	--		1.1 U	0.99 U	0.95 U	0.95 U	0.037 U	1.1 U	1.1 U	1.2 U	1.1 U	0.97 U
1,3,5-Trimethylbenzene	70,000	--	23 U	22 U	21 U	21 U	1.3	24 U	23 U	26 U	23 U	22 U
1,2,4-Trimethylbenzene	220,000	--	23 U	22 U	21 U	21 U	2.6	24 U	23 U	26 U	23 U	22 U
sec-Butylbenzene	220,000	--	23 U	22 U	21 U	21 U	0.87	24 U	23 U	26 U	23 U	22 U
4-Isopropyltoluene	--	--	23 U	22 U	21 U	21 U	1.8	24 U	23 U	26 U	23 U	22 U
1,4-Dichlorobenzene	7,900	20,000	5.6 U	5.5 U	5.2 U	5.2 U	0.054 U	6 U	5.7 U	6.5 U	5.6 U	5.4 U
n-Butylbenzene	240,000	--	23 U	22 U	21 U	21 U	3	24 U	23 U	26 U	23 U	22 U
Hexachlorobutadiene	220,000	--	23 U	22 U	21 U	21 U	--	24 U	23 U	26 U	23 U	22 U
Naphthalene	190,000	10,000	23 U	22 U	21 U	21 U	1	24 U	23 U	26 U	23 U	22 U

Sample Location:	Preliminary Screening Levels		T4S1SB-75	T4S1SB-76	T4S1SB-77	T4S1SB-78	T4S1SB-79	T4S1SB-80	T4S1SB-81	AOC72-S1	AOC72-S3	T4S1S-23D
Sample ID:			T4S1SB-75-1-1	T4S1SB-76-1-1	T4S1SB-77-3-1	T4S1SB-78-3-1	T4S1SB-79-3-1	T4S1SB-80-3-1	T4S1SB-81-3-1	AOC72-S1-1.5	AOC72-S3-1.5	T4S1S-23D
Sample Interval:	PRG	SLV	1 - 2	1 - 2	1.5 - 3	2.5 - 3	2.5 - 3.5	2.5 - 3.5	2.5 - 3.5	1.5 - 2.5	1.5 - 2.5	0 - 1
Date Sampled:			8/26/2004	38225	8/30/2004	8/30/2004	8/30/2004	8/30/2004	8/30/2004	3/8/2004	3/8/2004	9/12/2005
VOCs (µg/kg)												
Acetone	54,000,000	1,250,000	22 U	24 U	21 U	21 U	22 U	21 U	20 U	22 U	22 U	2,650 U
Carbon Disulfide	720,000	--	5.5 U	5.9 U	5.1 U	5.2 U	5.4 U	5.2 U	4.9 U	5.5 U	5.3 U	1,060 U
Dichloromethane (Methylene Chloride)	21,000	730,000	5 J	3.4 J	3.1 J	3.3 J	7.5 J	3.7 J	3.5 J	11 U	11 U	529 U, D
2-Butanone (MEK)	110,000,000	200,000,000	22 U	24 U	21 U	21 U	22 U	21 U	20 U	22 U	22 U	1,060 U
Chloroform	470	1,875,000	5.5 U	5.9 U	5.1 U	5.2 U	5.4 U	5.2 U	4.9 U	5.5 U	5.3 U	106 U
Carbon Tetrachloride	550	1,000,000	5.5 U	5.9 U	5.1 U	5.2 U	5.4 U	5.2 U	4.9 U	5.5 U	5.3 U	106 U
Benzene	1,400	3,300,000	5.5 U	5.9 U	5.1 U	5.2 U	5.4 U	5.2 U	4.9 U	5.5 U	5.3 U	106 U
Trichloroethene (TCE)	110	40,000	5.5 U	5.9 U	5.1 U	5.2 U	5.4 U	5.2 U	4.9 U	5.5 U	5.3 U	106 U
Toluene	520,000	200,000	5.5 U	5.9 U	5.1 U	5.2 U	5.4 U	5.2 U	4.9 U	5.5 U	5.3 U	106 U
Tetrachloroethene (PCE)	1,300	10,000	5.5 U	5.9 U	5.1 U	5.2 U	5.4 U	5.2 U	4.9 U	5.5 U	5.3 U	106 U
Chlorobenzene	530,000	40,000	5.5 U	5.9 U	5.1 U	5.2 U	5.4 U	5.2 U	4.9 U	5.5 U	5.3 U	106 U
Ethylbenzene	400,000	--	5.5 U	5.9 U	5.1 U	5.2 U	5.4 U	5.2 U	4.9 U	5.5 U	5.3 U	106 U
m,p-Xylenes	420,000	--	5.5 U	5.9 U	5.1 U	5.2 U	5.4 U	5.2 U	4.9 U	5.5 U	5.3 U	212 U, D
o-Xylene	420,000	1,000	5.5 U	5.9 U	5.1 U	5.2 U	5.4 U	5.2 U	4.9 U	5.5 U	5.3 U	106 U
Isopropylbenzene	2,000,000	--	22 U	24 U	21 U	21 U	22 U	21 U	20 U	22 U	22 U	212 U
n-Propylbenzene	240,000	--	22 U	24 U	21 U	21 U	22 U	21 U	20 U	22 U	22 U	106 U
1,2,3-Trichlorobenzene	--		1.0 U	1.1 U	0.97 U	0.95 U	0.98 U	0.95 U	0.96 U	1.0 U	0.97 U	83.6 J, D
1,3,5-Trimethylbenzene	70,000	--	22 U	24 U	21 U	21 U	22 U	21 U	20 U	22 U	22 U	106 U
1,2,4-Trimethylbenzene	220,000	--	22 U	24 U	21 U	21 U	22 U	21 U	20 U	22 U	22 U	106 U
sec-Butylbenzene	220,000	--	22 U	24 U	21 U	21 U	22 U	21 U	20 U	22 U	22 U	22.2 J, D
4-Isopropyltoluene	--	--	22 U	24 U	21 U	21 U	22 U	21 U	20 U	22 U	22 U	21.2 J, D
1,4-Dichlorobenzene	7,900	20,000	5.5 U	5.9 U	5.1 U	5.2 U	5.4 U	5.2 U	4.9 U	5.5 U	5.3 U	106 U
n-Butylbenzene	240,000	--	22 U	24 U	21 U	21 U	22 U	21 U	20 U	22 U	22 U	43.4 J, D
Hexachlorobutadiene	220,000		22 U	24 U	21 U	21 U	22 U	21 U	20 U	22 U	22 U	226 J, D
Naphthalene	190,000	10,000	22 U	24 U	1.9 J	1.2 J	22 U	21 U	20 U	22 U	22 U	212 U

Notes:

1. Only detected compounds are reported in the table. The complete analyte list is presented in the Sampling and Analysis Plan (Appendix A) of the RI Work Plan (Hart Crowser, 2004a)
2. VOCs = Volatile Organic Compounds by EPA Method 8260B
3. µg/kg = Micrograms per kilogram.
4. PRG = EPA Region 9 Preliminary Remediation Goal (PRG) for Industrial Soil (October 2004)
5. -- = No screening level available or not analyzed
6. J = The result is an estimated concentration that is less than the method reporting limit (MRL) but greater than or equal to the method detection limit (MDL
7. U = The compound was analyzed for but was not detected at or above the MRL/MDL
8. Sample ID nomenclature is per the following: type of sample-sample number-depth in feet-designation.
   For example T4S1SB-46-1-1 = soil boring (SB) number 46, collected 1 foot below the ground surface, primary sample (1). T4S1S-6 = surface soil sample number
9. SLV = Oregon Department of Environmental Quality Level II Screening Level Values (SLVs) for Terrestrial Receptors (lowest available value

TABLE 12B
SOIL CHEMISTRY RESULTS: METALS - OU2

REMEDIAL INVESTIGATION
PORT OF PORTLAND - TERMINAL 4 SLIP 1

Sample Location:	Preliminary Screening Levels			T4S1SB-07	T4S1SB-08	T4S1SB-53	T4S1SB-55	T4S1SB-58	T4S1SB-61	T4S1SB-62	T4S1SB-67
Sample ID:				SB07-2.0-1	SB08-2.0-1	T4S1SB-53-1-1	T4S1SB-55-1-1	T4S1SB-58-1-1	T4S1SB-61-0-1	T4S1SB-62-0-1	T4S1SB-67-18-1
Sample Interval:	Background	PRG	SLV	2 - 2.5	2 - 2.5	0.5 - 1	1 - 2	1 - 2	0.5 - 2	0.5 - 1.5	18 - 19
Date Sampled:				03/30/2004	03/31/2004	8/27/2004	8/31/2004	8/31/2004	9/9/2004	9/9/2004	9/8/2004
Metals (mg/kg)											
Antimony	5	410	5	0.06	0.06	0.38 N	0.1 N	0.07 N	0.19 N	0.4 N	0.06 N
Arsenic	5.8	1.6	10	2.6	2.6	2.65	2.61	2.29	1.12	1.58	2.32
Beryllium	2.1	1,900	10	0.308	0.286	0.314	0.452	0.322	0.373	0.385	0.301
Cadmium	0.9	450	4	0.09	0.1	0.817	0.456	0.07	0.361	0.706	0.061
Chromium	26	450	0.4	9.76	11.4	18.3	15.9	15.3	9.52	9.26	17
Copper	34	41,000	50	12.4	12.5	17.4	15.9	12.2	15.5	18.1	12
Lead	17	800	16	2.35	2.94	89.8 *	4.86 *	2.76 *	43.8	85.1	2.69
Mercury	0.04	310	0.1	0.02	0.02	0.042	0.012 B	0.017 U	0.012 B	0.048	0.019 U
Nickel	21	20,000	30	14.6	14.4	23.4	20	15.4	4.2 U	6.7	20.4
Selenium	0.8	5,100	1	1.1 U	1.1 U	0.3 B	0.2 B	0.3 B	0.4 B	0.5 B	0.3 B
Silver	0.6	5,100	2	0.02 U	0.02 U	0.234	0.021	0.017 B	0.089	0.305	0.025
Thallium	<5	67	1	0.051	0.048	0.059	0.044	0.044	0.08	0.089	0.046
Zinc	95	100,000	50	34.5	35.3	170	191	51.4	116	258	50.4

Sample Location:	Preliminary Screening Levels			T4S1SB-70	T4S1SB-71	T4S1SB-72	T4S1SB-73	T4S1SB-74	T4S1SB-75	T4S1SB-76
Sample ID:				T4S1SB-70-1-1	T4S1SB-71-1-1	T4S1SB-72-1-1	T4S1SB-73-1-1	T4S1SB-74-1-1	T4S1SB-75-1-1	T4S1SB-76-1-1
Sample Interval:	Background	PRG	SLV	1 - 2	1 - 2	1 - 2	0.5 - 1.5	1 - 2	1 - 2	1 - 2
Date Sampled:				08/26/2004	8/26/2004	8/26/2004	8/26/2004	8/26/2004	8/26/2004	8/26/2004
Metals (mg/kg)										
Antimony	5	410	5	0.19 N	0.07 N	0.11 N	0.12 N	0.16 N	0.89 N	0.17 N
Arsenic	5.8	1.6	10	5	2.48	1.75	2.51	2.1	12.8	2.52
Beryllium	2.1	1,900	10	0.277	0.278	0.37	0.298	0.26	0.344	0.328
Cadmium	0.9	450	4	0.122	0.07	1.65	0.166	0.073	3.74	0.299
Chromium	26	450	0.4	18	14.6	21.5	16.4	17.4	14.4	24.7
Copper	34	41,000	50	17	12.8	16.9	13.8	12.9	25.1	18.2
Lead	17	800	16	9.05	2.7	5.97	10	3.09	322	12.7
Mercury	0.04	310	0.1	0.011 B	0.009 B	0.016 B	0.011 B	0.037	0.041	0.018 B
Nickel	21	20,000	30	21.7	16.8	28	20	22.8	19.3	26.6
Selenium	0.8	5,100	1	0.2 B	0.2 B	0.3 B	0.2 B	0.3 B	0.3 B	0.4 B
Silver	0.6	5,100	2	0.052	0.017 B	0.037	0.047	0.019 B	0.419	0.065
Thallium	<5	67	1	0.05	0.048	0.058	0.048	0.061	0.083	0.06
Zinc	95	100,000	50	63.2	49.5	514	60	51.4	320	101

Sample Location:	Preliminary Screening Levels			T4S1SB-77	T4S1SB-77	T4S1SB-77	T4S1SB-78	T4S1SB-79	T4S1SB-80	T4S1SB-81
Sample ID:				T4S1SB-77-0.5-1	T4S1SB-77-1-1	T4S1SB-77-2-1	T4S1SB-78-1-1	T4S1SB-79-3-1	T4S1SB-80-3-1	T4S1SB-81-3-1
Sample Interval:	Background	PRG	SLV	0.5 - 1	1 - 1.5	2 - 2.5	0.5 - 1.5	2.5 - 3.5	2.5 - 3.5	2.5 - 3.5
Date Sampled:				9/8/2005	8/30/2004	9/8/2005	08/30/2004	8/30/2004	8/30/2004	8/30/2004
Metals (mg/kg)										
Antimony	5	410	5	--	0.3 N	--	0.11 N	0.12 N	0.09 N	0.11 N
Arsenic	5.8	1.6	10	--	2.85	--	3.66	2.77	2.67	2.17
Beryllium	2.1	1,900	10	--	0.336	--	0.297	0.316	0.265	0.27
Cadmium	0.9	450	4	--	0.123	--	0.122	0.125	0.066	0.071
Chromium	26	450	0.4	--	18.9	--	17.2	15.9	14.8	18.2
Copper	34	41,000	50	--	21.6	--	23.1	15.7	13.1	13.8
Lead	17	800	16	189	1,060 *	37.1	43 *	10.4 *	2.24 *	2.43 *
Mercury	0.04	310	0.1	--	0.067	--	0.017	0.014	0.01 B	0.009 B
Nickel	21	20,000	30	--	23.7	--	46.7	16.8	17.2	21
Selenium	0.8	5,100	1	--	0.4 B	--	2.4	0.3 B	0.2 B	0.3 B
Silver	0.6	5,100	2	--	0.037	--	0.049	0.072	0.019 B	0.019 B
Thallium	<5	67	1	--	0.068	--	0.071	0.065	0.049	0.047
Zinc	95	100,000	50	--	70.6	--	63.3	68.2	47.7	52.5

Please refer to notes at end of table.

TABLE 12B
SOIL CHEMISTRY RESULTS: METALS - OU2

REMEDIAL INVESTIGATION
PORT OF PORTLAND - TERMINAL 4 SLIP 1

Sample Location:	Preliminary Screening Levels			AOC72-S1	AOC72-S1	AOC72-S2	AOC72-S2	AOC72-S3	AOC72-S3	T4S1MW11	T4S1MW12
Sample ID:	Background	PRG	SLV	AOC72-S1-0.5	AOC72-S1-1.5	AOC72-S2-0.5	AOC72-S2-1.5	AOC72-S3-0.5	AOC72-S3-1.5	MW11-0.5-1	MW12-2.0-1
Sample Interval:				0.5 - 1	1.5 - 2.5	0.5 - 1	1.5 - 2.5	0.5 - 1	1.5 - 2.5	0.5 - 1	2 - 2.5
Date Sampled:				03/08/2004	03/08/2004	03/08/2004	03/08/2004	03/08/2004	03/08/2004	03/30/2004	03/30/2004
Metals (mg/kg)											
Antimony	5	410	5	0.12 N	0.03 B	0.07 N	0.05 B	0.06 N	0.03 UJ	0.12	0.07
Arsenic	5.8	1.6	10	4.7	1.7	1.9	1.9	2	1.8	2.1	3
Beryllium	2.1	1,900	10	0.455	0.317	0.255	0.359	0.296	0.258	0.304	0.36
Cadmium	0.9	450	4	0.185	0.155	0.266	0.217	0.16	0.148	0.12	0.12
Chromium	26	450	0.4	10.8	5.92	5.26	6.50	8.23	6.06	8.66	12.6
Copper	34	41,000	50	21	18.6	18.3	20.8	17.9	16.6	11.6	14.6
Lead	17	800	16	11	2.85	5.25	3.05	3.02	2.46	6.03	2.95
Mercury	0.04	310	0.1	0.015 B	0.009 U	0.010 U	0.009 U	0.009 U	0.010 U	0.01	0.01
Nickel	21	20,000	30	12.3	9.32	9.49	10.8	9.86	9.79	13.9	16.1
Selenium	0.8	5,100	1	0.09 B	0.06 B	0.10 B	0.07 B	0.03 U	0.02 U	1.1 U	1.1 U
Silver	0.6	5,100	2	0.051	0.030	0.040	0.03	0.030	0.028	0.03	0.02
Thallium	<5	67	1	0.103 U	0.065	0.061 U	0.064	0.068	0.052	0.048	0.053
Zinc	95	100,000	50	50.6	42.6	53.3	44.8	45.6	41.1	35.2	42.1

Sample Location:	Preliminary Screening Levels			T4S1MW13	T4S1MW15	T4S1MW16	T4S1S-20	T4S1S-21	T4S1S-22
Sample ID:	Background	PRG	SLV	MW13-2.5-1	MW15-0.5-1	MW16-0.5-1	T4S1S-20-0.5-1	T4S1S-21-0.5-1	T4S1S-22-0.5-1
Sample Interval:				2.5 - 3	0.5 - 1	0.5 - 1	0.5 - 1	0.5 - 1	0.5 - 1
Date Sampled:				04/01/2004	03/29/2004	03/29/2004	9/8/2005	9/8/2005	9/8/2005
Metals (mg/kg)									
Antimony	5	410	5	0.07 N	0.09	0.09	--	--	--
Arsenic	5.8	1.6	10	2.8	2.3	2.7	--	--	--
Beryllium	2.1	1,900	10	0.347	0.357	0.362	--	--	--
Cadmium	0.9	450	4	0.14	0.39	0.18	--	--	--
Chromium	26	450	0.4	12	13.6	14.6	--	--	--
Copper	34	41,000	50	14.2	15.4	16.5	--	--	--
Lead	17	800	16	7.81	7.73	14.4	49.8	548	65.4
Mercury	0.04	310	0.1	0.014 B	0.02	0.05	--	--	--
Nickel	21	20,000	30	16.5	16.9	16.6	--	--	--
Selenium	0.8	5,100	1	0.2 U	1.2 U	1.2 U	--	--	--
Silver	0.6	5,100	2	0.02	0.04	0.07	--	--	--
Thallium	<5	67	1	0.051	0.064	0.065	--	--	--
Zinc	95	100,000	50	46.6	64.9	56.9	--	--	--

Sample Location:	Preliminary Screening Levels			T4S1S-23	T4S1S-24	T4S1S-25	T4S1S-26	T4S1S-26A	T4S1S-26B	T4S1S-26C	T4S1S-26D
Sample ID:	Background	PRG	SLV	T4S1S-23	T4S1S-24	T4S1S-25	T4S1S-26	T4S1S-26A	T4S1S-26B	T4S1S-26C	T4S1S-26D
Sample Interval:				0 - 1	0 - 1	0 - 1	0 - 1	0 - 1	0 - 1	0 - 1	0 - 1
Date Sampled:				9/12/2005	9/12/2005	9/12/2005	9/13/2005	9/13/2005	9/13/2005	9/13/2005	9/13/2005
Metals (mg/kg)											
Antimony	5	410	5	1.48 U, D	1.58 U, D	1.59 U	0.0728 J	1.53 U	1.53 U	1.54 U	1.74 U
Arsenic	5.8	1.6	10	2.81 D	3.08 D	2.69	10.9	2.49	2.23	2.97	15.7
Beryllium	2.1	1,900	10	0.326 J, D	0.321 J, D	0.296 J	0.260 J	0.209 J	0.285 J	0.277 J	0.186 J
Cadmium	0.9	450	4	0.158 J, D	0.110 J, D	0.122 J	7.02	0.220 J	0.270 J	0.646	25.3
Chromium	26	450	0.4	13.4 D	14.8 D	13.9	16.4	12.3	14.5	15.2	23.6
Copper	34	41,000	50	13.5 D	13.7 D	14.1	78.1	12.0	14.0	16.9	219 D
Lead	17	800	16	6.24 D	4.59 D	5.07	479 D	7.78	12.6	43.6	868 D
Mercury	0.04	310	0.1	0.0954 U, D	0.00920 J, D	0.0108 J, D	0.0947 J	0.126 U, D	0.131 U, D	0.130 U, D	0.325 D
Nickel	21	20,000	30	16.7 D	18.0 D	19.2	18.4	16.2	16.6	17.5	19.3
Selenium	0.8	5,100	1	0.252 J, D	0.479 J, D	0.338 J	0.286 J	0.184 J	0.163 J	0.159 J	0.407 J
Silver	0.6	5,100	2	0.495 U, D	0.526 U, D	0.529 U	1.16	0.511 U	0.509 U	0.123 J	2.10
Thallium	<5	67	1	0.495 U, D	0.526 U, D	0.529 U	0.0624 J	0.511 U	0.509 U	0.513 U	0.122 J
Zinc	95	100,000	50	52.6 D	52.9 D	55.9	949 D	55.7	64.0	127	3,320 D

Please refer to notes at end of table.

TABLE 12B
SOIL CHEMISTRY RESULTS: METALS - OU2

REMEDIAL INVESTIGATION
PORT OF PORTLAND - TERMINAL 4 SLIP 1

Sample Location:	Preliminary Screening Levels			T4S1S-27	T4S1S-28	T4S1S-29D	T4S1S-30
Sample ID:				T4S1S-27	T4S1S-28	T4S1S-29	T4S1S-30
Sample Interval:	Background	PRG	SLV	0 - 1	0 - 1	0 - 1	0 - 1
Date Sampled:				9/13/2005	9/13/2005	9/13/2005	9/13/2005
Metals (mg/kg)							
Antimony	5	410	5	1.53 U	1.53 U	1.51 U, D	1.53 U, D
Arsenic	5.8	1.6	10	2.59	3.72	14.5 D	2.47 D
Beryllium	2.1	1,900	10	0.295 J	0.316 J	0.292 J, D	0.352 J, D
Cadmium	0.9	450	4	0.402 J	0.815	2.12 D	0.352 J, D
Chromium	26	450	0.4	16.0	16.6	23.8 D	16.8 D
Copper	34	41,000	50	16.7	19.5	38.5 D	17.0 D
Lead	17	800	16	30.4	88.8	276 D	41.8 D
Mercury	0.04	310	0.1	0.102 U	0.0261 J, D	0.0799 J, D	0.0340 J, D
Nickel	21	20,000	30	19.5	19.0	17.7 D	20.5 D
Selenium	0.8	5,100	1	0.229 J	0.295 J	0.347 J, D	0.250 J, D
Silver	0.6	5,100	2	0.509 U	0.0967 J	0.660 D	0.510 U, D
Thallium	<5	67	1	0.509 U	0.509 U	0.504 U, D	0.510 U, D
Zinc	95	100,000	50	112	181	328 D	91.4 D

Notes:

1. All analytes are reported in the table.
2. Metals using EPA 6000-7000 Series Methods.
3. mg/kg = Milligrams per kilogram.
4. PRG = EPA Region 9 Preliminary Remediation Goal (PRG) for Industrial Soil (October 2004).
5. -- = No screening level available or not analyzed.
6. U = The compound was analyzed for but was not detected at or above the MRL/MDL.
7. B = The result is an estimated concentration that is less than the MRL but greater than or equal to the method detection limit (MDL).
8. N = The matrix spike sample recovery is not within control limits. The case narrative suggests that soil samples digested with EPA Method 3050 for Antimony should only be used as indicators to estimate concentrations.
9. * = The laboratory duplicate analysis was not within control limits. The laboratory attributed the variability to the heterogeneous character of the sample.
10. Shaded values indicate that the detected concentration exceeds the background and PRG.
11. Background Levels are from the Washington Department of Ecology's publication Natural Background Soil Metals Concentrations in Washington State, dated October 1994. Values are the 90th percentile values for Clark County, except for antimony, selenium, silver and thallium where state-wide data were used due to a limited number of detections.
12. Boxed values indicate that the detected concentration exceeds the SLV (only samples from 0 to 3 feet were screened against the SLV).

TABLE 13B
GROUNDWATER CHEMISTRY RESULTS: PETROLEUM HYDROCARBONS - OU2

REMEDIAL INVESTIGATION
PORT OF PORTLAND - TERMINAL 4 SLIP 1

			HCID (µg/L)			TPH (µg/L)		
Sample Location:	**Sample ID:**	**Date Sampled:**	**Gasoline Range**	**Diesel Range**	**Residual Range**	**Gasoline Range**	**Diesel Range**	**Residual Range**
T4S1MW04s	T4S1MW04s-GW-1	4/19/2004	--	--	--	50 U	270 U	530 U
T4S1MW04s	T4S1MW04s-GW-1	8/31/2004	--	--	--	250 U	240 U	480 U
T4S1MW04s	T4S1MW04s-GW-1	2/8/2005	--	--	--	250 U	250 U	47 J
T4S1MW04s	T4S1MW04s-GW-1	5/9/2005	--	--	--	250 U	250 U	500 U
T4S1MW09	T4S1MW09-GW-1	4/20/2004	--	--	--	50 U	260 U	520
T4S1MW09	T4S1MW09-GW-1	9/1/2004	--	--	--	250 U	250 U	500 U
T4S1MW09	T4S1MW09-GW-1	2/9/2005	--	--	--	250 U	250 U	35 J
T4S1MW09	T4S1MW09-GW-1	5/9/2005	--	--	--	250 U	250 U	500 U
T4S1MW10	T4S1MW10-GW-1	4/19/2004	--	--	--	50 U	270 U	530 U
T4S1MW10	T4S1MW10-GW-1	9/1/2004	--	--	--	250 U	250 U	500 U
T4S1MW10	T4S1MW10-GW-1	2/4/2005	--	--	--	13 J	250 U	500 U
T4S1MW10	T4S1MW10-GW-1	5/9/2005	--	--	--	250 U	250 U	500 U
T4S1MW11	T4S1MW11-GW-1	4/19/2004	--	--	--	50 U	290 U	570 U
T4S1MW11	T4S1MW11-GW-1	9/1/2004	250 U	630 U	630 U	--	--	--
T4S1MW11	T4S1MW11-GW-1	2/8/2005	--	--	--	250 U	29 J	56 J
T4S1MW11	T4S1MW11-GW-1	5/10/2005	260 U	650 U	650 U	250 U	260 U	520 U
T4S1MW12	T4S1MW12-GW-1	4/19/2004	--	--	--	50 U	330 U	650 U
T4S1MW13	T4S1MW13-GW-1	4/16/2004	--	--	--	50 U	250 U	500 U
T4S1MW14	T4S1MW14-GW-1	4/16/2004	--	--	--	50 U	320 U	500 U
T4S1MW14	T4S1MW14-GW-1	8/31/2004	--	--	--	250 U	120 U	240 U
T4S1MW14	T4S1MW14-GW-1	2/8/2005	--	--	--	250 U	250 U	500 U
T4S1MW14	T4S1MW14-GW-1	5/10/2005	--	--	--	250 U	260 U	520 U
T4S1MW15	T4S1MW15-GW-1	4/16/2004	--	--	--	50 U	250 U	500 U
T4S1MW15	T4S1MW15-GW-1	2/9/2005	250 U	630 U	630 U	--	--	--
T4S1MW15	T4S1MW15-GW-1	5/4/2005	250 U	630 U	630 U	14 J	21 J	37 J
T4S1MW16	T4S1MW16-GW-1	4/19/2004	--	--	--	50 U	320 U	630 U
T4S1MW16	T4S1MW16-GW-1	8/27/2004	--	--	--	250 U	250 U	500 U
T4S1MW16	T4S1MW16-GW-1	2/10/2005	--	--	--	250 U	250 U	43 J
T4S1MW18	T4S1MW18-GW-1	2/1/2005	--	--	--	13 U	26 J	51 J
T4S1MW20	T4S1MW20-GW-1	9/2/2004	--	--	--	18 J	250 U	500 U
T4S1MW20	T4S1MW20-GW-1	2/10/2005	--	--	--	250 U	40 J	85 J
T4S1MW20	T4S1MW20-GW-1	5/11/2005	--	--	--	250 U	250 U	500 U
T4S1MW21	T4S1MW21-GW-1	9/2/2004	--	--	--	250 U	250 U	500 U
T4S1MW21	T4S1MW21-GW-1	2/10/2005	--	--	--	250 U	24 J	89 J
T4S1MW21	T4S1MW21-GW-1	5/11/2005	--	--	--	250 U	250 U	500 U
T4S1MW23	T4S1MW23-GW-1	9/2/2004	--	--	--	250 U	250 U	500 U
T4S1MW23	T4S1MW23-GW-1	2/4/2005	--	--	--	15 J	65 J	190 J
T4S1MW24	T4S1MW24-GW-1	9/1/2004	--	--	--	250 U	250 U	500 U
T4S1MW24	T4S1MW24-GW-1	2/3/2005	--	--	--	13 J	30 J	46 J
	Preliminary	**Fish Consumption SLV**	--	--	--	--	--	--
	Screening Levels	**Aquatic SLV**	--	--	--	1,000	1,000	1,000

Notes:

1. TPH =Total petroleum hydrocarbons (TPH) by Northwest Total Petroleum Hydrocarbons (NWTPH).
2. µg/L = Micrograms per liter.
3. Fish Consumption SLV = EPA National Recommended Water Quality Criteria: 2002 Human Health for Consumption of Fish. None available for TPH.
4. Aquatic SLV = EPA National Recommended Water Quality Criteria: 2002 for CCC Freshwater Biota. Where CCC values are not available, Oregon Department of Environmental Quality Level II Screening Level Values (SLVs) for Surface Water Aquatic are listed. None available for TPH. In accordance with DEQ policy, 1,000 µg/L used for TPH screening level for surface water ecological receptors.
5. -- = No screening level available or not analyzed.
6. J = The result is an estimated concentration that is less than the method reporting limit (MRL) but greater than or equal to the method detection limit (MDL).
7. U = The compound was analyzed for but was not detected at or above the MRL/MDL.

TABLE 14B
GROUNDWATER CHEMISTRY RESULTS: POLYNUCLEAR AROMATIC HYDROCARBONS - OU2

REMEDIAL INVESTIGATION
PORT OF PORTLAND - TERMINAL 4 SLIP 1

			PAHs (µg/L)																		
Sample Location:	**Sample ID:**	**Date Sampled:**	Naphthalene	1-Methylnaphthalene	2-Methylnaphthalene	Acenaphthylene	Acenaphthene	Dibenzofuran	Fluorene	Phenanthrene	Anthracene	Fluoranthene	Pyrene	Benz(a)anthracene	Chrysene	Benzo(b)fluoranthene	Benzo(k)fluoranthene	Benzo(a)pyrene	Indeno(1,2,3-cd)pyrene	Dibenz(a,h)anthracene	Benzo(g,h,i)perylene
T4S1MW04s	T4S1MW04s-GW-1	4/19/2004	0.0083 J	--	0.025 U	0.025 U	0.025 U	--	0.025 U	0.025 U	0.025 U	0.025 U	0.025 U	0.025 U	0.025 U	0.025 U	0.025 U	0.025 U	0.025 U	0.025 U	0.025 U
T4S1MW04s	T4S1MW04s-GW-1	8/31/2004	0.019 J	--	0.008 J	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U
T4S1MW04s	T4S1MW04s-GW-1	2/8/2005	0.0082 J	--	0.019 U	0.019 U	0.019 U	0.019 U	0.019 U	0.019 U	0.019 U	0.019 U	0.019 U	0.019 U	0.019 U	0.019 U	0.019 U	0.019 U	0.019 U	0.019 U	0.019 U
T4S1MW04s	T4S1MW04s-GW-1	5/9/2005	0.017 J	0.0085 J	0.013 J	0.0019 J	0.0020 U	0.0071 U	0.0031 J	0.0061 J	0.0019 J	0.014 J	0.014 J	0.0076 J	0.0086 J	0.0060 J	0.0065 J	0.0048 J	0.0043 J	0.0017 U, J	0.0040 J
T4S1MW09	T4S1MW09-GW-1	4/20/2004	0.0087 J	--	--	0.0026 J	0.0028 J	--	0.004 J	0.0075 J	0.05	0.0081 J	0.0078 J	0.0062 J	0.0045 J	0.0043 J	0.0045 J	0.003 J	0.0025 J	0.022 U	0.0036 J
T4S1MW09	T4S1MW09-GW-1	9/1/2004	0.022	--	0.013 J	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.03	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U
T4S1MW09	T4S1MW09-GW-1	2/9/2005	0.0080 J	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.0043 J	0.043	0.020 U	0.0042 J	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U
T4S1MW09	T4S1MW09-GW-1	5/9/2005	0.033	0.0076 J	0.012 J	0.0022 J	0.0020 U	0.0071 U	0.0026 U	0.0081 J	0.025	0.018 J	0.017 J	0.010 J	0.013 J	0.011 J	0.010 J	0.011 J	0.0090 J	0.0017 U, J	0.0094 J
T4S1MW10	T4S1MW10-GW-1	4/19/2004	0.011 J	--	--	0.0019 J	0.027 U	--	0.027 U	0.0047 J	0.087	0.0064 J	0.0050 J	0.027 U	0.027 U	0.027 U	0.027 U	0.027 U	0.027 U	0.027 U	0.027 U
T4S1MW10	T4S1MW10-GW-1	9/1/2004	0.025	--	0.014 J	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.094	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U
T4S1MW10	T4S1MW10-GW-1	2/4/2005	0.0014 J	0.0039 J	0.0057 J	0.0062 J	0.020 U	0.020 U	0.020 U	0.020 U	0.076	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U
T4S1MW10	T4S1MW10-GW-1	5/9/2005	0.037	0.0090 J	0.014 J	0.0022 J	0.0020 U	0.0071 U	0.0026 U	0.0032 U	0.070	0.0024 U	0.0023 U	0.0021 U	0.0013 U	0.0020 U	0.0014 U	0.0016 U	0.0021 U, J	0.0017 U, J	0.020 U
T4S1MW11	T4S1MW11-GW-1	4/19/2004	0.0068 J	--	--	0.0018 J	0.025 U	--	0.0037 J	0.028	0.027	0.024 J	0.025 J	0.0038 J	0.0041 J	0.025 U	0.025 U	0.0019 J	0.025 U	0.025 U	0.025 U
T4S1MW11	T4S1MW11-GW-1	9/1/2004	0.043	--	0.024	0.0034 J	0.020 U	0.020 U	0.020 U	0.013 J	0.032	0.020	0.028	0.013 J	0.012 J	0.005 J	0.0071 J	0.0089 J	0.0043 J	0.020 U	0.020 U
T4S1MW11	T4S1MW11-GW-1	2/8/2005	0.012 J	--	0.0073 J	0.019 U	0.019 U	0.019 U	0.019 U	0.0059 J	0.015 J	0.019 U	0.0056 J	0.019 U	0.019 U	0.019 U	0.019 U	0.019 U	0.019 U	0.019 U	0.019 U
T4S1MW11	T4S1MW11-GW-1	5/10/2005	0.02 U	0.020 U	0.0030 J	0.0026 J	0.020 U	0.020 U	0.020 U	0.0094 J	0.025	0.016 J	0.023	0.011 J	0.0098 J	0.0053 J	0.0064 J	0.0070 J	0.0062 J	0.0023 J	0.0050 J
T4S1MW12	T4S1MW12-GW-1	4/19/2004	0.0063 J	--	--	0.025 U	0.025 U	--	0.025 U	0.025 U	0.025 U	0.025 U	0.025 U	0.025 U	0.025 U	0.025 U	0.025 U	0.025 U	0.025 U	0.025 U	0.025 U
T4S1MW13	T4S1MW13-GW-1	4/16/2004	0.011 J	0.022 U	0.022 U	0.022 U	0.022 U	--	0.022 U	0.020 J	0.025	0.014 J	0.025	0.0037 J	0.022 U	0.022 U	0.022 U	0.022 U	0.022 U	0.0030 J	0.0044 J
T4S1MW13	T4S1MW13-GW-1	8/31/2004	0.029	--	0.017 J	0.020 U	0.020 U	0.020 U	0.020 U	0.0048 J	0.018 J	0.006 J	0.0097 J	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U
T4S1MW14	T4S1MW14-GW-1	4/16/2004	0.0067 J	0.023 U	0.023 U	0.023 U	0.023 U	--	0.023 U	0.023 U	0.023 U	0.023 U	0.023 U	0.023 U	0.023 U	0.023 U	0.023 U	0.023 U	0.023 U	0.0032 J	0.0034 J
T4S1MW14	T4S1MW14-GW-1	8/31/2004	0.035	--	0.024	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.0049 J	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U
T4S1MW14	T4S1MW14-GW-1	2/8/2005	0.0099 J	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.013 J	0.019 J	0.0058 J	0.0078 J	0.0046 J	0.020 U	0.0048 J	0.020 U	0.0084 J	0.0043 J	0.020 U	0.0043 J
T4S1MW14	T4S1MW14-GW-1	5/10/2005	0.02 U	0.020 U	0.0028 J	0.020 U	0.020 U	0.020 U	0.020 U	0.0042 J	0.0036 J	0.0061 J	0.0055 J	0.0024 J	0.0031 J	0.0030 J	0.0029 J	0.0033 J	0.0041 J	0.020 U	0.020 U
T4S1MW15	T4S1MW15-GW-1	4/16/2004	0.0089 J	0.0056 J	0.020 U	0.020 U	0.0052 J	--	0.020 U	0.0075 J	0.028	0.0085 J	0.022	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U
T4S1MW15	T4S1MW15-GW-1	2/3/2005	0.0087 J	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.0060 J	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U
T4S1MW16	T4S1MW16-GW-1	4/19/2004	0.010 J	--	--	0.0045 J	0.0066 J	--	0.0098 J	0.018 J	0.024 J	0.023 J	0.021 J	0.012 J	0.010 J	0.0087 J	0.0084 J	0.0069 J	0.0062 J	0.0058 J	0.0091 J
T4S1MW16	T4S1MW16-GW-1	8/27/2004	0.012 J	--	0.0044 J	0.020 U	0.020 U	0.020 U	0.020 U	0.0042 J	0.027	0.0076 J	0.008 J	0.0048 J	0.0044 J	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U
T4S1MW16	T4S1MW16-GW-1	2/10/2005	0.056	0.011 J	0.016 J	0.0037 J	0.020 U	0.020 U	0.020 U	0.0067 J	0.027	0.0071 J	0.0081 J	0.0049 J	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U
T4S1MW16	T4S1MW16-GW-1	5/10/2005	0.0062	0.011 J	0.015 J	0.0052 J	0.0096 J	0.020 U	0.0086 J	0.079	0.027	0.15	0.13	0.075	0.11	0.096	0.087	0.095	0.094 J	0.019 J	0.079
T4S1MW20	T4S1MW20-GW-1	9/2/2004	0.14	--	0.015 J	0.0099 J	0.018 J	0.020 U	0.018 J	0.075	0.022	0.023	0.024	0.0074 J	0.0076 J	0.0045 J	0.0043 J	0.0059 J	0.0034 J	0.020 U	0.020 U
T4S1MW20	T4S1MW20-GW-1	2/10/2005	0.074	0.024	0.024	0.020 U	0.020 U	0.020 U	0.0072 J	0.015 J	0.031	0.012 J	0.016 J	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U
T4S1MW20	T4S1MW20-GW-1	5/11/2005	0.025	0.0029 J	0.0040 J	0.020 U	0.020 U	0.020 U	0.020 U	0.0071 J	0.020	0.017 J	0.016 J	0.0092 J	0.010 J	0.010 J	0.0062 J	0.0088 J	0.0086 J	0.0022 J	0.0076 J
T4S1MW21	T4S1MW21-GW-1	9/2/2004	0.015 J	--	0.0058 J	0.0022 J	0.0056 J	0.020 U	0.0046 J	0.021	0.011 J	0.013 J	0.012 J	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U
T4S1MW21	T4S1MW21-GW-1	2/10/2005	0.072	0.026	0.027	0.0038 J	0.0058 J	0.0050 J	0.0075 J	0.0098 J	0.027	0.0066 J	0.0089 J	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U
T4S1MW21	T4S1MW21-GW-1	5/11/2005	0.0088 J	0.020 U	0.0027 J	0.020 U	0.020 U	0.020 U	0.020 U	0.0044 J	0.026	0.020	0.018 J	0.020 U	0.0019 J	0.020 U	0.020 U	0.020 U	0.020 U, J	0.020 U, J	0.020 U
T4S1MW25	T4S1MW25-GW-1	11/9/2005	0.476 U	--	--	0.476 U	0.476 U		0.244 J, D	0.0952 U	0.0952 U	0.0952 U	0.0952 U	0.0952 U	0.0952 U	0.0952 U	0.0952 U	0.0952 U	0.0952 U	0.190 U	0.0952 U
	Preliminary	**Fish Consumption SLV**	--	--	--	--	990	--	5,300	--	40,000	140	4,000	0.018	0.018	0.018	0.018	0.018	0.018	0.018	--
	Screening Levels	**Aquatic SLV**	620	--	--	--	520	3.7	3.9	6.3	13	6.16	--	0.027 [a.]	--	--	--	0.014	--	--	--

Notes:
1. Only detected compounds are reported in the table. The complete analyte list is presented in the Sampling and Analysis Plan (Appendix A) of the RI Work Plan (Hart Crowser, 2004a).
2. PAHs = Polynuclear Aromatic Hydrocarbons by EPA Method 8270C (SIM).
3. µg/L = Micrograms per liter.
4. Fish Consumption SLV = EPA National Recommended Water Quality Criteria: 2002 Human Health for Consumption of Fish.
5. Aquatic SLV = EPA National Recommended Water Quality Criteria: 2002 for CCC Freshwater Biota (noted with [a.]). Where CCC values are not available, Oregon Department of Environmental Quality Level II Screening Level Values (SLVs) for Surface Water Aquatic are listed.
6. -- = No screening level available or not analyzed.
7. J = The result is an estimated concentration that is less than the method reporting limit (MRL) but greater than or equal to the method detection limit (MDL).
8. U = The compound was analyzed for but was not detected at or above the MRL/MDL.
9. Boxed values indicate that the detected concentration exceeds the Ecological Screening Criteria.
10. Shaded values indicate that the detected concentration exceeds the EPA AWQC criteria.

TABLE 16B
GROUNDWATER CHEMISTRY RESULTS: VOLATILE ORGANIC COMPOUNDS - OU2

REMEDIAL INVESTIGATION
PORT OF PORTLAND - TERMINAL 4 SLIP 1

			VOCs (µg/L)																									
Sample Location:	**Sample ID:**	**Date Sampled:**	Vinyl Chloride	Acetone	1,1-Dichloroethene (1,1-DCE)	Carbon Disulfide	trans-1,2-Dichloroethene	1,1-Dichloroethane (1,1-DCA)	2-Butanone (MEK)	cis-1,2-Dichloroethene	Chloroform	1,1,1-Trichloroethane (TCA)	Benzene	Trichloroethene (TCE)	Toluene	Tetrachloroethene (PCE)	Chlorobenzene	Ethylbenzene	m,p-Xylenes	o-Xylene	Isopropylbenzene	n-Propylbenzene	1,2,4-Trimethylbenzene	sec-Butylbenzene	1,3-Dichlorobenzene	1,4-Dichlorobenzene	n-Butylbenzene	Naphthalene
T4S1MW04s	T4S1MW04s-GW-1	4/19/2004	0.50 U	20 U	0.50 U	0.41	0.50 U	0.50 U	20 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.26 J	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	2 U	2 U	2 U	2 U	0.50 U	0.50 U	2 U	2 U
T4S1MW04s	T4S1MW04s-GW-1	8/31/2004	0.50 U	20 U	0.50 U	0.38 J	0.50 U	0.50 U	20 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	2 U	2 U	2 U	2 U	0.50 U	0.5 U	2 U	2 U
T4S1MW04s	T4S1MW04s-GW-1	2/8/2005	0.50 U	20 U	0.50 U	0.17 J	0.50 U	0.50 U	20 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.35 J	0.50 U	0.50 U	0.50 U	0.27 J	0.12 J	2.0 U	2.0 U	2.0 U	2.0 U	0.50 U	0.50 U	2.0 U	2.0 U
T4S1MW04s	T4S1MW04s-GW-1	5/9/2005	0.22 U	4.1 U	0.13 U	0.41 J	0.15 U	0.11 U	2.0 U	0.12 U	0.14 U	0.12 U	0.14 U	0.14 U	0.36 J	0.13 U	0.14 U	0.29 J	1.5	0.76	0.11 U	0.34 J	3.1	0.13 U	0.11 U	0.12 U	0.23 U, J	1.6 J
T4S1MW09	T4S1MW09-GW-1	4/20/2004	0.50 U	20 U	0.50 U	0.50 U	0.50 U	0.50 U	20 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.15	0.50 U	0.50 U	0.50 U	0.50 U	2 U	2 U	2 U	2 U	0.50 U	0.50 U	2 U	2 U
T4S1MW09	T4S1MW09-GW-1	9/1/2004	0.50 U	20 U	0.50 U	0.50 U	0.50 U	0.50 U	20 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	2 U	2 U	2 U	2 U	0.50 U	0.5 U	2 U	2 U
T4S1MW09	T4S1MW09-GW-1	2/9/2005	0.50 U, J	20 U	0.50 U, J	0.50 U	0.50 U	0.50 U	20 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	2.0 U	2.0 U	2.0 U	2.0 U	0.50 U	0.50 U	2.0 U	2.0 U
T4S1MW09	T4S1MW09-GW-1	5/9/2005	0.22 U	4.1 U	0.13 U	0.16 U	0.15 U	0.11 U	2.0 U	0.12 U	0.14 U	0.12 U	0.14 U	0.14 U	0.26 J	0.13 U	0.14 U	0.13 U	0.22 U	0.11 U	0.11 U	0.098 U	0.15 U, J	0.13 U	0.11 U	0.12 U	0.23 U, J	0.29 U
T4S1MW10	T4S1MW10-GW-1	4/19/2004	0.50 U	20 U	0.50 U	0.50 U	0.50 U	0.10 J	20 U	0.19 J	0.50 U	0.50 U	0.50 U	0.19 J	0.22 J	0.24	0.50 U	0.50 U	0.50 U	0.50 U	2 U	2 U	2 U	2 U	0.50 U	0.50 U	2 U	2 U
T4S1MW10	T4S1MW10-GW-1	9/1/2004	0.50 U	20 U	0.50 U	0.50 U	0.50 U	0.18 J	20 U	0.13 J	0.50 U	0.50 U	0.50 U	0.21 J	0.50 U	0.33 J	0.50 U	0.5 U	0.50 U	0.50 U	2 U	2 U	2 U	2 U	0.50 U	0.5 U	2 U	2 U
T4S1MW10	T4S1MW10-GW-1	2/4/2005	0.50 U	20 U	0.50 U	0.50 U	0.50 U	0.19 J	20 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 J	0.50 U	0.51	0.50 U	0.50 U	0.50 U	0.50 U	2.0 U	2.0 U	2.0 U	2.0 U	0.50 U	0.50 U	2.0 U	2.0 U
T4S1MW10	T4S1MW10-GW-1	5/9/2005	0.22 U	4.1 U	0.13 U	0.16 U	0.15 U	0.17 J	2.0 U	0.14 J	0.14 U	0.12 U	0.14 U	0.24 J	0.37 J	0.41 J	0.14 U	0.13 U	0.36 J	0.17 J	0.11 U	0.098 U	0.15 U, J	0.13 U	0.11 U	0.12 U	0.23 U, J	0.29 U
T4S1MW11	T4S1MW11-GW-1	4/19/2004	0.50 U	20 U	0.50 U	0.50 U	0.50 U	0.50 U	20 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.20 J	0.39 U	0.50 U	0.50 U	0.50 U	0.50 U	2 U	2 U	2 U	2 U	0.50 U	0.50 U	2 U	2 U
T4S1MW11	T4S1MW11-GW-1	9/1/2004	0.50 U	20 U	0.50 U	0.50 U	0.50 U	0.50 U	20 U	0.50 U	0.50 U	0.50 U	0.50 U	0.5 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	2 U	2 U	2 U	2 U	0.50 U	0.50 U	2 U	2 U
T4S1MW11	T4S1MW11-GW-1	2/8/2005	0.50 U	20 U	0.50 U	0.50 U	0.50 U	0.50 U	20 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 J	0.50 U	0.50 U	0.50 U	0.50 U	2.0 U	2.0 U	2.0 U	2.0 U	0.50 U	0.50 U	2.0 U	2.0 U
T4S1MW11	T4S1MW11-GW-1	5/10/2005	0.50 U	20 U	0.50 U	0.50 U	0.50 U	0.50 U	20 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	2.0 U	2.0 U	2.0 U	2.0 U	0.50 U	0.50 U	2.0 U	2.0 U
T4S1MW12	T4S1MW12-GW-1	4/19/2004	0.50 U	20 U	0.50 U	0.21 J	0.50 U	0.50 U	20 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	2 U	2 U	2 U	2 U	0.50 U	0.50 U	2 U	2 U
T4S1MW13	T4S1MW13-GW-1	4/16/2004	0.50 U	20 U	0.50 U	0.50 U	0.50 U	0.50 U	20 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.13 J	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	2 U	2 U	2 U	2 U	0.50 U	0.50 U	2 U	2 U
T4S1MW14	T4S1MW14-GW-1	4/16/2004	0.50 U	20 U	0.50 U	0.50 U	0.50 U	0.50 U	20 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.16 J	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	2 U	2 U	2 U	2 U	0.50 U	0.50 U	2 U	2 U
T4S1MW14	T4S1MW14-GW-1	8/31/2004	0.50 U	20 U	0.50 U	0.50 U	0.50 U	0.50 U	20 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	2 U	2 U	2 U	2 U	0.50 U	0.50 U	2 U	2 U
T4S1MW14	T4S1MW14-GW-1	2/8/2005	0.50 U	20 U	0.50 U, J	0.50 U	0.50 U	0.50 U	20 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.11 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	2.0 U	2.0 U	2.0 U	2.0 U	0.50 U	0.50 U	2.0 U	2.0 U
T4S1MW14	T4S1MW14-GW-1	5/10/2005	0.50 U	20 U	0.50 U	0.19 J	0.50 U	0.50 U	20 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.31 J	0.50 U	0.50 U	0.50 U	0.34 J	0.14 J	2.0 U	2.0 U	0.20 J	2.0 U	0.50 U	0.12 J	2.0 U	2.0 U
T4S1MW15	T4S1MW15-GW-1	4/16/2004	0.50 U	20 U	0.50 U	0.50 U	0.50 U	0.50 U	20 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.13 J	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	2 U	2 U	2 U	2 U	0.50 U	0.50 U	2 U	2 U
T4S1MW16	T4S1MW16-GW-1	4/19/2004	0.50 U	20 U	0.50 U	0.50 U	0.50 U	0.50 U	20 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.90	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	2 U	2 U	2 U	2 U	1.4	0.50 U	2 U	2 U
T4S1MW16	T4S1MW16-GW-1	8/27/2004	0.50 U	20 U	0.50 U	0.50 U	0.50 U	0.50 U	20 U	0.50 U	0.75	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	2 U	2 U	2 U	2 U	0.50 U	0.50 U	2 U	2 U
T4S1MW16	T4S1MW16-GW-1	2/10/2005	0.50 U, J	20 U	0.50 U, J	1.7	0.50 U	0.50 U	20 U	0.50 U	4.4	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	2.0 U	2.0 U	2.0 U	2.0 U	0.50 U	0.50 U	2.0 U	2.0 U
T4S1MW16	T4S1MW16-GW-1	5/10/2005	0.50 U	20 U	0.50 U	0.50 U	0.50 U	0.50 U	20 U	0.50 U	3.1	0.50 U	0.50 U	0.50 U	0.50	0.50 U	0.50 U	0.50 U	0.36 J	0.15 J	2.0 U	2.0 U	2.0 U	2.0 U	0.50 U	0.50 U	2.0 U	2.0 U
T4S1MW20	T4S1MW20-GW-1	9/2/2004	0.50 U	20 U	0.50 U	0.50 U	0.50 U	0.50 U	20 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	2 U	2 U	2 U	2 U	0.50 U	0.50 U	2 U	2 U
T4S1MW20	T4S1MW20-GW-1	2/10/2005	0.50 U, J	20 U	0.50 U, J	0.50 U	0.50 U	0.50 U	20 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.19 J	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	2.0 U	2.0 U	2.0 U	2.0 U	0.50 U	0.50 U	2.0 U	2.0 U
T4S1MW20	T4S1MW20-GW-1	5/11/2005	0.50 U	20 U	0.50 U	0.50 U	0.50 U	0.50 U	20 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.13 J	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	2.0 U	2.0 U	2.0 U	2.0 U	0.50 U	0.50 U	2.0 U	2.0 U
T4S1MW21	T4S1MW21-GW-1	9/2/2004	0.50 U	20 U	0.50 U	0.50 U	0.50 U	0.50 U	20 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	2 U	2 U	2 U	2 U	0.50 U	0.50 U	2 U	2 U
T4S1MW21	T4S1MW21-GW-1	2/10/2005	0.50 U, J	20 U	0.50 U, J	0.50 U	0.50 U	0.50 U	20 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	2.0 U	2.0 U	2.0 U	2.0 U	0.50 U	0.50 U	2.0 U	2.0 U
T4S1MW21	T4S1MW21-GW-1	5/11/2005	0.50 U	20 U	0.50 U	0.50 U	0.50 U	0.50 U	20 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.15 J	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	2.0 U	2.0 U	2.0 U	2.0 U	0.50 U	0.50 U	2.0 U	2.0 U
	Preliminary	**Fish Consumption SLV**	530	--	3.2	--	140,000	--	--	--	470	--	51	30	200,000	3.3	21,000	29,000	--	--	--	--	--	--	960	2,600	--	--
	Screening Levels	**Aquatic SLV**	--	1,500	25	0.92	590	47	--	590	1,240	11	130	21,900	9.8	840	50	7.3	1.8	--	--	--	--	--	71	15	--	620

Notes:

1. Only detected compounds are reported in the table. The complete analyte list is presented in the Sampling and Analysis Plan (Appendix A) of the RI Work Plan (Hart Crowser, 2004a).
2. VOCs = Volatile Organic Compounds by EPA Method 8260B.
3. µg/L = Micrograms per liter.
4. Fish Consumption SLV = EPA National Recommended Water Quality Criteria: 2002 Human Health for Consumption of Fish.
5. Aquatic SLV = EPA National Recommended Water Quality Criteria: 2002 for CCC Freshwater Biota (noted with). Where CCC values are not available, Oregon Department of Environmental Quality Level II Screening Level Values (SLVs) for Surface Water Aquatic are listed.
6. -- = No screening level available or not analyzed.
7. J = The result is an estimated concentration that is less than the method reporting limit (MRL) but greater than or equal to the method detection limit (MDL).
8. U = The compound was analyzed for but was not detected at or above the MRL/MDL.
9. Boxed values indicate that the detected concentration exceeds the Ecological Screening Criteria.

TABLE 18B
GROUNDWATER CHEMISTRY RESULTS: PESTICIDES - OU2

REMEDIAL INVESTIGATION
PORT OF PORTLAND - TERMINAL 4 SLIP 1

			Pesticides (µg/L)																	
Sample Location:	**Sample ID:**	**Date Sampled:**	alpha-BHC	beta-BHC	gamma-BHC (Lindane)	delta-BHC	Heptachlor	Aldrin	Heptachlor Epoxide	Endosulfan I	alpha-Chlordane	Dieldrin	4,4'-DDE	Endrin	Endosulfan II	4,4'-DDD	Endrin Aldehyde	4,4'-DDT	Endrin Ketone	Methoxychlor
T4S1MW09	T4S1MW09-GW-1	04/20/2004	0.012 U	0.0033 U	0.012 U	0.012 U	0.012 U	0.013 U	0.012 U	0.012 U	0.0028 U	0.012 U	0.012 U	0.012 U	0.0015	0.012 U	0.012 U	0.012 U	0.012 U	0.012 U
T4S1MW09	T4S1MW09-GW-1	9/1/2004	0.0097 U	0.0097 U	0.0097 U	0.0097 U	0.0097 U	0.0097 U	0.0097 Ui	0.0097 U	0.0097 U	0.0097 U	0.0097 U	0.0097 U	0.0097 U	0.0097 U	0.0097 U	0.0097 U	0.0097 U	0.0097 U
T4S1MW09	T4S1MW09-GW-1	2/3/2005	0.0095 U	0.0095 U	0.0095 U	0.0095 U	0.0095 U	0.0095 U	0.0095 U	0.0095 Ui	0.0095 U	0.0095 Ui	0.0095 Ui	0.0095 U	0.0095 U	0.0095 U	0.0095 U	0.0030 J	--	0.0095 U
T4S1MW09	T4S1MW09-GW-1	5/9/2005	0.0096 U	0.0096 U	0.0096 U	0.0096 U	0.0096 U	0.0096 U	0.0096 U	0.0096 U	0.0096 U	0.0096 U	0.0096 U	0.0096 U	0.0096 U	0.0096 U	0.0096 U	0.0096 U	0.0096 U	0.0096 U
T4S1MW10	T4S1MW10-GW-1	04/19/2004	0.012 U	0.0035 U	0.012 U	0.012 U	0.012 U	0.013 U	0.012 U	0.012 U	0.013 U	0.0044 JP	0.012 U	0.012 U	0.012 U	0.012 U	0.012 U	0.012 U	0.012 U	0.012 U
T4S1MW10	T4S1MW10-GW-1	9/1/2004	0.0097 U	0.0097 U	0.0097 U	0.0097 U	0.0097 U	0.0097 U	0.0097 U	0.0097 U	0.0097 U	0.0097 U	0.0097 U	0.0097 U	0.0097 U	0.0097 U	0.0097 U	0.0097 U	0.0097 U	0.0097 U
T4S1MW10	T4S1MW10-GW-1	2/9/2005	0.0097 U	0.0097 U	0.0097 U	0.0097 U	0.0097 U	0.0097 U	0.0097 U	0.0097 Ui	0.0097 U	0.0097 U	0.0097 U	0.0097 U	0.0097 Ui	0.0097 U	0.0097 U	0.0097 U	--	0.0097 U
T4S1MW10	T4S1MW10-GW-1	5/9/2005	0.0096 U	0.0096 U	0.0096 U	0.0096 U	0.0096 U	0.0096 U	0.0096 Ui	0.0096 Ui	0.0096 U	0.0096 U	0.0096 U	0.0096 U	0.0096 U	0.0096 U	0.0096 U	0.0096 U	0.0096 U	0.0096 U
T4S1MW11	T4S1MW11-GW-1	04/19/2004	0.013 U	0.0037 U	0.013 U	0.013 U	0.013 U	0.013 U	0.013 U	0.013 U	0.013 U	0.013 U	0.013 U	0.013 Ui	0.013 U	0.0026 J	0.013 U	0.013 U	0.013 U	0.013 U
T4S1MW11	T4S1MW11-GW-1	9/1/2004	0.0097 U	0.0097 U	0.0097 U	0.0097 U	0.0097 U	0.0012 J	0.0097 U	0.0097 U	0.0097 U	0.0097 U	0.0097 U	0.0097 U	0.0097 U	0.0097 Ui	0.0097 U	0.0014 JP	0.0097 U	0.0097 U
T4S1MW11	T4S1MW11-GW-1	5/10/2005	0.0096 U	0.0096 U	0.0096 U	0.0096 U	0.0096 U	0.0096 U	0.0096 U	0.0096 U	0.0096 U	0.0096 U	0.0096 U	0.0096 U	0.0096 U	0.0096 Ui	0.0096 U	0.0096 U	0.0096 U	0.0096 U
	Preliminary	**Fish Consumption SLV**	0.0049	0.017	0.063	--	8E-05	5E-05	0.000039	89	0.00081	5E-05	0.00022	0.81	89	0.00031	0.3	0.0002	--	--
	Screening Levels	**Aquatic SLV**	2.2	2.2	0.08	--	0.0038 [a.]	0.06 [a.]	0.0038 [a.]	0.056 [a.]	0.0043 [a.]	0.056 [a.]	--	0.036 [a.]	0.056 [a.]	0.001	--	0.001	--	0.03

Notes:

1. Only detected compounds are reported in the table. The complete analyte list is presented in the Sampling and Analysis Plan (Appendix A) of the RI Work Plan (Hart Crowser, 2004a).
2. Organochlorine Pesticides by EPA Method 8081A. Organophosphorus Pesticides by EPA Method 8141A.
3. µg/L = Micrograms per liter.
4. Fish Consumption SLV = EPA National Recommended Water Quality Criteria: 2002 Human Health for Consumption of Fish.
5. Aquatic SLV = EPA National Recommended Water Quality Criteria: 2002 for CCC Freshwater Biota (noted with [a.]). Where CCC values are not available, Oregon Department of Environmental Quality Level II Screening Level Values (SLVs) for Surface Water Aquatic are listed.
6. -- = No screening level available or not analyzed.
7. J = The result is an estimated concentration that is less than the method reporting limit (MRL) but greater than or equal to the method detection limit (MDL).
8. U = The compound was analyzed for but was not detected at or above the MRL/MDL.
9. i = The MRL/MDL was raised due to a chromatographic interference.
10. P = The GC or HPLC confirmation criteria was exceeded. The relative percent difference is greater than 25 percent between the two analytical results.
11. Boxed values indicate that the detected concentration exceeds the Ecological Screening Criteria.
12. Shaded values indicate that the detected concentration exceeds the EPA AWQC criteria.

TABLE 19B
GROUNDWATER CHEMISTRY RESULTS: METALS - OU2

REMEDIAL INVESTIGATION
PORT OF PORTLAND - TERMINAL 4 SLIP 1

			Total Metals (µg/L)												
Sample Location:	**Sample ID:**	**Date Sampled:**	Antimony	Arsenic	Beryllium	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver	Thallium	Zinc
T4S1MW09	T4S1MW09-GW-1	9/1/2004	0.05 U	8.3	0.02 U	0.02 U	0.23	0.52	0.016 B	0.04 B	3.36	0.4 B	0.02 U	0.009 B	0.8
T4S1MW09	T4S1MW09-GW-1	2/9/2005	0.03 B	11.2	0.015 B	0.069 U	2.65	1.30	0.190	0.20 U	5.49	1.0 U	0.027 U	0.008 J	2.6
T4S1MW09	T4S1MW09-GW-1	5/9/2005	0.05 B	10.6	0.052	0.16	6.29	2.88	0.8	0.2 U	7.82	0.1 B	0.006 B	0.015 B	8.11
T4S1MW10	T4S1MW10-GW-1	9/1/2004	0.05 U	0.6	0.024	0.02 U	0.6	1.9	0.156	0.05 B	5.7	0.3 B	0.02 U	0.004 B	2.3
T4S1MW10	T4S1MW10-GW-1	2/4/2005	0.05 U	0.4 B	0.020 U	0.06	0.81	0.62	0.046	0.05 B	3.6	0.3 B	0.020 U	0.020 U	5.5
T4S1MW10	T4S1MW10-GW-1	5/9/2005	0.02 B	0.35 B	0.020 U	0.08	0.43	0.79	0.06	0.2 U	4.61	0.2 B	0.020 U	0.007 B	2.53
T4S1MW11	T4S1MW11-GW-1	04/19/2004	0.03 B	7.6	0.02 U	0.05	0.43	2.13	0.26	0.10 U	4.95	0.8 B	0.01 U	0.018 U	9
T4S1MW11	T4S1MW11-GW-1	9/1/2004	0.04 B	17	0.02 B	0.02	0.37	1.24	0.092	0.04 B	4.64	1 U	0.02 U	0.014 B	2.3
T4S1MW11	T4S1MW11-GW-1	2/8/2005	0.05 U	10.0	0.020 U	0.03	0.26	0.44	0.017 B	0.20 U	3.1	0.2 B	0.020 U	0.020 U	0.6
T4S1MW11	T4S1MW11-GW-1	5/10/2005	0.05 U	6.9 J	0.02 U	0.02 U	0.96	1 U	0.075 U	0.20 U	1.85 J	1.0 U	0.02 U	0.02 U	1.95 U
T4S1MW12	T4S1MW12-GW-1	04/19/2004	0.03 B	2.1	0.03	0.02	0.56	6.36	0.2	0.10 U	3.96	1.2	0.01 U	0.017 B	3.56
T4S1MW12	T4S1MW12-GW-1	8/31/2004	0.05 U	10 U	0.01 B	0.02 U	2.71	0.87	0.13	0.2 U	3.47	5 U	0.02 U	0.02 U	1.6
T4S1MW12	T4S1MW12-GW-1	2/7/2005	0.04 B	1.1	0.006 B	0.03	0.84	0.87	0.062	0.06 B	2.6	0.3 B	0.015 B	0.020 U	6.5
T4S1MW12	T4S1MW12-GW-1	5/9/2005	0.14	3.1	0.036	0.15	12.3	3.74	2.27	0.2 U	11.9	0.2 B	0.020 U	0.008 B	11.5
T4S1MW13	T4S1MW13-GW-1	04/16/2004	0.03 B	15.4	0.02 U	0.02 B	0.66	0.72	0.03	0.10 U	2.3	0.3 B	0.01 B	0.041	1.2
T4S1MW13	T4S1MW13-GW-1	8/31/2004	0.05 U	5.8 B	0.02 U	0.02 U	2.55	0.39	0.02 U	0.2 U	3.51	5 U	0.02 U	0.02 U	0.5 B
T4S1MW13	T4S1MW13-GW-1	2/8/2005	0.05 U	14.2	0.020 U	0.02 U	0.47	0.29	0.030	0.05 B	2.1	1.0 U	0.020 U	0.020 U	1.2
T4S1MW13	T4S1MW13-GW-1	5/10/2005	0.05 U	15.4 J	0.02 U	0.024 U	1.63	0.83 B	0.292	0.20 U	1.97 J	1.0 U	0.02 U	0.02 U	2.73 U
T4S1MW15	T4S1MW15-GW-1	04/16/2004	0.02 U	0.02 U	0.02 U	0.01 B	0.43	1.34	0.05	0.10 U	0.3 B	0.2 U	0.01 U	0.006 B	0.6
T4S1MW15	T4S1MW15-GW-1	8/27/2004	0.05 U	10 U	0.01 B	0.02 U	4.12	1.91	1.1	0.2 U	9.56	5 U	0.02 U	0.02 U	3.1
T4S1MW15	T4S1MW15-GW-1	2/9/2005	0.05 U	0.3 B	0.008 B	0.086	1.36	1.32	0.425	0.20 U, J	9.44	1.0 U	0.020 U	0.020 U	2.3
T4S1MW15	T4S1MW15-GW-1	5/10/2005	0.1 U	2.7 J	0.112	0.056	21.9	9.23	10.9	0.20 U	20.4 J	2.0 U	0.04 U	0.04 U	31.5
T4S1MW16	T4S1MW16-GW-1	04/19/2004	0.06	0.9	0.04	0.18	0.23	4.98	0.11	0.10 U	7.34	1.8	0.03	0.072	9.68
T4S1MW16	T4S1MW16-GW-1	8/27/2004	0.33	0.8	0.058	0.06	1.65	14.3	1.12	0.2 U	4.62	0.5 B	0.02 U	0.01 B	13.7
T4S1MW16	T4S1MW16-GW-1	2/10/2005	0.11	0.5 B	0.011 B	0.222	0.57	3.89	0.689	0.20 U	2.52	0.5 B	0.02 U	0.020 U, J	10.3
T4S1MW20	T4S1MW20-GW-1	9/2/2004	0.05 U	1.9	0.027	0.03	0.85	0.95	0.186	0.2 U	10.8	0.8 B	0.02 U	0.005 B	4.4
T4S1MW20	T4S1MW20-GW-1	2/10/2005	0.05 U	1.5	0.011 B	0.095 U	0.21 U	0.64	0.133	0.20 U	10.1	0.7 B	0.02 U	0.008 J	2.3
T4S1MW20	T4S1MW20-GW-1	5/11/2005	0.05 U	1.1 J	0.02 U	0.038 U	1.37	0.69 B	0.176	0.20 U	7.14 J	1.0 U	0.02 U	0.02 U	2.74 U
T4S1MW21	T4S1MW21-GW-1	9/2/2004	0.05 U	0.2 B	0.017 B	0.04	0.48	0.59	0.056	0.2 U	20.3	0.3 B	0.011 B	0.007 B	3.1
T4S1MW21	T4S1MW21-GW-1	2/10/2005	0.05 U	0.5 U	0.015 B	0.113	0.24 U	0.68	0.100	0.20 U	18.0	0.2 B	0.02 U	0.009 J	4.5
T4S1MW21	T4S1MW21-GW-1	5/11/2005	0.063 U	0.4 J	0.035 U	0.397	3.25	1.48	1.110	0.20 U	11.7 J	1.0 U	0.02 U	0.02 U	5.78 U
	Preliminary	**Fish Consumption SLV**	640	0.14	--	--	--	--	--	--	4,600	4,200	--	6.3	26,000
	Screening Levels	**Aquatic SLV**	1,600	150 [a.]	5.3	0.25	74 $^{III.}$, 11 $^{VI.}$	9 [a.]	2.5 [a.]	0.77 [a.]	52 [a.]	5 [a.]	0.12	40	120 [a.]

Please refer to notes at end of table.

TABLE 19B
GROUNDWATER CHEMISTRY RESULTS: METALS - OU2

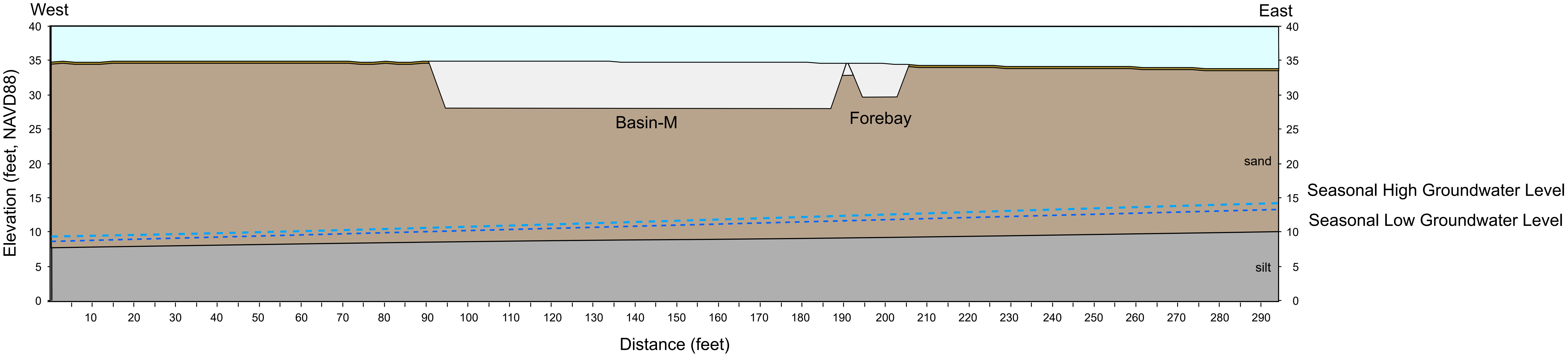
REMEDIAL INVESTIGATION
PORT OF PORTLAND - TERMINAL 4 SLIP 1

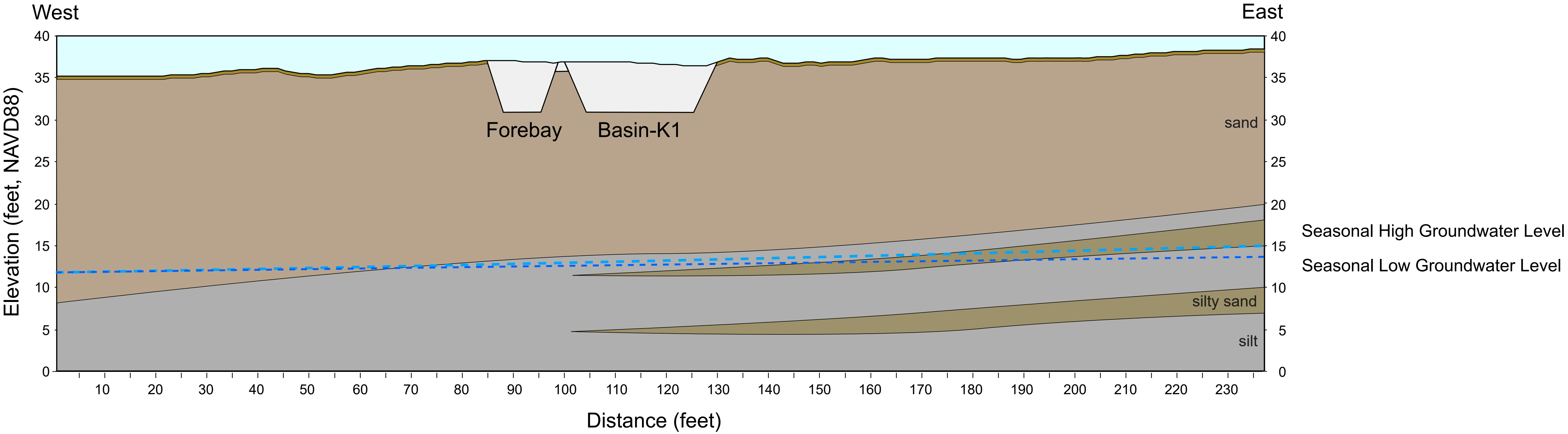
			Dissolved Metals (µg/L)												
Sample Location:	**Sample ID:**	**Date Sampled:**	Antimony	Arsenic	Beryllium	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver	Thallium	Zinc
T4S1MW09	T4S1MW09-GW-1	9/1/2004	0.05 U	8.6	0.02 U	0.02 U	0.57	0.52	0.02 U	0.2 U	3.39	1 U	0.02 U	0.007 B	1
T4S1MW09	T4S1MW09-GW-1	2/9/2005	0.05 U	9.7	0.020 U	0.053	0.91	0.41	0.063	0.20 U	5.45	1.0 U	0.020 U	0.020 U	1.1
T4S1MW09	T4S1MW09-GW-1	5/9/2005	0.05 U	11.5	0.020 U	0.06	1.82	0.55	0.01 B	0.2 U	5.98	1 U	0.020 U	0.007 B	2.01
T4S1MW10	T4S1MW10-GW-1	9/1/2004	0.05 U	0.3 B	0.02 U	0.02 U	0.51	1.37	0.042	0.05 B	6.07	0.4 B	0.02 U	0.02 U	1
T4S1MW10	T4S1MW10-GW-1	2/4/2005	0.05 U	0.4 B	0.020 U	0.04	0.16 B	0.50	0.020 U	0.06 B	3.5	0.3 B	0.020 U	0.020 U	5.5
T4S1MW10	T4S1MW10-GW-1	5/9/2005	0.05 U	0.38 B	0.020 U	0.06	1.17	0.84	0.01 B	0.2 U	5.21	1 U	0.020 U	0.020 U	1.76
T4S1MW11	T4S1MW11-GW-1	04/19/2004	0.13	7.4	0.02 U	0.02	0.09 B	0.69	0.01 U	0.10 U	4.44	0.2 U	0.01 U	0.01 B	2.17
T4S1MW11	T4S1MW11-GW-1	9/1/2004	0.05 U	7.2	0.02 U	0.02 U	0.68	0.52	0.02 U	0.05 B	4.55	1 U	0.02 U	0.02 U	0.9
T4S1MW11	T4S1MW11-GW-1	2/8/2005	0.06	8.0	0.020 U	0.03	0.46	0.33	0.078	0.08 B	3.1	0.4 B	0.020 U	0.020 U	0.8
T4S1MW11	T4S1MW11-GW-1	5/10/2005	0.05 U	6.0 J	0.020 U	0.02 U	0.47	1 U	0.02 U	0.20 U	2.93 J	1.0 U	0.020 U	0.02 U	1.08 U
T4S1MW12	T4S1MW12-GW-1	04/19/2004	0.14	2	0.02 U	0.02 B	0.22	0.82	0.01 B	0.10 U	3.82	1.3	0.01 U	0.015 B	2.65
T4S1MW12	T4S1MW12-GW-1	8/31/2004	0.05 U	10 U	0.02 U	0.02 U	0.93	0.24	0.02 U	0.2 U	2.75	5 U	0.02 U	0.02 U	0.5
T4S1MW12	T4S1MW12-GW-1	2/7/2005	0.05 U	0.6	0.020 U	0.02 U	0.52	0.12	0.020 U	0.09 B	2.6	1.0 U	0.020 U	0.020 U	4.2
T4S1MW12	T4S1MW12-GW-1	5/9/2005	0.02 B	0.55	0.020 U	0.03 J	1.37	0.37	0.03	0.2 U	5.83	1 B	0.020 U	0.020 U	2.82
T4S1MW13	T4S1MW13-GW-1	04/16/2004	0.09	14.6	0.02 U	0.01 U	0.66	0.56	0.01 B	0.10 U	2.4	0.2 U	0.01 U	0.007 B	1.5
T4S1MW13	T4S1MW13-GW-1	8/31/2004	0.05 U	6.4 B	0.02 U	0.02 U	0.75	0.35	0.02 U	0.2 U	3.1	5 U	0.02 U	0.02 U	0.6
T4S1MW13	T4S1MW13-GW-1	2/8/2005	0.05 U	14.4	0.020 U	0.02	0.52	0.18	0.026	0.07 B	2.4	0.2 B	0.020 U	0.020 U	1.3
T4S1MW13	T4S1MW13-GW-1	5/10/2005	0.05 U	12.4 J	0.02 U	0.02 U	0.38 U	1 U	0.022 U	0.20 U	1.05 J	1.0 U	0.02 U	0.020 U	1.01 U
T4S1MW15	T4S1MW15-GW-1	04/16/2004	0.06	0.2 U	0.02 U	0.02	0.47	1.28	0.01 U	0.10 U	0.4	0.2 U	0.01 U	0.006 B	0.5
T4S1MW15	T4S1MW15-GW-1	8/27/2004	0.05 U	10 U	0.02 U	0.02 U	6.8	1.07	0.02	0.2 U	9.45	5 U	0.02 U	0.02 U	0.6
T4S1MW15	T4S1MW15-GW-1	2/9/2005	0.05 U	0.3 B	0.020 U	0.090	1.18	1.00	0.068	0.20 U, J	10.1	1.0 U	0.020 U	0.020 U	1.6
T4S1MW15	T4S1MW15-GW-1	5/10/2005	0.05 U	0.2 J	0.020 U	0.02 U	1.96	1 U	0.023 U	0.20 U	3.36 J	1.0 U	0.02 U	0.020 U	1.60 U
T4S1MW16	T4S1MW16-GW-1	04/19/2004	0.18	0.5	0.02 U	0.14	0.06 U	4.02	0.02	0.10 U	7.19	1.1	0.02 U	0.039	9.18
T4S1MW16	T4S1MW16-GW-1	8/27/2004	0.02 B	0.3 B	0.007 B	0.03	0.46	2.93	0.036	0.05 B	4.18	0.4 B	0.02 U	0.006 B	4.2
T4S1MW16	T4S1MW16-GW-1	2/10/2005	0.05	0.3 B	0.020 U	0.202	0.93	2.16	0.600	0.20 U, J	2.91	0.4 B	0.020 U	0.020 U	4.3
T4S1MW20	T4S1MW20-GW-1	9/2/2004	0.05 U	1.8	0.014 B	0.02	0.25	0.61	0.01 B	0.2 U	10.2	0.6 B	0.02 U	0.005 B	3.2
T4S1MW20	T4S1MW20-GW-1	2/10/2005	0.05 U	1.3	0.011 B	0.075	0.31	0.57	0.070	0.20 U, J	10.2	0.7 B	0.020 U	0.020 U	1.5
T4S1MW20	T4S1MW20-GW-1	5/11/2005	0.05 U	1.4 J	0.02 U	0.027 U	0.80	1 U	0.020 U	0.20 U	7.51 J	1.0 U	0.020 U	0.02 U	2.35 U
T4S1MW21	T4S1MW21-GW-1	9/2/2004	0.05 U	0.3 B	0.013 B	0.04	0.29	0.55	0.035	0.2 U	19.9	0.2 B	0.02 U	0.005 B	3.2
T4S1MW21	T4S1MW21-GW-1	2/10/2005	0.02 B	0.5 U	0.012 B	0.110	0.33	0.65	0.091	0.20 U, J	18.4	1.0 U	0.020 U	0.007 B	4.4
T4S1MW21	T4S1MW21-GW-1	5/11/2005	0.05 U	0.1 J	0.02 U	0.086	0.75	1 U	0.022 U	0.20 U	10.4 J	1.0 U	0.020 U	0.02 U	3.26 U
	Preliminary	**Fish Consumption SLV**	640	0.14	--	--	--	--	--	--	4,600	4,200	--	6.3	26,000
	Screening Levels	**Aquatic SLV**	1,600	150 $^{a.}$	5.3	0.25 $^{a.}$	74 $^{III.}$, 11 $^{VI.}$	9 $^{a.}$	2.5 $^{a.}$	0.77 $^{a.}$	52 $^{a.}$	5 $^{a.}$	0.12	40	120 $^{a.}$

Notes:
1. All analytes are reported in the table.
2. Total/Dissolved Metals using EPA 6000-7000 Series Methods.
3. µg/L = Micrograms per liter.
4. Fish Consumption SLV = EPA National Recommended Water Quality Criteria: 2002 Human Health for Consumption of Fish.
5. Aquatic SLV = EPA National Recommended Water Quality Criteria: 2002 for CCC Freshwater Biota (noted with ^{a}). Where CCC values are not available, Oregon Department of Environmental Quality Level II Screening Level Values (SLVs) for Surface Water Aquatic are listed.
6. -- = No screening level available or not analyzed.
7. B = The result is an estimated concentration that is less than the MRL but greater than or equal to the method detection limit (MDL).
8. U = The compound was analyzed for but was not detected at or above the MRL/MDL.
9. N = The matrix spike sample recovery is not within control limits. The case narrative suggests that this sample may be biased low.
10. $^{III.}$ = SLV for Chromium III.
11. $^{VI.}$ = SLV for Chromium VI.
12. Boxed values indicate that the detected concentration exceeds the Ecological Screening Criteria (for chromium, Chromium III used).
13. Shaded values indicate that the detected concentration exceeds the EPA AWQC criteria.

Attachment C3

Cross-Section Drawings of Proposed Stormwater SCMs at Basin M and Basin K1


West
East
Elevation (feet, NAVD88)
0
5
10
15
20
25
30
35
40
Basin-M
Forebay
sand
silt
Seasonal High Groundwater Level
Seasonal Low Groundwater Level
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250
260
270
280
290
Distance (feet)


West
East
Elevation (feet, NAVD88)
40
35
30
25
20
15
10
5
0
Forebay
Basin-K1
sand
silty sand
silt
Seasonal High Groundwater Level
Seasonal Low Groundwater Level
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
Distance (feet)

Appendix D

Drainage Basin K1 Groundwater Mounding Analysis

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Technical Memorandum

Date: December 20, 2019; Revised September 3, 2020

To: Kelly Madalinski, Ben Ahn, and Roger Anderson, Port of Portland

From: Bob Anderson, LHG[1], James Peale, LHG[1], RG[2], Marc Leisenring, PE[1,2] and Myles Gray, Geosyntec Consultants

1 – Registered in Washington, 2 – Registered in Oregon

Subject: Groundwater Mounding Analysis for the Planned Bioinfiltration Basin in Drainage Basin K1 at Terminal 4

A vegetated infiltration basin (i.e. bioinfiltration basin) is proposed at Port of Portland Terminal 4 (T4) to treat and infiltrate runoff from drainage Basin K1. The basin would be located in a gravel area northeast of Slip 3. A groundwater plume of diesel-range petroleum hydrocarbons and light, non-aqueous phase liquid (LNAPL) exists east of Slip 3 in the adjacent drainage basins (Drainage Basins K2 and J).[1] The groundwater plume and LNAPL are located approximately 300 feet from the proposed bioinfiltration basin. While the bioinfiltration basin is not expected to exacerbate the lateral or vertical transport of the plume, an assessment of the potential impacts of infiltration in this vicinity was conducted to support the design and confirm no adverse impacts on the contaminated groundwater plume.

ANALYSIS APPROACH

An analysis of mounding at the proposed T4 bioinfiltration Basin K1 was conducted using a spreadsheet tool that estimates the height of a groundwater mound beneath a stormwater infiltration basin. The purpose of the analysis was to evaluate whether infiltration at Basin K1 could cause excessive groundwater mounding that could increase groundwater gradients and

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[1] These impacts are described by the Oregon Department of Environmental Quality as ECSI Site 272 – Terminal 4 Slip 3. LNAPL monitoring and recovery continues consistent with the Record of Decision for the site.

thereby affect the movement of the contaminated groundwater plume. The spreadsheet used for the calculations is available through the U.S. Geological Survey (USGS) Scientific Investigations Report 2010-5102 "Simulation of groundwater mounding beneath hypothetical stormwater infiltration basins", which also contains a summary of the methodology used. The spreadsheet solves the Hantush (1967) equation for groundwater mounding beneath an infiltration basin, which describes the growth and decay of groundwater mounds in response to infiltration from a rectangular basin. The spreadsheet generates a profile figure of the height of groundwater above the static water-level as a function of lateral distance from the center of the infiltration basin. No changes were made to the structure or calculations of the USGS spreadsheet model. User-specified parameters in the spreadsheet tool include:

- Infiltration recharge rate (I) (feet per day)
- Specific yield of the aquifer receiving infiltration (Sy) (dimensionless, between 0 and 1)
- Horizontal hydraulic conductivity of the aquifer receiving infiltration (Kh) (feet per day)
- Basin dimensions (x, y) (feet)
- Duration of infiltration (t) (days)
- Initial saturated thickness of the aquifer receiving infiltration (H0) (feet)

The tool assumes that all water applied to the infiltration basin infiltrates (i.e., soil infiltration rate is greater than basin recharge rate). This is very likely true for the proposed Basin K1 vegetated infiltration basin given that field infiltration testing in the proposed location determined rates as high as 80 inches/hour; a value of 20 inches/hour was used as the design infiltration recharge rate to size the proposed pump station. The tool also assumes that all water applied to infiltration basins reaches the groundwater table without any temporal of volumetric attenuation in the unsaturated zone. Given that the bottom of the proposed Basin K1 vegetated infiltration basin would be located approximately 20 feet above the static groundwater table (see Attachment C3 of Appendix C), some temporal and volumetric attenuation would be expected, so the tool would be expected to generate slightly conservative results.

Analyses were completed using best estimates for user-specified parameter values for a long duration storm and for a shorter but more intense storm event. A sensitivity analysis was also completed to assess the potential for larger mounding due to uncertainty in some of the user-specific parameters.

ANTICIPATED GROUNDWATER MOUNDING

Two design storm events were simulated using the spreadsheet tool:

- Run A: 0.1 cfs for 48 hours
- Run B: 0.2 cfs for 12 hours.

User-specified parameter values were based on the best available data to generate anticipated groundwater mounding profiles. Additional parameter values were included in the sensitivity analysis.

These two design flow rates represent the range of stormwater design inflow rates from the duplex pump station. Run A represents a longer duration but lower intensity storm while Run B represents a short duration but higher intensity event. The durations of each of these flow rates are based on conservative assumptions. Based on a rainfall frequency analysis of 50 years of hourly PDX rainfall data[2], there is less than a 1% chance in any given year that the site would receive sustained rainfall intensities capable of producing the design flow rates for greater than these durations. Each run was analyzed for an expected case scenario and a worst-case scenario. Mounding heights beneath the proposed bioinfiltration basin and at the edge of the groundwater contaminant plume were extracted from the spreadsheet tool. Parameter values and mounding results are presented in Table 1. Assumptions for different parameters are discussed below.

Table 1. Parameters and mounding height results for mounding analysis

Design Parameter	**Units**	**Run A**	**Run B**
Basin Dimensions	ft x ft	30 x 30	30 x 30
Infiltration Recharge Rate	ft/day	9.6	19.2
Infiltration Duration	hours	48	12
Specific yield	ft/ft	0.1	0.1
Horizontal K_{sat}	ft/day	65	65
Aquifer thickness	ft	2	2
Mounding beneath basin (x = 0)	ft	8.62	7.00
Mounding at edge of plume (x = 300)	ft	0.06	0.02

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[2] NCDC data for Portland International Airport (Coop ID: 356751) from 10/1/1949 to 10/1/2011

Using a conceptual basin footprint, infiltration recharge rates were calculated from the design flow rates and durations using the equation below.

$$I\left(\frac{ft}{day}\right) = \frac{Q_{design}\left(\frac{ft^3}{s}\right) * \frac{8640\ s}{1\ day}}{A_{basin}\ (ft^2)}$$

Square basin dimensions were used because they result in higher groundwater mounding heights than rectangular basin dimensions. Typical soil specific yield values range from about 0.2 to 0.4 (Carlton, 2010) so a value of 0.1 was chosen for the expected case analysis as a conservative estimate of site conditions.

Horizontal hydraulic conductivity was estimated based on data from a pump test completed in 1994 on monitoring well MW-2. Hydraulic conductivity results from this pump test were reported as 65 feet per day in the Terminal 4 Slip 3 Upland Remedial Investigation Report (T4S3 RI; Hart Crowser, 2000). Boring logs the T4S3 RI indicate approximately 20 to 25 feet of medium sand fill material overlying alluvial silts and clays. The screened interval in MW-2 spans the trasition between fill and alluvial material, however, as reported in the T4S3 RI, hydraulic conductivity of 65 feet per day likely corresponds to the overlying fill material and not the underlying alluvial material. Recent infiltration testing completed at the Site in February 2020, found a vertical infiltration rate of 80 inches per hour (equivalent to 160 ft/day) at a depth of 7.5 feet below the existing surface in the footprint of the proposed vegetated infiltration basin. Soils typically exhibit anisotropy in hydraulic conductivity, with horizontal hydraulic conductivity values typically being at least 2 to 5 times greater than vertical hydraulic conductivity values. It is likely that the material at 7.5 feet of depth is fill and may be extremely similar to other fill materials overlying the alluvial materials. This suggests that actual horizontal hydraulic conductivity values in the fill materials could be substantially higher than the 65 ft/day that was measured in 1995.

The initial aquifer thickness was estimated as 2 feet corresponding to the depth of water in the fill material overlying the alluvial materials. This differs slightly from the soil profile figures in Appendix A which were based on well logs from Slip 1, however, well logs included in the T4S3 RI generally show 1 to 3 feet of groundwater depth within the sandier fill material (above the finer alluvial material). Since the hydraulic conductivity value used in the analysis corresponds to the fill material, the alluvial material was assumed to be a confining layer even though silt materials would not typically be considered confining layers. This will yield a conservative estimate of mounding.

Results are presented in Table 1 and Figure 1 for both runs. Run A results indicate that, for the 48-hour design event, the expected rise in groundwater level beneath the basin would be about 8.5 feet, and the rise at a distance of 300 feet from the basin would be 0.06 feet. Run B results indicate that, for a 12-hour design event, the expected rise in groundwater level beneath the basin would be about 7.0 feet, and the rise at a distance of 300 feet from the basin would be 0.02 feet.

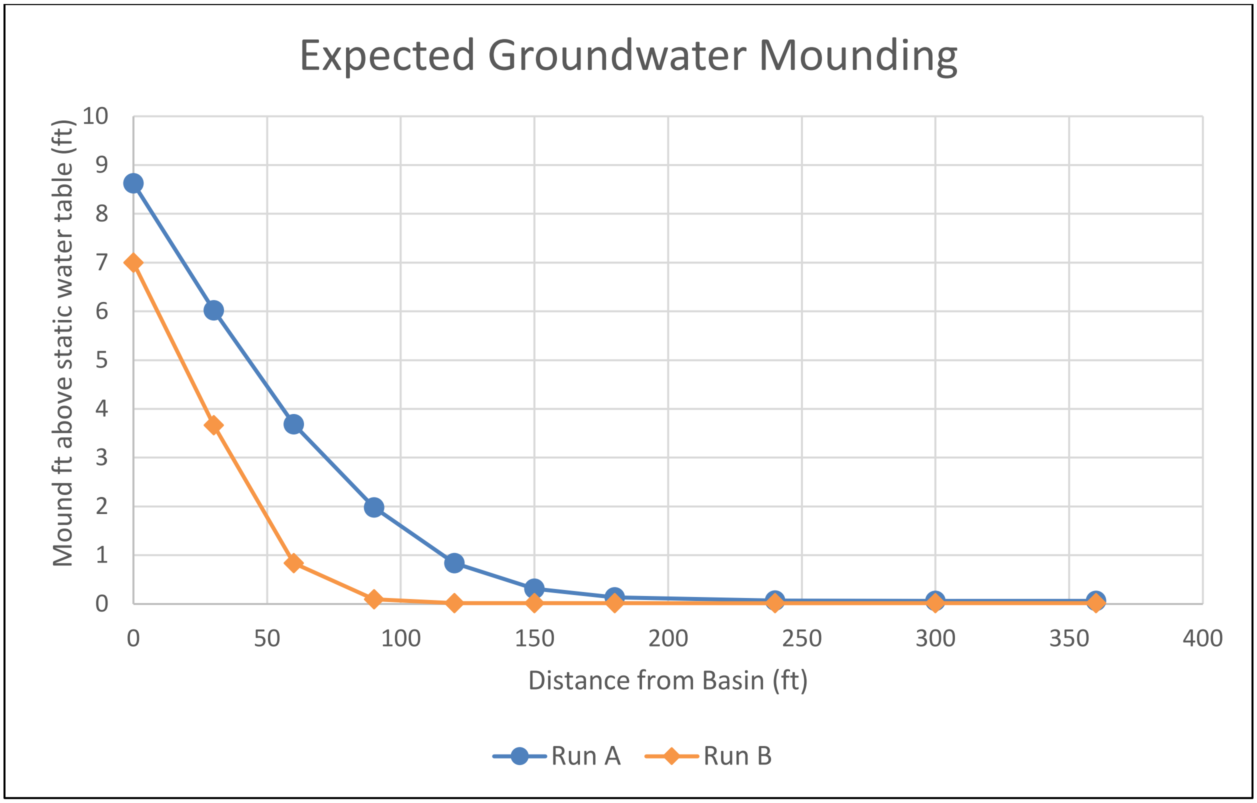

Figure 1. Groundwater mounding results for Run A.

The results indicate only slight increases in groundwater elevations at the edge of the plume for both runs using both expected values and conservative values. The elevation changes at the edge of the plume for Run B are within the range of measurement error for standard groundwater depth measuring equipment. The elevation changes at the edge of the plume for Run A (both cases) are well within seasonal and tidally-induced fluctuations in groundwater elevations in wells located adjacent to or near the Willamette River.

To further assess the potential of groundwater mounding to promote increased migration of the groundwater contamination plume, groundwater mounding gradients were calculated for both runs for each 100-foot interval from the proposed vegetated infiltration basin to the edge of the plume. Results from this analysis are presented in Table 2.

Table 2. Groundwater gradients resulting from groundwater mounding beneath proposed vegetated infiltration basin.

Lateral Distance from Proposed Infiltration Basin	Groundwater Mounding Gradient (ft/ft)	
	Run A	Run B
0 to 100 feet	0.070	0.069
100 to 200 feet	0.015	0.0005
200 to 300 feet	0.0005	<0.0001

Geosyntec also reviewed groundwater elevation maps produced by Ash Creek Associates (Ash Creek, 2007) for eight groundwater monitoring events completed between February 1, 2005 and September 14, 2005 based on water level data in groundwater monitoring wells located near Slip 3. For those monitoring events, groundwater gradients from the proposed bioinfiltration basin to the edge of the contaminated plume ranged from 0.005 to 0.0092 ft/ft, with an average gradient of 0.0073 ft/ft. For all results in Table 2, the estimated groundwater gradients due to mounding from 200 to 300 feet away from the proposed vegetated infiltration basin are more than an order of magnitude smaller than gradients based on historic groundwater levels. Additionally, the increases in groundwater levels at the edge of the plume (i.e., at 300 feet from the proposed vegetated infiltration basin) are so small that they would not meaningfully change groundwater gradients beneath the Site. Based on these results, the proposed vegetated infiltration basin is not anticipated to adversely impact the contaminated groundwater plume.

SENSITIVITY ANALYSIS

A sensitivity analysis of the user-input parameters was performed using the spreadsheet tool to investigate how groundwater mounding heights directly beneath the proposed bioinfiltration basin and at the edge of the contaminated plume would be affected by changes in individual parameter values. Particularly sensitive parameters could justify more accurate and/or more conservative input values.

The sensitivity analysis was completed using Run A as the base case. Sensitivity analysis parameter ranges are presented in Table 4. The infiltration recharge rate was varied from 0.05 cfs (representing low flows from intermittent pumping) to 0.2 cfs (representing the maximum pumping rate). The specific yield was varied from 0.05 (an extremely conservative value) to 0.3, which is the upper limit for most normal soils (Carleton, 2010). The hydraulic conductivity was varied around the field-estimated estimated hydraulic conductivity at the site of 65 ft/day, ranging from 25 ft/day to 125 ft/day. The thickness of the saturated zone was varied around the base value of 2 ft, ranging from 0 ft to 5 ft. Parameters were varied one at a time, so all other parameters were held constant (at the base case values) during sensitivity analysis for a given parameter.

Table 3. Ranges of Parameter Values used in Sensitivity Analysis

Parameter	Minimum	Base case	Maximum
Infiltration Recharge Rate	4.8 ft/day (0.05 cfs)	9.6 ft/day (0.1 cfs)	19.2 ft/day (0.2 cfs)
Specific Yield	0.05	0.1	0.3
Hydraulic Conductivity	25 ft/day	65 ft/day	125 ft/day
Thickness of the Saturated Zone	0 ft	2 ft	5 ft

Figures 3 and 4 present the results of the sensitivity analysis on the groundwater mounding heights beneath the proposed bioinfiltration basin and at the edge of the contaminated plume, respectively. The x-axis represents the relative percent difference in parameter input values relative to the value used in the base case. The y-axis represents the groundwater mound height resulting from the corresponding change in parameter.

As shown in Figure 3, mounding heights beneath the basin are most sensitive to the horizontal hydraulic conductivity and the infiltration recharge rate while variations in initial aquifer thickness and specific yield result in only minor differences in the resulting groundwater mound height. Because the infiltration recharge rate is controlled by the size of the proposed pump station, a value of 19.2 ft/day is the absolute maximum that could be achieved. At this infiltration recharge rate the groundwater mound beneath the proposed vegetated infiltration basin would be approximately 13 feet, which would still be below the bottom of the proposed facility. Low values of horizontal hydraulic conductivity also result in higher mounding beneath the proposed facility, with a value of 25 ft/day resulting in a fourteen-foot-high mound. However, as noted previously, based on recent infiltration testing at the Site it is likely that horizontal hydraulic conductivity values are higher than the 65 ft/day measured in 1995, not lower.

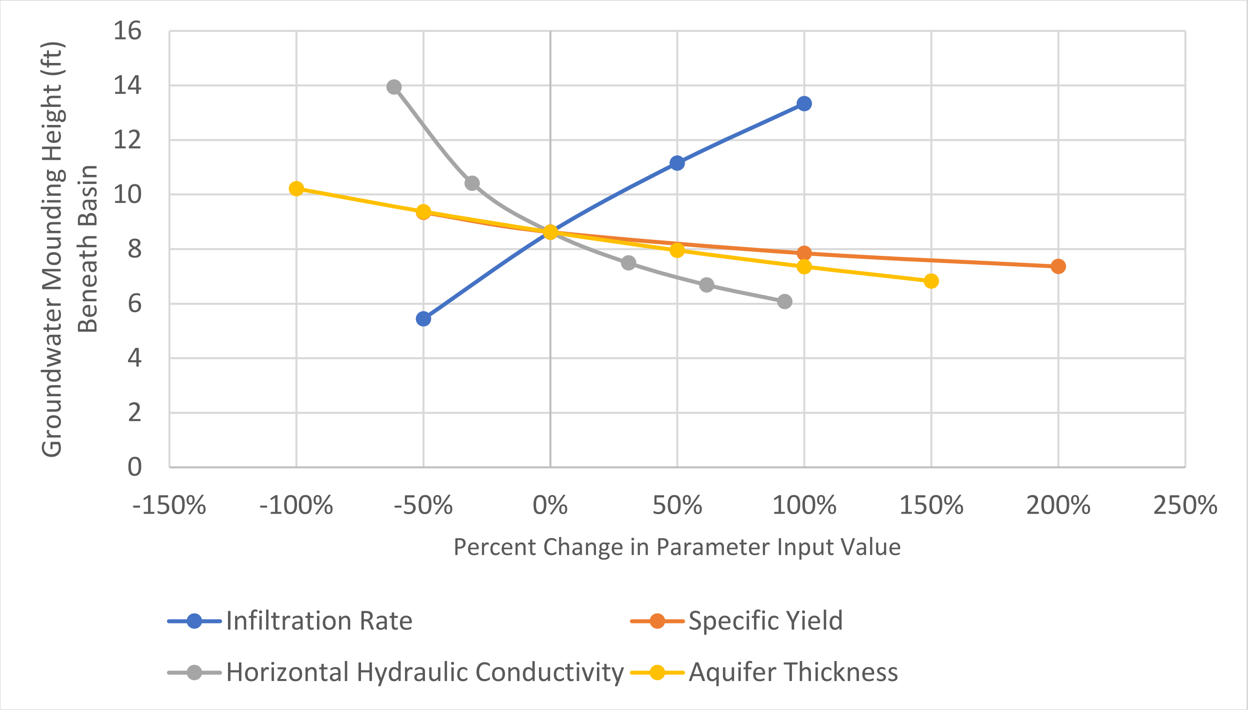

Figure 2. Sensitivity analysis of groundwater mounding beneath proposed bioinfiltration basin.

As shown in Figure 4, mounding heights at the edge of the contaminated groundwater plume are most affected by the specific yield and infiltration recharge rate, however even large variations in these parameters do not result in meaningful changes in groundwater mounding at the edge of the plume.

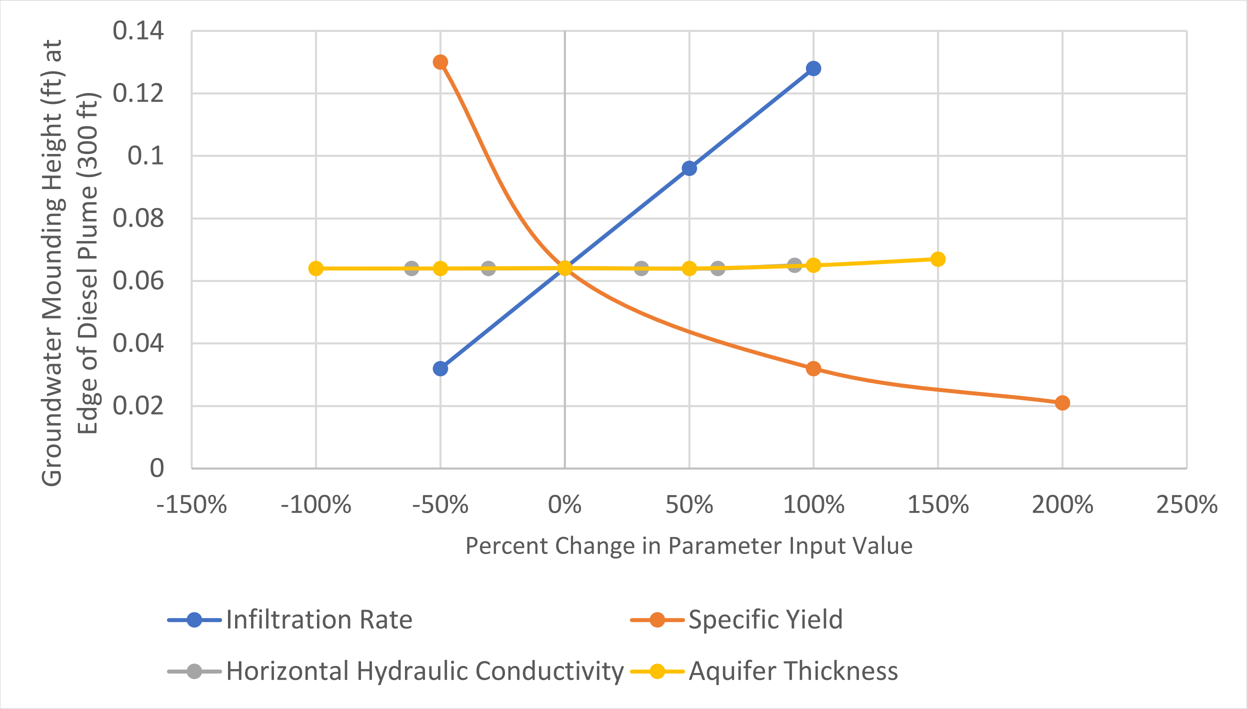

Figure 3. Sensitivity analysis of groundwater mounding at edge of contaminated plume.

The sensitivity analysis results suggest that while parameter uncertainty could result in larger than predicted groundwater mounding heights near the proposed bioinfiltration basin, parameter uncertainty would not likely result in a meaningful increase in mounding height at the edge of the contaminated groundwater plume.

REFERENCES

Ash Creek Associates, Inc. Remedial Investigation: Terminal 4 Slip 1 Upland Facility, Portland, OR. August, 2007.

Carleton, G.B., 2010, Simulation of groundwater mounding beneath hypothetical stormwater infiltration basins: U.S. Geological Survey Scientific Investigations Report 2010-5102, 64 p

Hart Crowser, 2010. Remedial Investigation Report Terminal 4, Slip 3 Upland Port of Portland.

Hantush, M.S., 1967, Growth and decay of groundwater mounds in response to uniform percolation: Water Resources Research, v. 3, p. 227–234.

Appendix E

Modeling Appendix

Modeling Appendix

1. INTRODUCTION

This modeling appendix documents the hydrologic and hydraulic (H&H) models that have been developed for the proposed Vegetated Infiltration Basin Source Control Measures (SCMs) to treat stormwater runoff from Basins K1 and M at the Port of Portland (PoP) Terminal 4 (T4) facility (Site). H&H models were developed using the Environmental Protection Agency (EPA) Stormwater Management Model (SWMM) version 5.1.

Baseline models of the existing condition of Basin M and Basin K1 were developed to estimate the stormwater runoff from the drainage areas. The baseline model for Basin M is calibrated using monitored flow data and best professional judgement and calibrated subcatchment parameterization were used to assign subcatchment parameters for Basin K1. The proposed stormwater SCMs were subsequently added to the baseline models.

The developed models for both stormwater SCMs in Basin K1 and Basin M were used to size the proposed diversion flowrate according to the design standards applicable to the Site:

1) A long-term runoff simulation was developed to demonstrate that more than 90% of the stormwater runoff from approximately 20 years of rainfall record is captured by the proposed SCMs;
2) A storm-event simulation with the Oregon Department of Environmental Quality (DEQ) 1200-Z design storm (50% of a 2-year 24-hour event) was developed to demonstrate that the proposed SCMs captures the entirety of the runoff from the design storm.

In addition to using the models to size the proposed stormwater SCMs, the models were also used to demonstrate that no adverse drainage condition would be created from the proposed designs:

- A storm-event simulation with the 25-year 24-hour design storm was developed to demonstrate that no adverse drainage condition would be created from the proposed design of the stormwater SCMs.

2. MODEL INPUT

2.1 Assumptions

The existing storm drain network was modeled using information derived from Port databases and as-built drawings for selected drainage features. The Port storm drain database includes pipe diameters, material types, and flow inverts for storm drains across T4. Limited data gaps were present in this database, so assumptions were made for the missing information. Given the elevation of the outfalls, potential backwater effects from high water in the Willamette River were considered minimal and were neglected. Further description of model development is included in the following sections.

2.2 Tributary Areas

Separate models were developed for Basin M and Basin K1. Basin M is approximately 26.5 acres with less than 1.8 acres of impervious area directly connected to storm pipes. The remainder of Basin M consists of pervious areas (mostly gravel and grass), permeable asphalt pavement, impervious paved areas draining to pervious areas, and rail yard ballast areas with gravel underlain by perforated drainage piping. Basin K1 is a mix of compacted gravel and paved areas, but the exact areas of gravel and paved areas are not well-delineated, so impervious area estimates are approximate. Summary information for Basins K1 and M are presented in Table 1. Figure 1 presents a map of Basins M and K1, with sub-basins shown for Basin M.

Table 1. Basin Area Overview

Basin	Area (ac)	Total Impervious Area (ac)	Directly Connected Impervious Area (ac)
M	26.5	5.9[1]	1.8
K1	1.24	0.62	0.62

[1] Total impervious area for Basin M does not include permeable pavement

2.3 General Model Input

Both models were simulated using SWMM hydraulic and hydrologic parameters presented in Table 2. More information regarding calibrated hydrologic parameters is presented in the following sections for Basins K and M. Hydraulic parameters were not used in calibrations.

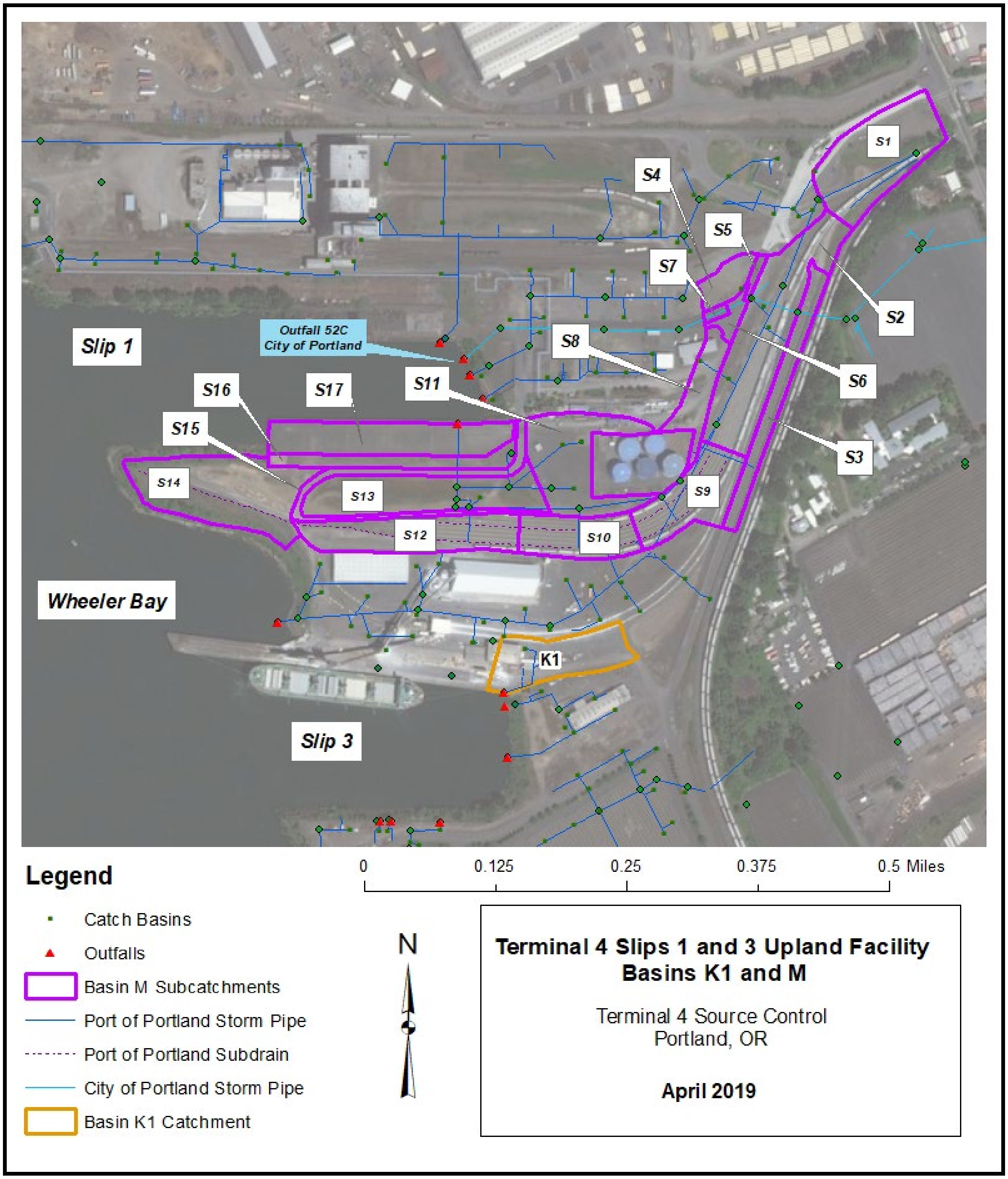

Figure 1. Basins K1 and M, including sub-basins.

Table 2. SWMM hydrologic and hydraulic parameters

Parameter	Units	Value / Option
Wet time step	Seconds	300
Dry time step	Seconds	3,600
Manning's n		Sub-basin calibration parameter[1]
Impervious depression storage	Inches	0.05
Pervious depression storage	Inches	0.7[2]
Soil Hydraulic Conductivity	Inches/hour	0.1[2]
Flow routing Routine		Dynamic Wave
Normal Flow Criterion		Slope & Froude
Routing Time Step		15 seconds
Infiltration Routine		Green-Ampt

[1] Manning's n values were calibrated for sub-basin types as described in Basin M Calibration

[2] Soil hydraulic conductivity and pervious depression storage were calibrated for Basin M

Precipitation Data

Hourly rainfall data were downloaded from the United States Geological Survey (USGS) / City of Portland Hydra Network for the WPCL Rain Gauge and the Shipyard Rain Gauge. Data from the Shipyard Gauge were used for model calibration of Basin M. This gauge is located approximately ½ mile north of T4 and has an 8-year period of record (POR) with no missing values. Data from the WPCL, which is located approximately 1.4 miles southeast of T4 and has a POR of nearly 20 years, were used for longer model simulations to estimate flow rates required to treat 90% of average annual runoff.

Precipitation data were formatted for use in EPA SWMM and missing hourly values were filled as zeros. Approximately 1% of the hourly rainfall data is missing at this rain gauge over the POR of nearly 20 years. The average annual precipitation at the WPCL rain gauge for the POR from March 1999 to October 2018 was 39.0 inches.

Precipitation data for the Oregon DEQ Tier II design storm was based on data acquired from NOAA Atlas 2, which indicated that the 2-year 24-hour storm depth at the site is 2.17 inches. The Oregon DEQ Tier II design storm is equal to half of this depth, or 1.09 inches. This depth value was distributed according to a Natural Resources Conservation Service (NRCS) Type 1A distribution and formatted for use in SWMM.

Precipitation data for the 25-year, 24-hour storm event, also based on NOAA Atlas 2, is 3.9 inches for the Site. This depth was distributed according to a Natural Resources Conservation Service (NRCS) Type 1A distribution and formatted for use in SWMM.

3. MODEL DEVELOPMENT

3.1 Basin M Model Development and Calibration

Stormwater runoff flow rates were monitored in Basin M from March 23, 2015 through June 25th, 2015 and then again from October 10, 2015 through January 25, 2016. This POR was used for model calibration of Basin M. Notably, this POR included December 2015, during which more than 15 inches of rain fell at the Portland International Airport (PDX), making it the rainiest calendar month on record at PDX. Flow was measured using a Thel-mar Weir and a water level bubbler installed in STSMH2589, which is the most downstream manhole in Basin M. All known runoff enters the Basin M storm drain network upstream of this manhole.

Basin M was sub-delineated into 17 subcatchments primarily to split those areas with different imperviousness and to introduce runoff to different points within the storm drain network. The storm drainage network was extracted from PortGIS and input into the model. The percent imperviousness of each sub-basin was estimated using aerial imagery. Permeable pavement was assumed to be pervious area. Gravel areas in the vicinity of rail lines were assumed to be impervious areas draining to perforated ballast pipes. The slope of each sub-basin was estimated using GIS analysis of LIDAR data.

Two storage units were included in the model to simulate the hydrologic impacts of the perforated ballast piping beneath rail lines in Basin M. According to Record Drawings for the 2005 Rail Line Improvement Project, 6-inch perforated pipes are located 4-inches above the bottom of 16-inch wide gravel trenches installed directly beneath the rail lines at T4. The properties of the model storage units were developed to simulate the behavior of this drainage design, with an assumed infiltration rate or 0.1 inches per hour from the gravel-filled trenches to underlying soils. Essentially, these storage units were simulated as infiltration vaults with orifice-controlled discharges (i.e. pipes) offset above the infiltration surface. The net effect of these units is to significantly decrease the peak runoff flow rates and total runoff volumes from Basin M, while extending the hydrographs.

Model calibration was primarily completed by modifying parameters for pervious area infiltration rates and depression storage. To limit the number of potential calibration iterations, all such modifications were completed across Basin M, and not on a sub-basin basis. The accuracy of subcatchment parametrization for individual sub-basins could be important if multiple distributed stormwater SCMs were considered in the design. However, with a single infiltration basin treating runoff from all of Basin M, the rate and volume of runoff from individual sub-basins is not critical for the design or the performance of the proposed facility. All calibration model runs were completed for the POR from March 23, 2015 through January 25, 2016 during those intervals when flow monitoring data was available for calibration. Model iterations were completed to minimize the root mean squared error between modeled and measured flow rates throughout the calibration POR. Final calibrated parameters for the different sub-basin types are presented in Table 3.

Table 3. Model calibration parameters for Basin M

Sub-basin Type	**Manning's n, impervious**	**Manning's n, pervious**	**Depression storage, impervious (in)**	**Depression storage, pervious (in)**
Regular Pavement	0.013	0.032	0.05	0.70
Permeable Pavement[1]	0.013	0.013	0.05	0.70
Gravel	0.013	0.030	0.05	0.70
Grass	0.013	0.038	0.05	0.70
Ballast[2]	0.032	0.032	0.05	0.70

[1] Permeable pavement was categorized as pervious

[2] Ballast gravel was categorized as impervious area draining to model storage elements

The other subcatchment parameters are shown in Table 4 for each of the 17 sub-catchments delineated for the Basin M Drainage Area as shown in Figure 1.

Table 4 Other Subcatchment Parameters for Basin M Drainage Area

Catchment	Area (acres)	% Impervious	Maximum Distance to Catch Basin (ft)	Percent Slope
S1	2.63	10	728	3.43
S2	3.57	55	1205	1.33
S3	1.2	100	1372	0.88
S4	0.53	0	345	3.16
S5	0.1	0	239	0.81
S6	0.24	99	283	2.08
S7	0.08	0	132	1.91
S8	0.92	50	993	0.35
S9	1.7	90	923	0.54
S10	1.38	100	647	0.92
S11	2.24	80	3807	0.18
S12	2.1	70	877	0.06
S13	2.52	5	1555	0.13
S14	3.09	20	676	0.74
S15	0.96	80	36	1.39
S16	0.95	0	59	1.69
S17	2.24	99	174	1.15

Table 5 presents modeled and measured values for total POR runoff and peak discharge flow rate for the final Basin M calibrated model. Figure 2 shows modeled and measured flow rates for a portion of the calibration POR and Figure 3 shows the same information for the entire calibration POR.

Table 5. Modeled vs. measured values for Basin M.

	Peak Discharge, cfs	**Total Runoff Volume, Million Gallons**
Monitoring Data	3.93	7.43
Model Output	3.78	7.47
Difference	+4%	-1%

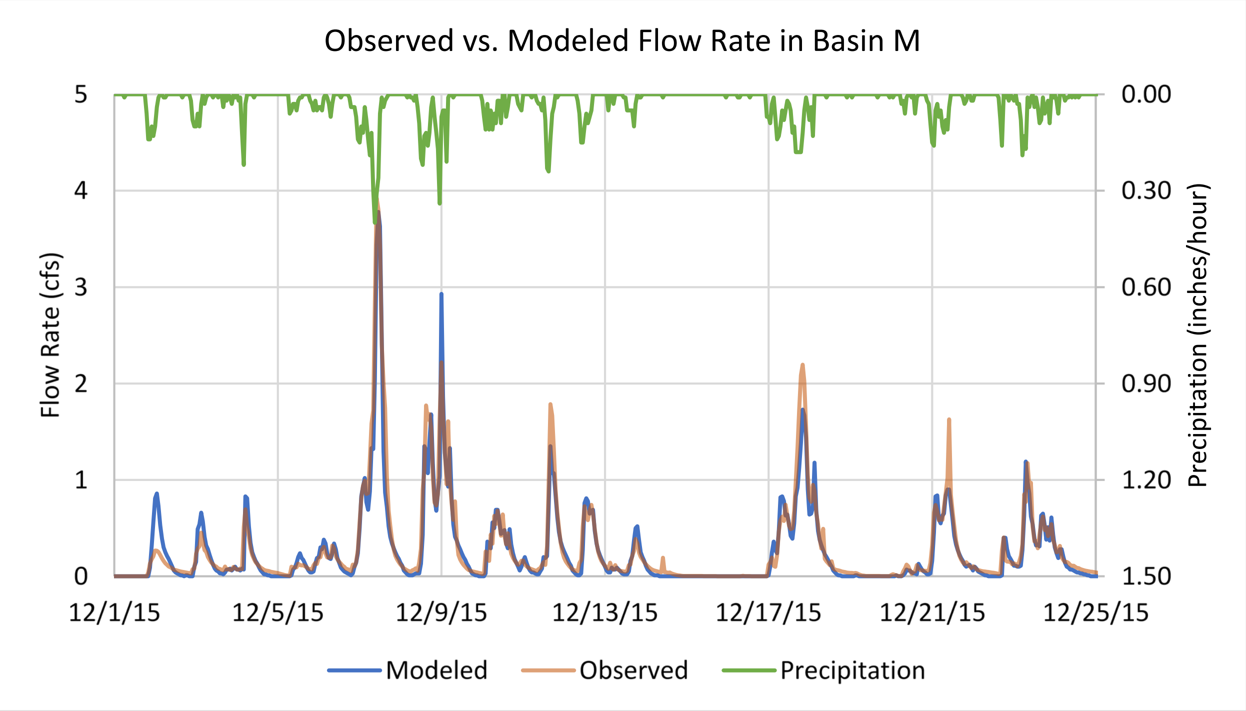

Figure 2. Observed vs. modeled flow rates for Basin M. This figure presents only a subset of the calibration period of record.

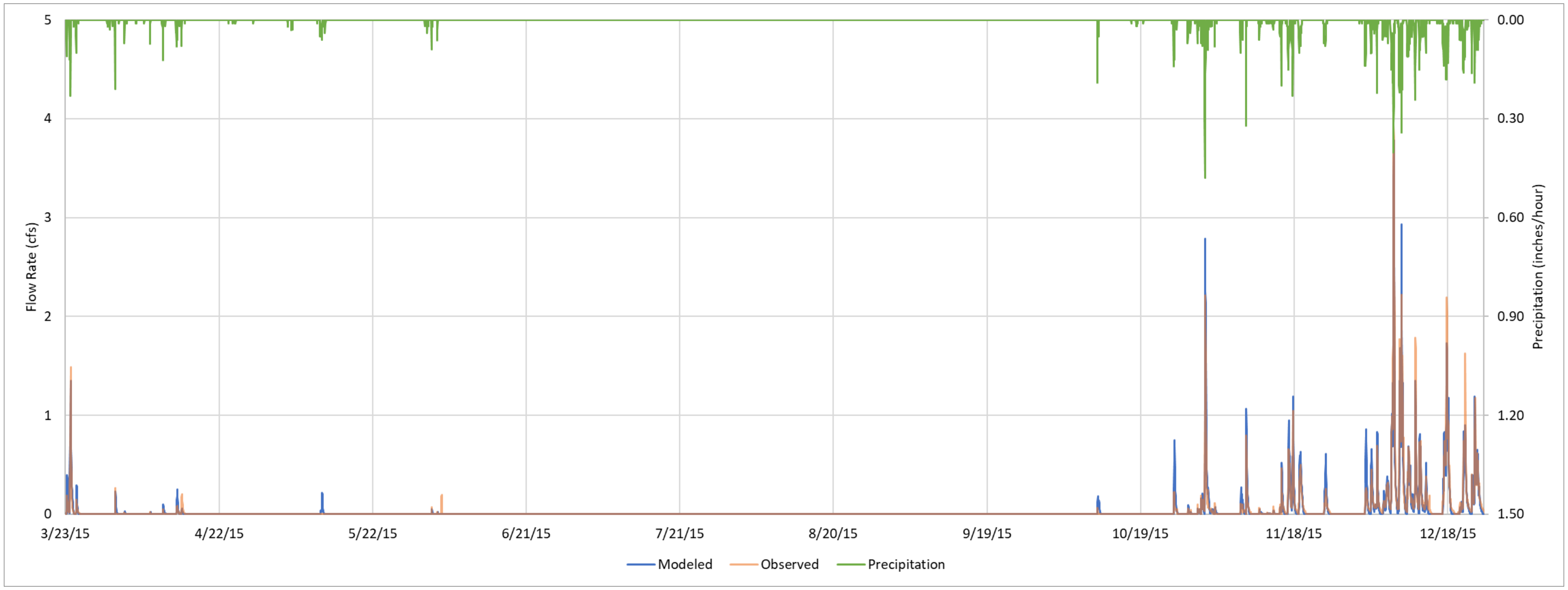

Figure 3. Observed vs. Modeled Flow Rates for Basin M for the Entire Calibration Period of Record.

3.2 Basin K1 Model Development

A model for Basin K1 was developed using available GIS data, certain parameters from the calibrated Basin M model, and best professional judgement. Given its small size, Basin K1 was modeled as a single basin (i.e. no sub-basins). GIS analysis was used to estimate the total area of Basin K1, the percent imperviousness, and the slope. It was difficult to accurately estimate percent imperviousness of Basin K1 using available aerial imagery because the open graveled area could not be readily distinguished from paved and graveled access roads. Therefore, two scenarios were developed for Basin K1: one scenario assuming 100% impervious and the other assuming 50% imperviousness which was estimated from aerial imagery. Pervious area infiltration rates and pervious area depressions storage values were taken from the calibrated Basin M model. No model calibration was completed for Basin K1 because no flow monitoring data was available.

3.3 Stormwater SCM Sizing

The proposed stormwater SCMs are added into the existing condition (baseline) models for Basin M and Basin K1. A diversion manhole, a pump station vault and an infiltration facility are modeled as storage units in SWMM for each drainage basin. A pump is modeled between the pump station vault and the infiltration basin and a bypass weir is modeled in the diversion weir. The pump station vault size, pump rate and infiltration basin footprint were adjusted to achieve full capture of runoff from the 1200Z Tier II design storm and 90% capture of long-term stormwater runoff.

4. MODEL RESULTS AND ANLAYSIS

4.1 Design Standard Sizing Analysis

Long term simulations and Oregon DEQ design storm simulations were completed using the calibrated model for Basin M and the two imperviousness scenario models for Basin K1. Long-term simulations were completed in SWMM using twenty years of precipitation data from the WPCL rain gauge. Total runoff and peak runoff were assessed in the most downstream node within each model. Inlet flow rate data for these nodes was analyzed to determine the diversion (i.e., pump) flow rate that would be required to capture at least 90% of average annual runoff from each basin scenario and the peak runoff flowrate during the Oregon DEQ design storm.

Long-term and Oregon DEQ design storm simulation results are presented in Table 6. As shown in Table 5, the proposed diversion flowrate for both stormwater SCMs in Basin K1 and Basin M equal to the flowrate required to: 1) capture 90% of long-term stormwater runoff, and 2) capture the Oregon DEQ design storm. As a result, the simulation results show that the 30% design of the SCMs conform to the applicable standards for this project at Terminal 4.

Table 6. Modeling summary and results

Basin / Scenario	Area (acres)	Total Long-term Runoff (MG)	Average Annual Runoff (in/yr)[1]	Long-term 90% Capture Flow Rate (cfs)	Flow Rate to Capture DEQ Design Storm (cfs)	Diversion Flowrate in the Proposed 30% Design (cfs)
Basin K1 / 100% impervious	1.24	23.4	35.5	0.14	0.20	0.20
Basin K1 / 50% impervious	1.24	12.3	18.7	0.07	0.10	
Basin M / Calibrated	26.5	150.7	10.7	0.69	0.81	0.81

[1] Average annual runoff data use a POR length of 19.6 years and basin area values. For reference, average rainfall during the POR was 39.0 inches.

4.2 Adverse Drainage Condition Analysis

The 25-year 24-hour storm event simulation was used to analyze the potential upsizing needed for the two stormwater SCMs should future development occurs. The existing condition model and the proposed condition model with the stormwater SCMs for both Basin M and Basin K1 were ran with the 25-year storm. The comparison in model results show no additional surcharging or flooding in manholes and pipes in the existing drainage network after the implementation of the stormwater SCMs.

As shown in Table 7, the proposed stormwater SCM in Basin M only increases the maximum hydraulic grade line (HGL) at the diversion manhole and the manhole immediately upstream of the diversion manhole (MH11) by less than 2 ft. The maximum HGL at these two manholes are more than 7 feet below their respective ground elevation. As a result, the modeling result in Basin M shows that no adverse drainage condition is created by the proposed SCM during a 25-year 24-hour storm event.

As shown in Table 8, the proposed SCM at Basin K1 increases the maximum HGL in the diversion manhole by 0.1 foot. The resulting maximum HGL at the manhole is more than 5 feet below ground surface. As a result, the modeling result in Basin K1 shows that no adverse drainage condition is created by the proposed SCM during a 25-year 24-hour storm.

Table 7 Maximum HGL Comparison between Existing and Proposed Condition in the Basin M Drainage Basin

Node	Maximum HGL in Existing Condition, ft	Maximum HGL in Proposed Condition, ft	Difference, ft	Ground Surface Elevation, ft	Distance below Ground Surface in Proposed Condition, ft
MH1	45.77	45.77	0	48.97	3.2
MH2	40.59	40.59	0	45.36	4.77
MH3	36.02	36.02	0	41.58	5.56
MH4	33.39	33.39	0	37.36	3.97
MH5	32.22	32.22	0	37.28	5.06
MH6	31.76	31.76	0	37.21	5.45
MH7	31.14	31.14	0	33.91	2.77
MH8	30.96	30.96	0	32.41	1.45
MH9	30.93	30.93	0	32.5	1.57
MH10	30.92	30.92	0	33.12	2.2
MH11	26.2	27.11	0.91	34.27	7.16
MH12	32.94	32.94	0	34.33	1.39
MH13	31.76	31.76	0	34.32	2.56
Diversion Manhole	25.23	26.93	1.7	34.04	7.11

Table 8 Maximum HGL Comparison between Existing and Proposed Condition in the Basin K1 Drainage Basin

Node	Maximum HGL in Existing Condition, ft	Maximum HGL in Proposed Condition, ft	Difference, ft	Ground Surface Elevation, ft	Distance below Ground Surface in Proposed Condition, ft
Diversion Manhole	30.64	30.74	0.1	36.2	5.46

5. SUMMARY AND CONCLUSIONS

The model calibrations and long-term simulations presented in this Appendix were used to support development of the 30% designs presented in the Preliminary Engineer's Report for the proposed SCMs. This modeling analysis demonstrated that:

- The proposed stormwater SCMs in Basin M and Basin K1 are sized adequately to capture the entire runoff from the Oregon DEQ 1200-Z design storm (50% of a 2-year 24-hour event) and 90% of the long-term runoff from their respective drainage basin.
- The proposed stormwater SCMs in Basin M and Basin K1 do not create any adverse drainage condition compared to the existing condition.